

Additional Material

Full Descriptions of Adaptation Recommendations

This document provides additional information for each of the Adaptation Recommendations, including the following:

- Potential implementation mechanisms
- Related efforts
- Research and information needs

In some cases, sections are expanded from what is provided in the Climate Action Plan Interim Report.

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 CO₂ 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 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 varieties 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 CO₂;
- Introduction of new crop varieties 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.

Potential Implementation Mechanisms

Establish a coordinated, multi-disciplinary and multi-institutional applied research program focused on agricultural adaptation strategies. For this particular action, an emphasis should be placed on the development of crops adapted to anticipated climatic changes.

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.

Potential Implementation Mechanisms

Establish a coordinated, multi-disciplinary and multi-institutional applied research program focused on agricultural adaptation strategies. For this particular action, an emphasis should be placed on adoption or modification of new and existing management strategies.

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.

Potential Implementation Mechanisms

Establish a coordinated, multi-disciplinary and multi-institutional applied research program focused on agricultural adaptation strategies. For this particular action, an emphasis should be placed on management of increasing weed, disease, and insect pressure as a result of a changing climate.

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.

Potential Implementation Mechanisms

Expand the existing Network for Environment and Weather Applications (NEWA).

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.

Potential Implementation Mechanisms:

Establish a coordinated, multi-disciplinary and multi-institutional applied research program focused on agricultural adaptation strategies. For this particular action, an emphasis should be placed on decision-making tools to provide the critical link between applied research and on-the-ground implementation of 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.

Potential Implementation Mechanisms:

Delivering this program to the agricultural and forestry communities through a network of established and trusted advisors (public and private, including cooperative extensions, soil and water conservation districts, private agricultural planners, and consultant foresters) using a framework familiar to the target

audience (Agricultural Environmental Management – AEM Program) will greatly enhance the ability to realize the levels of behavior changes necessary to achieve maximum benefits at the lowest costs. This policy action would be the mechanism for delivering the decision-making tools to the end-users and ultimate decision-makers.

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.

Potential Implementation Mechanisms:

Decisions-making tools need to provide various adaptation strategy options, ranging from low-cost to higher-cost, along with the expected level of benefits of each option. Outreach and education programs need to recognize equity issues by developing specific efforts to reach traditionally underserved segments and regions of agricultural and forestry sectors. Additionally, cost-share incentive programs should be structured to recognize equity issues.

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.

Of these regions and groups, those most vulnerable to climate change include small family farms with little capital to invest in on-farm adaptation strategies, such as new infrastructure, stress-tolerant plant varieties, new crop species or increased chemical and water inputs. Small family farms also are less able to take advantage of cost-related scale economies associated with such measures. Small farms, particularly those in the dairy sector, already face severe competitive pressures due to rising production costs and flat or declining commodity prices. Climate change is likely to exacerbate cost pressures on small farms, particularly if adaptation requires significant capital investments, thus accelerating trends toward consolidation within the industry. Survival for

many smaller farms will hinge, in part, on making good decisions regarding not only the type of adaptation measures to take but also in 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.

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 CO₂ 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 CO₂ 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 (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).

Related Efforts

Although there are knowledge gaps regarding agricultural adaptation strategies, many practices already exist and can be implemented immediately. However, the implementation of these practices will not be cost- or risk-free, and inequities in availability of capital and/or information for strategic adaptation may become an issue for certain sectors of the agricultural economy.

Since many of these practices and strategies also represent mitigation practices, it is imperative that these decision tools be developed in parallel and integrated with on-farm mitigation strategies. A comprehensive and integrated approach to climate change and agriculture will be the most cost-effective approach in reducing the rate of change while proactively positioning the sector to adapt to impending change that cannot be forestalled.

The above policy options are consistent with and should be integrated into mitigation strategy AFW 4 - Integrated Farm Management Planning and Application, which includes a component for water conservation and efficiency, and AFW 6 – Increase On-Farm Energy Efficiency and Production of Renewable Energy, which includes components for comprehensive on-farm energy audits and can account for anticipated changes in energy use required to adapt to a changing climate. Both of these mitigation strategies have a strong planning component into which adaptation strategies can be easily integrated.

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 CO₂ 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.

Potential Implementation Mechanisms

Initiate a comprehensive review and evaluation of existing programs addressing weed, disease, and insect threats.

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 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 (CAPS) 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).

Potential Implementation Mechanisms

- Ensure that the NYS Integrated Pest Management Program (IPM) is fully funded.
- Establish a mechanism to ensure long-term funding for the IPM program as opposed to the current year-to-year funding.
- Expand and coordinate outreach and education efforts. Expand/build technical capacity within organizations providing on the ground support for the IPM program.
- Increase the integration of IPM into the existing NYS Agricultural Environmental Management (AEM) program.
- Increase research funding to develop pest-resistant plant varieties and response strategies.
- Increase regional coordination for early detection of emerging threats.
- Identify and monitor pathways of pest introduction.
- Expand state efforts and increase funding to proactively identify and monitor emerging weed, disease, and insect threats (e.g., through the NYS Cooperative Agricultural Pest Survey (CAPS) program).
- Develop multiple response tactics to manage individual threats, including biological, organic, mechanical, and chemical options.
- Enhance coordination and develop protocol among government agencies with regulatory oversight to ensure a rapid response to emerging plant threats.

Impacts/Vulnerabilities Addressed

Invasive weeds, disease, and insect pressure due to increases in temperature are expected to spread from south to north, with a corresponding distribution of impacts. Warmer winters and an increase in carbon dioxide levels will likely result in periodic outbreaks of new and existing threats that may not be based on geographic factors. The scale of these periodic outbreaks will likely be difficult to track and quantify.

The agricultural resources that will be impacted include all agricultural crops, both annual and perennial, as well as forestry impacts. The overall risk to agriculture of increased weed, disease, and insect pressure is generally high; this may vary between medium and high according to individual climate factors. Since the vulnerabilities are often the same regardless of the climate factor, the cumulative overall risk is high. The risk from increased weed, disease, and insect pressure will manifest itself in impacts ranging from decreases in crop yields to total crop failures.

While the capacity for agriculture to adapt to these impacts is moderate, this adaptive capacity is not without challenges. Absent the development of decision-making tools, as well as significant outreach and education efforts to the agricultural community, the first and sometimes only line of defense will be to increase chemical applications. This control method carries with it inherent environmental and economic costs.

Environmental Justice Considerations

Small family farms with little capital to invest in on-farm adaptation strategies, such as new infrastructure, stress tolerant plant varieties, new crop species, or increased chemical and water inputs are often the most vulnerable to climate change. Small family farms are also less able to take advantage of cost-related scale of economies associated with such measures and already face severe competitive pressures due to rising production costs and flat or declining commodity prices. Climate change is likely to exacerbate cost pressures on small farmers, particularly if adaptation requires significant capital investments, thus accelerating trends toward consolidation within the industry. Survival for many farms, both large and small, will hinge, in part on making good decisions regarding not only the type of adaptation measures to take but also in 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 access risk and uncertainty. 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.

Related Efforts

The NYS IPM program was established through legislation in 1985. Funding for the NYS IPM Program goes to the Cornell College of Agriculture and Life Sciences (CAL S) through a yearly budget appropriation given to the NYS Dept. of Agriculture & Markets. The Department contracts with Cornell for the NYS Agricultural IPM Program. In 1994 CAL S initiated a Community IPM program to target areas of pest management not covered by the Agricultural IPM program, including school interior/exterior, golf courses, athletic fields, landscapes, structures such as hospitals and office buildings, homes, utility and highway ROWs, and any other settings requiring environmentally sound pest management. In 1999 CAL S contracted with NYS DEC to provide a Community IPM program modeled after the successful agricultural program.

The IPM program has a well established organizational structure in place and includes working groups, Operating Committees, Executive Committee, Grower Advisory Committee, and Community Coordinating Council. The IPM program primarily relates to the State of New York through the Dept. of Agriculture and Markets and the NYSDEC, although connections are maintained with other state agencies, the Governor's Office, and the Legislature.

The Cooperative Agricultural Pest Survey (NY-CAPS) is directed by USDA's State Plant Health Director and NYS's State Plant Regulatory Officer and is conducted by the Division of Plant Industry of NYS Department of Agriculture and Markets. The primary objective of NY-CAPS is the early detection of exotic plant pests to minimize agricultural production costs and enhance product quality and marketability.

NY-CAPS partners with USDA's Animal Plant Health Inspection Service/Plant Protection and Quarantine (APHIS/PPQ) and other state agencies, industries, and professional organizations to develop and maintain effective emergency response systems to detect, respond to, and eliminate outbreaks of invasive pests and diseases. NY-CAPS continually strives to broaden its network of partners and improve its information sharing with cooperators.

NYS IPM program and NY-CAPS and the Agricultural Environmental Management (AEM) program are established statewide programs. As such, the feasibility of this policy option being successfully implemented, producing measurable results, and being resilient under a changing climate is high.

Delivery of the IPM agricultural component is consistent with and can be integrated into mitigation strategy AFW 4 – Integrated Farm Management and Planning, which includes a component for IPM (AFW 4 1.2(e)) and establishes a timeline with numeric goals for implementation.

Other related efforts include the Ecosystems Adaptation Workgroup, Invasive Species Task Force, and Climate Smart Communities.

Research/Information Needs

See Recommendation 1

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.

Potential Implementation Mechanisms

Increase funding levels to the NYS Pro-Dairy Program at Cornell University and other NYS agricultural schools to continue research and development of feed ration and feeding regime modification for dairy cows and other livestock to mitigate the effects of climate change induced heat stress. Also provide adequate funding for outreach and education efforts focused on feed management modification as a climate change adaptation strategy.

Any feed management modifications to ameliorate heat stress should take into account current efforts to reduce nitrogen, phosphorus, and enteric methane via the same pathway, to ensure modifications are not at cross purposes. Additionally, changes in feed management will need to be evaluated and tailored to individual farms prior to implementation.

This policy option is consistent with and can be integrated into mitigation strategy AFW 4 - Integrated Farm Management Planning and Application which has a Precision Feeding component. Although this is a mitigation strategy, any adjustment in feed rations/regime must simultaneously address multiple environmental and economic objectives, including water quality and economic issues related to overall production.

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.

Potential Implementation Mechanisms

- Provide technical and cost-sharing financial support for the structural and mechanical modifications required to increase the cooling capacity in existing livestock housing facilities. All mechanical modifications should be required to be Energy Star certified where appropriate or achieve the maximum energy efficiency practicable. Structural and mechanical modifications may include fans, sprinklers, and evaporative cooling systems. Planning and design of structural and mechanical cooling systems may vary significantly from one operation to the next, thus requiring a farm-specific engineering approach.
- Provide technical and cost-sharing financial support to ensure an adequate water supply. Daily water intake by livestock may increase 20-50% under heat-stress conditions. A significant portion of this increased water usage may be mitigated through the implementation of structural and mechanical modifications. Evaporative cooling systems will also increase water usage. In locations where water availability is a limiting factor, a cost-benefit analysis will need to be undertaken to determine the most efficient strategy.
- Installation and increased use of cooling systems will bring increased expenditures for labor and energy costs. From a greenhouse gas perspective, increases in energy demand required by an adaptation strategy should be supplied by renewable energy wherever and whenever possible. Fortunately, farms have abundant access to multiple renewable energy sources, including solar, wind, and manure (anaerobic digestion). Increases in energy use and the CO₂ associated with it can potentially be offset through the deployment of renewable energy technologies on farms.

The above policy options are consistent with and should be integrated into mitigation strategy AFW 6 – Increase On-Farm Energy Efficiency and Production of Renewable Energy, which includes components for comprehensive on-farm energy audits and can account for anticipated changes in energy use required to adapt to a changing climate, and AFW 4 - Integrated Farm Management Planning and Application, which includes a component for water conservation and efficiency. Both of these mitigation strategies have a strong planning component into which adaptation strategies can be easily integrated.

- Support the development of construction guidelines for new dairy facilities which incorporate adequate cooling capacity to mitigate the anticipated rise in temperature in the coming decades, as well as green building technologies. Provide technical assistance to farmers constructing new or expanding existing livestock housing facilities.

Impacts/Vulnerabilities Addressed

New York State is the third largest dairy state in the country with over 600,000 head producing over 12 billion pounds of milk annually. In 2007, New York dairies generated \$2.3 billion in revenue, supporting more than 20,000 farmers and employees, as well as, many local businesses that supply or provide services to the dairy industry. According to the NYS Comptroller, it is estimated that each dairy cow is worth about \$13,737 to the area's economy and about \$40 in municipal taxes.

The dairy industry in New York has prospered due to many factors, not the least of which are proximity to major markets and a relatively cool historic climate benefiting the industry by minimizing heat stress. Rising temperatures under climate change are expected to cause longer and more frequent episodes of heat stress for dairy cows, larger potential losses in productivity, and greater vulnerability to annual variability in temperature. During the unusually warm summer of 2005, New York dairies reported decreases in milk production ranging from 8 to 20% below normal production. A recent Northeast assessment to model dairy cow performance associated with climate model projections for the region concluded that negative economic impacts on the dairy industry will be substantial unless dairies are able to adapt. Compounding the problem for New York dairies is the very nature of the states industry. Unlike large dairy states in warmer climates in the western part of the US, the industry in New York has evolved over the last century and a half, the average herd size for New York dairies is just over 100 head and many of the dairy barns are between 50 and 100+ years old.

New York livestock operations, overwhelmingly dominated by the dairy industry are often times the main economic driver for many rural communities and they have historically operated on very narrow profit margins. The recent downturn in the economy has hit the dairy industry exceptionally hard, for the past 11/2 most dairies in the country have operated at a loss resulting in many dairy farms either going under and/or incurring significant debt to stay in business until the economy turns around. Any negative impact to these farms bottom line, such as reduced production, will exasperate this problem. As such the overall risk is characterized as high.

Increasing temperatures are expected to impact the entire state. Although dairies pre-dominate certain regions of the state, they are found across the state outside of metropolitan areas. The risk is widespread.

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

Related Efforts

NYS Climate Action Plan Agriculture, Forestry and Waste technical working group (AFW-TWG) Proposed Policy Options; AFW 4 - Integrated Farm Management Planning and Application, AFW 6 – Increase On-Farm Energy Efficiency and Production of Renewable Energy.

NYS Renewable Portfolio Customer Sited Tier (RPS-CST) – provides incentives to deploy on-site generation of renewable energy.

NYS Energy Efficiency Portfolio Standard (EEPS).

Agricultural Energy Efficiency Program – provides incentives to deploy energy efficiency measures.

NYS Flexible Technical Assistance (FlexTech) Program.

Research/Information Needs

See Recommendation 1

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 Coastal Zone 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.

- Sea level has risen 15 inches in New York Harbor over the last 150 years and 4-6 inches since the 1960s (Colle et al, 2010). The rate of sea level rise is accelerating over the course of time, due to a natural lag between increases in atmospheric greenhouse gases and ocean and glacial ice melt responses. The rate will continue to increase through the second half of the 21st century. Based on the best available science, adjusted for conditions specific to New York, additional sea level rise of between 2 and 10 inches is anticipated by 2020, and a rise of up to 55 inches is possible by the 2080s (NPCC, 2010; NYSERDA ClimAID, 2010; NYS Sea Level Rise Task Force, 2010).
- Sea level rise will affect human and natural systems along the entire Atlantic and estuarine coastline of NYS. This includes shorelines and embayments along Long Island Sound, East River, Jamaica Bay, Raritan Bay, and New York Harbor. Recent research and historical observation indicate that sea level rise will affect water levels in the Hudson estuary up to the Federal Dam at Troy at the same magnitude as the Atlantic coastline (New York State Sea Level Rise Task Force, 2010; NYSERDA ClimAID, 2010).
- In the coming decades, sea level rise will also shorten flood recurrence intervals. The New York City Panel on Climate Change (NPCC, 2010) estimates that due to sea level rise alone, flood levels that now occur on average once per decade may occur once every one to three years by the end of the 21st century. Predictions for New York City suggest that if the flooding events that occurred between 1997 and 2007

were repeated with sea level 50 cm (~20 inches) higher, there would be a coastal flood warning issued for NYC nearly twice per week (Colle et al, 2010). A 20 inch increase in water levels could occur as early as 2050 under the rapid ice melt scenario of the projections adopted by NYS for sea level rise.

- The risk of coastal hazards associated with sea level rise, such as storm surge related flooding, erosion, and groundwater intrusion will increase in magnitude over time with sea level rise; the geographic area at risk will also increase. These changes will impact human communities, with risks to human health and life, natural systems including wetlands, dunes, barrier beaches, water quality, and critical public facilities and infrastructure. Maps of areas vulnerable to sea level rise have not been completed for the entire coastal area of NYS so no comprehensive estimate exists for how much the area vulnerable to sea level rise will increase over time. However, we do have estimates of areas currently at high risk of a powerful coastal storm based on FEMA FIRMS.
- According to the State Multi-Hazard Mitigation Plan developed by the State Office of Emergency Management, over two million people currently reside in areas of NYS vulnerable to a Category 3 hurricane, and for a Category 4 hurricane more than 3 million. Residential structures in the 100-year floodplain of New York City and Nassau, Suffolk and Westchester counties have a total estimated value of over \$125 billion. While this figure includes riverine as well as coastal flood plains, it reflects the scale of flood exposure in the region. (SEMO, 2008). Coastal development and public investment in infrastructure continues to be sited in areas at high risk of coastal hazards.
- Due to the long life cycle of major infrastructure it is critical to plan to adapt to the increasing risk of flooding and coastal hazards as early as possible in order to utilize maintenance and capital development programs to improve resilience over time. Given the value of critical facilities to NYS and the cost of flood risk mitigation measures it is in the best interest of NYS to identify which facilities will be at greatest risk at a high level of detail and plan now to adapt to rising waters. Relying on maps with a coarse level of detail could cost the state millions to billions of dollars to protect structures that may have been inaccurately identified to be at risk or, worse, to rebuild facilities or communities following a powerful storm that were incorrectly identified to be safe from harm.
- According to a report by the U.S. Climate Change Science Program (Titus et al, 2009) without changes to regulatory and administrative procedures much of the marine shoreline area of New York will be armored to address sea level rise impacts. Shoreline armoring to protect human development will create barriers to upland migration of natural areas such as wetlands and submerged aquatic vegetation. As water levels rise the barriers will drown these natural systems. The shallow coastal waters that will be most affected by sea level rise are also some of the most important and productive habitats for natural resources, and are vital to a variety of fish, shellfish and bird species during critical portions of their life cycle. These resources are essential to the quality of life along our shorelines and across the state. They perform important and valuable services for human communities including buffering storm impacts, filtering runoff, storm water storage, ground water recharge and providing public access and tourism amenities. The continued state funding of shoreline protective structures will not only have devastating effects on these natural systems, it also continues to foster development in high risk areas.
- NYS has several options. It may allow communities to respond to events as they occur, with state assistance in emergencies. It may fund shore defenses for most of the state's shorelines. Or it may choose to foster regional adaptation over the course of time based on rationally prepared plans. If decisions are not coordinated among local governments it is likely that there will be dramatic differences among neighboring communities in vulnerability, needs for emergency services, natural resource management, and a general failure to address regional vulnerabilities in a holistic way. Ad hoc storm responses are likely to result in escalating chronic damages, coupled with escalating environmental impairments, as sea level rises.
- Individual agencies are already beginning to incorporate sea level rise into their decision making, however, it is important that permitting, funding and programming in the coastal area are coordinated across agencies to ensure the agencies are not working at cross purposes. In addition, if agencies attempt

to address the broad integrated issues of climate change in a piecemeal fashion it is highly likely that resources will be wasted, contradictory management efforts will be initiated and operating principles and policies will remain at cross purposes, which at best leads to ineffective protection of resources, and at worst lead to accelerated losses.

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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.

Potential Implementation Mechanisms

These projections should be officially adopted by the state for planning purposes via a directive from the Governor's Office. The directive should call for a formal administrative process for regularly updating sea level rise projections, with state agency representatives, including DEC, DOS, SUNY, SEMO, federal agencies such as the U.S. Geological Survey and the National Aeronautic and Space Administration, and academic partners. Short and long term (100+ years) projections must be reviewed, updated and adopted on a regular basis. DEC and DOS should lead the effort to incorporate projections for sea level rise into all relevant state agency policies and regulations. Local governments should also be encouraged or required to adopt these projections for the purposes of planning, zoning, and permitting development projects.

The hurdle to adopting the existing well-reviewed projections of sea level rise above is largely political. This hurdle could potentially be overcome if the recommendation is implemented via executive order and agency use of the projections for planning purposes is well-outlined to the public. If implemented and used in combination with appropriate policies, regulations and planning, this action is likely to be very effective at increasing resilience over the long term.

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.

Research/Information Needs

It is likely that the amount of sea level rise in state waters will not be uniform and will not match global average projections. Regional downscaled sea level rise projections appropriate for the coastal regions of the state, and identification of changes in storm recurrence intervals, should be prepared on an ongoing basis.

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.

