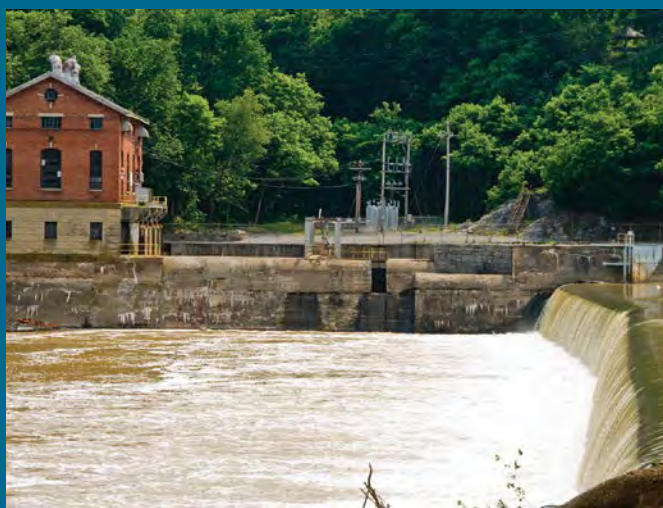


Greenhouse Gas Reduction Plan

Chapter 8: Adaptation



This report is a graphically enhanced version of Chapter 8 of Maryland's Greenhouse Gas Reduction Plan. It provides an update on adaptation strategies in Maryland and is a product of the Maryland Commission on Climate Change.

For more information

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Front cover photos

Top left: Flooding during high tide on the Eastern Shore, Jane Hawkey, IAN Image Library

Top right: Eastern Shore Farmers Market (Bhaskaran Subramanian)

Bottom left: Hydroelectric dam (Wikimedia Commons)

Bottom right: Farm Fields (Ben Longstaff)

Science communication

Caroline Wicks (Integration and Application Network, UMCES)

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List of acronyms

CBP	U.S. EPA Chesapeake Bay Program
CDC	U.S. Centers for Disease Control and Prevention
DBED	Maryland Department of Business and Economic Development
DGS	Maryland Geological Survey
DHMH	Maryland Department of Health and Mental Hygiene
DNR	Maryland Department of Natural Resources
MDA	Maryland Department of Agriculture
MEMA	Maryland Emergency Management Agency
MEA	Maryland Energy Administration
MDE	Maryland Department of the Environment
MHT	Maryland Historical Trust
MHCD	Maryland Department of Housing and Community Development
MDOT	Maryland Department of Transportation
MDP	Maryland Department of Planning
MIA	Maryland Insurance Administration
MPA	Maryland Port Administration
MPO	Metropolitan Planning Organization
NASA	National Aeronautics and Space Administration
NGO	Non-governmental organization
NOAA	National Oceanic and Atmospheric Administration
NRCS	U.S. Natural Resource Conservation Service
PSC	Maryland Public Service Commission
SCD	State Soil Conservation District
SHA	Maryland State Highway Administration
UMCES	University of Maryland Center for Environmental Science
UMD	University of Maryland
UMD-Extension	University of Maryland Extension Service
USACE	U.S. Army Corps of Engineers
USDOJ	U.S. Department of the Interior
USEPA	U.S. Environmental Protection Agency
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey



INTRODUCTION

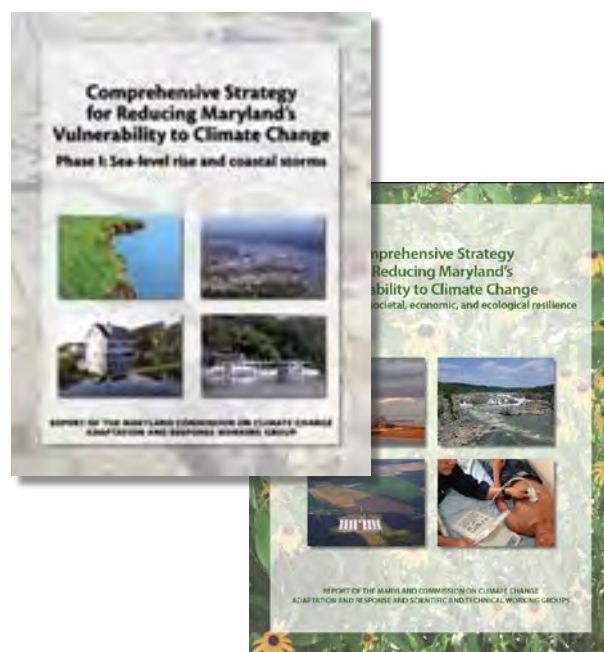
Climate change will affect Maryland in a variety of ways. More obvious impacts could include an increased risk for extreme events such as drought, storms, flooding, and forest fires; more heat-related stress; the spread of existing or new vector-borne disease; and increased erosion and inundation of low-lying areas along the State's shoreline and coast. In many cases, Maryland is already experiencing these problems to some degree, today. Climate change raises the stakes in managing these problems by changing the frequency, intensity, extent, and magnitude of these problems.

As the State moves forward with actions that will reduce greenhouse gases and ultimately result in increased energy efficiency, a more sustainable economy, and cleaner air; climate impacts will still be felt into the future. Therefore, adaptation, together with mitigation, is necessary to address climate change. It is noted, however, that these actions are by no means independent of each other and any program or policy to mitigate the effects of climate change will complement steps to reduce the state's risk to climate impacts.

Climate change adaptation is an extremely complex process and there is no single means of response. As stressed in a recent report by the National Academies, climate change adaptation must be a highly integrated process that occurs on a continuum, across all levels of government, involving many internal and external partners and individual actions, and often evolves at different spatial and temporal scales. That said, the State is already taking steps to enhance the resilience of a broad spectrum of natural and human-based systems to the consequences of climate change.

MARYLAND'S STRATEGY FOR INCREASING RESILIENCE

Maryland's Climate Action Plan includes two climate change adaptation strategies that are currently being used to guide state-level adaptation planning efforts. The first strategy (Phase I), released in 2008, addresses the impacts associated with sea level rise and coastal storms. The second strategy (Phase II), released in 2011 as a compendium to the Climate Action Plan, addresses changes in precipitation patterns and increased temperature and the likely impacts to human health, agriculture, forest and terrestrial ecosystems, bay and aquatic environments, water resources, and population growth and infrastructure. Together, the strategies are the product of the work of more than 100 experts from the governmental,



There are two adaptation strategies used in Maryland to guide state-level adaptation planning efforts.

nonprofit, and private sectors that held a series of meetings for the purpose of interpreting the most recent climate change literature, evaluating adaptation options, and recommending strategies to reduce Maryland's overall climate change vulnerability.

The strategies provide the basis for guiding and prioritizing state-level activities with respect to both climate science and adaptation policy over the near and longer terms. Implementation of a variety of projects designed to implement components of the strategies is well underway and additional efforts have been identified as high-priorities for early action. Summaries of Maryland's Phase I and II adaptation strategies, including current and planned near-term implementation efforts are outlined below.

LEADING BY EXAMPLE

Building resilience to climate change Department of Natural Resources

The DNR has the lead role among state agencies in advancing the scientific understanding of Maryland's vulnerability to climate change, and advocating for sound planning to avoid or minimize the anticipated impacts. In October 2010, the DNR issued a new policy to direct its investments in and management of land, resources, and assets so as to better understand, mitigate and adapt to climate change. The policy establishes practices and procedures related to new land investments, facility siting and design, habitat

restoration, government operations, research and monitoring, and resource planning. The goal of the policy is to lead by example; and along the way, encourage and educate others in the methods for managing natural resources and designing facilities with an understanding of the effects of climate change.

SEA LEVEL RISE AND COASTAL STORMS

The Chesapeake Bay region's geography and geology make the state one of the three most vulnerable areas of the country to changes resulting from sea level rise—only Louisiana and Southern Florida are more susceptible. Historic tide records show sea level increased approximately one foot in the Chesapeake Bay over the last 100 years. Estimates provided by the Scientific and Technical Workgroup of the Maryland Commission on Climate Change indicate that Maryland is projected to experience between 2.7 to 3.4 feet of sea level rise over the next century.

The Phase I Strategy, produced by the Maryland Commission on Climate Change's Adaptation and Response Working Group, detailed the actions necessary to protect Maryland's future economic well-being, environmental heritage, and public safety in the face of climate change and sea level rise.

In 2008, Maryland passed two pieces of key legislation called for in the Strategy: The Living Shoreline Protection Act, and amendments to the Chesapeake and Coastal Bays Critical Area Act. Both will reduce Maryland's vulnerability over time, and protect natural resources from the impacts of sea level rise by restoring natural shoreline buffers such as grasses and wetlands, helping to limit new growth in vulnerable areas. In addition to these two pieces



Flooded roads are just one impact that will occur with climate change.

of legislation, a variety of other projects designed to implement the Strategy have been completed or are currently underway.

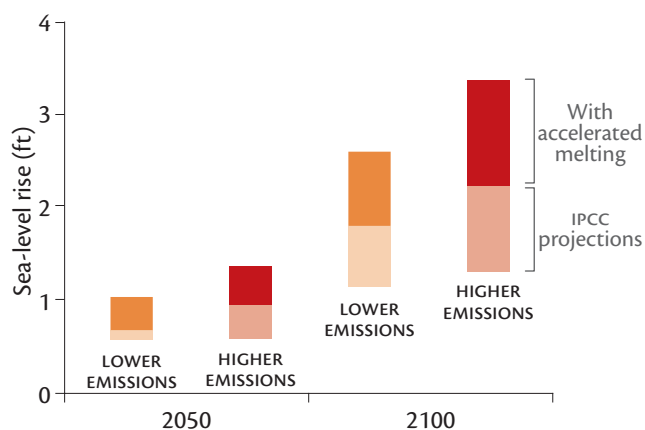
Climate Change and Coast Smart Construction Executive Order State of Maryland

On December 27, 2012, Governor O'Malley signed the Climate Change and Coast Smart Construction Executive Order, enacting a number of policy directives, including directing all State agencies to consider the risk of coastal flooding and sea level rise when they design capital budget projects and charging the Department of General Services with updating its architecture and engineering guidelines to require new and rebuilt State structures be elevated two or more feet above the 100-year base flood level.

The EO also charges the Maryland Department of Natural Resources to work with the Maryland Commission on Climate Change, local governments and other parties as appropriate, to develop additional Coast Smart guidelines within nine months, for the siting and construction of new and rebuilt State structures, as well as other infrastructure improvements such as roads, bridges, sewer and water systems, and other essential public utilities. Recommendations for applying the new construction guidelines to non-state infrastructure projects that are partially or fully funded in the State's capital budget will also be developed.

Additionally, the EO requests that the Critical Area Commission for the Chesapeake and Atlantic Coastal Bays evaluate existing regulations and policies for State Agency Actions Resulting in Development on State-Owned Lands and consider the adoption of new

Sea-level rise projections in Maryland



Sea level rise projections in Maryland under lower and higher emissions scenarios.



SEA LEVEL RISE AND COASTAL STORMS

Priority Recommendations		Lead Agency	Key Partners	Priority	Timeframe
<i>Reduce impact to existing and future growth and development</i>					
Take action now to protect human habitat and infrastructure from future risks	Require the integration of coastal erosion, coastal storm, and sea level rise adaptation and response strategies into existing state and local policies and programs.	DNR, MDP	MDE, MDOT, DHCD, local governments	high	ongoing
	Develop and implement State and local adaptation policies (i.e., protect, retreat, abandon) for vulnerable public and private sector infrastructure.	DNR	MDP, MDE, MDOT, local governments	high	ongoing
	Strengthen building codes and construction techniques for new infrastructure and buildings in vulnerable areas.	DHCD, DNR	MDP, MDOT, MDE, local governments	high	ongoing
<i>Financial and economic well-being</i>					
Minimize risks and shift to sustainable economies and investments	Develop and implement long-range plans to minimize the economic impacts of sea level rise to natural resource-based industries.	DBED	DNR	medium	long
	Establish an independent Blue Ribbon Advisory Committee to advise the State of the risks that climate change poses to the availability and affordability of insurance.	MIA	DNR	high	complete
	Recruit, foster, and promote market opportunities related to climate change adaptation and response.	DBED	DNR	low	long
<i>Protection of human health, safety, and welfare</i>					
Guarantee the safety and well-being of Maryland's citizens in times of foreseen and unforeseen risk	Strengthen coordination and management across agencies responsible for human health and safety.	DHMH	MDA, DNR,	high	ongoing
	Conduct Health Impact Assessments to evaluate the public health consequences of climate change and sea level rise-related projects and/or policies.	DHMH	MDA, MDE, DNR, MDP	high	medium
				high	medium
	Develop a coordinated plan to assure adequacy of Vector-borne Surveillance and Control Programs.	DHMH, MDA	DNR, MDE		
<i>Natural resource protection</i>					
Retain and expand forests, wetlands, and beaches to protect us from coastal flooding	Identify high priority protection areas and strategically and cost effectively direct protection and restoration actions.	DNR	MDE	high	ongoing
	Develop and implement a package of appropriate regulations, financial incentives, educational, outreach, and enforcement approaches to retain and expand forests and wetlands in areas suitable for long-term survival.	DNR	MDE	high	ongoing
	Promote and support sustainable shoreline and buffer area management practices.	DNR	MDE	high	ongoing
<i>Adaptation and response toolbox</i>					
Give State and local governments the right tools to anticipate and plan for sea level rise and climate change	Strengthen federal, state, local, and regional observation systems to improve the detection of biological, physical, and chemical responses to climate change and sea level rise.	DNR, UMD	NOAA, EPA	high	ongoing
	Update and maintain state-wide sea level rise mapping, modeling, and monitoring products.	DNR	NOAA	high	ongoing
	Utilize new and existing education, outreach, training, and capacity-building programs to disseminate information and resources related to climate change and sea level rise.	DNR, UMD	MDE, MDP	high	ongoing



SEA LEVEL RISE AND COASTAL STORMS (CONTINUED)

Priority Recommendations		Lead Agency	Key Partners	Priority	Timeframe
<i>Future steps and directions</i>					
State and local governments must commit resources and time to assure progress	Develop state-wide sea level planning guidance to advise adaptation and response planning at the local level.	DNR	MDP, local governments	high	ongoing
	Develop and implement a system of performance measures to track Maryland's success at reducing its vulnerability to climate change and sea level rise.	DNR	Other state agencies	medium	ongoing
	Pursue the development of adaptation strategies to reduce climate change vulnerability among affected sectors, including agriculture, forestry, water resources, aquatic and terrestrial ecosystems, and human health.	DNR, UMD	Other state agencies	high	complete

or revised provisions that address climate change and the risk of sea level rise and other extreme weather-related impacts.

Lastly, the EO tasks the Scientific and Technical Working Group of the Maryland Commission on Climate Change with providing updated sea level rise projections for Maryland. In 2008, the Scientific and Technical Working Group published sea level rise projections for Maryland, with a high end range of 3.4 feet by the year 2100. However, considerable new research on sea level rise has since been published requiring the updating of these projections. New sea level rise projections are required to be issued by June 28, 2013.

Local Government Technical and Financial Assistance: Coast Smart Communities Department of Natural Resources

DNR's Coast Smart Communities Initiative supports local level implementation of the adaptation strategy. Under the initiative, the DNR administers a competitive grant program to provide financial and technical assistance to local governments looking to reduce their vulnerability to the effects of coastal hazards and sea level rise through planning and permitting activities. Grants of up to \$75,000, drawn from the state's federal Coastal Zone Management Act funds, are awarded on an annual basis and may be renewed for up to three additional years. A community self-assessment tool currently in development will allow for improved targeting of grants to help address coastal hazards in the most vulnerable communities.

Adaptation Toolbox: The Coastal Atlas Department of Natural Resources

Maryland is using the latest technology, and detailed information to undertake state-of-the-art sea level rise mapping and research. Results acquired by both the DNR and individual Maryland counties is housed on the Coastal Atlas (<http://dnr.maryland.gov/ccp/coastalatlas/index.asp>), an online toolbox of resources available to assist local governments with becoming ready, adaptive, and resilient to the impacts of sea level rise and coastal storms. Data products and technical tools currently available on the Coastal Atlas include: statewide sea level rise vulnerability mapping, historic shoreline position and erosion rate calculations, a comprehensive coastal inventory, and the Erosion Vulnerability Assessment Tool. The Coastal Atlas mapping application will be continuously updated as new data becomes available or as updates to existing data are made.

Sustainable Shoreline and Buffer Area Management Department of Natural Resources

DNR is working to implement buffer reforestation, wetland restoration, and shoreline practices to enhance ecosystem resilience to the impacts of climate change. Practices include on-the-ground habitat restoration projects such as stream and shoreline buffer plantings, stream-floodplain reconnection, marsh hydrology restoration, and living shorelines. DNR Staff provide various technical assistances (site visits and evaluations, problem assessments and

recommended solutions) for different stakeholders (private citizens, local government, non-profit organizations, state and federal agencies). Assurances also include various outreach and educational programs including pamphlets and other educational materials, workshops, etc. All of these practices increase ecosystem resiliency by improving water quality, reducing erosion, and enhancing habitat condition and connectivity. Due to the fact that most living shoreline projects involve a channelward encroachment with sand fill, these shoreline restoration techniques provide space for potential marsh migration in response to sea level rise.

Climate Adaptation Initiatives Department of Transportation

The MDOT is working to assess Maryland's critical transportation facilities and systems' vulnerability to projected sea level rise and extreme weather damage. This assessment will provide the information necessary to evaluate options for dealing with potential impacts to infrastructure and connectivity, as well as aid in the development of adaptation policies for existing and planned transportation facilities. The assessment will ultimately influence long-term strategic planning for system adaptation that can account for the uncertainty of future climatic conditions.

State Highway Administration Transportation Vulnerability Assessment Department of Transportation

Among Maryland agencies, SHA has the largest and most geographically dispersed network of facilities requiring the most complex long-term action plan. SHA is studying the effects of severe weather and climate change to the infrastructure on the highway system. Initial mapping has been developed to document road closures in 2011 which include flooding (especially after storms Irene & Lee) on SHA maintained roads. This data along with inundation modeling and floodplain mapping will be incorporated into a vulnerability assessment currently in progress.