Potential Implementation Mechanisms

Direction should be via executive order from the Governor. DEC's Office of Climate Change and DOS's Division of Coastal Resources should establish a joint work group to work with each relevant agency to provide information and assistance to other agencies to fulfill this recommendation.

Given the value of resources in the coastal regions of NYS it is both feasible and prudent to direct state agencies to respond to sea level rise.

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.

Related Efforts

Integrating sea level rise and its projected impact on flood recurrence intervals into agency programs is also a top priority recommendation of the NYS Sea Level Rise Task Force, the New York City Panel on Climate Change (NPCC), and the draft CLIMAID Statewide Climate Impacts Assessment. By way of example, the Department of Environmental Conservation has issued a commissioner's policy that would direct staff to incorporate climate change mitigation and adaptation strategies into DEC programs, actions and activities, as applicable, and to consider climate change implications as DEC staff perform relevant activities. Although some other agencies, e.g., NYSDOT, have begun to incorporate sea level rise projections into some programs, it is not yet the norm nor institutionalized. DEC's draft policy could serve as a model for other agencies.

Research/Information Needs

Agencies and programs that will be affected by or will affect management of human and natural assets from sea level rise and powerful storms in high risk coastal areas should be identified. More detailed evaluations including the relative benefit of comparable adaptation strategies and the economic and environmental justice considerations of policy changes should be undertaken prior to changes in regulation and programming.

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 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.

Potential Implementation Mechanisms

This multi-layered mapping project would require participation of a number of institutions, including Department of State, Department of Environmental Conservation, the Office of Cybersecurity and Critical Infrastructure, and the NYS GIS Clearinghouse. The Federal Emergency Management Agency, United States Geological Survey, and the state Office of Emergency Management (formerly the State Emergency

Management Office), and local governments, academic institutions, and non-governmental organizations may serve in an advisory role as users of the information and to build support for the effort.

The project is highly feasible and is necessary to enable adaptation recommendations 2 and 4. Integrative electronic mapping tools to distribute the information are available through DEC and the Nature Conservancy and are expected to be developed through FEMA (see below).

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.

Related Efforts

This recommendation is consistent with and critical to the implementation of several recommendations of the NYS Sea Level Rise Task Force and the draft CLIMAID Statewide Climate Impacts Assessment.

The Nature Conservancy (TNC) and a consortium of partners have developed an interactive mapping tool for Suffolk County for government and public use (www.coastalresilience.org). They are expanding this effort to distribute data to the Peconic Estuary and the northern shoreline of Long Island. This tool allows users to visualize flooding scenarios under sea level rise and storm surge, assess risk to ecological and socio-economic resources and identify potential adaptive solutions.

The NYS Sea Level Rise Task Force has adopted TNC's Coastal Resilience tool as the best available mapping tool for planning for sea level rise in NYS. The interagency body described in Recommendation 5 should, as a matter of high priority, undertake a comprehensive review of integrative mapping tools and, as appropriate establish partnership(s) with TNC and/or other organizations to develop tools to meet state and local mapping and analytical needs.

FEMA is now striving to provide electronically-accessible Digital Flood Insurance Rate Maps (DFIRMs) nation-wide, however, it is expected to take many years for full implementation. While states may request mapping of projected areas of sea level rise on FIRMs as they are updated, current updates in NYS do not include projections of sea level rise or areas of dune, barrier beach, and/or wetland migration in response to sea level rise.

Critical data, including high resolution elevation/bathymetry data, have been, or are planned to be, collected in most coastal areas in NYS (see below).

Research/Information Needs

- Sea level rise and storm inundation projections must be updated on a regular basis and used to update identification of high-risk areas.
- The existing information regarding the distribution of coastal storm impacts over the landscape is poor. This storm information should be improved through literature searches to help describe the location and scale of impacts from historic events, as well as modeling to help describe the likelihood and scale of

future events. To aid planning, the reporting system for storm damages should be improved to help guide future adaptive measures. DOS has a draft reporting form that addresses this need.

- Means to direct SEMO Hazard Mitigation Plans and FEMA post-disaster mitigation funding towards long term resilience measures and away from rebuilding in high risk areas should be developed.
- High-resolution elevation data of entire coastline are critical to mapping the projected impacts of sea level rise and related storm surge and flood risks. All coastal counties in NYS except for Nassau, Rockland, Columbia and Rensselaer have been mapped using LiDAR (light detection and ranging technology). A USGS-funded project is planned to obtain data for Nassau, Rockland, and the estuarine shorelines of Columbia and Rensselaer. The state should pursue or provide financial resources to obtain LiDAR data for any areas not mapped by this project.
- New York State's coastal erosion hazard areas (CEHA) must be remapped to minimize investment in areas subject to coastal storm damage, erosion and inundation, and sea level rise. State law and regulations require review and remapping at least every ten years. The original CEHA maps are over 20 years old and are based on imagery over 30 years old. Structural hazard areas have not been mapped along the marine coast. Because of obsolete technology, the current blue-line paper copy CEHA maps can no longer be reproduced and provided to local governments or the public. The original maps must be replaced with digital maps, using GIS software and current imagery, and with accurate coastal erosion hazard areas delineated. Subsequent periodic review and update of CEHA maps will also be needed. Identification of at-risk natural resources and infrastructure.
- The state must maintain complete and current maps of tidal and freshwater wetlands. The existing tidal wetlands maps are 36 years old and need to be updated.
- Criteria should be developed to map areas of tidal wetland, dune, barrier beach, and submerged aquatic vegetation migration in response to sea level rise. Following the development of a methodology, these areas should be included in updates to tidal wetland and other appropriate maps.
- The state must map the location and status of critical habitats, natural (barrier islands, wetlands, etc) and human-made shoreline protective features, infrastructure and critical facilities, and vulnerable communities in high risk coastal areas.

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.

Potential Implementation Mechanisms

Executive order provides direction to DEC, DOS, ESDC, DOT, OGS, OEM, and other agencies as appropriate. DOS will work with other agencies to ensure that policies of this recommendation are consistent with NYS Coastal Policies.

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.

Related Efforts

This recommendation is a priority of the Sea Level Rise Task Force, and takes advantage of the authority of local governments to regulate land use to avoid loss of life and community damages. It also utilizes the technical and funding of the Department of State Local Waterfront Revitalization Program, interagency Climate Smart Communities program, and the Hazard Mitigation Plans and federal mitigation funding administered by the Office of Emergency Management (formerly the State Emergency Management Office). In addition, enhanced information tools available through DEC, SEMO, FEMA, USGS and the U.S. Army Corps of Engineers can provide assistance. Finally, sea level rise projections available through tools like coastalresilience.org (see Recommendation 3), developed by The Nature Conservancy with partners at the NOAA, NASA, the Association of State Floodplain Managers and others, enable communities to project the locations at highest risk and focus resources where they will accomplish the most. SUNY Stony Brook also has a coastal inundation model that may provide useful information for regional local governments in New York City, Nassau, Suffolk and Westchester counties, and with communities of the lower Hudson Valley.

Research/Information Needs

- Sea level rise and storm inundation projections must be updated on a regular basis and used to update identification of high-risk areas.
- High-resolution elevation data of entire coastline are critical to mapping the projected impacts of sea level rise and related storm surge and flood risks. The state should pursue or provide financial resources to obtain LiDAR data for any unmapped areas.
- New York State's coastal erosion hazard areas (CEHA) must be remapped to minimize investment in areas subject to coastal storm damage, erosion and inundation, and sea level rise. State law and regulations

require review and remapping at least every ten years. The original CEHA maps are over 20 years old and are based on imagery over 30 years old. Structural hazard areas have not been mapped along the marine coast. Because of obsolete technology, the current blue-line paper copy CEHA maps can no longer be reproduced and provided to local governments or the public. The original maps must be replaced with digital maps, using GIS software and current imagery, and with accurate coastal erosion hazard areas delineated. Subsequent periodic review and update of CEHA maps will also be needed as well as identification of at-risk natural resources and infrastructure.

- The state must maintain complete and current maps of tidal and freshwater wetlands. The existing tidal wetlands maps are 36 years old and must be updated to include all existing tidal wetland areas. Following this, the Tidal Wetland Act must be modified to include consideration of the effects of sea level rise on tidal wetlands over time. Guidance and criteria to map areas of tidal wetland migration must be developed and incorporated into mapping protocols and regulation and tidal wetlands must be inventoried again to include migration areas.
- The state must map the location and status of critical habitats, natural (barrier islands, wetlands, etc) and human-made shoreline protective features, infrastructure and critical facilities, and vulnerable communities in high risk coastal areas.
- State planning policies should support, and provide incentives for, identification and preservation of potential receiving areas. These should be cataloged at the state level for post-storm redevelopment purposes.
- The state must maintain complete and current maps of tidal and freshwater wetlands. Mapping should include identification of potential landward migration and barriers to migration.
- An array of decision-support tools has been developed. An interagency work group has been established and charged with examining tool applicability, recommending those most suitable for New York State and supporting development of tools and information to provide currently unmet needs.

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 New York State Sea Level Rise Task Force (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.

Potential Implementation Mechanisms

An interagency team should be responsible for developing climate change adaptation priorities, based on knowledge of agency operations and responsibilities and climate change expertise. The participating agencies should work to implement agreed-upon priorities and to incorporate findings related to climate change and sea level rise into all state agency regulations, operations and planning processes. The interagency group should be coordinated by the DEC Office of Climate Change and the DOS Coastal Program and should include adequate involvement from non-governmental stakeholders.

Statewide agency coordination on climate change is necessary. A formal directive via executive order could serve to define the scope of interagency coordination and assign responsibility for coordinating agency climate change adaptation planning and addressing state needs for climate change information, policy, planning and capital development. This recommendation is highly feasible and a current partnership among DEC, DOS, NYSERDA, and OEM (formerly SEMO) on local/regional adaptation could be broadened to address the needs identified in this recommendation.

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.

Related Efforts

This is also a top priority recommendation of the NYS SLRTF and the New York City Panel on Climate Change (NPCC). Existing interagency efforts, such as the state Sea Level Rise Task Force, Ocean and Great Lakes Ecosystem Council and the PlaNYC effort in New York City may serve as models for interagency coordination.

Research/Information Needs

- Evaluation of federal policies and programs and development of priority recommendations to federal agencies that could be furthered by a joint state agency effort.
- Identification of opportunities within the state university system and other public and private colleges and universities to develop planning tools and information for state agencies and local governments.
- Evaluation and prioritization of scientific research needs related to sea level rise including the following:
 - Understanding of the areas at greatest risk of flooding due to sea level rise and the impacts of high-intensity storms.
 - Tracking tidal wetland trends at a landscape scale and understanding the key factors contributing to their loss.
 - Understanding how hazards associated with sea level rise affect shoreline change, water quality and aquatic habitats.
 - Monitoring of key indicators to coastline conditions via satellite, ocean temperatures, wetland area, real-property losses due to flooding/erosion, and climate-related public health impacts.
- Economic analyses of climate change impacts and the relative value of alternative adaptation strategies.
- Cost/benefit analyses of policies/regulation change including full evaluation of ecosystem services
- Detailed evaluation of EJ impacts of adaptation strategies and public health impacts
- Evaluation of potential funding sources

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 CO₂ 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 PRISMs 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.

Impacts/Vulnerabilities Addressed

It is anticipated that an increase in mean annual temperature could cause potential changes in plant growth and productivity/regeneration, with large differences between species, as well as allow for more insect generations per season. This may result in altered plant productivity and community structure, and a greater potential for a more rapid and widespread distribution of invasive species. These impacts will be felt by all sectors, including agriculture, transportation, power supply and generation, coastal resources, commercial and recreational fishing, and others. Invasive species that are currently limited by temperature are expected to spread from south to north, with a corresponding distribution of impacts. In addition, as precipitation rates change and corresponding changes to stream flow and water levels happen, impacts to aquatic environments will also be amplified.

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 than the impact of no action. A discussion of this is included in the Invasive Species Task Force 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.

Related Efforts

As stated above, the Invasive Species Council, Invasive Species Advisory Committee, and PRISMS have all been formed to address the spread of invasive species statewide and on the local level. In addition, the federal government has established the National Invasive Species Council to coordinate efforts of the federal agencies and states, and have created the National Invasive Species Management Plan (<http://www.invasivespecies.gov/>). State efforts to control invasives must continue to be integrated and coordinated with these broader federal efforts.

Research/information needs

Although much is known about this issue, there are still research and information needs into what emerging Invasive species could cause the greatest threats to the state's ecosystems, how to structure a rapid response plan that would be most effective to address emerging invasive species, and better estimates of the economic impacts of no action versus investments in control and eradication would better inform our adaptation strategies.

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 health¹. 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.

Impacts/Vulnerabilities Addressed

Climate change impacts will be widespread, increasing the potential for high ecological and economic costs. An increase in mean annual temperature could cause changes in plant growth and productivity/regeneration, which may result in a greater potential for a more rapid and widespread distribution of invasive species. Examples of areas expected to be especially impacted two of New York’s EBM Demonstration Areas: in the Great South Bay, by impacting the growth of seagrass, salt marshes and life cycle of hard clams; and in the Sandy Creeks Watershed EBM Demonstration Area, by impacting the spread of invasive species such as Pale Swallow-wort and Purple Loosestrife.

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.

¹ See Draft Summary Report of Agency Guidelines and Recommendations. <http://nyoglecc.org/reports.html>

Related Efforts

The Department of State (DOS) spearheaded the creation of the Mid-Atlantic Regional Council on the Ocean (MARCO) Mid-Atlantic Regional Council on the Ocean (MARCO) that has brought together the Governors of the five Mid-Atlantic States to address four issues regional issues (climate change adaptation, water quality improvement, renewable energy development and habitat protection and conservation). DOS is also engaged in the revision of some of its 44 coastal policies to reflect EBM principles and embarked upon amending its federally-approved Coastal Management Plan to provide for Offshore Spatial Planning.

In addition, the Department of Environmental Conservation (DEC) has posted its Commissioner's Climate Change Policy on its website (<http://www.dec.ny.gov/regulations/65034.html#Policy>) which will incorporate climate change considerations in all aspects of its activities, including but not limited to decision-making, planning, permitting, remediation, rulemaking, grants administration, natural resource management, enforcement, land stewardship and facilities management, internal operations, contracting, procurement, and public outreach and education.

DOS's 2010 Atlantic Ocean Amendment work is focused on amending the state's Coastal Management Program (CMP) to appropriately site renewable energy and provide greater protection of ocean habitats. This will contribute to advancing New York's renewable energy goals, reducing the state's dependence on fossil fuels and creating green jobs.

The Department of Agriculture and Markets (DAM) led the effort to make the soil and water conservation districts a primary local resource for implementing EBM and has committed to updating the voluntary, incentive-based Agricultural Environmental Management (AEM) worksheets to include EBM principles.

Office of Parks Recreation and Historic Preservation (OPRHP) has focused on providing EBM training to staff throughout the agency, integrating EBM into its Agency Master Plan Initiative and specific park master plan revisions and instituted EBM into its Statewide Comprehensive Outdoor Recreation Plan, draft Wildlife Policy, and Natural Resource Stewardship projects. OPRHP has also implemented EBM projects on its properties and created a statewide scientific research permitting, database and tracking system.

The Office of General Services (OGS) was one of the first agencies to incorporate the EBM concept and principles into the agency mission statement and strategic goals and has, through the EO 4 Interagency Committee on Sustainability and Green Procurement, co-chaired by OGS and DEC, developed 19 statewide specifications for over 36 products since 2008. OGS incorporated Green Leasing guidelines to reduce negative impact on the environment and, as manager of state's underwater lands, formed an interagency working group to identify sensitive ecological underwater lands in the Hudson River and transfer ownership of those lands to ensure conservation goals are achieved.

In addition, OGS has partnered with NYSERDA to implement the Plug-In Hybrid Electric Vehicle (PHEV) Initiative to accelerate the adoption and use of PHEV's. It is also working with NYSERDA to develop the infrastructure to support the increased use of these vehicles.

Many of the agency guidelines work and related agency EBM initiatives undertaken have the potential to reduce carbon footprints and emissions. For example, under the authority of EO 111, the Office of General Services (OGS) is implementing a 35% reduction in energy consumption in building that it own, leases or operates by 2010 (relative to 1990 levels). NYSERDA is also addressing the environmental impacts of alternative energy facilities in the ocean and Great Lakes areas through its Environmental Monitoring, Evaluation and Protection program.

Launched in a design and operation phase in 2008 and 2009, the Department of Transportation's (DOT) GreenLITES (Leadership In Transportation and Environmental Sustainability certification program

recognizes and increases the awareness of the sustainable methods and practices the Department incorporates into its project designs and daily operations and expands the use of these and other innovative alternatives which will contribute to improving transportation sustainability.

Research/information needs

A fundamental component of the integration of EBM into decision-making is the reliance on new data and information driven by science-based research. As a result, the on-going science projects related to EBM work must continue to advance in order to achieve its full potential. For example, the State University of New York (SUNY) at Stony Brook is developing and deploying a real time environmental observing system and creating a computer simulation model of the Bay ecosystem. This project will generate real time data about environmental factors and allow the assessment of various management scenarios for the Great South Bay that can be applied statewide. SUNY also intends to integrate this work with the Mid-Atlantic Coastal Ocean Observing Regional Association (MACOORA), which coordinates and facilitates observations of the ocean and estuaries between Cape Hatteras and Cape Cod.

DOS spearheaded development of the New York Ocean and Great Lakes Atlas Data Viewer (<http://nyoglatlas.org/index.cfm?&userSkin=4>), an online web mapping application. The Atlas is an on-line information system providing easy access to nearly 400 data sets for decision-makers and the general public. Future planned upgrades for Atlas include: linking the features of the Atlas data viewer with the data portal, enhance easy access for technical users and provide technically complex geospatial analyses, such as inundation and nonpoint modeling, in an easy to use way for non-technical users.

An overview of research and monitoring needs to advance ecosystem health are identified in a 2008 “Research and Monitoring Priorities for EBM of New York’s Ocean and Great Lakes” prepared by NYGLECC’s Scientific Advisory Group (SAG) (<http://nyoglecc.org/reports.html>).

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.

Impacts/Vulnerabilities Addressed

The forests of the Northeast will undoubtedly be impacted by climate change. Species composition will change, particularly in the boreal forest, which is currently at the southern terminus of its range. In addition, the threats from disease and insects will change. It is too early to project the magnitude of these impacts. Clearly some diseases and insects will increase and some will decrease. Overly simplistic estimates of the impact are unwarranted at this time.

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.

Potential Implementation Mechanisms

State forest lands should be managed as demonstration areas for adaptive forest management targeted at maintaining landscape diversity and forest resilience. This should include developing new or additional Best Management Practices for forest management (on state and private land) that ensures resiliency and diversity in ecological systems.

New York's State Forests should serve as the state's model for adapting to the impacts of climate change. This can be accomplished by forming a collaborative between the staff of research forests (such as the Adirondack Ecological Center, the Carey Institute for Ecosystem Studies, Shingle Shanty Preserve and Research Station and others) and the DEC's office of Lands and Forests to research and demonstrate adaptive management strategies as climate change affects forest health, species composition, biodiversity and sensitivity to insect and disease infestations.

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.

Related Efforts

The Society of American Forests, the US Forest Service, every forest research institution, and virtually every NGO related to forests or forest management have climate change on their current agenda. Therefore, those working on demonstrating management practices adaptive to climate change must be aware of these efforts in order to avoid costly duplication of efforts. At the same time New York should be a major participant in this arena, because of the vast forest resources of this state and the historic leadership role of the research institutions of this state.

Research/Information Needs

The impacts of climate change on forests are very complicated. They will vary by forest type, soils, growth index, latitude and water availability. We are only beginning to learn of the potential impacts. Therefore, the very essence of this recommendation is⁴² for adaptive forest management on state lands and a close tie with the research community so that adaptation is linked to the most recent science as results are made available. The United States had traditionally lagged in the technology transfer of science to practice. This recommendation is aimed at illustrating that this need not be the case in the adaptation of forests as they respond to climate change.

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.

Impacts/Vulnerabilities Addressed

Many species of fish and wildlife will be affected by increasing temperature and altered hydrology and will likely endeavor to adjust their ranges in response to these changing environmental conditions. For many species, this will be a northward range expansion or a move to higher elevations. If species do not have the ability to adjust their ranges and localized conditions become incompatible with the physiological requirements of the species or to changes in habitat structure and vegetative composition, there will be local extirpations of species. Over large ranges, this may result in species extinctions. Most fish and wildlife biologists working with climate change impacts consider this impact as highly likely, and one that is already in progress. Providing for corridors is similarly recognized broadly as one of the most highly recommended adaptation strategies for both effectiveness and practicality.

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.

Potential Implementation Mechanisms

Several and diverse simultaneous approaches will help ensure the success of these strategies. These include: working with state and local transportation agencies to ensure that bridges or culverts allow for the passage of fish and wildlife; through incentives and education working with landowners to provide adequate riparian buffers, replace culverts and other structures acting as hydraulic barriers, decrease impervious surfaces, and restore natural shorelines; developing comprehensive legislation and in-stream flow standards to regulate water withdrawals in the state, including the establishment of a permitting program for water withdrawals; and extending the jurisdiction of the Environmental Conservation Law to provide legal protection not just for lake and streambeds but for adjacent buffers and corridors for all our streams, lakes, wetlands, and rivers.