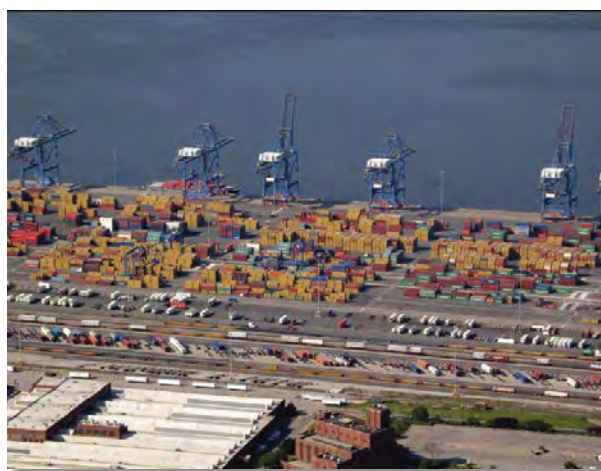
SHA with the Maryland Transportation Administration developed a climate change adaptation strategy and implementation plan to address severe weather and climate change impacts to the state maintained highway network. This plan was drafted in early 2012 and is in the process of being finalized for use when addressing the results of the vulnerability assessment. SHA will need to

assess the entire network and analyze areas locally where multiple flooding locations may be caused by the same source to determine the best solution for resolving the problem.

Port Administration Climate Change Vulnerability Assessment and Recommendations Department of Transportation

As a component of the overall Maryland Transportation Initiative described above, the Maryland Port Administration prepared the report, "Climate Change Vulnerability Assessment and Recommendations" in 2010. The report provides recommendations for future capital investments based on the findings of the vulnerability assessment. In response, the MPA developed a policy titled "Incorporating Climate Change and Sea Level Rise Information into the Public Marine Terminal and Harbor Development Process." The policy identifies the need for the MPA to make infrastructure and facility improvement decisions that consider climate change and sea level rise.

As the MPA reviews its Strategic Plan and Marine Terminal Development Plans, it plans to factor sea level rise and potential storm surge inundation into its evaluation of proposed projects. Additionally, the MPA proposes, as a participant in the Maryland Dredged Material Management and Federal Dredge Material Management Programs, to work with its partners to incorporate climate change vulnerability analysis into decision-making processes.



The Maryland Port Administration plans to factor sea level rise and other climate change impacts into proposed projects.

Historical, Archaeological, and Cultural Resources Vulnerability Study

Department of Planning, Historical Trust

Rising sea levels, erosion, and major storms pose a significant threat to historic and archaeological sites, districts, and landscapes. In 2010, the MHT completed a preliminary vulnerability assessment of historical and cultural resources in Maryland. The study was completed using inundation level data from the DNR. The results from this assessment raise awareness of this issue, which will be addressed through the PreserveMaryland planning process, and included in the forthcoming long-range historic preservation comprehensive plan.

MHT was awarded a Coastal Zone Management Grant, through DNR, to complete a pilot project focusing on the Choptank River watershed to develop a methodology for an in-depth analysis of vulnerable sites that provides details for management prioritization. In this phase, sea level rise layers and additional shoreline data from DNR and their partners were incorporated, including erosion rates and other shoreline risk data. These layers were used to construct a general model of areas within the pilot project zone which are subject to various levels of impact from coastal hazards and sea level rise. As a pilot in-depth cultural resource vulnerability analysis, MHT analyzed the recorded historic buildings and districts which are located in the pilot area impact zone. A methodology was developed to characterize each resource according to its level of recordation, extent of survey, extent and nature of potential impact, and the property's significance. This analysis will allow MHT to begin to identify and prioritize high value historic resources that are most threatened in the pilot area for documentation and/or mitigation.

Climate Change Insurance Advisory Committee

Insurance Administration

In the fall of 2008, the Maryland Insurance Commissioner convened a Climate Change Insurance Advisory Committee. The committee was charged with:

- Reviewing the adequacy of the data available to insurers to assess the risk imposed by climate change;
- Examining whether adaptive options are available to help mitigate losses and whether rating can be structured to provide an incentive for these options; and

- Reviewing ways to promote partnerships with policyholders for loss mitigation.

The committee released its final report in December 2010.

Living Shoreline Regulation Development

Department of the Environment

In 2008, the Maryland legislature enacted the Living Shoreline Protection Act. The Act requires riparian property owners to rely upon "living shorelines" defined as nonstructural shoreline stabilization measures such as marsh creation, whenever feasible, to protect shorelines from erosion while also providing critical wildlife habitat. A variety of state agencies are involved in implementing the program and related efforts.

Implementing Higher Regulatory Standards for Floodplain Management

Department of the Environment

Flood Insurance Rate Maps (FIRMs) are being updated throughout Maryland by the Federal Emergency Management Agency (FEMA). Part of this process requires communities that currently participate in the National Flood Insurance Program (NFIP) to update their local floodplain management regulations by the map effective date. At a minimum, these regulations must be consistent with federal regulatory requirements, but communities can choose to adopt higher regulatory standards. As the State Coordinating Office for the NFIP, MDE is assisting communities with this by providing a Maryland Model Floodplain Management Ordinance as a template containing higher regulatory standards such as a two-foot freeboard requirement. Freeboard can be a community tool to respond to sea level rise, and to achieve lower flood insurance premiums for property owners. Many communities are implementing these higher regulatory standards in order to gain additional points for the Community Rating System (CRS), a flood insurance discount program for communities that go beyond the minimum NFIP requirements.

Review of Current Statewide Building Codes and Recommendations for Enhancement in Coastal Regions of Maryland

Department of Housing and Community Development

As required under Section 2 of the Omnibus Coastal Property Insurance Reform Act of 2009 (Act), Chapter 540 (House Bill 1353), DHCD conducted



Many island and coastal communities in Maryland are already being affected by climate change.

reviews and prepared a report to members of the Senate Finance Committee and House Economic Matters Committee (Members) on “...enhanced building codes for coastal regions of the State that promote disaster-resistant construction in the coastal regions of the State...”. The report was delivered to Members in October, 2010. The report was also provided to planning boards of the counties in the coastal areas of the State.

In 2012, as required by Public Safety Article, 12-501- 12-507, Annotated Code of Maryland, DHCD adopted the 2012 International Building Code (IBC), the 2012 International Residential Code (IRC) and the 2012 International Energy Conservation Code (IECC) under the Maryland Building Performance Standards on January 1, 2012. DHCD adopted the 2012 International Green Construction Code (IgCC) as part of the Maryland Building Performance Standards.

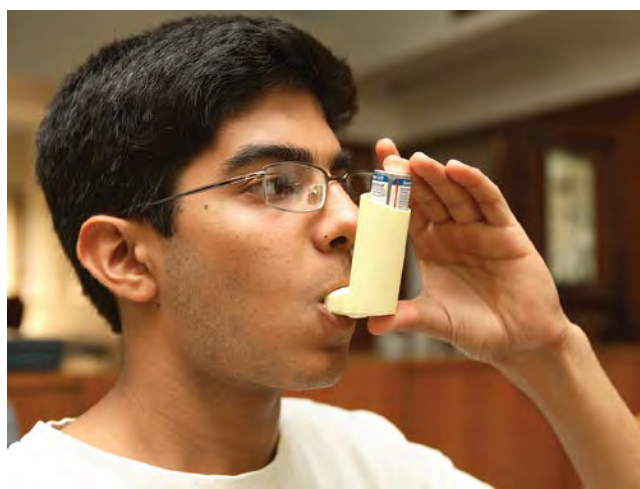
State Hazard Mitigation Plan Emergency Management Agency

Maryland’s 2011 State Hazard Mitigation Plan was approved by Governor Martin O’Malley in September 2011. Vulnerability to climate change, coastal hazards and sea level rise issues was evaluated as part of the State risk assessment and specific adaptation strategies were included in the overall mitigation plan. Future iterations of the State Hazard Mitigation Plan are expected to include risks associated with non-coastal impacts of climate change as prioritized in the mitigation plan.

HUMAN HEALTH

Climate change poses serious health risks to people in Maryland, including heat-related stress and cardiovascular mortality and morbidity, respiratory illness, altered infectious disease patterns (both vector-borne and water-borne diseases), impacts to water supply and quality, and direct or mental harm from extreme storm events and flooding. There is a need to manage these preventable impacts, particularly in a system that historically has been able to adapt to and reduce the vulnerability of health risks. But without appropriate action, highly preventable mortality and health complications that are influenced by climate are likely to increase.

Climate change represents an overlying stressor that changes the environmental context of health, and disproportionately affects certain populations and communities. Many of these health issues will result from interactions between climate change, ecological changes, and the characteristics of existing infrastructure (e.g., lack of shade or air conditioning; old or unsuitable water supply and treatment facilities). Other impacts to nutrition and mental health may occur, though these are less certain, and include increased food-borne illness or psychological effects from extreme events. Harmful algal blooms and water-borne diseases also may affect the health of Maryland’s citizens. The vulnerability of Maryland’s citizens to climate risks is shaped by the degree to which they are exposed to these influences and also by a number of factors affecting their sensitivity and adaptive capacity.



Individuals vulnerable to respiratory illness may be at an increased risk in Maryland’s future climate.



HUMAN HEALTH

	Priority Recommendations	Lead Agency	Key Partners	Priority	Timeframe
Conduct vulnerability assessments to gain a better understanding of risk and inform preventative measures.	Assess potential health threats and the sufficiency of Maryland's response capacity.	DHMH	MEMA	TBD	TBD
	Evaluate impacts to food safety and availability.	DHMH	MDA	medium	medium-term
	Assess the vulnerability of Maryland's populations and communities to changing health threats.	DHMH	MDP, MDE	medium	long-term
	Identify potential barriers to effective emergency response.	DHMH	MEMA	high	medium-term
Integrate impact reduction strategies into State and local planning practices.	Improve response capacity through the development of new or expanded programs.	DHMH	MEMA	medium	long-term
	Address climate-related health risks in hazard mitigation and emergency response plans.	DHMH	MEMA	medium	TBD
	Support community engagement in planning and emergency response decisions.	DHMH	MEMA	medium	long-term
	Pursue opportunities to enhance protection of Maryland's "green infrastructure".	DNR	DHMH, MDP	TBD	TBD
Streamline and revise data collection and information dissemination channels.	Improve the resolution and availability of health and population data.	DHMH	UMD, MDP, CDC, EPA	high	ongoing
	Analyze health and population data along with other spatially explicit information (e.g., land use, air quality, water quality).	DHMH	DNR, MDP, MDE, EPA, CDC	high	ongoing

State Climate Change Environmental Capacity Building

Department of Health and Mental Hygiene

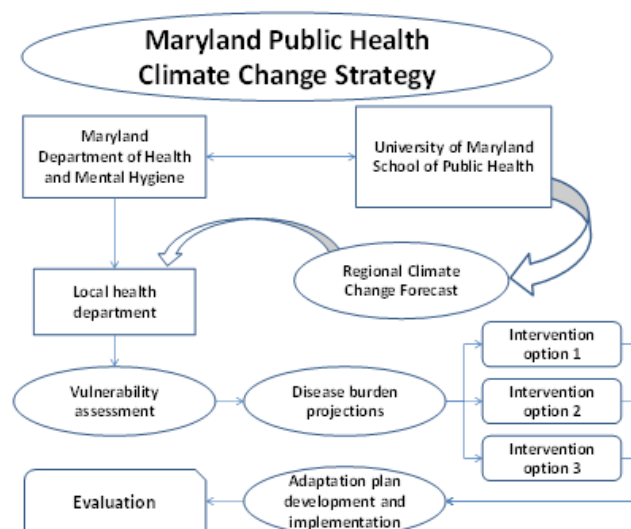
To ensure that risks, costs, and benefits are evaluated in a systematic manner, Maryland successfully competed for and was awarded a 2012 capacity building grant from the U.S. Centers for Disease Control and Prevention (CDC), "Maryland Public Health Strategy for Climate Change." The four-year award will enable DHMH to address identified needs in the following areas: (1) epidemiological capacity in injuries/disasters and vector-borne disease; (2) short, intermediate, and long-term climate change modeling and integration capacity; (3) training in health impact assessment (HIA); and integration of information management tools related to disasters with routine DHMH functions.

Enhanced Environmental Public Health Tracking infrastructure

Department of Health and Mental Hygiene

A combined effort is needed in order to minimize the public health risks of climate change. Through continued coordination between the DHMH and other state agencies, preemptive measures can be

taken to both prevent and minimize the impact of climate change on public health. In 2002, the DHMH received Center for Disease Control funding to plan for a statewide Environmental Public Health Tracking Network that will be part of the national tracking network. Maryland used the funding to build



Overall framework of proposed Maryland project on public health and climate change.

capacity and enhance infrastructure. The results range from starting or improving surveillance to enabling faster responses to environmental public health questions and faster action to prevent disease. These enhancements will be achieved through the CDC project on capacity building, integrating them with the environmental public health tracking project.

Development of Climate Health Indicators Department of Health and Mental Hygiene

The DHMH is working with the Commission on Environmental Justice and Sustainable Communities, the MDE, and the MDP on the introduction of health indicators that could be used by the MDP and other agencies to evaluate the potential impacts of climate change adaptation or mitigation strategies, as well as the potential health consequences of projects related to adaptation to sea level rise. The DHMH has strengthened its coordination with the DNR and the MDE related to monitoring and reporting of Chesapeake Bay-related health concerns, specifically with respect to harmful algal blooms.

State Heat Plan

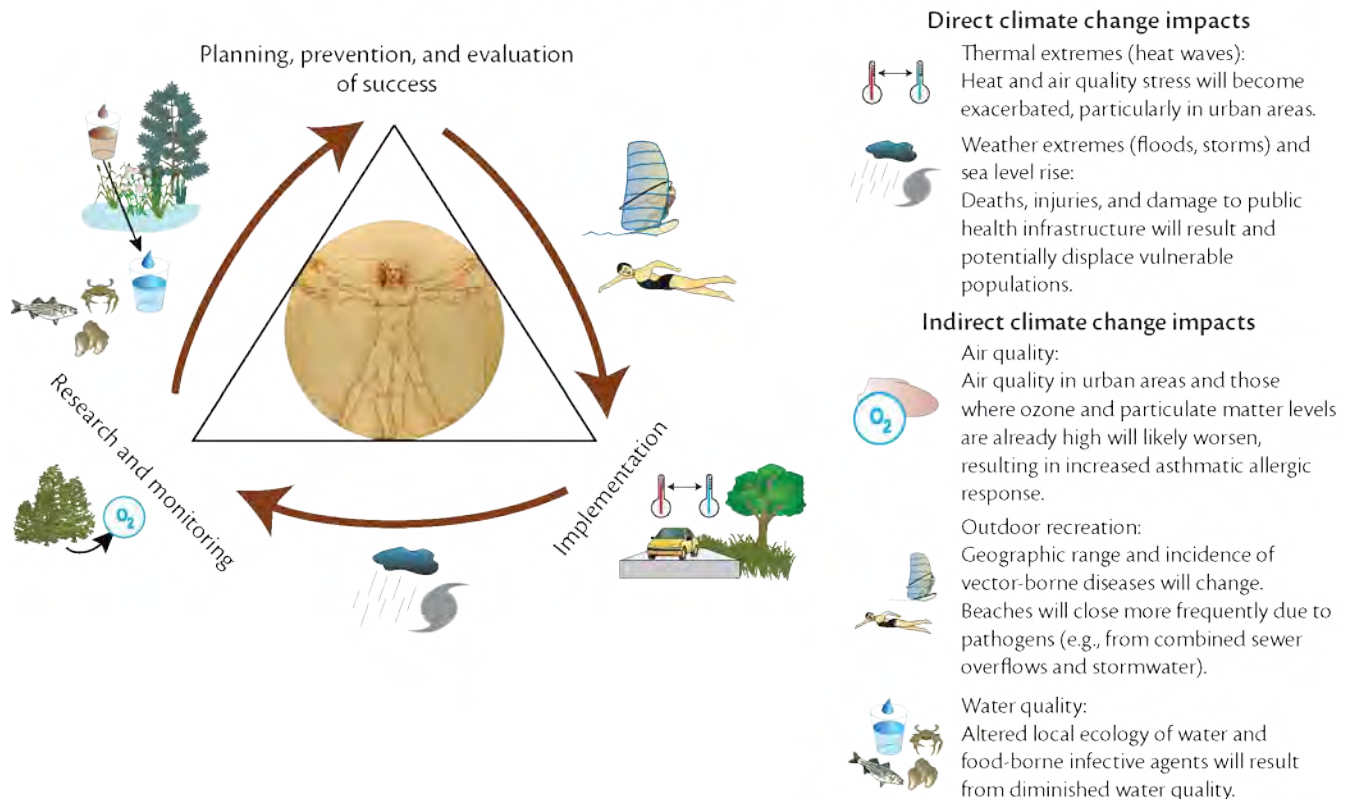
Department of Health and Mental Hygiene

In May, 2012, DHMH released the Maryland State Heat Emergency Plan which guides state actions during an Extreme Heat Event: a weather condition with excessive heat and/or humidity that has the potential to cause heat-related illnesses. An Extreme Heat Event is defined as a day or series of days when:

- The heat index is forecasted to be approximately 105 degrees or higher, or;
- The National Weather Service has issued a Heat Advisory, or;
- Weather or environmental conditions are such that a high incidence of heat-related illnesses can reasonably be expected.

DHMH has also activated the State Heat Emergency web site (<http://dhmh.maryland.gov/extremeheat>) which includes links to the State Heat Plan, Facts about Heat Related Illness, and weekly Heat Reports that provide guidance and information about deaths and illness caused by extreme heat in the region.

Climate impacts affecting human health



Climate change is likely to impact many of the current environmental influences on human health, by directly raising temperatures or increasing the frequency of extreme events. Indirectly, climate change will likely exacerbate existing stressors such as reduced air and water quality, and vector-prone and infectious diseases.

AGRICULTURE

Agriculture is the largest commercial industry in Maryland, employing about 350,000 people, primarily in the north-central and Eastern Shore regions. Farms occupy about two million acres, or about one-third of the State's land, though individually the farms are, on average, much smaller than those in other states. Maryland's agriculture is diverse, including nursery plants, dairy products, beef cattle, vegetables, wheat, horses, and fruit. Poultry, fed by largely locally produced corn and soybeans, maintains the largest market value. Projected increases in temperature, precipitation variability, and frequency of extreme events associated with climate change are likely to affect the conditions upon which farming has been established. Many of the stressors farms already face are likely to intensify or become less predictable: drought frequency, winter flooding, pests and disease, and ozone levels. These changes occur in the current context of the high economic uncertainty and small profit margins, and are likely to result in increased costs to both farmers and consumers.

To adapt to a changing climate, farmers will require guidance on climate smart crop species and strategies to reduce poultry and livestock loss and stress associated with heat. More intense water management will be needed to offset the impacts of growth



Agricultural irrigation on a farm on the Eastern Shore. Irrigation usage and costs will likely change with precipitation variability.

and uncertainty in water supplies on agricultural production and water resources.