Buffers are already advocated as important mechanisms for protecting water quality and there are existing public policies and programs in place to provide for incentives, technical assistance, and in some cases, regulatory requirements for the protection and/or restoration of riparian buffers. This policy would identify and further justify the use of buffers for climate change adaptation as well. Furthermore, by providing for riparian buffers, this policy helps to keep people and their structural development away from areas subject to flooding, which is projected to get worse (especially regarding intensity) with a changing climate. Because it has multiple benefits and is relatively inexpensive, this has the potential to be highly effective as an adaptation strategy. Because it re-establishes natural vegetation on existing stream corridors, it will be greatly facilitate resilience in this system, and as an adaptation strategy.

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.

Related Efforts

There are multiple riparian restoration programs in place already. However, there is no one program that effectively addresses the breadth of the entire riparian corridor, including in-stream habitat, shoreline, and terrestrial buffer. Key programs include the incentive-based and voluntary USDA Farm Bill programs, specifically the Conservation Reserve Program (<http://www.fsa.usda.gov/FSA/webapp?area=home&subject=copr&topic=crp>) and its spin-offs, Conservation Reserve Enhanced Program (<http://www.fsa.usda.gov/FSA/webapp?area=home&subject=copr&topic=cep>), Continuous Conservation Reserve Program (<http://www.fsa.usda.gov/FSA/webapp?area=home&subject=copr&topic=crp>), Wildlife Habitat Incentives Program (<http://www.nrcs.usda.gov/programs/whip/>), Floodplain Easement Program (<http://www.nrcs.usda.gov/programs/ewp/Floodplain/>), and the Environmental Quality Incentives Program (<http://www.nrcs.usda.gov/programs/eqip/>). The Hudson River Estuary Program's "Trees for Tribes" Initiative (<http://www.dec.ny.gov/lands/43668.html>) offers free native trees and shrubs for qualifying projects in the Hudson River Estuary watershed. The Estuary Program's Riparian Buffer Coordinator can assist with plant selection, designing a planting plan, and other technical information to ensure the success of buffers. EPA supports non-point source protection programs that address buffers; many are implemented through County Soil and Water Conservation Districts. The U. S Fish and Wildlife Service has a voluntary stream buffer restoration effort underway, Partners in Fish and Wildlife (<http://www.fws.gov/partners/>), wherein they provide the direct restoration on private lands under an agreement with the landowner. Although DEC implements a Stream Protection regulatory program that covers about 40% of New York's streams under Article 15 of the Environmental Conservation Law, it does not have an adjacent buffer component that would protect the riparian community. Similarly, the U.S. Army Corps of Engineers protects streams and adjacent wetlands under Section 404 of the federal Clean Water Act, and encourages but does not require buffers as mitigative measures for impacts to streams. A policy to protect and restore riparian buffers would complement the existing programs by elevating the urgency for these measures, providing additional funding and technical assistance to landowners (public and private alike), and identifying the multiple benefits of buffers, therein making them more salient to broader audiences. Adding regulatory restrictions on the conversion of existing buffers would strengthen existing stream protection programs and make them much more effective.

Research/information needs

Additional research is needed on minimum buffer widths for various species and for other riparian protection benefits. For example, a minimum of 30 - 50 feet is recommended for typical water quality buffers, but this would be insufficient for most species of wildlife to use as a dispersal corridor. Recommendations on planting and promotion of riparian buffers should be condensed into specific conservation practices detailing species to be planted, arrangement, and managing requirements. These conservation practices will vary depending on site condition and target species. Information is also needed on how to better market the value of buffers to local communities and landowners for voluntary measures.

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.

Impacts/Vulnerabilities Addressed

New York ecosystems are already experiencing climate change related impacts to species and habitats, and such impacts are highly likely well into the future. Some systems will be negatively impacted, while others may actually benefit. Aquatic ecosystems seem to be affected by climate change more immediately than terrestrial: coldwater fish species, such as salmon and trout, are showing impacts and may well disappear from parts of the state as waters warm. The migration and spawning patterns of coldwater species will also likely be altered. Conversely, warm water species may benefit from warming waters. The species composition of forest vegetation will continue to change, further affecting dependent fish and wildlife as habitats are redistributed. When the timing of vegetation growth patterns is altered, species' life cycles will be altered. The survival of pests and diseases that threaten plants, animals and humans will increase as winters warm.

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.

Potential Implementation Mechanisms

In order to effectively manage the natural resources of New York State, practitioners need to understand the baseline condition of species, habitats, and population trends. Resource agencies, led by the NYS Department of Environmental Conservation, need to begin gathering existing information in databases, GIS layers, and modeling programs. For data gaps, a network of reference communities should be established for measuring baseline condition and assessing change. Other state and federal agencies and non-governmental natural resource organizations (NGOs) are critical partners in this effort.

Rapidly changing climate and associated changes in habitats and ecological community structure may likely increase fish and wildlife exposure to stressors (both existing and those caused by climate change), and impact our ability to detect harmful trends in fish and wildlife ecology and health. We need to increase our capacity to identify key stressors to inform management decisions and abate threats. Wildlife veterinarians, academic research institutions, federal agency researchers, and NGOs can provide technical expertise in these areas.

In order to effectively prioritize conservation actions, vulnerability analyses due to expected climate impacts must be conducted of species and habitats, based on exposure, sensitivity, and adaptive capacity. State resource agencies in the northeast are currently partnering with NGOs to conduct a regional habitat vulnerability analysis. New York will soon begin a similar effort at the state level, and will be partnering with NGOs, and state and federal agency personnel. At the same time, the New York Natural Heritage Program will conduct a species vulnerability assessment using NatureServe's protocols.

The information gleaned from baseline condition surveys, stressor identification, and vulnerability analyses will directly inform the development of a research and monitoring plan for New York. It must be based on explicit, predictive, and measurable objectives and indicators, and monitoring protocols that can reliably detect signs of climate change impacts. Most importantly, adequate resources must be provided to implement the monitoring plan. With dollars scarce for such efforts, the DEC must be sure to work with local, state, and federal agencies, and NGO partners to most effectively monitor and report on the condition of natural resources in the state.

The efforts noted above are highly feasible and necessary to inform ecosystem adaptation Recommendations 2, 3, 4, 6, and 7. Too often, however, appropriately focused research and monitoring efforts are underfunded, and are some of the first programs cut in tough economic times. If we as a state truly want to effectively manage our natural resources in a changing climate, we absolutely must prioritize adequate funding to do so.

The DEC has posted a draft of its Commissioner's Climate Change Policy (http://www.dec.ny.gov/docs/administration_pdf/cpsc.pdf), which when finalized and implemented will help to prioritize climate change science and adaptation. It states, in part:

“Based on overwhelming scientific evidence, the New York State Department of Environmental Conservation (“Department” or “DEC”) recognizes that New York State’s (“State”) air and water quality, forests and wildlife habitats as well as people and communities, are at risk from climate change. In order to perform its core mission of conserving, improving, and protecting the State’s natural resources and environment, DEC must incorporate climate change considerations in all aspects of its activities, including but not limited to decision-making, planning, permitting, remediation, rulemaking, grants administration, natural resource management, enforcement, land stewardship and facilities management, internal operations, contracting, procurement, and public outreach and education.”

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.

Related Efforts

There are a number of projects recently completed that will directly inform research and monitoring efforts of natural resources in New York. While they don't focus specifically on climate change, they provide baseline information on species and habitats. They are:

Great Lakes Regional Aquatic Gap Analysis Project, USGS

http://www.glsc.usgs.gov/main.php?content=research_GAP&title=Aquatic%20GAP0&menu=research_NCE_GAP

Northeast Monitoring and Performance Reporting Framework, NEAFWA

<http://www.rcngrants.org/node/37>

Northeast Habitat Classification and Mapping Project, NEAFWA/NatureServe

<http://www.rcngrants.org/node/38>

Secured Lands Dataset; National Effectiveness Measures, TNC

<http://rcngrants.org/sites/default/files/securedareas.zip>

There are also a number of efforts related to research and monitoring impacts to natural resources from climate change. They are:

Forest Service Global Change Research Strategy Overview 2009-2019; October 2008 (USDA Forest Service Research and Development)

<http://www.fs.fed.us/research/climate/strategy.shtml>

USFWS Landscape Conservation Cooperatives:

<http://www.fws.gov/science/shc/lcc.html>

US Department of the Interior Climate Science Centers:

<http://www.doi.gov/whatwedo/climate/strategy/CSC-Map.cfm>

USGS National Climate Change and Wildlife Science Center:

<http://nccw.usgs.gov/>

USA Phenology Network:

<http://www.usanpn.org/>

Research/information needs

The research and monitoring efforts described above will do the following:

- Identify data gaps and research needs to reduce key uncertainties associated with climate change challenges, including long-term trends and ecosystem responses.
- Identify conservation strategies, including measures of effectiveness in order to inform adaptive management.
- Develop a concerted disease response plan that can be implemented at the first signs of a fish or wildlife disease.

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 best management practices (BMP) 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.

Impacts/Vulnerabilities Addressed

Spring is arriving earlier, winter snow cover is decreasing, rising sea levels are increasing the risk of flooding, short-term droughts are expected to become more frequent, and diseases associated with warmer climates are beginning to appear. These trends suggest that climate change will continue and have a greater effect on future generations, and that most sectors of our state's natural resources and economy will be impacted. An important strategy for adapting to and mitigating these potential impacts begins with educating New York's students about the effects of climate change on natural areas and the services those ecosystems provide to human communities. Ensuring that New York State private landowners are using climate-smart best practices to manage their land resources is paramount to adapting to and mitigating climate change impacts.

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.

Related Efforts

There are numerous efforts to expand climate education currently underway across New York State including the Alliance for Climate Education which travels to high schools across New York educating students about GHG emissions and effects on the living environment (<http://www.acespace.org/about>), and the New York City Research Initiative which partners high school and undergraduate students with graduate students conducting NASA funded research as a means of facilitating early development of citizen science (<http://education.gsfc.nasa.gov/nycrri/>). Another important program is lead by investigators and educators from Clarkson University and NYSERDA. With funding from NASA, the three-tiered project strives to improve climate literacy among New York middle school and high school students, college students, and STEM teachers by creating and disseminating climate change curricular modules that are based on NASA data (http://www.clarkson.edu/highschool/Climate_Change_Education/index.html). Formal incorporation and standardization of these and other climate curricula modules by NYSED would expand and focus current education and outreach mechanisms and ultimately facilitate the success of the Climate Action Plan.

Informative climate-smart demonstration sites exist across New York State. The Northeast States for Coordinated Air Use Management (NESCAUM) sponsors a Clean Air Communities electric shuttle bus program in the Bronx, New York City (<http://www.nescaum.org/focus-areas/climate-and-energy>). The New York Institute of Technology received funding from USDE to construct a Building Efficiency Project integrating solar panels on carports for off-use electric car power generation. Utilizing accessible, on-the-ground demonstration projects for climate education and outreach serves to expand awareness and climate literacy. New York state agencies responsible for resource management, education, and community planning must be required to establish climate demonstration projects focused on effective adaptation or mitigation solutions being undertaken by that agency.

Research/information needs

To ensure that broad-based education and outreach strategies are implemented effectively, progress benchmarks must be delineated and success metrics need to be outlined. Research must be conducted on what efforts are currently underway across sectors, what efforts are redundant and ineffective and what efforts could be streamlined. Statewide assessments regarding the extent of climate education initiatives, and landowner and community technical assistance programs across New York must be conducted prior to policy implementation in order to maximize potential success.

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).

Potential Implementation Mechanisms

Partners who likely need to be involved include: New York Independent System Operator (NYISO), New York Department of Public Service (DPS), electric and gas utilities, energy services companies, independent power producers, the New York State Reliability Council and other State agencies.

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.

Co-Benefits and Unintended Consequences

Accurate forecasting and regional planning will result in greater certainty in meeting energy needs and support the attainment of a broad range of environmental goals.

Related Efforts

Energy Efficiency Portfolio Standard and Renewable Portfolio Standard for customer-sited projects can be used to effectively reduce or meet regional loads, and postpone the need for new centralized power sources, or reduce the need for output from existing fossil generation. See also PSD-2 Incentives for Grid-based Renewable Generation, PSD-3 Energy Storage, PSD-4 Distribution Network Upgrading including EV and Smart Grid Infrastructure, RCI-2 Energy Efficiency Incentives, RCI-4 Tax Structure and Private Financing, RCI-5 Education, Outreach and Behavioral Change, RCI-7 Enhanced Building Codes, Appliance Standards and Enforcement, RCI-8 Building Commissioning, Benchmarking and Upgrades, RCI-9 Research, Development and Demonstration Needs, and RCI-10 Rate Restructuring and Flexible Metering.

Research/information needs

The State ClimAID program has developed a common data set of projected impacts of climate change on various regions within New York. This data set, and specifically the regional temperature changes, should be disseminated amongst stakeholders to facilitate accurate load forecasts and updated on a regular basis.

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 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.

Potential Implementation Mechanisms

Partners who would likely need to be involved include: New York State Division of Homeland Security and Emergency Services (DHSES), gas and electric utilities, energy generators, natural gas pipeline companies, New York Department of Public Service, the New York State Independent System Operator, and petroleum providers and suppliers.

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.

Co-Benefits and Unintended Consequences

Recognizing and accepting that storms in New York State will continue to increase in frequency and intensity as a result of climate change will help to facilitate better planning for infrastructure reliability. This advanced preparation will benefit many other industries that depend on a reliable electricity supply, such as the telecommunications and public health sectors.

Related Efforts

Communication pathways between emergency responders, utility providers, and customers must be continually reassessed and modified for improvement to ensure that the public is adequately informed and protected during and after a storm event.

The New York State Division of Homeland Security and Emergency Services has identified and could continue to refine information on areas that contain critical infrastructure and that are also particularly vulnerable to the effects of extreme storm events, including damage from wind, flooding, and ice, to help decision-makers direct scarce public resources for their protection in a more effective and efficient manner. Information from maps would be made available to key decision-makers for planning at the municipal, county, and state levels, while providing for the confidential treatment of such information for consistent with the requirements of existing law.

Research/information needs

The State ClimAID program has developed a common data set of projected impacts of climate change on various regions within New York. This data set, and specifically the storm projections, must be regularly updated and disseminated amongst stakeholders to facilitate open and transparent communication of risks. Additionally, there may be a need to collect and analyze data in preparation for identifying major storm risk boundaries for mapping purposes.

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.

Introduction

Climate change threatens the health of the people of New York State. These threats are associated with anticipated increases in extreme heat events, increases in the frequency and severity of storms, increases in flooding events, changes in environmental conditions favorable to the spread of vector-, water-, and food-borne disease, declines in outdoor air quality, possible increases in drought events, sea level rise, and others.

Some of the climate threats, such as increases in the frequency of extreme heat events and severe storms, pose immediate and acute health concerns. Others, such as sea level rise, require the immediate initiation of longer-term planning with a goal of avoiding health consequences in the future. To minimize or avoid the potentially significant public health consequences of climate change, adaptation planning must begin now for all of the climate threats discussed in this section. Therefore, the overall goal of these public health adaptation strategies is to identify actions that will protect and promote public health by reducing individual and community vulnerability to the possible consequences of climate change.

The possible health consequences associated with these threats are many. Extreme heat events can cause fatalities. Severe storms can cause flooding that can lead to injuries, drownings, biological and/or chemical contamination, and damage to personal property and health care facilities. Warming temperatures may increase the populations and ranges of disease vectors such as ticks and mosquitoes, leading to increases in diseases such as Lyme disease, West Nile virus, and Eastern equine encephalitis. Declining air quality may exacerbate respiratory illness and cardiovascular disease. Droughts may lead to declines in drinking water supplies and may affect agricultural productivity, causing a decline in food security. Sea level rise may displace individuals and communities and may result in more severe flooding during coastal storms. These and numerous other possible health consequences of climate change are well documented (see, for example, CCSP, 2008; Confalonieri et al., 2007; NRC, 2010). The health consequences of climate change also are discussed briefly on the following pages.

While all New Yorkers are at risk of the health impacts of climate change, all are not equally at risk. There are geographic differences in vulnerabilities. For example, the heat island effect may make people who live in urban areas more vulnerable to the health effects of extreme heat. Sea level rise/coastal storms will have a greater effect on people living in coastal areas than on those who live inland. Also, some populations, regardless of geographic area, are more susceptible to certain climate change-related health effects. These include infants/young children, older adults, people with certain health conditions, people in some occupations, and others. Of particular importance are the health disparities associated with environmental public health risks to ethnic and racial minorities and people who have low incomes. Citing events such as Hurricane Katrina, Frumkin et al. (2008) indicate that climate change is expected to perpetuate health disparities and that public health actions related to climate change need to focus on eliminating health disparities. A Climate Change Science Program (CCSP, 2008) report also indicates that the greatest health burdens of climate change are likely to fall on those with the lowest socioeconomic status. New York must begin immediately to implement actions to assess and address the most immediate climate-related health risks for the most vulnerable people.

With the exception of some of the consequences of sea level rise, the anticipated consequences of climate change are not new, although climate change may alter the severity and frequency of the events that lead to

these consequences. Public health agencies, as well as other agencies, have established programs that address these consequences to some extent. However, the existing programs need to be examined to determine if current policies and practices adequately account for the anticipated increase in the severity and frequency of climate-related events. Existing programs may need to be enhanced and new programs may need to be implemented to help New York State adapt to a changing climate.

Frumkin et al. (2008) state:

“As climate change has become a certainty, so has the need for public health action to anticipate, manage, and ameliorate the health burdens it will impose.”

These authors describe the public health response to climate change in the context of the 10 Essential Services of Public Health that were developed in 1994 by the American Public Health Association in collaboration with federal, state, and local agencies and other partners (Public Health Functions Steering Committee, 1994). The authors provided a table, shown below, that summarizes the 10 Essential Services of Public Health and provides climate change examples for each:

Table 1: The Ten Essential Services of Public Health, with Climate Change Examples

Service	Climate Change Example
Monitor health status to identify and solve community health problems	Tracking of diseases and trends related to climate change
Diagnose and investigate health problems and health hazards in the community	Investigation of infectious water-, food-, and vector-borne disease outbreaks
Inform, educate, and empower people about health issues	Informing the public and policymakers about health impacts of climate change
Mobilize community partnerships and action to identify and solve health problems	Public health partnerships with industry, other professional groups, faith community, and others, to craft and implement solutions
Develop policies and plans that support individual and community health efforts	Municipal heat-wave preparedness plans
Enforce laws and regulations that protect health and ensure safety	(Little role for public health)
Link people to needed personal health services and ensure the provision of health care when otherwise unavailable	Health care service provision following disasters
Ensure competent public and personal health care workforce	Training of health care providers on health aspects of climate change
Evaluate effectiveness, accessibility, and quality of personal and population-based health services	Program assessment of preparedness efforts such as heat-wave plans
Research for new insights and innovative solutions to health problems	Research on health effects of climate change, including innovative techniques such as modeling, and research on optimal adaptation strategies

Source: Public Health Functions Steering Committee, 1994.

New York State must immediately begin to adopt and implement strategies to help protect the health of its citizens from the anticipated consequences of climate change. Waiting may decrease the effectiveness and increase the cost of the strategies. Waiting also may jeopardize the health and safety of New Yorkers.

Recommended adaptation strategies for reducing or eliminating the public health consequences of climate change are described below.

Recommended Public Health Adaptation Strategies

Information related to each of seven recommended adaptation strategies is presented below. The reader should note that the information presented on the following pages is not intended as a comprehensive discussion of the issues on the public health consequences of climate change. Rather, it is intended to provide the reader with sufficient information to understand the issues and understand why the recommended adaptation strategies are necessary.

All of these recommended strategies essentially build upon existing or already planned programs in New York State. Therefore, with the leadership that can be provided by the Governor and State agency officials, and with the availability of adequate resources, implementing all of these recommendations is feasible. Although the ultimate effectiveness of some of the recommended actions for the seven strategies may be uncertain (e.g., the effectiveness of “green cool down” actions in reducing urban heat island effects; the effectiveness of education/outreach campaigns in altering people’s behavior), the established effectiveness of existing public health programs strongly suggests that building upon these programs also should be effective. Enhancing existing public health programs and, where necessary, implementing new programs (e.g., a “green cool down” plan, statewide promotion of healthy built environments) will help to make people and communities in New York State more resilient to the anticipated consequences of climate change.

Priority Action Recommendations

Recognizing that implementing all of the strategies/actions immediately may not be feasible, strategies/actions that warrant priority attention are identified here.

Addressing the Needs of People Who are Most Vulnerable

All New Yorkers are not equally at risk to the health consequences of climate change. However, identifying a “most at risk” or “most vulnerable” population or geographic area is not possible because of the disparate nature of the effects of climate change. People who live without access to air conditioning in urban centers may be at the greatest risk from extreme heat events. However, as described above, older adults, young children, people with certain chronic medical conditions, and others also are at elevated risk. People who live in coastal areas are at the greatest risk of the effects from coastal storm flooding, but more affluent people may be better able to avoid the effects than low-income people. The potential consequences associated with power outages from severe storms can affect anyone in the state but may be most severe for people who depend on electricity because of certain medical conditions. The published literature and government reports consistently indicate that climate change will exacerbate existing health disparities, and the greatest health burdens are likely to be on socially and economically disadvantaged people. Therefore, adaptation measures that address the possible health consequences to people who are the most vulnerable and at the greatest risk must be given the highest priority. Protecting public health and safety, particularly for the people who are the most vulnerable to the adverse consequences of climate change, is of utmost priority in New York State. Since the kinds of climate impacts that may affect public health and safety are diverse, they all have the potential to significantly affect vulnerable populations, and it is difficult to identify which actions are of greater priority. However, among the actions listed in this section, those that should be considered of highest immediate priority for protecting vulnerable populations include:

- Recommendation 1
- Recommendation 2
- Recommendation 4-A
- Recommendation 6

Heat-Related Morbidity and Mortality

The National Weather Service states that heat is the number one weather-related killer in the U.S. (<http://www.nws.noaa.gov/om/heat/index.shtml>). A report by the National Research Council indicates that over the 21st century, it is very likely that heat waves will become more intense, more frequent, and longer lasting (NRC, 2010). For these reasons, the actions related to reducing heat-related morbidity and mortality (Recommendation 1) must be given high priority.

Education and Outreach

Successfully adapting to climate change will require individuals, community leaders, businesses, institutions, health care providers, policy makers, and government officials to recognize that climate change is occurring, that it has the potential to cause serious and widespread health consequences, and that actions can be taken to reduce or eliminate those consequences. Therefore, high priority must be given to the recommended actions to “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” (Recommendation 2).

State and Local Agency Planning

Leadership on public health adaptation to climate change can be provided by the state agencies in collaboration with local agencies. Therefore, a priority action is to require state and local agencies to consider the possible public health-related impacts of climate change in planning, programs, policies, and regulations. This is the first recommended action (4-A) under Recommendation 4: “Build community resilience and integrated public health capacity to reduce human health impacts of climate change.”

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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.

Potential Implementation Mechanisms

The NYS Department of Health is developing expertise in understanding the relationship between excessive heat and morbidity and mortality and could lead an effort to examine the adequacy of existing heat warning systems. This effort is likely to require other collaborators including, for example, local health departments, the National Weather Service, the NYS Department of Environmental Conservation, the NYS Emergency Management Office and academic researchers. Implementing the cooling center aspect of this action could be accomplished by designating a state agency to collaborate with partners that could include other state agency representatives, local (e.g., county/town/city) officials, and community representatives to develop a statewide plan for expanding/enhancing cooling center capacity.

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.

Potential Implementation Mechanisms

Relevant state agencies will need to identify and collaborate with strategic partners, including local health departments and community-based representatives/organizations to develop and implement a cohesive education and outreach program.

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.

Potential Implementation Mechanisms

This action could be implemented by designating a state agency to lead/coordinate an effort to work with strategic partners to develop a plan for assessing and addressing this potentially urgent public health issue.

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.

Potential Implementation Mechanisms

This action can be implemented as a component of 1-A.

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.

Potential Implementation Mechanisms

Relevant state agencies and authorities (such as the NYS Department of Environmental Conservation, NYS Department of State, NYS Department of Health, NYS Energy Research and Development Authority) could be directed to identify and collaborate with strategic partners to develop this plan.

Impacts/Vulnerabilities Addressed

According to the National Weather Service, heat is the number one weather-related killer in the US (<http://www.nws.noaa.gov/om/heat/index.shtml>). Climate change estimates project an increase in mean warming of between 3°C and 5°C for the northeastern U.S. (Knowlton *et al.*, 2007). Climate change is likely to increase the frequency, intensity, and duration of extreme heat events in New York State (NRC, 2010). Such events usually are defined by summertime weather that is substantially hotter and/or more humid than average for a location at that time of year. However, because how hot it feels depends on the interaction of multiple meteorological variables (*e.g.*, temperature, humidity, cloud cover), reliable fixed absolute criteria for defining extreme heat events are unlikely to be specified (http://www.epa.gov/heatisland/about/pdf/EHEguide_final.pdf).

Extreme heat can directly cause an increase in heat-related morbidity and mortality. A total of 3,442 heat-related deaths (an annual average of 688) were reported in the US from 1999 to 2003 (CDC, 2006). Studies have found that during heat waves there are statistically significant increased risks of hospital admission rates for co-morbid conditions such as chronic cardiovascular disease, renal disease, emphysema, epilepsy, cerebrovascular events, and diabetes (Semenza *et al.*, 1999). A NYS DOH study found that extreme high temperature was associated with increased hospital admissions for cardiovascular (1.4-3.6% increase) and respiratory diseases (2.7-3.1% increase) in New York City (Lin *et al.*, 2009).

Some information indicates that there may be a relationship between aggressive behavior and high temperatures. For example, Anderson (1989; 2001) indicates that hot temperatures may increase aggression by increasing feelings of hostility and aggressive thoughts, and that warming trends may increase violent crime rates. This issue was also the topic of an e-Brief (“Does Hot Weather = Hot Tempers”) issued by the Office of Violence Prevention of the Chicago Department of Public Health.

Should electric power be disrupted for any reason during an extreme heat event, it could have consequences for public health:

- loss of cooling capacity (e.g., air conditioning and fans) in homes, schools and workplaces, which may exacerbate the kinds of health problems associated with extreme heat;
- loss of refrigeration which can affect residential and commercial food storage causing a potential increase in food-borne illness; discarded perishables may be attractive to rodents and lead to an increase in rodent populations;
- loss of refrigeration could cause vaccine spoilage;
- loss of residential water supply for some populations;
- effects on people who depend on electricity for mobility (e.g., use of elevators by people with mobility impairments); and
- effects on people who depend on electricity for medical conditions (e.g., oxygen concentrators for oxygen therapy).

Weather conditions associated with extreme heat events (e.g., stagnant air masses, temperature inversions) often lead to an overall decline in air quality (i.e., increase in air pollution) (Jacobson, 2008), which may be exacerbated by increased demand on electric generating facilities. Extreme heat events may increase chemical interactions between nitrogen oxide, volatile organic gases, and sunlight, leading to higher ambient ozone concentrations especially in urban areas (Jacobson, 2008). Poor air quality, such as high levels of ambient ozone, have been found to be positively associated with childhood respiratory diseases, chronic obstructive pulmonary disease, and cardiovascular disease in NYS (Lin *et al.*, 2008).

All New Yorkers are vulnerable to the range of possible public health consequences associated with extreme heat events. However, certain sensitive populations are especially at risk for heat-related morbidity and mortality (Basu and Ostro, 2008) (also see http://www.bt.cdc.gov/disasters/extremeheat/heat_guide.asp):

- older adults (Basu and Ostro, 2008; Medina-Ramón *et al.*, 2006);
- young children (Basu and Ostro, 2008);
- people who are overweight/obese;
- people who do not perspire normally;
- people with some chronic medical conditions such as history of dehydration, heart problems (Semenza *et al.*, 1999), diabetes (Medina-Ramon *et al.*, 2006), and respiratory or lung problems;
- people who take certain medications that cause sensitivity to the sun or interfere with the body’s ability to sweat and stay cool (some medicines that affect the body’s cooling system include antihistamines, antidepressants, over-the-counter sleeping pills, anti-diarrhea pills, beta blockers, anti-Parkinson’s drugs, and psychiatric drugs); and
- people who work outdoors or in hot settings (such as workers in the construction and agriculture industries) (e.g., see http://www.bt.cdc.gov/disasters/extremeheat/heat_guide.asp).

The effects of extreme heat may be exacerbated in urban areas because of urban heat island effects (North America Climate Change 2007) (also see http://ams.confex.com/ams/90annual/techprogram/paper_163985.htm; http://geography.hunter.cuny.edu/courses/geog702/articles/heat_island_effect.pdf). Additionally, some people (e.g., in more rural, northern) may less readily acclimatize to heat and may be more sensitive to extreme heat events. NYS DOH studies have found that health impacts of a heat wave were higher in the Northeastern US than in California (Lin et al., 2009). The stronger heat effect at lower temperatures in NYS suggest a role for acclimatization, such that residents of more temperate climates are less acclimated to heat and are therefore more susceptible to extreme heat than are residents of hotter climates.

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.

Related Efforts

The National Weather Service issues several heat-related products as conditions warrant (see <http://www.nws.noaa.gov/om/heat/index.shtml>). An "Excessive Heat Outlook" may be issued when the potential exists for an excessive heat event in the next three to seven days. An outlook is used to indicate that a heat event may develop. It is intended to provide information to those who need considerable lead time to prepare for the event, such as public utilities, emergency management and public health officials. An "Excessive Heat Watch" may be issued when conditions are favorable for an excessive heat event in the next 12 to 48 hours. A watch is used when the risk of a heat wave has increased, but its occurrence and timing is still uncertain. It is intended to provide enough lead time so those who need to set their plans in motion can do so, such as established individual city excessive heat event mitigation plans. An "Excessive Heat

Warning/Advisory” may be issued when an excessive heat event is expected in the next 36 hours. These products are issued when an excessive heat event is occurring, is imminent, or has a very high probability of occurrence. The warning is used for conditions posing a threat to life or property. An advisory is for less serious conditions that cause significant discomfort or inconvenience and, if caution is not taken, could lead to a threat to life and/or property.

The NY State Emergency Management Office (SEMO) maintains a Federal Emergency Management Agency-approved New York State Standard Multi-hazard Mitigation Plan (also known as the State Mitigation Plan), which is updated every three years. This plan can be used by local governments to develop their own local mitigation plan, which allows access to federal mitigation project funding. Extreme heat is one of the hazards included in the State Mitigation Plan (see <http://www.semo.state.ny.us/programs/planning/hazmitplan.cfm>). SEMO also maintains the “NY-Alert” system. Through NY-Alert, people are provided with information about warnings and emergencies, including severe weather warnings such as the heat watches, advisories and warnings issued by the National Weather Service. People can sign up for NY-Alert for free and receive information via the web, cell phone, email and other technologies. More information on NY-Alert is available at <http://www.nyalert.gov/home.aspx>). SEMO’s public website also provides “Heat Safety Tips” (see <http://www.semo.state.ny.us/info/publicsafety/heataware.cfm>).

The NYC Office of Emergency Management (OEM) opens cooling centers in air-conditioned public community centers, senior centers, and public libraries to offer people relief from the heat. Individuals may call 311 (TTY: 212-504-4115) during a heat emergency to find the location of a cooling center or pool, or use an online finder at http://nyc.gov/html/oem/html/hazards/heat_cooling.shtml. The NYC Department for the Aging supplies facilities and staff to carry out this emergency response to extreme heat events. OEM also conducts public outreach with brochures (“Ready NY: Beat the Heat”) written in several languages.

MillionTreesNYC, launched by the Parks Department and New York Restoration Project, is one of 127 PlaNYC initiatives. It is a citywide, public-private program with the goal of planting and caring for one million new trees across the City’s five boroughs over the next decade. Trees help clean our air, and reduce the pollutants that trigger asthma attacks and exacerbate other respiratory diseases. They also cool our streets, sidewalks, and homes on hot summer days. For more information see <http://www.milliontreesnyc.org/html/about/about.shtml>.

New York’s Urban and Community Forestry (UCF) Program has worked with communities in a variety of ways to increase awareness of the importance of UCF and to help communities develop their own UCF programs. In 2000, New York identified nearly 650 communities that were capable of undertaking a UCF program. The US Forest Service, which provides funding for this program, directed the community support to focus on technical assistance, development of tree ordinances, tree boards and management plans for these communities. The Forest Service tracks the state’s activities through the Community Accomplishment Reporting System (CARS). As of 2009, nearly half of the CARS communities were engaged in urban forestry programs or activities. For more information see <http://www.dec.ny.gov/lands/4957.html>.

The US Environmental Protection Agency has produced the “Excessive Heat Events Guidebook” with assistance from federal, state and local and academic partners. The guidebook is designed to help community officials, emergency managers, meteorologists, and others plan for and respond to excessive heat events, the guidebook highlights best practices that have been employed to save lives during excessive heat events in different urban areas and provides a menu of options that officials can use to respond to these events in their communities (see <http://www.epa.gov/heatisland/about/heatguidebook.html>).

A Centers for Disease Control and Prevention website provides information to help people recognize and respond promptly to warning signs of heat-related illness (see <http://www.bt.cdc.gov/disasters/extremeheat/>).

The NYS DOH continues statewide distribution of a fact sheet (“Keep Your Cool During Summer Heat”) that provides information on what to do before and during a heat wave, how to recognize and act on the symptoms

of heat-related illness, and who is most at risk for heat-related illness (see <http://www.health.state.ny.us/publications/1243.pdf>). This factsheet (available in English and Spanish) was posted on the Department website and local health departments were made aware of its availability. It also has been distributed to state and local health officials, the National Weather Service, the State Emergency Management Office, the Department of Environmental Conservation, the NYS Office for the Aging, the State Education Department, the Red Cross and others.

The NYS DOH also has worked with the State Environmental Health Collaborative (SEHC) Climate Workgroup to develop several climate indicators. These include the vulnerable population indicator (elderly and people living in poor neighborhoods), cardiovascular disease indicator, hospital readmission for respiratory diseases due to heat indicator, maximum/ minimum temperature indicator, and air pollution change due to heat indicator. A template to describe these climate indicators and a “How to Guide” document have been developed. This information can be used to develop indicator maps and vulnerability maps to guide public health preparedness and intervention.

Research/Information Needs

In the context of the heat-related adaptation recommendations described above, there are three key areas for which additional research/information gathering is required:

- **An assessment of the adequacy of "cooling center" programs in NYS to determine needs for the siting of additional cooling centers:** Cooling centers can be an essential means of helping people, especially in urban areas, to avoid the possible consequences of extreme heat. Information on the need for additional cooling centers in NYS, how to optimally site the centers, how to provide means for people to access the centers, and how to encourage people to use the centers can help to make cooling center programs effective in protecting people's health.
- **Research to evaluate data on temperature/other meteorological factors and heat-related morbidity/mortality to determine if current heat warning system(s) adequately protect public health:** Heat warning systems are designed to be activated once temperature and/or other weather factors are forecast to approach or exceed predefined values which are expected to be associated with adverse health effects. These values are commonly referred to as triggers. The optimal setting of triggers facilitates efficient and coordinated emergency responses and effective communication among civil protection, meteorological, and public health authorities and morbidity (Hajat *et al.*, 2010).
- **Continued research on strategies to reduce the urban heat island effect (e.g., urban forestry, green roofs, cool roofs, and cool pavements in urban areas):** For example, such research could build upon the information presented in the October 2006 NYSERDA report on the New York City Regional Heat Island Initiative (“Mitigating New York City's Heat Island With Urban Forestry, Living Roofs, and Light Surfaces,” NYSERDA, 2006) by following up on the report's recommendation to “Conduct ongoing analyses and monitoring of tree-planting programs, living roofs, and light surfaces to observe actual mitigation levels over time and use results to improve calibration and validation of regional climate models for further documentation of heat island mitigation.”

On the national level, a report by the Interagency Working Group on Climate Change and Health (2010) outlines research needs on the human health effects of climate change.

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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.

Potential Implementation Mechanisms

This action can be implemented by establishing an ongoing, statewide, education and outreach campaign. It is similar to action 1-A but more broad in scope as it includes all of the public health consequences of climate change (1-A is focused on reducing heat-related morbidity and mortality). Being similar to 1-A, a similar implementation mechanism can be used (*i.e.*, relevant state agencies will need to identify and collaborate with strategic partners, including local health departments and community-based representatives/organizations to develop and implement a cohesive education and outreach program). Although the specific details of how the action will be implemented will be best determined by the agencies/partners involved, possible approaches include incorporating public health climate change messages into existing education and outreach efforts, developing curricula/educational materials for specific populations (*e.g.*, school-age children, business leaders, public health practitioners, physicians, vulnerable populations), developing season-specific messages/materials for media distribution and others.

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.

Potential Implementation Mechanisms

This action should be implemented as a component of 2-A.

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 (Sterman, 2008). Individuals 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. Public health professionals can play a vital role in building public understanding and support to recognize health effects, to adapt with preventative measures, and to mitigate the risks of climate change by aggressively reducing greenhouse gases. Incorporation of the public health co-benefits of adaptation and greenhouse gas reductions, such as reduction of other air pollution and healthier communities, can further assist this important effort.

Certain people may require enhanced communication strategies. For example, people who are low-income, homeless, physically disadvantaged (e.g., sight- or hearing- impaired), or technologically disadvantaged (e.g., do not own computers, television, or telephones) will require special attention to help reduce or prevent adverse health outcomes. Health educators need to engage communities most likely to be adversely affected by climate change in an interactive process so that communication barriers are overcome and effective risk communication strategies are developed.

If communication mechanisms fail during public health emergencies such as those that may occur as a result of climate change, people's lives are at risk (Cole and Fellows, 2008). Crisis messages need to be prepared in advance of an event and must consider various scenarios and demographic audiences. Messages must be understandable and delivered by credible sources to be effective (Cole and Fellows, 2008).

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.

Related Efforts

Local, state, and federal agencies as well as other entities conduct public outreach on public health issues, many of which are relevant to the possible public health consequences associated with climate change (e.g., excessive heat, floods, disease, power outages). With the scientific community reaching broad consensus on our warming planet, communication efforts are informing the public and policy makers about the known and potential impacts of climate change. Although scientists cannot fully predict how climate change will affect society and public health, individuals, communities and public health systems need to be prepared and willing to address the public health hazards and consequences associated with climate change. Public health agencies and other organizations need to improve and develop communication-based adaptation strategies to lessen our warming

climate's impact on the health of New Yorkers. Thus, existing outreach and risk communications efforts may need to be expanded and enhanced, and in most cases "re-framed," to address our changing climate and protect vulnerable people and communities. Public health educators need to engage people in the process, understand communication barriers and work with audiences to develop messages and strategies. New York State will need to continue to collaborate with federal and local agencies and other organizations to coordinate an effective interactive communication process in order to successfully adapt to climate change. The following paragraphs describe some examples of existing activities that are relevant to this recommended adaptation strategy.

Federal, state and local government agencies, through the conduct of programs related to public health, use various communication strategies (public service announcements, press releases, web postings, mailings) to inform people about important public health issues and to help them prepare for public health emergencies, including those related to climate change. These entities include the US Department of Health and Human Services (DHHS) (which, among other offices includes the Agency for Toxic Substances and Disease Registry (ATSDR) , the Centers for Disease Control and Prevention (CDC)), the Occupational Safety and Health Administration, the US Environmental Protection Agency, the NYS DOH, and the NYC Department of Health and Mental Hygiene (NYCDOHMH).

Emergency response and management officials from federal, state and local governments develop and implement "all hazard" plans (e.g., for severe weather events) to help guide coordinated preparation, response and recovery efforts. Entities such as the Federal Emergency Management Agency, National Weather Service, NYS State Emergency Management Office (SEMO), New York City Office of Emergency Management (NYCOEM), and others routinely communicate advice to the public on how to protect lives and properties in the event of severe weather and other emergency situations.

For example, SEMO manages an emergency alert system called NY-Alert to disseminate critical health and safety information for all hazards and emergencies to the public via the internet (web and email), cell phones and media outlets. Emergency management websites offer safety tips for various weather-related emergencies (e.g., floods, heat, severe storms). SEMO works with local officials to develop emergency response plans that include communication strategies. For example, the municipalities identified by SEMO as prone to coastal flooding associated with storm surges and hurricanes (<http://www.semo.state.ny.us/info/safety.cfm>) have communication plans in place, including evacuation route signage, to help people move to safer areas. Similarly, the New York City Office of Emergency Management disseminates emergency information and offers numerous resources to help New York City residents and businesses prepare for and respond to emergencies (see: <http://www.nyc.gov/html/oem/html/home/home.shtml>).

The issuance of heat wave alerts, safety tips and information on cooling center locations is an example of outreach activities to inform people about the health effects associated with extreme heat. When the National Weather Service issues a heat message, multiple entities (e.g., SEMO, NYCOEM, the Red Cross) provide information to inform people about the hazards of extreme heat and how to reduce the risk of heat-related health effects. Prior to the summer months, health and emergency management agencies announce the availability of heat-related information resources as a reminder to prepare for extreme heat events, and uses mechanisms in various forms (e.g., other languages and in audio format). Examples of internet-based information are:

<http://www.hhs.gov/disasters/emergency/naturaldisasters/heat/>

<http://www.fema.gov/areyouready/heat.shtm>

<http://www.nyhealth.gov/publications/1243/>

http://www.nyc.gov/html/oem/html/ready/heat_guide.shtml

<http://www.osha.gov/SLTC/heatstress/recognition.html>

Various agencies (e.g., NYS DOH, CDC, NYCOEM) inform the public about vector-borne diseases (e.g., Lyme disease and West Nile Virus), food-borne disease risks (e.g., E.coli, Salmonella) and water-borne health concerns (e.g., harmful algal blooms). Public health and environmental agencies also provide people with information about poor air quality (e.g., days on which elevated ozone levels are forecast) so that they can take health-protective measures (e.g., the NYS DEC/NYS DOH air quality alerts).