It is the broad goal of these strategies to help reduce stress on agricultural operations and to build the resilience of Maryland farms, despite changes they may face in the future, and to improve the quality of the Chesapeake Bay and its watershed. As climate change may affect the intensity of how farmers manage, alter effectiveness of agricultural BMPs, and



AGRICULTURE

	Priority Recommendations	Lead Agency	Key Partners	Priority	Timeframe
Increase crop diversity, protect against pests and disease, and intensify water management.	Promote diversification of crop species and varieties.	MDA	UMD-Extension, local agricultural producers	low	ongoing
	Intensify water management and conservation through research, funding, and incentives.	MDA	UMD-Extension, MDE, DNR, USDA, EPA, Bay Trust	high	ongoing
	Protect against incoming pests, weeds, and disease.	MDA	UMD-Extension	low	ongoing
	Support innovative solutions that foster adaptation and also reduce energy costs and carbon footprints.	MDA	UMD-Extension, MEA	medium	ongoing
Strengthen applied research, risk communication, and technical support	Enhance dissemination channels to improve the relay of climate information.	MDA	UMD-Extension, SCDs, NRCS, NGOs, commodity orgs	low	ongoing
	Identify opportunities to support the transition of farm and agricultural practices.	MDA	UME, NRCS, Farm Credit, insurance industry	low	long-term
	Enhance emergency response and risk management.	MDA	UME, Farm Credit, insurance industry	low	ongoing
Enhance existing best management practices and land conservation targets.	Evaluate the effectiveness of BMPs under future climate change scenarios.	MDA	UMD, DNR, MDE	low	ongoing
	Assess and revise targets for agricultural land preservation.	MDA	local and regional land trusts	low	ongoing

affect the implementation of relevant regulations, farmers need to be prepared and supported for adjustments that may be required.

Invasive Plants Advisory Committee **Department of Agriculture**

Signed by the Governor on April 12, 2011, invasive plant bill HB 831 provided a mechanism to reduce the negative impacts of an increase in invasive species expected to occur as a result of changes in temperature and rainfall patterns. The bill established the Invasive Plants Advisory Committee in the Department of Agriculture and mandated that in its first year of activity, the IPAC would advise the Secretary of Agriculture in adopting a comprehensive, science-based risk assessment protocol to assess the invasive risk of selected plants. IPAC submitted regulations to the Secretary, which will become effective January 21 2013, adopting the USDA APHIS Weed Risk Assessment tool. The WRA tool documents the economic, ecological, and health impacts of invasive species and aims to identify their

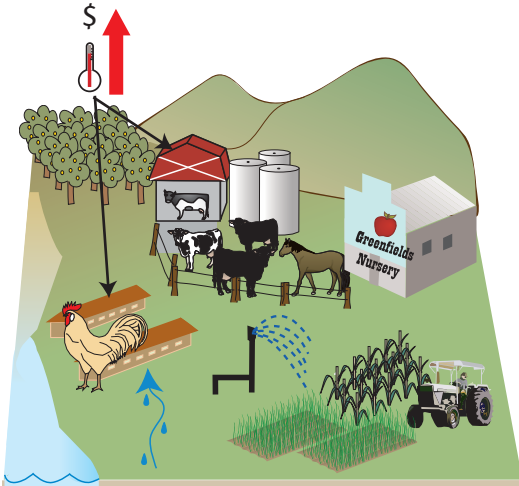
character and potential for damage. It will support IPAC's designation of assessed species as Tier 1 (banned) and Tier 2 (still marketable but with specific caveats and signage) plants. IPAC is seeking funding to support the work of assessing more than 200 invasive and potentially invasive plants. Publication of an initial list of 30 assessments and Tier designations is anticipated in the fall of 2013.

Vector-borne disease surveillance and control

Department of Health and Mental Hygiene/ Department of Natural Resources/ Department of Agriculture

Maryland State officials continue to track the spread of WNV and other arboviral activity in the State in vector species, host animals, and humans. This allows for ongoing enhancement and deployment of effective tools to support surveillance, prevention, and control of West Nile virus and other arthropod-borne viruses, including novel or emerging pathogens that threaten the health of Maryland residents. In addition, the

Major Maryland Agriculture Products, Likely Climate Impacts, and Adaptation Strategies

	Product (ranked by 2007 market value, USDA Census)	Climate impact	Adaptation strategy
 <p>Impacts</p> <ul style="list-style-type: none"> Heat affecting animal production, resulting in increased cooling/energy cost Drier soils due to lengthened summer drought Increased need for irrigation 	Poultry	Increased cooling costs; decreased production; changing disease presence	Improve energy efficiency of housing; bioenergy use; improve ability to monitor disease and quarantine
	Grains, oilseeds, dry beans, peas	Water stress: increased irrigation use; winter flooding; changes in crop yield quantity and quality	Diversify cultivar and crop types; improve water management systems; improve pest forecasting
	Nursery, greenhouse, floriculture, sod	Increased cooling costs; water stress	Establish emergency response systems; improve energy efficiency of housing
	Milk and dairy	Decreased milk productivity; changing disease presence; low-quality pasture during drought	Increase shade and cooling; improve ability to monitor disease and quarantine; manage pastures for drought
	Cattle and calves	Changing disease presence; heat stress; low-quality pasture during drought	Increase shade and cooling; improve ability to monitor disease and quarantine; manage pastures for drought; farm heat-tolerant breeds
	Vegetables, melons, potatoes, other crops, hay	Water stress: increased irrigation use; winter flooding; changes in crop yield quantity and quality	Diversify cultivar and crop types; improve water management systems; improve pest forecasting
	Horses, ponies, mules, burros, donkeys	Heat stress; low-quality pasture during drought	Increase shade and cooling; manage pastures for drought education about heat stress
	Fruit trees, nuts, berries	Water stress: increased irrigation use; increased pest damage	Diversify cultivar and crop types; improve water management systems; improve pest forecasting

Mid-Atlantic Zoonotic and Vector Borne Disease Inter-Agency Workgroup (MAZV), a collaboration between DHMH, DNR, MDA, and researchers, practitioners, and federal agency partners meets regularly to monitor and discuss vector borne disease activities in Maryland and the surrounding regions.

FORESTS AND TERRESTRIAL ECOSYSTEMS

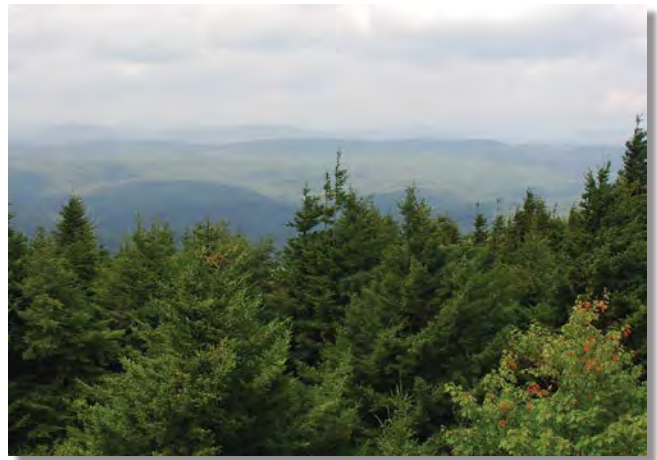
The diversity of Maryland's forests and terrestrial ecosystems reflects the wide variety of environmental conditions found across the State's five major physiographic provinces. Not only do forested systems regulate climate and sequester carbon, but they play a major role in any adaptation plan to reduce the impacts of urban heat, enhance migration corridors, mitigate flooding, protect drinking water supplies, and reduce nutrient and sediment runoff. From the mountains to the sea, one can hike through western Maryland's thick groves of hemlock lining deep gorges, across grassy serpentine barrens supporting the unique purple-flowered fringed gentian, by vernal pools inhabited by salamanders, and through the pine forests and hardwood swamps of the Eastern Shore. The State's forests are mostly privately owned and only 27% are permanently protected from development. These habitats and their plant and animal communities are shaped mainly by geology, climate, and interactions with other species. They also are subject to many existing stressors such as development, pests, and pollution, limiting their capacity to adapt.

Forests and terrestrial ecosystems contribute an estimated \$2.2 billion to Maryland's economy and \$24 billion in ecological services. The condition of these ecosystems and the services they provide is likely to be altered by climate change. Climate change will alter distributions of species and habitats and exacerbate existing stressors at an uncertain rate and degree. Native species populations may decline, increase, or migrate from the State while new species may migrate in due to habitat shifts. Services provided by forests such as temperature regulation, water filtration, aesthetic value, and habitat may be altered. Existing stressors on species and habitats may be exacerbated by climate change.

GreenPrint Update

Department of Natural Resources

Maryland's GreenPrint initiative identifies the most ecologically valuable areas in the State and designates these lands and waters as "Targeted Ecological Areas



Current high-elevation forest species such as these red spruce, or the Eastern hemlock, will likely disappear from Maryland as climate changes.

(TEAs)". TEAs are the "best of the best" natural resources across the State. TEAs were first defined in 2008 and included the most ecologically important large blocks of forests and wetlands; wildlife and rare species habitats; aquatic biodiversity areas; and forests for protecting water quality. In 2011, DNR updated the TEA designations to include coastal ecosystems; habitats for climate change adaptation and marsh migration, and areas for supporting commercial and recreational fisheries. Together, these areas are identified as conservation priorities for natural resources protection. DNR is now using these updated conservation priorities to target Stateside Program Open Space land conservation projects.

Wildlife Vulnerability Assessment **Department of Natural Resources**

The DNR has conducted a vulnerability assessment of GCN species using Nature Serve's Climate Change Vulnerability Index. The DNR is also participating in an expert panel effort in the northeast headed by the Manomet Center for Conservation Science to assess the likely impacts of climate change on northeastern fish and wildlife habitats and species of greatest conservation need. All of this information is planned for incorporation into the next version of the Maryland's State Wildlife Action Plan.

Forest Management Plans **Department of Natural Resources**

In 2011, DNR's Forest Service included climate change and adaptation information as a required element in forest management plans. These plans are required



FORESTS AND TERRESTRIAL ECOSYSTEMS

	Priority Recommendations	Lead Agency	Key Partners	Priority	Timeframe
Expand land protection and restoration and revise targeting priorities.	Integrate climate data and models into existing resource assessments and spatial planning frameworks.	DNR	EPA, CBP, USDOJ, USFWS, NGOs, NASA, NOAA	high	medium-term
	Incorporate climate change adaptation strategies into State resource management plans.	DNR	MDP, EPA, CBP, USDOJ, USFWS, NOAA, USFS, NGOs	high	medium-term
	Collaborate with federal partners to support regional and national adaptation planning.	DNR	EPA, CBP, USDOJ, USFWS, NOAA, USFS, NGOs	medium	medium-term
	Update existing land protection targeting programs and project evaluation protocols.	DNR	EPA, CBP, USDOJ, USFWS, NOAA, USFS, NGOs	high	ongoing
	Develop climate change adaptation guidance and technical tools suitable for local government planning.	DNR	MDP, UMD-Extension	high	ongoing
Adjust management practices and reduce existing stressors.	Strengthen State and local programs to slow the loss and fragmentation of forest and terrestrial ecosystems to new development.	DNR	MDP, MDE, MDOT, USFWS, USFS, EPA, CBP, NGOs	high	ongoing
	Review and revise forestry best management practices.	DNR	UMD-Extension	medium	medium-term
	Continue to support incorporation of the policies and strategies of Maryland's Sustainable Forestry Act of 2009 into State and local planning decisions.	DNR	State Forest Conservancy District Boards	high	ongoing
	Evaluate sustainable forestry certification programs for opportunities to enhance climate resilience.	DNR	Sustainable Forestry Initiative, Forestry Boards, Forest Stewardship Councils	medium	medium-term
	Improve capacity to manage and respond to stressors exacerbated by climate change.	DNR	MDA, MD Invasive Species Council, Forest Health Emergency Contingency Program	medium	short-term
Foster stewardship on private lands.	Develop new tools to guide adaptation stewardship activities on private lands.	DNR	Forest Stewardship Councils, UMD Extension	high	short-term
	Incorporate adaptation concerns into existing programs.	DNR	USFS, Forest Stewardship Councils, UMD Extension	high	short-term
	Develop new conservation easement mechanisms to promote adaptation stewardship activities on private lands.	DNR	USFS, Forest Stewardship Councils, UMD-Extension, MDA	high	ongoing

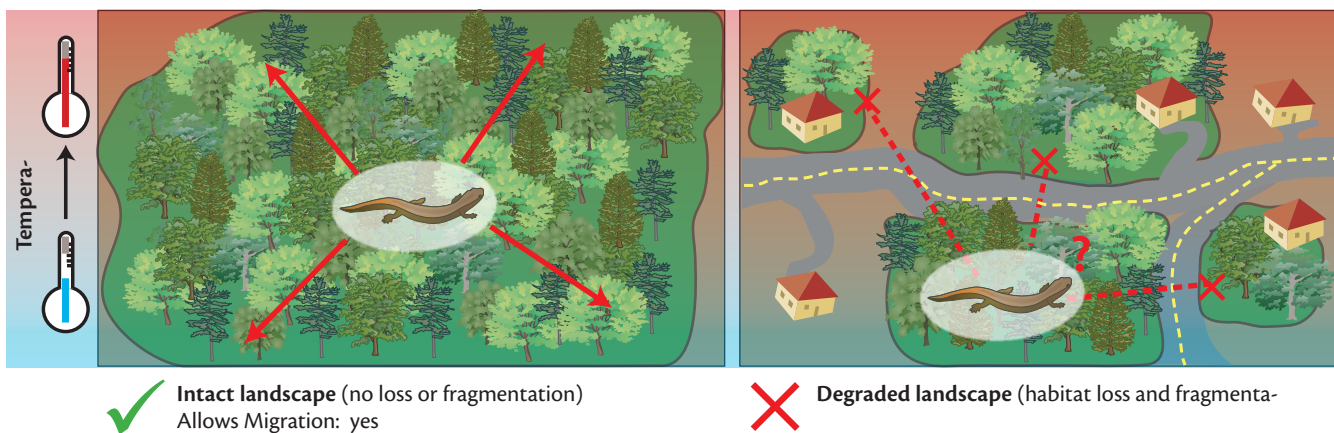
by any forest landowner who participates in State property tax abatement programs or USDA forestry programs and thus will reach a wide audience.

Forest Resource Assessment and Strategy Department of Natural Resources

The DNR Forest Service has incorporated climate change into their 2010 Forest Resource Assessments as an additional stressor. Climate change was also identified as one of the top five areas for action in their five year strategy. As part of this, the Forest Service is working with other local, state, and federal agencies to incorporate adaptation into existing forestry programs.

Urban Tree Canopy Assessment Department of Natural Resources

DNR is currently working to maintain and improve the health and longevity of trees in urban areas and increase the urban tree canopy cover throughout Maryland. Urban trees shield buildings from cold winds, lower ambient summertime temperatures, reduce heating and cooling costs, decrease the demand for energy production and reduce vulnerability to the effects of heat waves on at risk populations. Reduced heat slows the formation of ground level ozone as well as the evaporation of fuel from motor vehicles. Thirty-seven communities in



Fragmentation and habitat degradation interact with climate change by limiting species' ability to retreat or find refuge from rising temperatures or extreme events.

Maryland have committed to participation in the UTC Goal effort to date. Baltimore City, Annapolis, and the Frederick County Board of Education have already adopted goals; the other communities are in the process of assessing their existing and potential UTC. Communities like Baltimore City have also begun to prioritize plantings for urban heat reduction and water quality improvement.

BAY AND AQUATIC ECOSYSTEMS

The Chesapeake Bay is the largest estuary in the United States, fed by a watershed that stretches from mountains to sea, across 64,000 square miles (166,000 square kilometers), spanning six states—Maryland, Delaware, Virginia, West Virginia, Pennsylvania, New York, and the District of Columbia. Within its watersheds and oceanfront, Maryland's extensive aquatic ecosystems range from freshwater swamps and bogs, tidal and non-tidal freshwater rivers and marshes, tidal brackish and saline rivers and marshes, and coastal bays. These ecosystems are influenced by precipitation, temperature, tropical storms, and human activity. Currently, the services provided by the Bay are estimated to be approximately \$1 trillion, annually. However, human development and pollution have degraded their natural resilience, leaving them more vulnerable to extreme events. Climate change will likely exacerbate this problem, creating a greater threat to these ecosystems. The Bay has already warmed by 3 degrees Fahrenheit since the 1930s, and additional temperature increases could change the composition of commercial fisheries and increase anoxia in the Bay. To protect its marine, estuarine and aquatic ecosystems against future damage, the

action is needed to alleviate existing stressors and to strategically conserve and restore critical bay and aquatic habitats.

Climate Change Criteria for Conservation Department of Natural Resources

The DNR recently completed a project, "Coastal Land Conservation in Maryland: Targeting Tools and Techniques for Sea Level Rise Adaptation and Response." The purpose of the project was to develop new conservation criteria to identify coastal habitats that may help Maryland proactively adapt to sea level rise and increased storm events associated with climate change. Climate change targeting criteria resulting from this project was used to develop new conservation areas for "GreenPrint" and a parcel-level scorecard used to review land acquisition projects. Trainings have been held with state land managers and conservation planners to share the new tools and datasets, and to implement them into current land conservation targeting and review processes.

Temperature Sensitive Stream Regulations Department of Natural Resources

In 2011, the DNR and the MDE collaborated to create an update to Use Class III (naturally-reproducing trout) streams. Future coldwater protections are being assessed for contributing watersheds to these streams and for the protection of streams that harbor coldwater dependent invertebrate species. Future models may address those streams that will be most sensitive to climate change and those that will remain coldwater systems.



BAY AND AQUATIC ECOSYSTEMS

	Priority Recommendations	Lead Agency	Key Partners	Priority	Timeframe
Advance protection of at-risk species and habitats.	Revise state-level protection targeting programs to reflect climate change adaptation priorities.	DNR	UMD, USACE, USGS, USFWS, NOAA, NGOs	high	ongoing
	Develop new protection and conservation mechanisms to promote adaptation stewardship activities on private lands.	DNR	UMD, USACE, USGS, USDOJ, USFWS, NOAA, NGOs	medium	medium-term
	Amend legal mechanisms to designate and protect temperature-sensitive streams.	DNR	MDE, EPA	high	ongoing
	Implement an adaptive management approach.	DNR	MDE, MDOT, MDA, MDP, federal partners, NGOs	high	medium-term
Restore critical bay and aquatic habitats to enhance resilience.	Proactively pursue, design, and construct habitat restoration projects to enhance the resilience of bay and aquatic ecosystems.	DNR	USACE, USGS, USFWS, NOAA, EPA, CBP, NGOs	high	long-term
	Conduct an audit of state-owned lands to identify habitat restoration potential for enhancing ecosystem resilience and increasing on-site carbon sequestration.	DNR		medium	short-term
	Increase on-the-ground implementation of existing stream restoration practices.	DNR	USGS, EPA, CBP, USFWS	high	short-term
Reduce existing stressors.	Remove barriers to habitat connectivity.	DNR	MDE, USFWS, NOAA	high	ongoing
	Reduce impervious surface cover.	DNR, MDE	MDP	high	ongoing
	Prepare for new or expanding ranges of invasive species.	DNR	MDA, MD Invasive Species Council, USFWS	high	ongoing
Foster a collective response to climate change.	Adjust bay and watershed restoration priorities in light of a changing climate.	DNR	MDE, UMD, NOAA, USGS, EPA, Penn State, USFWS	medium	ongoing in Coastal Plain
	Integrate both adaptation and mitigation reduction strategies into natural resource management plans and programs.	DNR	USFWS, NOAA, NGOs	high	short-term
	Revise fishery and wildlife management to build climate resilient safeguards.	DNR	USFWS, NOAA, NGOs	high	long-term
	Increase collaboration among federal, state, regional, and local climate change adaptation partners.	DNR	UMD, NOAA, USGS, EPA, NGOs	high	short-term