The NYS DOH through its on-going research on the health outcomes of climate change/variability in New York State, and the potential future establishment of a climate-health tracking system for surveillance, preparedness, and public health response will help NYS DEC and other state agencies develop communication strategies to:

- identify the health outcomes associated with climate variability/change, target the most vulnerable communities for education and outreach efforts, and use census and climate health surveillance data to help select the most effective communications media and develop consistent messaging over time; and
- coordinate with state agencies and local departments involved in effecting climate change outreach to achieve consistent and appropriate messaging for raising climate change awareness and taking preparedness measures to minimize health impacts.

Research/Information Needs

Leiserowitz et al. (2005) suggest that people are not aware of the potential public health consequences associated with climate change. Communication professionals need to research effective strategies for overcoming barriers to the public receiving, understanding, and following with public health advice. Research also may be needed on how to develop strong, effective connections with communities.

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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.

Potential Implementation Mechanisms

State agencies with roles related to public health preparedness, response and recovery (e.g., NYS Department of Health, NYS Emergency Management Office, NYS Department of Environmental Conservation) could be directed to collaborate with appropriate partners (e.g., through the formation of a working group) to assess the current capacity of existing programs to address anticipated future climate-related public health impacts and to develop and implement a plan for expanding capacity as necessary.

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.

Potential Implementation Mechanisms

This action can be implemented as a component of 3-A.

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.

Related Efforts

Emergency response and management officials from federal, state and local governments work together with other organizations (e.g., the American Red Cross) to develop and implement disaster response/management plans. Together they help prepare for, protect against, coordinate responses to, and recover from "all hazards." These programs involve hazard identification, loss prevention, planning, training, operational response to emergencies, technical support, and disaster recovery assistance. Government agencies such as the Federal Emergency Management Agency (FEMA), National Weather Service, NYS Division of Homeland Security and Emergency Services (NYS DHSES), New York City Office of Emergency Management, NYS DOH, NYS DEC, the US Armed Forces, and local emergency officials routinely work together to protect lives and properties in the event of emergencies, such as those that may be caused by climate change. Because all emergency response begins at a local scale then expands in scope as necessary, NYS and federal agencies can help coordinate responses and deploy resources and support to local emergency responders. Protection of public health and safety (including the health and safety of emergency responders) is integral to all preparedness programs.

The NYS DHSES was recently created through the consolidation of the NYS Offices of Homeland Security (NYS OHS), Emergency Management (NY SEMO), Fire Prevention and Control (NYS OFPC), the Statewide Interoperability Program (NYS SIPO) and Cyber Security and Critical Infrastructure Coordination (NYS CSCIC). This consolidation brings together these specialized offices to operate a single, multi-purpose agency focused on first responders and public safety. Collectively, the new Division is responsible for analysis, information sharing, physical- and cyber- security, disaster preparedness and relief, interoperable and emergency communications, fire safety, and emergency response. NYS DHSES coordinates the US Department of Homeland Security National Incident Management System (NIMS). NIMS provides a systematic, proactive approach guiding departments and agencies at all levels of government, the private sector, and non-governmental organizations to prepare for, prevent, respond to, recover from and mitigate the effects of incidents, regardless of cause, size, location, or complexity, in order to reduce the loss of life, property and harm to the environment. This consistency across all emergency response providers establishes foundation for implementation of the NIMS for all incidents, ranging from daily occurrences to large-scale incidents requiring a coordinated federal response.

Within NYS DHSES, SEMO is responsible for coordinating the activities of all NYS agencies to protect New York's communities (including people's health), the State's economic well-being, and the environment from natural and man-made disasters and emergencies. SEMO is responsible for developing and updating the NYS Comprehensive Emergency Management Plan that identifies the state's overarching policies, authorities and response organizational structure that will be implemented in an emergency or disaster situation that warrants a state response. SEMO works with all levels of government, the private sector, and volunteer organizations to identify local hazards, develop plans and strategies to reduce risks and provide the necessary training and exercises to improve the capabilities of communities. In order to be eligible for federal recovery and mitigation

assistance, SEMO oversees the development of a (FEMA-approved) Multi-Hazard State Mitigation Plan. SEMO's Training and Exercise Program serves all emergency management professionals, including:

- public health,
- fire service
- law enforcement
- emergency medical services,
- emergency management,
- public works,
- business and industry,
- state and federal agencies,
- utility representatives (e.g., NYS Department of Public Service, NYS Independent System Operator), and
- cooperating agencies (e.g., regional and local chapters of the American Red Cross).

Representatives from these agencies and organizations provide NYS capacity to prepare, assess and respond to disasters (including catastrophic) to protect public health, the environment and property. For example, by coordinating with other critical state agencies, SEMO's State Emergency Response Commission (SERC) and Local Emergency Planning Committees (LEPCs) implement the Emergency Planning and Community Right-To-Know Act (EPCRA), also known as Title III of the Superfund Amendments and Reauthorization Act, work together to inform the public of chemical hazards in the community and to oversee disaster response in response to a chemical release. SEMO also works with partners such as the Citizen Corps program, the NYS Voluntary Organizations Active in Disaster, the Radio Amateur Civil Emergency Service and the Northeast States Emergency Consortium to communicate and streamline emergency response, even if traditional communication mechanisms are unavailable. SEMO also reaches out to communities affected by disasters to distribute recovery funds dispersed by the federal and state governments. SEMO has developed and maintains a web-based, multi-modal alert and notification system: NY-ALERT, which provides for the rapid notification of citizens of critical information via their cellular or landline telephones, webpage, RSS feed, text messaging, email, faxing, Emergency Alert System and/or alpha-numeric pagers.

Because coordination and effective use of resources is critical to emergency preparedness, response and recovery, many state and local agencies have created their own emergency preparedness programs. This is in addition to dedicate emergency first responders such as NYS Police, County Sheriffs, state and local fire departments and emergency medical personnel. For example, the NYS DOH and NYC DOHMH have staff that routinely work with emergency management officials and technical staff to help prepare for, respond to and recover from an event. Similarly, NYS DEC has an emergency response program that assesses major chemical release events, responds to spills and oversees dam safety. The NYS Department of Transportation Highway Emergency Local Patrol (HELP) program responds to calls of disabled vehicles and other major transportation emergencies.

The NYS DOH Public Health Emergency Preparedness Program serves as the liaison to NYSEMO, other local, state and federal agencies and public service organizations. This statewide public health system routinely works with county and local health officials and organizations to coordinate public health-related logistical support (e.g., Strategic National Stockpile, Vendor Managed Inventory) and assist in preparedness, readiness, response and recovery activities to protect public health. NYC government (e.g., NYC Department of Health and Mental Hygiene and NYC Office of Emergency Management) carries out similar functions. To assess existing public health preparedness programs, the NYS Public Health Emergency Preparedness Program is working cooperatively with the Centers for Disease Control and Prevention in developing a comprehensive health preparedness metric for the evaluation of program activities that include planning, emergency response and

recovery activities. Specifically, the performance evaluation process aims to assist program enhancements across a broad range of public health preparedness activities including disease surveillance, hospital preparedness and emergency response activities.

The above discussion, while not comprehensive, describes systems already in place that are capable of responding to climate change-related emergencies (e.g., heat, floods, tornadoes, hurricanes, wildfires, earthquakes, severe winter storms, and radiological and chemical emergencies associated with storm damage) in order protect public health to the fullest extent possible.

Research/Information Needs

Potential research/information needs related to public health preparedness, response and recovery programs include:

- approaches for optimizing coordination/communication among all parties with responsibilities during an emergency event,
- the adequacy of existing early warning systems and evacuation plans,
- the effectiveness of employing alternative communications technologies and social networking systems in early warning systems, and
- approaches for addressing urgent public health needs of all New Yorker's resulting from power outages associated with severe weather events.

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.

Potential Implementation Mechanisms

State agencies, as well as local governments (*e.g.*, counties, towns, cities, villages) could be required to consider climate change and its corresponding public health implications in all relevant planning and in developing programs, policies and regulations. These entities could initially be required to review existing programs, policies and regulations for “compatibility” with protecting public health from climate-change related impacts and to develop plans to address any identified “incompatibilities.” The entities also could be required to adopt measures for incorporating consideration of climate-related health impacts into future planning (including infrastructure planning) and when new policies, programs and regulations are developed. A potentially efficient approach could be to statewide guidance on this matter for state agencies and local governments.

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.

Potential Implementation Mechanisms

Implementation of this action may be best accomplished by establishing an interagency working group that should also include other relevant stakeholders, charged with developing a plan to accomplish the intent of the action.

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.

Potential Implementation Mechanisms

While this action is related to enhancing community resilience to climate change, it could be implemented as a component of action 3-A.

Impacts/Vulnerabilities Addressed

Adequate integrated public health capacity and the resilience of communities will serve to minimize the impacts and associated consequences of climate change discussed throughout this document. These impacts are many and diverse. For example, climate change, and associated changes in weather, may have direct impacts on the public health of New Yorkers through the effects of heat, catastrophic flooding and severe storms, increases in vector-borne disease, and increased psychological stress. In addition, climate change will impact multiple resources and service sectors upon which New Yorkers depend. For example, our coastal resources including beaches, fisheries, estuaries, and marinas, will likely be impacted by flooding and increased storm frequency and intensity. Similarly, our residential, commercial, and industrial building stock may be impacted by increased wildfire frequencies, changes in moisture and indoor humidity and flooding. While some of our water supplies could be impacted by flooding, others will be faced with increased evaporation and decreased recharge. Our air quality may deteriorate due to increased ground level ozone formation and other impacts. Our agricultural food production system will be affected by changes in temperature and precipitation regimes. Heat-loving crops may benefit from a longer, warmer summer while certain cool-weather crops may be harmed by prolonged periods of elevated temperatures. All crops may face increasing summer heat stress, drought, and competition from weeds and pests (Wolfe et al., 2008). Habitat for fish and game and other wildlife may also be impacted. Forest fires may become more frequent and intense due to dry seasons that start earlier and end later. The electrical sector will be impacted by summertime demand spikes and resulting outages, while the transportation sector - certain roadways and other travel routes - may be affected by rising water levels.

Impacts on each of these resources and sectors can in turn have indirect effects on public health. For example, effects on the agricultural sector and coastal fisheries may translate into changes in the availability of nutritional foods with potential impacts on the nutritional health status of consumers. Impacts on fish and game could also affect the availability of protein-rich foods for some New Yorkers. Decreased levels of high-quality drinking water in some areas can result in use of lower-quality drinking water with resulting water-borne disease, while surface water flooding in other areas can cause increases in other vector-borne diseases. These effects and other indirect effects can compound the more direct public health impacts of change in climate and weather patterns.

New York State is composed of its communities, which have grown and evolved—with the help of public agencies, programs, response systems and other infrastructure—while contending with events and conditions of much the same general nature as those that can result from climate change. There are doctors, hospitals, and urgent care facilities to treat disease and other medical conditions. There are fire departments, paramedics, and other emergency responders to respond to fires and other emergencies. However, all these systems and programs are based on current climate and weather patterns and baseline levels of human health outcomes and events that affect resources and sectors with public health implications. As climate changes, the specific nature, frequency, and severity of these outcomes and events will likely change. These changes will impose stresses on communities and the infrastructure they depend upon to support their health and essential resources.

It follows, then, that the communities themselves and supportive infrastructure will be impacted by climate change. Physical and mental health status of communities may change. The health care system, fire departments and emergency responders, and coastal barrier and storm response systems may be stressed by increased health outcomes and adverse events. Disease surveillance agencies and systems may need to address unexpected outbreaks or changing patterns in health outcomes. Stresses may be imposed upon farmers and fishermen as conditions with which they are familiar begin to change. Transportation planners, engineers, and construction firms may need to address infrastructure damage, or the inadequacy of current infrastructure in some low-lying areas of the state. The electricity sector will be challenged by a combination of increasing summertime electricity demand and requirements to meet increasingly stringent emissions regulations. Food distribution systems, soil erosion-prevention programs, municipal water suppliers, the construction industry, and the agencies responsible for building code development and enforcement (Kelly, 2010; CCSP, 2008)—all may face unfamiliar conditions that tax their ability to respond. In general, impacts on communities and supportive infrastructure will have economic consequences as well, increasing the costs associated with some resources.

As a result of stresses imposed on supportive infrastructure, communities may encounter deterioration in local governance; lack of integration and synchronization of local, state, and federal government programs; gaps in public understanding and awareness; lack of access to up-to-date scientific information or appropriate technologies; and reduced access to natural and economic resources essential for public health. As sources of stress grow and combine, the social and political structures are expected to be challenged, especially in locales with relatively limited social and political capital (CCSP, 2008).

The ability of New York, its communities, non-governmental organizations (NGOs), local and state agencies, and other institutions to adapt effectively and in a timely fashion to these many changes and stresses, and to recover from health and resource impacts that do occur will reflect their resilience. Community resilience is a key aspect of a robust response to climate change in public health (Hess et al., 2008).

The impacts and stresses of climate change on public health, essential resources, and necessary infrastructure will vary throughout New York State on multiple scales. As is the case with many kinds of impacts, some individuals, communities, and institutions will be more vulnerable to climate change impacts than others. Vulnerability can result from either 1) limited capacity to cope with or recover from risk factors or 2) the degree of exposure to the risk factor (Kleim, 2008).

Elderly individuals have limited capacity to cope with the effects of heat and therefore are vulnerable, while children with existing respiratory conditions may be most vulnerable to decreased air quality. Handicapped

individuals may be vulnerable to weather-related emergencies and fires, while immuno-compromised individuals would be most vulnerable to infectious disease.

Individuals who make up a community may have low income, limited education, and/or be subject to language barriers. These conditions limit capacity to cope with stresses and can further limit access to resources, services, and information that may be scarce as infrastructure is impacted by the effects of climate change. Local infrastructure for public health and other resources may already be stressed due to lower tax bases in communities of low income, and may be vulnerable to increased stresses due to the effects of climate change, resulting in further limitations in their ability to provide services. Rural communities may have limited access to public health facilities and services, public transportation, and other services, resulting in a vulnerability to some climate change impacts. Location is an important determinant of hazards that may be encountered, and certain places will bear more risk than others (Hess et al., 2008). Communities in physical proximity to direct or indirect climate change impacts have higher exposure to risk factors and as such may be particularly vulnerable. For example, communities with building stock, transportation corridors, or other resources in coastal or riparian flood zones may be uniquely vulnerable to the effects of rising water levels and increased flooding. Some low-income inner-city communities with high prevalence of respiratory conditions may be vulnerable to the cumulative effects of elevated daytime temperatures, decreased air quality, and power outages.

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.

Restrictions on greenhouse-gas emissions are necessary to reduce the pace of global climate change, but these measures may raise the price of energy and energy-related products and services and low income communities may be unduly burdened by the higher costs of electricity (Stone and Fielder, 2008). Climate change could also impose economic burdens such as increasing consumer food costs due to impacts on national and world agriculture. Many of these communities are already overburdened by pollution, higher asthma rates and other environmentally related health problems. Residents of these communities are often financially unable to move or adapt to climate change impacts. Some limited evidence from a study in New York City suggests that the health consequences of ozone and other air pollution could be greater in environmental justice communities where a greater number of individuals may be asthmatic compared to other communities compared to other communities with similar air quality (NYSERDA, 2006). To the extent that low income and minority communities are located in areas of the state where sea level rise and or storm surge events are expected to take place, such climate change impacts could result in the displacement of many residents in these communities.

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.

Related Efforts

There are many current federal, state and local programs that contribute toward community resilience and/or integrated public health capacity that will help to reduce human health impacts of climate change. Below are some examples of federal and state programs that promote “climate smart” communities, contribute to the protection of food, water, and air resources, and help to strengthen public health infrastructure.

Climate Smart Communities is a state-local partnership to help municipalities combat climate change and build grass-roots support for climate action. It emphasizes emission reduction and adaptation steps that support community goals, save taxpayer dollars and help make New York's communities vibrant, desirable places to live and work. A total of 81 New York communities already have pledged to become Climate Smart, and are undertaking a variety of climate-related plans and projects. A community joins the Climate Smart network by adopting a ten point pledge to reduce greenhouse gas emissions, prepare for climate change, and invest in green economies. Climate Smart Communities receive regular updates from DEC concerning climate action and funding sources. For more information see <http://www.dec.ny.gov/energy/50845.html>.

In 2009, EPA launched a competitive grant program to assist local and tribal governments in establishing and implementing climate change initiatives. The overall goal of the Climate Showcase Communities grant program is to create replicable models of sustainable community action that generate cost-effective and persistent greenhouse gas reductions while improving the environmental, economic, public health, or social conditions in a community. (See: <http://www.epa.gov/statelocalclimate/local/showcase/>)

The Department of Health is currently working with Cornell University, Cornell Waste Management Institute, Cornell Cooperative Extension and the New York City Parks Department to encourage urban community gardening and agriculture. This effort is intended to promote the public health benefits of community gardening while considering potential health risk associated with soil contamination. It also has relevance to concerns related to future food security. The four-year “Healthy Soils, Healthy Communities” project, funded by the National Institutes of Health, intends to investigate the extent of soil contamination, evaluate exposure reduction strategies, and carry out community outreach to help communities facilitate healthy localized food production.

EPA’s Clean Water State Revolving Fund (CWSRF) programs provided more than \$5 billion annually in recent years to fund water quality protection projects for wastewater treatment, nonpoint source pollution control, and watershed and estuary management. This funding can improve the resilience of community water resources to drought and increased water demands. Dozens of NYS communities received funds from this program in 2009. (See: <http://www.epa.gov/owm/cwfinance/cwsrf/>)

DEC is engaged in a ‘first-of-a-kind’ multi-pollutant air quality planning pilot project with EPA called the Air Quality Management Plan (AQMP). DEC’s goal for the AQMP project is to develop an all-encompassing air quality plan that will look holistically at air quality planning by including consideration of climate change, air pollutants, transportation, energy and environmental justice. EPA is intending to use this project to create a national model for integrated air quality planning and New York State has been chosen as one of the three areas nationally with North Carolina and St. Louis metropolitan area. The project is in the conceptual model design phase and will be involving stakeholders, including the environmental justice community, in the AQMP development process. (See DEC’s EJ Interagency Task Force Action Agenda at http://www.dec.ny.gov/docs/permits_ej_operations_pdf/decdraftactplan.pdf)

New York State has a program, Clean Air NY, sponsored by the New York State Department of Transportation (NYSDOT), to improve the air quality in the New York City metropolitan area. The program works in collaboration with three transportation management associations in support of region-wide air quality efforts. Individuals, employers and other organizations (both private and nonprofit) can join the program by completing a form on-line. As a member, employers and organizations are asked to distribute to their employees information on how to reduce air pollution on Air Quality Action Days (days where NYSDEC has issued an Air Quality Advisory). Individuals are encouraged to make everyday choices to prevent air pollution. Individuals

can sign-up to receive real-time updates on Air Quality Action Days. (See <http://www.cleanairny.org/exthome.htm>)

In cooperation with NYSDEC, NYSDOT alerts the public of potential risks to health caused by exposure to ground-level ozone, fine particulate matter or both. When air quality is expected to be unhealthy for sensitive populations, NYSDOT issues an Air Quality Action Day notification and encourages New Yorkers to make special efforts to drive less and reduce activities that contribute to air pollution. On Air Quality Action Days, NYSDOT also posts messages on electronic variable message signs along state highways to encourage travelers to car pool, take public transit, drive less and reduce the number of trips they take. NYSDOT maintenance crews also reduce, to the extent possible, use of mowers and small engines on those days in order to lessen emissions.

DEC established the New York State Environmental Justice Advisory Group, which is directed and chaired by DEC staff and includes representatives from environmental justice advocacy groups, state, local and federal government, environmental organizations, and business. The Advisory Group meets several times a year and provides independent advice and recommendations to DEC on matters relating to environmental justice, including the integration of environmental justice principles into the DEC's programs, policies, regulations, legislative proposals and activities. More information on the DEC Environmental Justice Advisory Group can be found on DEC's website at <http://www.dec.ny.gov/public/907.html>.

NYSDEC has partnered with New York City to carry out a major enforcement action to address urban outdoor air quality in East Harlem. The initiative called, Stop Smoking Initiative for Trucks and Boilers will implement a targeted sweep identifying idling trucks and polluting boilers. NYSDEC also has placed air monitoring units on the grounds of Metropolitan Hospital and will monitor the air in the area for two months. Data from these enforcement actions will be used to develop a long-term strategy for addressing local outdoor air pollution sources in NYC and could be used to address concerns in other EJ communities.