Guidelines and mapping for vulnerable systems

Department of Natural Resources

The DNR has identified ephemeral and intermittent freshwater habitats that are highly sensitive to changes in precipitation regimes and ultimately climate change. These habitats include ephemeral, intermittent, and headwater stream systems and vernal pools. Headwater streams support rare and endangered species, serve as migratory corridors, and process and store proportionally larger amounts of nutrients and sediment than larger streams. Mechanisms are now being explored to increase mapping of these systems, to develop model



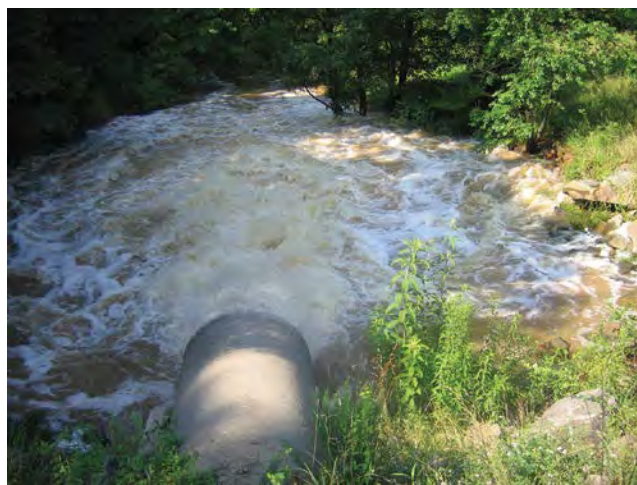
Tidal marshes are likely to need additional protection measures due to blockages that prevent their ability to migrate upland as sea level rises.

ordinances, and develop model field protocol for their identification and protection by local governments and organizations.

WATER RESOURCES

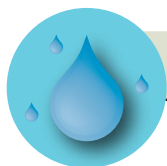
Generally, Maryland citizens are blessed with an abundant supply of water. However, many water systems are already stressed during droughts, and infrastructure damage and water contamination occurs during floods. Future population growth will combine with more uncertain weather patterns to place more communities at risk of property damage, regulatory liabilities, and uncertain access to drinking water. For example, the eastern shore is particularly susceptible to salt water intrusion as demand increases and sea level rise, while the growing population in central and western Maryland stresses aquifers with inherently short-term storage capacities and risk of contamination.

In the past 30 years, Maryland's climate has become wetter and hotter, resulting in more runoff and longer heat waves. The state is currently experiencing higher precipitation in September and January. With a changing climate, Marylanders should expect more



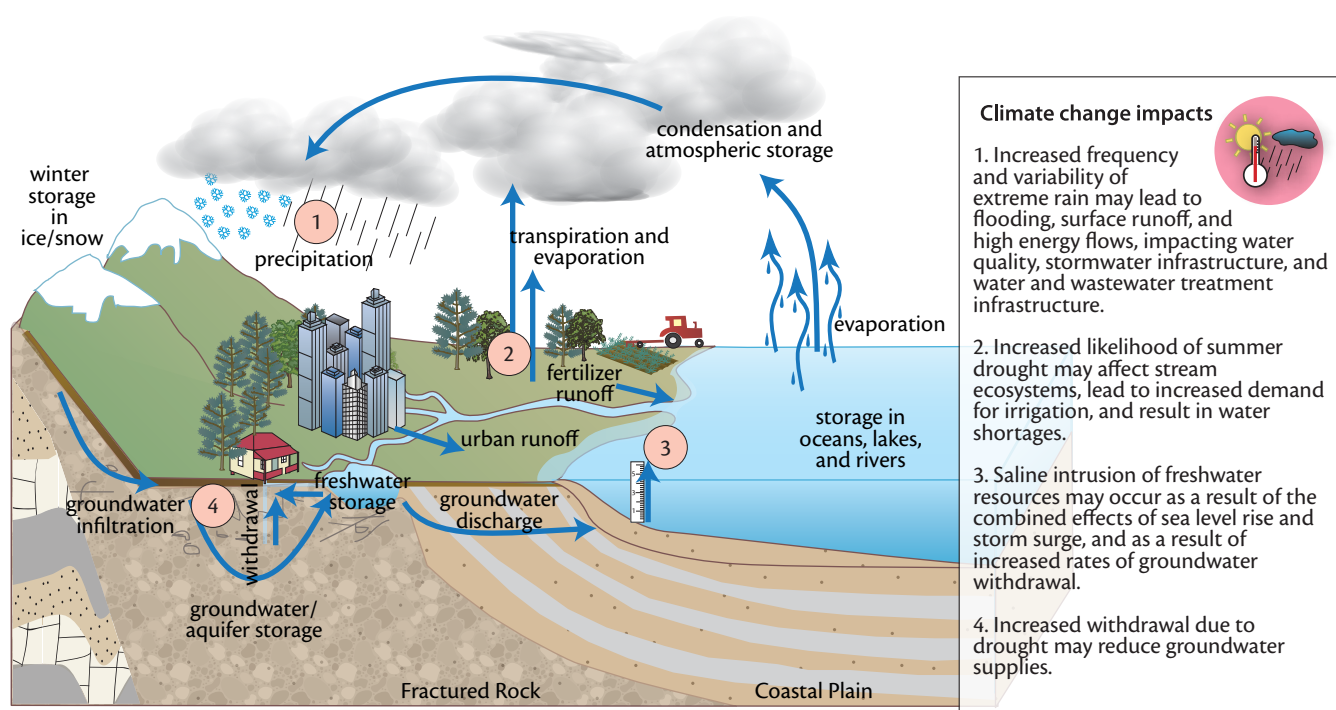
Water resources include the supply of water as well as the infrastructure to support it.

rain in the winter and spring and less in the summer, and more frequent and intense storm events. This will result in more frequent flooding and more numerous droughts. Current projections indicate that flooding will increase: 100-year floods will increase by 10-20 % and 10-year storms will increase by 16-30%. There



WATER RESOURCES

	Priority Recommendations	Lead Agency	Key Partners	Priority	Timeframe
Ensure long-term safe and adequate water supply for humans and ecosystems.	Adopt and fund the recommendations of the 2008 "Wolman Committee" report.	MDE	DNR, MDP, local governments, federal partners	high	ongoing
	Manage water through the lens of future climate and population.	MDE	MDP, DNR, local governments	high	ongoing
	Enhance planning and coordination within the water resource community.	MDE	MDP, local governments	high	long-term
	Encourage water suppliers to evaluate and improve their resilience.	MDE	water utilities, local governments, MEMA, EPA	high	long-term
	Promote demand management and water conservation practices.	MDE	local governments, MDA, business community	medium	ongoing
	Assess, target, and protect high quality water recharge areas.	MDE	DNR, MDP	medium	long-term
Reduce the impacts of flooding and stormwater.	Encourage the removal of vulnerable or high-hazard water supply and treatment infrastructure.	MDE	water utilities, local governments	low	long-term
	Prevent inundation and overflow of on-site disposal systems.	MDE	local governments	medium	long-term
	Revise Clean Water Revolving Fund criteria.	MDE		low	short-term
	Invest in an improved understanding and communication of flood probabilities and hazards.	MDE	DNR	medium	long-term



Climate change will likely affect the drivers of the water cycle and exacerbate some water quality impacts. Issues caused by urbanization in streams will be exacerbated.

is a greater likelihood that more powerful rain and windstorms will strike Maryland as ocean waters warm, accompanied by higher storm surges and rainfall.

Coastal Plain and Fractured Rock Studies Department of the Environment

The MDE has two long-term water supply studies that are conducted with the assistance of the Maryland Geological Survey, the U.S. Geological Survey, and the Department of Natural Resources Monitoring and Non-Tidal Assessment Division. The Coastal Plain and Fractured Rock studies were initiated in 2006 and 2009, respectively. These studies will develop information and tools to help the MDE make sound science-based decisions about water allocations, ensure ongoing sustainability of the resource, and evaluate the potential impacts of withdrawals on aquatic habitat. In addition, the studies will provide valuable information to assist local governments as they plan for future growth and water use needs.

The Coastal Plain study involves a complex aquifer model, which will be capable of modeling various management scenarios as well as potential impacts of climate change. The MDE is already using two important tools developed as part of these studies known as the Coastal Plain and Fractured Rock Aquifer Information Systems. These geographically-referenced tools provide MDE's permit project

managers with up-to-date and easily accessible data, including geophysical logs, aquifer test information, water levels, well locations, and selected water quality data. Funding to continue the studies beyond SFY 2012 has not been identified to date.

Source water protection measures Department of the Environment

The MDE has delineated areas around each public water supply well or intake where measures should be taken to protect the water supplies from water quality impacts. More than three hundred communities around the State have adopted land use ordinances or other measures to protect their water sources. In 2011, MDE contracted with two private consultants to assist twenty vulnerable groundwater communities to assist them in developing and implementing protection measures. This project will be complete in 2013.