EPA's State Grant Program allocates funds to participating states to implement grant and loan programs for clean diesel projects. To support states in the development of clean diesel programs, EPA has developed a toolkit for state and local governments. Grant programs like these can help communities adapt to higher temperatures by reducing potential for localized air quality impacts exacerbated by higher temperatures. (See <http://www.epa.gov/diesel/prgstate.htm>)

In New York City, PlaNYC is a sweeping plan for city's sustainable future. This plan, which has the potential to substantially enhance the resilience of the city and its communities, addresses five key dimensions of the city's environment – land, water, transportation, energy, air and climate change. The plan includes initiatives on expanding greenspace, city-wide tree planting, creating public plazas in all communities, promoting the use of cleaner burning heating fuels, reducing motor vehicle emissions and numerous others. As NYC indicates, this plan can become a model for other cities. More information is available at <http://www.nyc.gov/html/planyc2030/html/home/home.shtml>.

State energy infrastructure planning considers climate change-related health impacts. The 2009 NYS Energy Plan specifically discusses these health impacts in the Climate Change and the Health, Energy Production and Energy Use Issue Briefs. For example, an issue identified in the Health, Energy Production and Energy Use Brief was that health outcome data can be an important resource for communities, scientists and government agencies for describing disease burdens, and can be considered along with other information when siting energy facilities, such as those that might be necessary to meet demand associated with higher summer temperatures. Health outreach and education materials can help communicate public health messages to empower communities and community members to make informed decisions to protect their health. (See <http://nysenergyplan.com/index.html>)

To better understand and plan for how climate change will affect our state, inclusive of health impacts on its population, the New York State Energy Research and Development Authority (NYSERDA) funded a two-year

study called Integrated Assessment for Effective Climate Change Adaptation Strategies in New York State. The goal of this effort is to identify and assess both near-term and longer-term potential impacts in New York under different climate change scenarios. This research will also identify and begin to evaluate adaptation strategies. (See http://www.nyscrda.org/programs/environment/emep/10851_project_update.pdf)

CDC is leading efforts to anticipate the health effects of climate change, to assure that systems are in place to detect and track them, and to take steps to prepare for, respond to, and manage associated risks. CDC is using its prevention expertise to address climate change and is preparing for the possibility of health effects related to climate change in the same way it prepares for the possibilities of bioterrorism and pandemic influenza. CDC is uniquely poised to lead efforts to anticipate, prevent and respond to the broad range of effects on the health of Americans and the nation's public health infrastructure. Building on existing programs and the Essential Public Health Services, CDC has identified 11 priority health actions for climate change. CDC partners with state and local health agencies on these efforts through the National Association of County and City Health Officials. (See <http://www.cdc.gov/climatechange/>)

CDC's Healthy People programs provide science-based, 10-year national objectives for promoting health and preventing disease for communities. Proposed objectives for Healthy People 2020 include many specific objectives for strengthening public health infrastructure, for example, by working with state, local and tribal agencies. (See <http://www.healthypeople.gov/hp2020/Objectives/TopicArea.aspx?id=40&TopicArea=Public+Health+Infrastructure>)

Many of the potential health effects of climate change are related to threats we already face, including heat waves, extreme weather events and emerging infectious diseases. Taking preparedness steps can keep the public safer and healthier when they do occur. Federal agencies such as CDC, and state agencies such as SEMO provide access to information that will help the public to prepare for the unexpected. These resources are intended to assist the public in getting an emergency supply kit, making a family emergency plan, and staying informed about the different types of emergencies that could occur and their appropriate responses. (See <http://www.ready.gov/>)

Research/Information Needs

The resilience of communities in the face of adversity is a relatively recent research topic, and the factors that contribute to resilience are not fully understood. While the difficulties encountered by communities and public health agencies to respond to some disasters has been well documented (e.g., Hurricane Katrina (e.g., Rodriguez and Aguirre, 2006)), these examples of community resilience or the lack thereof may be specific to the kind of disaster and more importantly the highly specific nature of the community. Conclusions from such studies may not be directly applicable to the communities and specific climate change impacts that may occur in New York. This necessitates further study of the capacity of New York communities to respond to stresses that are relevant to the unique physical, biological, economic and cultural makeup of this state. Such research will inform ongoing efforts to build community resilience and help target public health capacity expansion efforts.

In addition, there is a need to improve information exchange between NGOs, agencies and research organizations. There is also a need to bridge the gap between scientific and local knowledge in order to create programs capable of withstanding stresses (Blanco, 2006).

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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.

Potential Implementation Mechanisms

Provide the NYS Department of Health with the resources necessary to perform the recommended evaluation and, as necessary, the program enhancements.

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.

Potential Implementation Mechanisms

As part of performing the evaluation recommended in 5-A, the NYS Department of Health could provide a characterization of local government needs. Once those needs are identified, mechanisms for providing any necessary assistance to local governments can begin to be identified.

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.

Potential Implementation Mechanisms

This action can be implemented by including the NYS Department of Health's Wadsworth Center in implementing 5-A.

Additional Information on Overall Timing of Implementation

Although some impacts of climate change on water-, food- and vector-borne disease incidence can be predicted, we cannot anticipate the nature, magnitude or timing of all possible impacts. Therefore, enhanced surveillance to track increases in environmental indicators, disease agent populations, and disease incidence should begin as soon as feasible (Semenza & Menne, 2009). Disease prevention should be emphasized as the first line of defense against infectious agents but, because relevant disease prevention efforts are already substantial, comprehensive surveillance is needed to assist policy makers in identifying climate-related risks that warrant additional resources.

Likewise, evaluation of the capacity of existing programs related to vector-, water-, and food-borne diseases, especially diseases known to be associated with climate change, must be a high priority. These evaluations will inform efforts to re-deploy of scarce resources in anticipation of climate change impacts.

Immediate efforts to enhance surveillance and evaluate existing programs should not delay efforts to implement high-value strategies that are considered very likely to ameliorate the effects of climate change. For example, the NYS DOH should continue to emphasize the revision of existing watershed rules and regulations in anticipation of increased nutrient, toxin, and microbiological loads to source waters. Efforts to provide necessary assistance to local governments should also begin immediately, with a focus on building NYS DOH and NYS DEC capacity to provide free consultation to local officials.

Within two years, and after existing surveillance has been improved and existing programs have been evaluated, actions should be taken to enhance the capacity of public health programs that control, and/or respond to, vector-, water-, and food-borne disease causing agents, and mechanisms should be identified to provide necessary assistance to local governments.

As needs arise, analytical laboratory capacity should be expanded to support essential environmental monitoring, disease surveillance and outbreak investigation/control activities.

Impacts/Vulnerabilities Addressed

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. Both the potential for widespread impacts from emerging diseases—and the challenges encountered when attempting to determine the role of climate change in the emergence and spread of novel disease agents—are exemplified by *Borrelia burgdorferi*, the species of bacteria that causes Lyme disease. Evidence suggests that the rapid spread of Lyme disease since its discovery in Connecticut during the 1970s was due primarily to the spread of infected deer ticks (Magnarelli et al., 1984). However, climate-induced increases in wild rodent food sources, resulting in burgeoning rodent populations, may have contributed to tick dissemination (Ostfeld et al., 2006). After over 30 years of scientific study, the manner in which deer, rodents, ticks, humans, habitats, and climate interact to determine Lyme disease incidence rates in a given geographical region is still under investigation.

Similarly, the interaction of climate, vector populations, and other factors in determining incidence of mosquito-borne illnesses remains complex and not adequately understood. Gubler et al. (2001) point out that epidemic potential depends not just on temperature and rainfall, but upon the interaction of numerous virus, host, and environmental parameters. They suggest that sociological factors, such as a tendency to stay indoors, and technological advances, such as air conditioning and window screens, are important determinants of mosquito-borne disease incidence. As an example, the authors note that the summer mean temperature in the southeastern U.S. is actually 2 to 3 degrees centigrade higher than in Caribbean islands, yet Caribbean islands experience major epidemics of dengue fever, whereas the U.S. does not. Dengue is not established in the U.S., despite the fact that the mosquito vectors are present in the U.S. and that there has been increased imported dengue in the past 20 years.

On the other hand, climate change appears to have contributed to the extension of the tropical fungal pathogen *Cryptococcus gattii* into northwestern Canada and the U.S. (Frumkin et al., 2008). Hypervirulent strains of *Cryptococcus gattii* have generated surprisingly high mortality rates among infected patients in Oregon, a state where until recently outbreaks of the disease were unknown, and it is feared that these hypervirulent strains may next spread south, into northern California (Byrnes et al., 2010).

Despite the high degree of uncertainty associated with attempts to relate climate change and infectious disease risks, some general observations may be made. These were discussed in the U.S. National Assessment of the Potential Consequences of Climate Variability and Change (US Global Change Research Program, 2000) and are only briefly summarized here.

Most vector-borne diseases exhibit a distinct seasonal pattern, which clearly suggests that they are weather sensitive. Mosquitoes, which are vectors for West Nile Virus and other diseases, reproduce in larger numbers and feed more in warmer weather, and ticks may survive longer and have more opportunities for human contact with a favorable and milder climate during winters (Epstein, 2005). In addition, mosquito-borne illness may be associated with discharges of raw (untreated) wastewater to streams. Vazquez-Prokopec et al. (2010) recently reported that West Nile Virus infection in mosquitoes, corvids, and humans was spatially clustered and statistically associated with streams that received combined sewer overflow in urban Atlanta, Georgia.

Exposure to water-borne disease can result from drinking contaminated water, eating seafood from contaminated water, eating fresh produce irrigated or processed with contaminated water, or from activities such as fishing or swimming in contaminated water. Harmful algal blooms, which can produce toxins such as microcystins, may increase in frequency and duration under the influence of increasing temperatures and nutrient runoff. Changes in precipitation, temperature, humidity, salinity, and wind have a measurable effect on water quality. Climate changes projected to occur in the next several decades, in particular the likely increase in extreme precipitation events, will probably raise the risk of contamination events. Wastewater systems that combine storm drains, sewage, and industrial waste are still used in some New York communities. During rainstorms or spring snowmelt, when the volume of water discharged can exceed the capacity of the sewage treatment system, these systems are designed to overflow and discharge untreated sewage into surface waters. In 1994, EPA developed a framework to control such combined-sewer overflows under the federal Clean Water Act's water discharge permit program. If combined sewer systems remain in place and continue to discharge

untreated wastewater during storms, they will very likely pose an increased health risk under projected increases in intense precipitation events.

Increased temperature poses a direct risk for food contamination by providing favorable growth conditions for infectious agents such as *Salmonella* (D'Souza et al., 2004) and *Vibrio* species.²

People most vulnerable to infections include, by definition, those with developing or weakened immune function, such as infants, the elderly, and people with certain health conditions (e.g., pregnant women; transplant recipients; people being treated for autoimmune disorders; people taking antacids, antibiotics, or steroids; and people with inherited or acquired immunodeficiency syndromes, liver or kidney disease, inflammatory bowel disease, and sickle cell disease).

People expected to be at risk for increased exposures to microbial pathogens due to climate change include people who work or recreate in areas where disease vectors are endemic; swim or bathe in high-risk surface waters; or consume seafood from high-risk marine waters. Urban dwellers may be at greatest risk for developing vector-borne illnesses secondary to increased rodent populations (Hirschhorn and Hodge, 1999). Some of the groups at risk for increased exposures to microbial pathogens due to climate change are historically disadvantaged.

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.

Related Efforts

Programs implemented in New York State for the detection, prevention and control of vector-, water-, and food-borne diseases and disease-causing agents are extensive, and serve as high-quality models for the rest of the nation. A comprehensive review of these programs would be beyond the scope of this document. The following brief summaries are intended solely to illustrate the breadth of existing programs.

² The NYS DOH anticipates that risks of *Salmonella*- & *Vibrio*-related disease will increase if air and ocean temperatures increase, as pathogenic members of each genera prefer relatively warm temperatures, and case rates in New York typically peak during the hottest months.

In the area of vector control and vector-borne disease surveillance, local agencies play a key role, implementing programmatic strategies based on state plans, local conditions and community input. Examples include programs implemented in New York City, Suffolk County and Erie County.

In New York City, the Department of Health and Mental Hygiene's Office of Vector Surveillance and Control implements public education, surveillance, control and research activities focused primarily on reducing incidences of mosquito-borne and tick-borne illnesses (NYC DHMH, 2010). Observations of standing water reported by the public, government officials and other agencies prompt rapid remediation or treatment to reduce mosquito-breeding. Mosquito larvicide is applied to catch basins throughout the city to eliminate mosquito-breeding sites, and known mosquito-breeding locations are routinely treated.

Suffolk County implements a Vector Control and Wetlands Management Long-Term Plan that includes targeted applications of mosquito adulticide and larvicide, as well as environmental stewardship to restore tidal wetlands that were grid ditched during the 1930s, and which now require routine larvicide applications by air (Suffolk County, 2006).

Erie County's Vector Control Program focuses on rodent and mosquito control, and conducts active surveillance of rabies, leptospirosis and tick-related diseases (EC DOH, 2010). Erie County provides a tick identification service that is used by health providers, veterinarians and the public.

The New York State Department of Health (NYSDOH) also plays a key role in protecting the public from vector-borne diseases. The NYS DOH web site provides relevant information to the general public, and provides advice to physicians regarding procedures for testing and reporting suspected cases of mosquito-borne and tick-borne illnesses. The Department performs a wide variety of diagnostic laboratory tests, and conducts surveillance activities to facilitate the prompt recognition of human outbreaks.

The NYS DOH investigates unexplained infectious disease deaths, such as encephalitis cases due to unknown etiology.

NYS DOH scientists develop and validate molecular tools to detect and identify viruses and bacteria in clinical and environmental samples, methods that have helped address disease outbreaks caused by a wide variety of agents. Naturally occurring outbreaks involving bacteria are tracked with DNA typing (or bacterial fingerprinting) to confirm links between organisms causing human disease and their implicated presence in food or other products. This information is incorporated into a national database to proactively identify outbreaks that may affect neighboring states.

The New York State Department of Environmental Conservation (NYS DEC) also undertakes efforts to control vector-borne diseases. For example, the NYS DEC provides mosquito control recommendations on its web site, and establishes requirements for the safe application of pesticides including products that reduce mosquito and tick populations. The NYS DEC also regulates the management and recycling of waste tires that may harbor substantial mosquito populations. Illegal dumping has also been reported as a factor in the spread of vermin and disease.

In the area of water-borne disease prevention, direct efforts are again often undertaken by local authorities, although New York State and the federal government retain regulatory authority and provide considerable funding, oversight and consulting expertise. In areas where local and county water quality protection resources are few, NYS DOH regional offices provide the necessary expertise to ensure that local water sources are protected.

The NYS DOH and NYS DEC implement elements of the federal Safe Drinking Water Act and the Clean Water Act that protect water quality and minimize morbidity and mortality from waterborne diseases. The NYS DOH protects the public from waterborne pathogens in drinking water and recreational water, as well as cooling towers and other wet cooling devices.

The NYS DOH works closely with a wide array of private, public and pseudo-public entities such as the American Water Works Association, the New York State Rural Water Association, the Greater New York Hospital Association and the World Environment Fund to accomplish its goals. Watershed rules and regulations, put into place to preserve various source waters from degradation, are key components of this overall effort. For example, rules put into place to protect the New York City watershed are detailed, comprehensive, and a model for other municipalities. The rules include pathogen monitoring and other forms of surveillance to detect changes in water quality, such as changes that may result from climate change.

The federal Safe Drinking Water Act, as amended in 1996, established the Drinking Water State Revolving Fund (DWSRF) to make funds available to drinking water systems to finance infrastructure improvements. Also in 1996, New Yorkers approved the \$1.75 billion Clean Water/Clean Air Bond Act, which provides funding for a variety of environmental improvements related to five categories: Clean Water, Safe Drinking Water, Solid Waste, Municipal Environmental Restoration (Brownfields), and Air Quality. The Clean Water category includes funding for water quality improvements, habitat restoration, open space protection and development of waterfront parks, recreation and historic preservation projects.

Comprised of federal and Clean Water/Clean Air Bond Act moneys, the DWSRF program emphasizes provision of funds to small and disadvantaged communities, and to programs that encourage pollution prevention as a tool for ensuring safe drinking water. The NYS DOH works in conjunction with Environmental Facilities Corporation to implement the DWSRF program in New York. The Environmental Facilities Corporation serves as the financial arm and issues the actual loans, grants and bonds. The NYS DOH serves as the technical lead and scores proposed projects for prioritization purposes. The Department also conducts design reviews, approves designs, and inspects completed work.

The NYS DOH is also responsible for recreational beach and swimming pool water quality monitoring, and is developing a standard training curriculum for swimming pool inspectors.

The New York State Emergency Management Office (SEMO) makes available equipment on a temporary loan basis to local governments and state agencies primarily for drought relief, flooding, and emergency power and light generation. Available for loan are power generators; pumps, piping, and water filters; potable water tankers; portable light towers; chainsaws; chlorinators; and sandbag-filling machines.

In the area of food-borne disease prevention and surveillance, again city and county health agencies play a key role, deploying hundreds of sanitarians that inspect food preparation establishments and enforce laws ensuring such essential cleanliness, safe cooling and reheating of potentially hazardous foods, and hygiene requirements.

The NYS DOH provides standardized training to food sanitarians statewide, and has so far trained 500 inspectors. In addition, the NYS DOH works with the New York State Department of Agriculture and Markets, the US Department of Agriculture (USDA), the U. S. Food and Drug Administration (US FDA), and other agencies to identify and eliminate sources of food-borne illness outbreaks, and then modify inspector training, policies and, when necessary, NYS law to prevent recurrences.

The NYS DOH Emerging Infections Program is a population-based network that includes the Centers for Disease Control and Prevention and 10 state health departments, working with collaborators to assess the public health impact of emerging infections and to evaluate methods for their prevention and control. Core activities include active, laboratory-based surveillance for nine bacterial/parasitic food-borne pathogens, conducted principally by the food-borne Diseases Active Surveillance Network (FoodNet). FoodNet is a collaborative project of the Centers for Disease Control and Prevention, 10 states, the USDA, and the US FDA.

The project consists of active surveillance for food-borne diseases and related epidemiologic studies designed to help public health officials better understand the epidemiology of food-borne diseases in the US. The FoodNet program tracks food-borne illness using surveys of physicians and laboratories, case-control studies,

and active case finding of the following pathogens: Campylobacter, Cryptosporidium, Cyclospora, Shiga Toxin-Producing Escherichia coli (STEC), Listeria, Salmonella, Shigella, Vibrio and Yersinia.

The enforcement of New York State Agriculture and Markets Laws and Regulations provides a vital service that is critical in maintaining the safety of the food supply from producer to the retailer. The Division of Food Safety and Inspection is the Department of Agriculture and Markets largest division, with a staff of approximately 200 full-time employees including about 115 food inspectors. The Division has jurisdiction over approximately 28,000 food handling establishments and conducts a variety of activities including unannounced sanitary inspections of food manufacturers (wholesale bakeries, beverage processors, food warehouses, refrigerated warehouses, retail food stores, slaughterhouses not regulated by USDA, fish processors, and rendering/disposal plant and transportation services). The Division also collects food products samples for analysis by New York State Agriculture and Markets, conducts information seminars for the food Industry on food safety and labeling, investigates consumer complaints, licenses food service operators, consults with owners of food establishments and industry groups, seizes unfit or adulterated foods and evaluates and inspects food labeling and advertising. Enforcement activities include industry conferences, civil penalties, injunctions, license revocations or denials, hearings, temporary restraining orders and seizure and inspection warrants.

To a great extent, the impact of climate change on incidences of vector-borne and water-borne diseases in New York will depend upon the actions of New York and its neighbors.

The same cannot be said concerning the incidence of food-borne disease in New York, because much of the food consumed in New York is imported from other states and nations. The USDA and the US FDA are responsible for promulgating regulations, conducting inspections, and ultimately preventing unacceptable levels of pathogens in domestic foods that are transported into New York.

The Food Safety and Inspection Service (FSIS) is the public health agency in the USDA responsible for ensuring that the nation's commercial supply of meat, poultry, and egg products is safe, wholesome, and correctly labeled and packaged. FSIS operates under the Federal Meat Inspection Act, the Poultry Products Inspection Act, and the Egg Products Inspection Act, in addition to Executive Orders, small business protection laws and other guidance applicable to all federal agencies.

The US FDA is the public health agency in the US Department of Health and Human Services responsible for ensuring that foods imported into the United States are safe to eat. Under provisions of the US law contained in the US Federal Food, Drug and Cosmetic Act, importers of food products intended for introduction into US interstate commerce are responsible for ensuring that the products are safe, sanitary, and labeled according to US requirements. All imported food is considered to be interstate commerce. The US FDA is not authorized under the law to approve, certify, license or otherwise sanction individual food importers, products, labels or shipments. Importers can import foods into the US without prior sanction by the US FDA, as long as the facilities that produce, store or otherwise handle the products are registered with the US FDA, and prior notice of incoming shipments is provided to the US FDA. Imported food products are subject to US FDA inspection when offered for import at US ports of entry. The US FDA may detain shipments of products offered for import if the shipments are found not to be in compliance with US requirements. Both imported and domestically-produced foods must meet the same legal requirements in the US.

NYS government assesses and as necessary modifies laws, regulations and agency policies concerning the surveillance and control of vector-, water- and food-borne diseases and disease agents in response to changing conditions. For example, in response to increased awareness of terrorist threats since the attacks of September 11, 2001, the State Public Health Law (sec. 1125) now requires that all community water systems that serve more than 3,300 people prepare and submit a water supply emergency plan. These plans are submitted to the local health department or NYS DOH District Office. Some counties have additional emergency plan requirements that water systems must meet.

Research/Information Needs

As stated earlier, extensive programs are in place to prevent and respond to vector-, water- and food-borne disease threats within New York State. These programs provide a framework upon which to fashion specific climate change adaptation strategies, preferably based on science-based predictions of potential climate change impacts. However, there remains considerable uncertainty associated with such predictions (Gubler et al., 2001). Consequently, there is an acute need for scientific research in support of efforts to improve models that relate climate change to changes in vector populations and diseases incidence.

For example, additional research is needed regarding the degree to which increased ocean and bay temperatures, increased erosional run-off and increased combined sewer overflows may be expected to increase bacterial contamination of shellfish species. There is also a need for research to better understand why the public health system is sometimes able to quickly suppress outbreaks of diseases such as malaria—even though the diseases were once rampant throughout much of the nation, and have been repeatedly reintroduced—but cannot halt the spread of certain other diseases that have never been endemic to the US (e.g., *Cryptococcus gattii*-associated disease; West Nile Virus).

In some research areas, there is also a need for data more directly relevant to making predictions for the US Northeast, as opposed to other regions. For example, additional research is needed regarding the degree to which weather may be expected to increase rat populations, and incidences of rodent-borne rabies, leptospirosis, and food-borne illnesses, in the U.S. Northeast. Existing studies conducted in the US Southwest and elsewhere considered rodent populations, prevailing weather conditions and agents that may be poor surrogates for New York.

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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 New York State Sea Level Rise Task Force 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 recommendation³ 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 Sea Level Rise Task Force. According to the draft Sea Level Rise Task Force recommendation, full implementation may occur within two to five years.

Potential Implementation Mechanisms

This could be done through Executive Order. This will need to involve multiple State agencies and authorities.

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 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, including the following:

- create physical hazards that may result in drownings, electrocution from downed power lines, and motor vehicle accidents;
- damage or destroy people's homes and belongings, resulting in the need for temporary or permanent relocation;
- result in temporary or permanent loss of community centers, senior centers, schools, recreational areas, and similar facilities, which can lead to a decline in the quality of life and undermine community cohesion and identity;
- cause widespread power outages which can lead to hyperthermia or hypothermia (depending on the season of the year); effects on people who depend on electricity for mobility or for medical conditions (e.g., oxygen concentrators for people on oxygen therapy); loss of potable drinking water; loss of refrigeration, which may affect residential and commercial food safety; increased use of generators, which may increase carbon monoxide (CO) poisonings; and use of unsafe heating sources, which may increase CO poisonings and fires;
- cause biological and/or chemical contamination of drinking water;

³ <http://www.dec.ny.gov/energy/45202.html>

- affect drinking water treatment facilities directly, or indirectly if increased treatment is needed because of elevated contaminant loads in source waters;
- result in spills/releases from commercial/industrial facilities, which can contaminate soils and recreational water bodies;
- mobilize and transport hazardous substances/materials present in locations such as landfills, homes, and businesses;
- cause residential heating oil spills if oil storage tanks are damaged;
- increase combined sewer overflows and/or exceed the capacity of sewer systems, causing flooding of streets/basements with sewage-contaminated water that could expose people to pathogens;
- disrupt solid waste collection and disposal systems;
- result in mold growth in flooded buildings, increasing the incidence of health conditions associated with the presence of mold and health effects from the chemicals that people may use to treat mold growth;
- increase rodent food supplies and rodent populations and increase breeding opportunities for arthropod-borne disease vectors, leading to an increase in the risk of diseases such as plague, tularemia, rickettsial infections, hantavirus pulmonary syndrome, and West Nile virus.

In the absence of adaptive measures, sea level rise and its associated flooding also can erode soils, endangering buildings and other infrastructure upon which people depend and it may cause salt water contamination of public and private drinking water supplies.

Even in the absence of storm surge flooding, sea level rise and actions to adapt to it (e.g., protecting/relocating infrastructure and dwellings) is likely to disrupt communities and some people's lives and livelihoods. These disruptions, as well as the consequences of coastal storms and flooding may affect people's mental/emotional health (for example, see <http://www.cdc.gov/climatechange/effects/mentalhealth.htm> and Fritze et al., 2008).

In the absence of adaptive measures, sea level rise and its associated flooding also can erode soils, endangering buildings and other infrastructure upon which people depend, and it may cause salt water contamination of public and private drinking water supplies.

More comprehensive information on the resources affected by sea level rise and its possible public health consequences can be found in Frumhoff et al., 2007; CCSP (2008); NRC (2010); the U.S. Environmental Protection Agency's Climate Change – Coastal Zones and Sea Level Rise webpage (<http://www.epa.gov/climatechange/effects/coastal/sap4-1.html>); the US Global Change Research Program webpage (<http://www.globalchange.gov/>); and numerous other readily available documents.

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.

Related Efforts

Examples of activities related to sea level rise in New York State include the following:

Chapter 613 of the Laws of New York, 2007 established the New York State Sea Level Rise Task Force (“SLRTF”). The legislation charged the task force with producing a report to the governor and the State Legislature to assess the anticipated effects of sea level rise and make recommendations for state action to address them. Completion of the report is expected by January 1, 2011. More information about the work of the SLRTF is available at <http://www.dec.ny.gov/energy/45202.html>.

The New York City Panel on Climate Change issued the report “Climate Change Adaptation in New York City: Building a Risk Management Report” (NPCC, 2010) which includes New York City-specific climate change projections, tools to help entities identify climate vulnerabilities and develop adaptation strategies, and recommendations on how to foster an effective climate resilience program. The report addresses sea level rise and other climate change risks faced by New York City.

The New York City Department of Environmental Protection (DEP) Climate Change Program issued an “Assessment and Action Plan, A Report Based on the Ongoing Work of the DEP Climate Change Task Force” (NYC DEP, 2008). As indicated in the report, DEP has begun to implement programs that complement PlaNYC (Mayor Bloomberg’s plan for a sustainable city) by addressing climate change and its projected impacts on New York City’s drinking water delivery, stormwater management and wastewater treatment systems. The report summarizes analyses and actions, and presents a comprehensive adaptation strategy for DEP.

Rising Waters, a multi-stakeholder effort of the Eastern New York Chapter of the Nature Conservancy and its partners (NYS Department of Environmental Conservation Hudson River Estuary Program, Hudson River National Estuarine Research Reserve, Cary Institute for Ecosystem Studies, NYS Water Resource Institute at Cornell University and Sustainable Hudson Valley), aims to strengthen the preparedness and adaptive capacity of the Hudson River Estuary Watershed to meet the impacts of climate change. A report on the project is available at <http://www.nature.org/wherewework/northamerica/states/newyork/science/art23583.html>.

Additional information not specific to New York State is available on the US Environmental Protection Agency webpage at <http://epa.gov/climatechange/effects/coastal/index.html>.

Research/Information Needs

Assessments of sea level rise frequently discuss the fundamental choice of protecting coastal resources such as people’s homes, businesses and infrastructure or retreating from areas that may be affected by rising waters (e.g., CCSP, 2009). Informing decisions such as these may require continuing research on the effectiveness of methods/technologies for protecting coastal resources, the societal consequences of protect vs. retreat strategies and the overall sustainability of strategies. The effectiveness of alternative strategies in enhancing individual and community resilience also may be an information need that should be addressed. Sea level rise and flooding also may have long-term effects on mental health/emotional health. Additional research/information gathering may be needed to help understand and mitigate the causes.

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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.

Potential Implementation Mechanisms

The NYS Department of Health could collaborate with other agencies/authorities such as the NYS Department of Environmental Conservation and the NYS Energy Research and Development Authority and with other organizations and individuals with expertise in this area to develop a public health climate change research agenda for New York State. A schedule for regular updates should be a component of the research agenda.

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.

Potential Implementation Mechanisms

This action could be implemented as a component of 7-A.

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.”

Related Efforts

Scientific research into the public health consequences of climate change is progressing in several areas, although the research base needs to be expanded (Ebi et al., 2009). Relatively few investigations have been undertaken to characterize the effectiveness of public health adaptation strategies, but relevant studies should increase in number once more adaptation strategies are implemented. This section does not provide a comprehensive review of ongoing research efforts, but rather briefly summarizes those activities most relevant to adaptation in New York State, as well as some organized efforts to identify specific research priorities.

The New York State Department of Health (NYS DOH) is exploring the association between weather/climate change and human health with the ultimate goal of identifying appropriate public health adaptation strategies. For example, the NYS DOH has assessed the potential impact of hot weather on hospital admissions due to cardiovascular and respiratory diseases in New York City. NYS DOH scientists identified a threshold effect for the association between hospital admissions and increased temperature/apparent temperature. This research highlighted the need to develop strategies to help specific susceptible populations, such as Hispanics and the elderly, adapt to more frequent and prolonged high temperature events (Lin et al., 2009).

Additional NYS DOH research projects underway seek to better elucidate the relationship between weather/climate and increased incidence of in vector-borne diseases, water/food-borne diseases, adverse birth outcomes, and respiratory, cardiovascular and other diseases. The joint effects of multiple climate factors will be evaluated.

Beginning in 2002, the CDC funded implementation of an Environmental Public Health Tracking (EPHT) program in New York State. The purpose of EPHT is to improve community health by providing information to federal, state and local agencies so that they may evaluate geographic patterns, temporal trends, public health actions, and potential impacts of environmental hazards and exposures on human health. EPHT data are expected to be valuable to climate change researchers. The findings from other NYS DOH investigations will

be integrated into the current EPHT program in New York State to develop a climate-health surveillance system and guide New York State environmental and health agencies in planning adaptation strategies and preparedness programs. More information about EPHT in NYS is available at http://www.health.state.ny.us/statistics/environmental/public_health_tracking/

A study by the Northeast States for Coordinated Air Use Management (NESCAUM), in collaboration with NYS DEC and NYSERDA, is evaluating economic and air quality outcomes of various future energy scenarios for New York State. A comprehensive and detailed Multi-pollutant Policy Analysis Framework is using a northeast US-specific version of the Market Allocation economic model (MARKAL), a large-scale air quality model (CMAQ), the REMI model (Regional Economic Models, Inc.), and EPA's Environmental Benefits Mapping and Analysis Program (BenMAP), a tool for estimating the health impacts and economic values associated with changes in ambient air pollution. Results from this project will help assess environmental, economic, and public health consequences of greenhouse gases (GHGs), ozone and PM_{2.5} control strategies in New York State and the region.

The State Environmental Health Collaborative (SEHC) Climate Workgroup developed a comprehensive set of environmental health indicators of climate change, which incorporates health outcome, environmental, and population vulnerability indicators, along with indicators of mitigation and adaptation. These indicators are vital for program evaluation, health service planning, and communication. Data on these indicators will ultimately be of value to researchers investigating climate change adaptation strategies.

Organized efforts to identify specific public health research priorities have been or are being conducted by numerous entities. For example, research recommendations are provided in the NYSERDA and New York Academy of Sciences report on developing a climate change research strategy (NYSA/NYSERDA, 2007) and in Ebi et al. (2008). Still more focus areas are identified in the 2010 Interagency Working Group on Climate Change and Health (IWGCCCH) Report, A Human Health Perspective on Climate Change. NYSERDA's Integrated Assessment for Effective Climate Change Adaptation Strategies in New York State (ClimAID) project also will identify key focus areas. Research goals related to climate change adaptation that were identified by these efforts were mostly related to the prediction and tracking of climate change effects, risk communication and cost/benefit analysis. Examples of these goals include:

- Evaluate communication and educational outreach programs designed to increase climate change awareness, overcome communication barriers, and encourage behavior that reduces climate change as positive and desirable for environmental and public health protection;
- Develop and validate models that relate climate change to changes in vector-, water- and food-borne disease incidence in New York under plausible extreme climate variability and climate change scenarios;
- Develop a central database for climate change information to facilitate information access by researchers;
- Characterize exposure-response relationships, particularly at regional and local levels, identifying thresholds and particularly vulnerable groups;
- Conduct long-term surveys of vector-, food- and water-borne and zoonotic disease incidence, air quality indicators, pollen and mold counts, morbidity due to temperature extremes, and mental health endpoints related to extreme weather events;
- Develop methods to estimate the costs and benefits of adaptations;
- Develop climate projections at the local and regional scale to help in the conduct of the types of impact, vulnerability, and adaptation assessments that will enable adequate projections of and adaptations to climate change, and to determine the potential for interactions between climate and other risk factors, including societal, environmental, and economic factors.

Research/Information Needs

New York State must pursue a cohesive scientific research strategy designed to improve predictions of public health impacts related to climate change and identify effective public health adaptation strategies. Specific research needs have been discussed in this document, and additional recommendations have been generated by numerous entities.

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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/Vulnerabilities Addressed for All Recommendations

Imminent changes in climate are likely to adversely affect communications infrastructure and services throughout New York State. Sea level rise, extreme weather events, and rising temperatures are the prominent climate related risks that New York State faces (Zimmerman and Faris, 2010). 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. The potential increases in ice and snowfall in some portions of the state could demand more salting of many city roads; the salt may then wash into manholes/vaults, leech into ducts where fiber optic cables are located, and cause corrosion and the potential failure of the cables. Cell towers, the focal point for wireless communications, can fall when faced with extreme wind and ice events and can become corroded from unexpected exposure to seawater if sea level rise-driven flood storm surges occur (Zimmerman and Faris, 2010).

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. Electrical support devices such as relays, wiring, and switches associated with fiber optic cables are at risk (Zimmerman and Faris, 2010). The infrastructure can become inundated by floodwaters or be corroded by the infiltration of salt from seawater. Flooding, sea level rise, and storm surges are threats that could easily devastate central communication offices.

As with many cases associated with natural disasters, many indirect impacts are possible. For example, being unable to make or receive calls due to bandwidth limits being reached creates serious problems during times of disaster. Cross-sector impacts are also a concern. The delivery of communication services is sensitive to power outages, which may 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.

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.

Research/Information Needs

The industry generally lacks computerized (proprietary) data bases that readily show the location and elevations of installed communication facilities and lifelines and their operational capacity and other details. Such data can be crucial in emergencies and extreme weather events to make rapid damage, loss and consequence assessments in potential hazard and damage zones. These data bases need to be fully protected to allow only restricted, authorized accessibility for security reasons.

Additionally, an assessment should be conducted of co-dependency between the communications' and power sectors' relative vulnerabilities.

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.

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

The specific impacts on Environmental Justice communities are 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.

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.

Co-benefits and Unintended Consequences

Increasing redundancy and reliability in the telecommunications sector will reduce outages not only from a changing climate, but also from other non-climate related risks. Improving telecommunications technology reliability will also help to reduce greenhouse-gas emissions from travel.

At the same time, cooling and operating more telecommunications facilities and infrastructure will result in increased energy demands. These processes already account for 1.5 percent of the energy consumption in the United States (The Economist 2009).

Research/Information Needs

Develop and expand alternative communication technologies if they promise to increase redundancy and/or reliability, including free-space optics (which transmits data with light rather than physical connections), power line communications (which transmits data over electric power lines), and satellite phones.

The relative energy-efficiency of new technologies should also be better understood.

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.

Potential Implementation Mechanisms

Better reporting perhaps could be done by having service providers file quarterly or yearly reports to the New York Public Service Commission (NYS DPS, 2002). Also, the Telecommunications Service Priority Program, which is meant to help carriers with restoring service to important facilities, could be more widely used in New York State.

Environmental Justice Considerations

No immediate, identified issues.

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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

A sound transportation system is critical to a vibrant economy and a high quality of life. New York State has one of the largest and most diversified multimodal transportation systems in the nation, a network of highways, rail lines, transit systems, seaports and airports providing essential mobility for people and goods to move throughout the State. New York State's transportation system moves:

- About 137 billion vehicle miles of travel on more than 245,000 miles of highways and 17,400 bridges statewide;
- Approximately 2.6 billion passenger trips provided by more than 130 public transportation operators (including the Metropolitan Transportation Authority - MTA) throughout the State, accounting for one out of every three public transportation riders in the nation;
- Approximately 88 million passengers who travel through more than 500 public and private aviation facilities within the State;
- Approximately 1.5 million riders each year who use Amtrak's Empire and Adirondack services, and more than 8 million rail passengers who pass through Penn Station using Amtrak's Northeast Corridor;
- More than 150 million tons of freight that pass through four port authorities (the Port Authority of New York and New Jersey, Albany Port District Commission, Port of Oswego Authority and Ogdensburg Bridge & Port Authority), the Port of Buffalo and numerous private ports handling; and
- More than 75 million tons of freight that move across 3,500 miles of rail.
- 11 million licensed drivers utilizing 10.5 million motor vehicles.

Transportation agencies have weighed climate change, both projected and already experienced, and its impacts on the transportation system. Climate change related weather events of greatest concern to NY's transportation infrastructure were identified as intense precipitation, sea level rise, and storms with accompanying tidal surges in NY's coastal areas. In the Northeast, a storm that was expected to occur on average once every 100 years based on data from 1950 to 1978, now occurs more frequently, once every 65 years, based on more recent data, 1978-2007 (A.T. Gaetano, 2009); and the number of days with heavy rainfall has increased by 58% from 1958 to 2007 (US Global Climate Research Program). In recent history, flooding has occurred repeatedly throughout the state. Since 2003, NYS received over \$107 million in emergency repair cost for eighteen weather related incidents alone. Fourteen of these events related to precipitation events that caused extensive flooding.

Much of NYS's transportation drainage and bridge infrastructure is designed using hydraulic models based on 50 years of rain and stream gauge data. Although design is based on sound engineering practices, increased vulnerabilities to older infrastructure elements may occur due to increased rainfall intensities and extreme rainfall events since their original construction. Community and local systems incur a degree of risk with much of their infrastructure designed for lower magnitude storm events.

Sea level rise coupled with potential storm surges, such as those caused by Nor'easters or hurricane strength storms could bring about major transportation system outages in NY's coastal areas. New York City has undertaken steps to assess its vulnerability due to sea level rise and coastal storm surges. Similar assessments must be undertaken for other coastal areas as well, Long Island and Hudson River areas in particular. Infrastructure in need of protection includes roads, bridges, rail, airports and subways. The coastal areas are home of much of the state's population and ensuring availability of transportation resources during emergencies is paramount in order to provide goods and services during and following such event. While emergency evacuations and other related tasks are headed in part by the Department of Homeland Security, all relevant NYS agencies must be involved in assessing vulnerabilities and prioritizing critical infrastructure needs. Sea level rise projections should be officially endorsed by New York State and any projected permanent inundation of low lying coastal areas host to airports, roads and rail due to sea level rise over the coming century must be addressed.

In addition to the priority policy recommendations made in this report, other actions must be considered in transportation decision making including impacts from more frequent heat waves and other climate change related impacts. Climate change concerns are adding to the challenges facing the State' aging transportation system. New York State is faced with a large number of older bridges that are at the end of their design life - 3,000 additional bridges are expected to become deficient in this decade, adding to a growing backlog of bridge maintenance and repair needs. In addition, it is projected that New York State pavements will fail to meet minimum condition standards under GASB 34 (Government Accounting Standards Board, Statement 34) by the end of the decade, even if existing funds are applied in the most efficient manner possible.

Funding sources to mitigate climate change related impacts to transportation have yet to be identified. With current transportation funding being inadequate to address the backlog and projected deficiencies, it is difficult to fathom immediate large scale funding being made available for purposes of climate change impacts. However, one can safely propose that assessing vulnerabilities, regional and statewide, is within the scope of existing transportation resources. FHWA in concert with other federal agencies is supporting efforts to help states accomplish these assessments. Prioritizing and addressing critical infrastructure needs in light of climate change impacts should take current and future transportation maintenance and operational needs into account. Vice versa, transportation facilities that are now being designed or rehabilitated need to address vulnerabilities based on current and projected climate change data.

Finally, transportation managers, engineers and scientists agree that vulnerability assessments and near-term implementation of recommended actions are needed to protect NYS's transportation system in light of immediate climate threats. Long-term planning efforts must seek to improve transportation resiliency to climate change and ultimately construct a transportation system that is low-carbon, efficient, serves all people of New York State while enhancing the state's economy and environment.

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 take 12-18 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 CO₂ 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 assessment 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.

Potential Implementation Mechanisms

Using sea level rise and associated storm surge as an example, an agency could start by assessing which critical facilities are located within the current 1-in-100 year flood plain. Using the climate change projections, the agency would make a vulnerability assessment on the potential risk of future flooding impacts on an individual or group of interdependent facilities. This assessment would include the probability of the flooding occurring and a general estimate of the financial costs due to flooding damage as well as adaptation strategies for future

planning. Additionally, the agency can make an assessment on how the failure of this facility affects the users, with particular attention made to population who may solely depend on the facility for emergency purposes.

Partners who will likely need to be involved include: NYCDOT, NYSDOT, NYS Thruway, NYS Bridge Authority, NYS Thruway, MTA, MTA Metro North, PANYNJ, PANYNJ PATH, NJTransit, NYSDOS, NYSTA and Canal System, municipalities, local community groups, USACOE, FAA, FHWA, FTA, FRA, NYS Sea Level Rise Task Force, New York City Panel on Climate Change, NYSERDA, and the ClimAID team.

To prioritize infrastructure investment, NYS could establish a taskforce consisting of members from the following state and municipal agencies: NYCDOT, NYSDOT, NYS Thruway, NYS Bridge Authority, MTA, PANYNJ, NJTransit, and NYSDOS. This committee could also confer with federal agencies including FHWA, FTA, and FRA. The taskforce could use criteria based on critical movement of both people and freight and ability to interconnect regions within both NYS and adjacent states established under Recommendation 1. The committee could also use projections on how climate change will reshape demographic, economic and travel trends by the end of the century. The committee could then superimpose the above criteria on New York's transportation infrastructure to establish which modes and systems should be prioritized.

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.

Related Efforts

Within the general Transportation and Land Use recommendations, several items will rely directly on these inventories as a first step in the adaptation planning process. These inventories will be integrated into the long term planning vision for the state transportation plan, provide the necessary baseline for the prioritization of capital funds for adaptation strategies and help to identify where design standards need to be updated. New York City Panel on Climate Change and ClimAID have both provided general inventories for NYS transportation infrastructure, however, this recommendation will provide the first comprehensive baseline necessary for future planning

Research/ Information Needs

- Develop regional climate change projections, statewide, including sea level rise and storm surge contour maps.
- Develop comprehensive policies and procedures for inventorying critical infrastructures and assessing vulnerabilities and risks due to climate change impacts.
- Develop process for identifying assets and locations that are vulnerable to climate change.
- Develop tools and methods for analyzing vulnerability and evaluating adaptation options.
- Develop tools and methods for analyzing chances in the probability of climate extremes.

- Develop policies and procedures for inventorying critical infrastructures and assessing vulnerabilities and risks due to climate change impacts.
- Develop process for identifying assets and locations that are vulnerable to climate change.
- Develop tools and methods for analyzing vulnerability and evaluating adaptation options.
- Develop detailed evaluations of policy mechanisms required to affect mode split as well as more detailed evaluations of economic and environmental justice considerations of such policies.
- Assess how changes in freight movement will affect regional growth patterns.
- Assess how climate change will reshape demographic and travel trends by the end of the century.
- Quantify the costs and benefits of climate change on public and freight transportation and identify appropriate adaptation measures for each mode.

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.

Potential Implementation Mechanisms

Potential partners who would likely be involved include: Transportation Agencies and Authorities; Emergency Management Agencies; Emergency Responders (Fire, Police, Medical) Utilities

The critical transportation routes need to be identified by a separate process overseen by SEMO in conjunction with other Federal, State and local agencies. Climate change impacts for future years (2030, 2050, & 2080) would be identified by the entities responsible for maintaining the critical transportation routes based on climate change forecasts developed for each area of the state.

The funding directed for this effort could come from existing or new Federal and State programs. The funding would be directed to NYSDOT, other State Transportation Authorities, Counties, or Local Governments who have maintenance responsibility for the impacted transportation routes.

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.

Related Efforts

SEMO administers the statewide Hazard Mitigation Plan, which largely supports local efforts in identifying/resolving issues with hazard prone areas. The program includes transportation assets such as roads/bridges vulnerable to flooding.

Research/ Information Needs

- Develop a comprehensive methodology for identifying critical transportation routes.
- Develop a methodology for identifying specific climate change impacts on transportation routes.
- Combine potential climate change events with other “what-if” scenarios into emergency response scenario planning and develop strategies to effectively integrate emergency response plans.
- Evaluate and update current emergency preparedness.
- Develop data collection standards for informed risk analysis, asset management and decision making.

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.

Potential Implementation Mechanisms

NYSDOT should develop updated design criteria in coordination with climatologists, USGS and others engaged in climate projections for NYS. Once accomplished, NYSDOT publishes updated Design criteria and makes these available to others involved in transportation infrastructure design and construction.

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.

Potential Implementation Mechanisms

Update the NYSDEC SPDES permit.

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.

Potential Implementation Mechanisms

See Recommendation 3A.

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.

Related Efforts

Sea level rise, precipitation, temperature and other projections have been made by Columbia University/NASA Goddard Institute for Space Studies and under ClimAID. Current models of 24-hour precipitation events have also been developed at Cornell University. One model was conducted in conjunction with the USDA National Resources Conservation Service, the Northeast Climate Center, and the National Climate Center, which is part of NOAA.

Research/ Information Needs

- Develop sea level rise projections and regionalized flood severity trends to identify projects that will be at risk within their design life, and determine design criteria that will manage the risk with the minimum of cost and undesirable impact.

- Develop river flooding projections for regionalized changes in rainfall and storm intensities and stream flows.
- Develop database of adaptation options for specific facilities.
- Quantify the impacts of climate change on facility life.
- Integrate climate change into infrastructure planning and environmental decision making.
- Develop strategies and tools to change methods, codes and standards to respond to climate change.
- Understand institutional issues related to shortened construction schedules to avoid heat and longer construction seasons due to shorter winters.
- Develop pavement, bridge and other infrastructure design and materials specifications that account for expected climate change impacts, including climate change considerations in hydraulic modeling and design.
- Consider climate change adaptation in the transportation planning process.
- Develop cost/benefit guidance for incorporating adaptation strategies into specific transportation projects.

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.

Potential Implementation Mechanisms

The Transportation Master Plan is developed by NYSDOT. This specific action can be implemented through policy direction.

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.

Related Efforts

The comprehensive vulnerabilities inventories obtained through efforts under Recommendation 1 should be integrated into the Transportation Master Plan.

Research/ Information Needs

- Work with stakeholders to understand the implications of climate change on land use and transportation and identify appropriate adaptation actions.
- Develop strategies to fund climate change adaptation and assess the costs and benefits of adaptation.
- Develop financial analysis tools to allow longer planning periods and climate change adaptation.
- Assess how climate change impacts will affect asset management investment cycles and life cycles of major investments.
- Develop data collection standards for informed risk analysis, asset management and decision making.

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.

Potential Implementation Mechanisms

Infrastructure investments should be evaluated using environmental criteria, as well as dollar value risk per person, and should be consistent with the inventory and planning developed under Recommendations 1 and 4. Evaluation could be lead in part by NYSDOT and the Governor's Smart Growth Cabinet, which was created by Executive Order in December 2007, and could also include the taskforce developed under 5. This evaluation would result in a funding matrix that directs support for local transportation infrastructure. This Action follows the tasks outlined in the preceding Transportation Recommendations: an inventory should be established, official climate change projections should be incorporated into state and local planning efforts, and investments should be directed at the modes, infrastructure, and locations that are most resilient to climate change impacts.

Smart Growth is not a one-size-fits-all proposition that is mandated from above, and special consideration should be given to the fact that New York is currently a "Home Rule State." Every effort should be made to encourage coordinated and consistent Smart Growth throughout NYS. The Governor's Smart Growth Cabinet should work with other state agencies and local governments to incorporate the evaluation criteria in this recommendation into improved incentives, program enhancements and priority assistance to local communities.

This action could involve the State Legislature, along with the Governor's Smart Growth Cabinet and appropriate state agencies, regional Metropolitan Planning Organizations (MPO) throughout the state, and county and municipal governments and planners. To a certain extent, these principles are already being emphasized throughout NYS, but this recommendation calls for increased coordination among levels of government and professionals in the field as well as improved policies and incentives to further incentivize Smart Growth and TOD among local policy makers and developers.

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.

Potential Implementation Mechanisms

Many municipalities may not have expertise to make required evaluations of natural resource impacts. NYSDEC and other state agencies should provide guidance. Potential partners who will likely be involved include: NYSDOT, NYCDOT, NYS Thruway, NYS Bridge Authority, MTA, , PANYNJ, NJ Transit, NYSDOS, NYSTA and Canal System, municipalities, local community groups, railroads, USACOE, FAA, FHWA, FTA, FRA, NYS Sea Level Rise Task Force, New York City Panel on Climate Change, NYSERDA and ClimAID.

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.

Potential Implementation Mechanisms

Transportation choices are highly dependent on the prevailing land use patterns. This action could involve the State Legislature, along with the Governor’s Smart Growth Cabinet and appropriate state agencies, regional MPOs throughout the state, and county and municipal governments and planners. This recommendation calls for improved policies for land use and transportation planning that provides travel options by incentivizing shared modes, walking and biking.

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.

Related Efforts

It is imperative to recognize that efforts to reduce GHG emissions from the transportation sector will not eliminate the need to prepare for an address the impacts of climate change processes already underway. Proactive GHG adaptation planning and reduction strategies must be undertaken concurrently. If implemented correctly, many adaptation strategies put forth will have mitigation co-benefits and likewise, mitigation strategies will have adaptation benefits. For this reason, several efforts are mentioned that are not adaptation efforts on the surface, but may have co-benefits that will aid our adaptation strategies.

There are multiple efforts within NYS that call for inventories, risk assessments and priority investments. The New York City Panel on Climate Change recently released *Climate Change Adaptation in New York City: Building and Risk Management Response*. In addition, the NYS Sea Level Rise Task Force is expected to report to the legislature by January 2011.

The Transportation and Land Use Technical Working Group (TLU TWG) has recommended prioritizing investments toward public transportation and other energy efficient modes and technologies. This recommendation refines the TLU TWG recommendation by calling for measurable criteria and guidance that further prioritizes investments based not only on their ability to mitigate climate change, but how critical they are from an adaptation viewpoint.

The Transportation and Land Use Technical Working Group (TLU TWG) also recommends transforming mode split to 80% shared modes by 2050 for the purposes of climate change mitigation⁴. It is recommended here to aid in reducing transportation system vulnerabilities and in improving the resiliency of our transportation system statewide.

New York State DOT's *Strategies for a New Age: New York State's Transportation Master Plan for 2030* (Master Plan), has a broad series of environmental initiatives to help achieve air quality and State Energy Plan goals as well as promote improved mobility for the State's transportation customers. These initiatives are not necessarily aimed specifically at climate change adaptation, but they will aid adaptation efforts if implemented. The Master Plan acknowledges that support for public transportation and the development of strategies designed to increase ridership are fundamental to achieving the Energy Plan goals. The Master Plan also states that public transportation planning will be better integrated within a comprehensive transportation planning program that includes all levels of government and all appropriate operators in NYS. The Master Plan should be revisited from a climate change perspective to take advantage of all mitigation and adaptation opportunities (this relates to Transportation subgroup recommendation #7).

Opportunity for synergies may also exist with the NYS DEC Climate Smart Communities program. The Climate Smart Communities program is a network of local governments across New York that have committed to reduce their GHG emissions and to prepare for unavoidable changes in climate. Although this program is focused on local planning and initiatives, it will need to coordinate with the larger statewide plan.

⁴ TLU 7 – Transit and High Speed Rail recommendation

The US DOT released the Draft Strategic Plan FY2010-2015 in April of this year. This Strategic Plan is formed around a set of key priorities with the goal of transforming our transportation infrastructure into a truly multimodal system, offering safe, convenient, affordable, and environmentally sustainable transportation choices. In particular, the Livability goals in the Strategic Plan bring the DOT in partnership with the Department of Housing and Urban Development (HUD) and the Environmental Protection Agency (EPA) to promote well-coordinated and sustainable development.

Two documents from the Urban Land Institute (ULI) (*Growing Cooler* and *Moving Cooler*) stress the importance of bundling transportation and land use policies in order to achieve GHG reductions. ULI found that implementing bundled transportation efficient strategies could achieve higher GHG emissions reductions. In particular, land use changes combined with expanded transit services achieve stronger GHG reductions than when only one option is implemented. The ULI effort is focused on mitigation, but their findings would support adaptation efforts.

Quantifying Greenhouse Gas Emissions from Transit is a Recommended Practice from the Climate Changes Standards Working Group of the American Public Transportation Association (APTA). The Recommended Practice discusses the importance of and co-benefits resulting from efficient land use patterns and public transportation. Efficient land use has the potential to significantly change the way we live and travel. Higher densities allow for closer proximity of housing, employments and services. This pattern of development will allow communities to plan for and support energy-efficient transportation choices like transit. As a result, our transportation network will become more compact, resulting in less exposure and risk to climate impacts statewide. It will be easier to make necessary infrastructure improvements.

Research/ Information Needs

- Develop transportation investments that are smart growth/transit oriented.
- Deepen understanding of how smart growth reduces development pressure on natural systems.
- Work with agencies at all levels of government to influence land use decisions by developing disincentives for sprawl.

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 health 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.

Environmental Justice Considerations

Permitting of water withdrawals could be used to ensure that all communities have equal opportunity for economic growth and development. Depending on implementation, a water withdrawal permit program could have Environmental Justice benefits.

Co-Benefits and Unintended Consequences

Improved understanding of statewide water demand would allow New York to better plan and allocate its use of water supplies. Centralized access to water supply and use data would facilitate regional water resource planning, increasing New York's ability to plan water supply systems that are resilient to the effects of climate change. Having access to data about water demand from other Compact members would allow New York to verify that water resources are being allocated fairly and in accordance with the Compact.

Research/information needs

Once a permit program is in place, there is a need to manage permits, receive, verify and record data, and analyze the data for possible permit violations and for long-term trends.

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.

Potential Implementation Mechanisms

Planning and design of new or rehabilitated infrastructure is driven by engineering practice based on research, as well as government-set standards. New York's implementation of enhanced planning efforts should be driven by a regulatory framework, backed by targeted but significant funding incentives. New York should also seek reforms federal in water resources funding programs, so that better planning is encouraged at all levels of government.

Environmental Justice Considerations

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.

Related Efforts

The Federal Emergency Management Agency is updating flood insurance rate maps for the entire country. This ongoing effort can provide improved understanding of flood vulnerability; however, in many areas updated hydrologic information is not being used. Vulnerability assessments should include regional climate change projections such as those that have been developed by The Earth Institute at Columbia University and the Union of Concerned Scientists.

Research/information needs

Regularly updated climate projections and revised siting and design standards are needed. Financial and technical assistance should be available to allow water resource managers to factor climate change projections into their models to run scenarios of future climate change impacts on water systems and prioritize operational and infrastructure modifications that will help address these impacts.

- 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.

Potential Implementation Mechanisms

Once the USDA and other federal agencies adopt updated design standards, the state should move to adopt the new federal standards. Adoption of the updated standards should be driven by a federal and state regulatory framework, backed by targeted but significant funding incentives. New York should also seek reforms federal in water resources funding programs, so that better planning is encouraged at all levels of government.

Environmental Justice Considerations

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.

Co-benefits and Unintended Consequences

Implementation of updated design standards must occur in a manner that fully considers all the consequences. In some cases, retrofitting to new standards may not be appropriate. For instance, enlarging a dam's spillway to accommodate the larger flows expected during extreme flood events can reduce the dam's flood attenuation behavior, resulting in increased flooding during more frequent flood events.

Related Efforts

Although updated hydrologic data for the State exists, many water management agencies rely on data that is more than 40 years old for engineering design and regulation of water infrastructure. These data must be updated to include contemporary observations and the effects of predicted seasonal and inter-annual variations in precipitation for planning infrastructure projects.

Research/information needs

The updated hydrologic data will soon be available, and the Natural Resources Conservation Service will be updating its computer models to accommodate the updated hydrology. Better engineering tools must be developed to model the cumulative effects of the installation or alternation of flood infrastructure in a given watershed.

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.

Potential Implementation Mechanisms

Many of these concepts can be gradually incorporated into future versions of the New York State Stormwater Manual. These concepts are also being incorporated to some degree into the DEC's Stream Disturbance Permit program. However, additional research is needed to better understand how constructed infrastructure can best mimic natural processes. Many localities and developers may understand the benefit of, and be interested in, implementing these concepts, but more training is needed for planners, engineers, developers, and municipal officials. Research should inform the Manual and other technical guidance, and then training and outreach must be used to increase awareness of the state of knowledge in this area.

Environmental Justice Considerations

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.

Related Efforts

NYS Stormwater Manual is being revised to more strongly incorporate low impact development and better site design principles, the terms coined to address the stormwater hydrology issues. A DEC narrative flow standard is established, which states: "No alteration that will impair the waters for their best usages." A water supply bill for water withdrawal regulation is currently being proposed in the state legislature.

Research/information needs

Agencies and programs that will be affected by these policies should be identified. More detailed evaluations of economic and environmental justice considerations of policy changes should be undertaken prior to changes in regulation and programming. Proliferation of invasive species and their effect on native riparian vegetation should be examined and management strategies developed.

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.

Potential Implementation Mechanisms

Legislation and regulations for state approval of intermunicipal watershed management plans need to be passed. This legislation would give the plans long-term life, so that continuity would remain through changes in local and state administrations.

Environmental Justice Considerations

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.

Co-benefits and Unintended Consequences

Some municipalities will be reluctant to participate in the watershed management planning effort, because they will perceive it as a potential hindrance to future growth. Less than full participation within a watershed would make any plan incomplete.

Related Efforts

TMDL development and Phase II Stormwater Management Implementation have been seen as nested within the framework of broader watershed management planning. The Ocean and Great Lakes Council Report to the Governor calls for the preparation of watershed management plans. Both DEC (Hudson River Estuary Program) and DOS (Watershed Program) have developed models for intermunicipal watershed management planning.

Research/information needs

Conduct research to better characterize and project future water availability, human use and ecosystem requirements in a changing climate. There is a need for additional information regarding the quality of water obtained through private wells. In order to better manage the State's water resources, data collection and analysis are needed. This research will result in better understanding of water availability and regional water budgets and their relationship to human use and ecosystem requirements.

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.

Potential Implementation Mechanisms

The mapping effort described above needs to be completed, and a funding mechanism for regular updating of the maps must be established. The funding could come from premiums paid into the Federal Flood Insurance Program, passed through to New York State. Legislation and regulations need to be established to set state standards and to enable the state to enforce those standards, so that local governments feel less pressure to allow risky development in their flood prone areas.

Environmental Justice Considerations

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.

Related Efforts

Some of the related programs include Army Corp of Engineers protection of wetlands, NYSDEC wetland and adjacent area protection, NYSDEC Protection of Waters program, Federal FEMA Floodplain Insurance Program.

Research/information needs

Four additional research and information needs exist, depending on the desired approach taken to regulate and protect riparian corridors, including the following:

- Mapping: Additional mapping of riparian corridors may be needed, depending on the approach taken to regulate and protect these resources. Mapping may include a corridor zoning approach with distinct uses or regulated activities within delineated riparian corridor zones.
- Riparian corridor guidelines: It would be prudent to also develop guidelines or best practices for the riparian corridors, buffers, and floodplains.
- Municipal incentives: If protecting riparian corridors are protected voluntarily by municipalities, such as that through the model floodplain ordinance which places municipalities into the National Floodplain Insurance Program, creative incentives will need to be developed that encourage local governments to regulate riparian resources. Standards for municipal eligibility will also need to be considered and developed.
- A statewide river corridor advisory committee should be developed, consisting of representatives from a number of applicable federal, state, local, private and non-profit organizations that could explore possibilities regarding the creation and implementation of a statewide river corridor law.

Agencies and programs that will be affected by these policies should be identified. More detailed evaluations of economic and environmental justice considerations of policy changes should be undertaken prior to changes in regulation and programming.

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.

Potential Implementation Mechanisms

Several programs within the New York State Office of Emergency Management exist that can incorporate climate change science-based vulnerability assessments, and vulnerability and mitigation planning.

Environmental Justice Considerations

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).

Co-benefits and Unintended Consequences

Because droughts, floods, and other natural events already occur in New York, increased planning and mitigation efforts would provide a significant benefit, regardless of the future climate picture.

Related Efforts

The New York City Department of Environmental Protection is conducting modeling projects to quantify and provide a comprehensive understanding of the potential impacts of climate change on its water systems. The results of these studies will support recommendations for prioritizing proactive strategies that will maintain

operations at acceptable levels in a changing climatic regime. For more information see http://www.nyc.gov/html/dep/html/dep_projects/climate_change.shtml.

Research/information needs

Better research is needed to support decision-making in times of crisis, and this research needs to be disseminated and incorporated into vulnerability assessments and plans. Emergency managers need to understand and plan for crises that require increased support to infrastructure (for instance protecting vulnerable water supplies) versus crises when short-term support, such as importing water, issuing boil-water alerts, or evacuating residents, would be more effective.