Tools for water utilities Department of the Environment

The MDE has produced a publication for public drinking water systems that provides the systems with information about the possible impacts of climate change on utilities and recommends a variety of adaptation measures to help water systems prepare for and/or avoid these impacts. The publication has been distributed by mail to all community water systems in the State.

Environmental Site Design Department of the Environment

Current Maryland law and regulations require that Environmental Site Design (ESD) be used to the maximum extent practicable (MEP) to control stormwater from new and redevelopment. The goal is that ESD planning techniques and practices are to be implemented to replicate runoff characteristics similar to “woods in good condition.” These practices reduce runoff and improve water quality and ultimately help buffer communities from the impacts of climate change.

POPULATION GROWTH AND INFRASTRUCTURE

Maryland’s growing population lives and works primarily in a built environment and is reliant on transportation, water, and communication and energy networks, spanning a wide range of landscapes, from cooler Appalachian Mountains in the west, to low-lying areas of the Eastern Shore. These systems, regulated in part at the state level, but more directly influenced by local decision-making, are subject to pressures of shifting population and to often unreliable sources of funding to address needed maintenance, planning, and upgrades. The projected effects of climate change, including increases in precipitation variability and extremes, winter precipitation and temperature, are likely to affect the frequency, severity and timing of many existing problems, such as stormwater, or buckling of roads and malfunctioning train systems due to heat waves. Historical and current climate conditions will no longer be adequate to guide planning, design, operation and maintenance decisions.

For sustainable development, planning efforts must reflect and address projections for both population growth and the effects of climate change. Many areas in Maryland are expected to experience increased growth and development. Decisions about growth need to factor in climate impact projections. Temperature and precipitation extremes will likely harm infrastructure and affect human health. Increases in precipitation and the intensity of storm events will likely exacerbate existing problems, particularly in urban areas. Problems associated with stormwater, flooding, heat stress and air quality will likely worsen. Building codes, infrastructure design, emergency management and planned development should be oriented to reduce impacts caused by increased climate variability and extremes. Maryland’s built environment needs to be reinforced

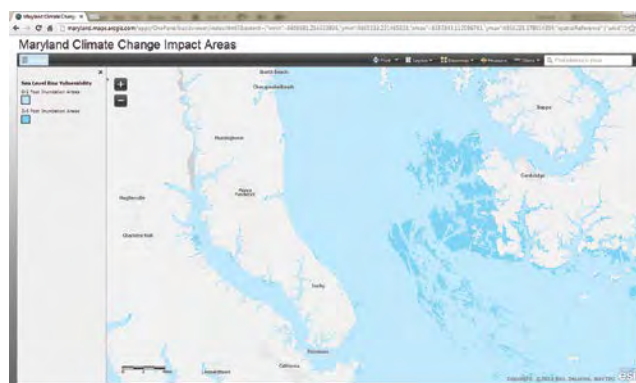


Maryland’s growing population is reliant on transportation and other services.

to prepare for new temperature and precipitation regimes. Over time, changes to the system including the operation, maintenance, design and management of much of the State’s built infrastructure may become necessary.

State Development Plan: PlanMaryland Department of Planning

Governor Martin O’Malley on Dec. 19, 2011 accepted “PlanMaryland,” the State’s first long-range plan for sustainable growth, from Secretary Richard E. Hall of the Maryland Department of Planning, achieving a vision first laid out by the General Assembly a half-century ago. The Governor also filed an Executive Order to provide an overview of the process for implementation of the plan. Climate Change Impact Areas were identified as one of Plan Maryland’s Areas of Special Designation. Climate Change Impact Areas include: projected 50- and 100-year Sea Level Rise Inundation Zones, 50-Year Erosion Vulnerable Zones, Category 2 Storm Surge Inundation Zones, Marsh Transition Zones, Temperature Sensitive Streams, Drought Hazard, and Wildfire Risk Areas. The intent



Climate Change Impact Areas, such as sea level inundation areas, are available on the Department of Natural Resources website. <http://bit.ly/UIX4Hw>



POPULATION GROWTH AND INFRASTRUCTURE

	Priority Recommendations	Lead Agency	Key Partners	Priority	Timeframe
Ensure safety, clean water, clean air, and sufficient infrastructure.	Address funding and revenue constraints to ensure adequate support for current and future infrastructure needs.	MDOT, MDE	MEMA, DGS, utilities, local governments	medium	ongoing
	Conduct a comprehensive analysis of the vulnerability of Maryland's infrastructure.	MDOT, MDE	MEMA, DGS, utilities, local governments	medium	ongoing
	Develop a "lead by example" investment policy to guide State investments.	DNR	all State agencies	high	short-term
	Reduce regional air quality impacts in Maryland.	MDE	MDOT, EPA, MPOs, other states	high	medium-term
Plan for precipitation-related weather extremes and increase resilience to rising temperatures.	Assess the economic costs resulting from severe weather events.	MDOT	MEMA, utility providers, local governments	low	TBD
	Identify State investment needs to prepare for future weather emergencies.	MDOT, MEMA	utility providers, local governments	low	TBD
	Accelerate use of improved stormwater management strategies and environmental site design (ESD).	MDE	DGS, DNR, MDOT, UMD, local governments	high	ongoing
	Enhance the preparedness of transportation system and utility providers.	MDOT, MEMA	PSC, MEA, utility providers, MPOs	low	TBD
	Develop operation contingency plans for critical infrastructure.	MDOT, MEMA	utility providers	medium	ongoing
	Increase urban tree canopy.	DNR	local government	high	ongoing
	Strengthen building and infrastructure design standards.	DHCD	local government, MDOT, MEA, MDE, MEMA	high	ongoing
Institutionalize consideration of climate change.	Promote integration of climate change adaptation strategies into State and local policies and programs.	MDP	DNR, MEMA	high	long-term
	Integrate climate vulnerability data into State and local spatial planning frameworks.	MDP	DNR	high	long-term
	Consider climate change issues in combination with ongoing growth and development planning efforts.	MDP	Sustainable Growth Commission, local governments	high	short-term
	Explore incentives to promote sound planning practices.	MDP	MEA, UMD	high	medium-term
	Investigate the impacts of climate change on future energy needs.	DNR	MDE, MEA, MDA, DBED, MDP, MDOT	high	ongoing
	Create a framework and standards for the placement and use of alternative energy.	DNR, MEA	MDE, MDA, DBED, MDP, MDOT, Critical Area Commission, UMD	high	ongoing

of these designations is to ensure that the State and local governments make wise decisions about how we protect our natural resources, and where and how we develop and redevelop in light of climate change induced hazards and risks. Guidelines for reducing climate change impacts within these areas include:

- Promoting the safety and well-being of Maryland's citizens by avoiding infrastructure capacity improvements that increase human exposure to natural disasters; avoid assumption of the financial risk of development and

redevelopment in vulnerable or hazardous coastal areas;

- Ensuring the wise and sound public investments in Maryland's sea level rise inundation zone. However, appropriate conservation efforts along Maryland's shorelines should not preclude important investment in the State's water-dependent infrastructure, such as our seaports;
- Analyzing climate change impacts on historical and cultural resources and prioritize necessary recovery, documentation, and protection efforts; and

- Protecting critical natural environments from impacts of climate change (i.e., sea level rise, temperature increase, precipitation change) and climate-induced natural hazards.

Community Connections Protocol **Department of Natural Resources**

DNR has developed an additional protocol for assessing land conservation projects based on their value and ability to connect people to the land. The assessment includes a Climate Change Resilience component, which considers on-site adaptation benefits including community storm surge protection, shoreline stabilization and restoration, urban tree canopy protection, and future planned abandonment and relocation facilitation. The community connections protocol and scorecard will be used for appropriate proposed projects to be funded by Program Open Space.

State-wide Land Preservation and Recreation Plan **Department of Natural Resources**

DNR is currently developing the 2014 State-wide Land Preservation and Recreation Plan (LPRP) in coordination with the Maryland Department of Planning, local governments, a wide range of stakeholders, and public input. This will be the first iteration of the LPRP to provide an analysis of how climate change may impact Maryland's natural and cultural resources, open space, recreation and tourism, as well as provide strategies for ensuring sustainability and increasing resilience. The LPRP will be a working resource and tool for state-wide outdoor recreation and open space planning.

Sustainable Maryland **University of Maryland, Environmental Finance Center**

The Sustainable Maryland Certified Program (<http://www.efc.umd.edu/SustainableMaryland.html>) was launched in June 2011. Certification criteria for a Climate Change Adaptation Element was developed by the Planning and Built Environment Task Force and is included in the program elements.

TOOLS, RESEARCH, AND EDUCATION TO INFORM SOUND DECISIONS

Maryland managers and decision-makers need the right tools to anticipate and plan for climate change. Long-term monitoring and research efforts

are critical. As Maryland experiences a new suite of hydrological and temperature conditions, the State will need to gain a better understanding of these conditions. Financial, educational, scientific and political support will also be necessary in order to assess conditions and to research new ways to build up the resilience of natural and built infrastructure to the impending impacts of climate change.

Investment in education is also essential to teach public officials, planners, and other decision makers how to use the tools to formulate and implement specific actions. Coordination with the public is necessary, particularly those most vulnerable and without the necessary resources to respond. In the short-term, there is a critical need to establish and disseminate state-specific climate data and information in order to develop a common understanding of future planning needs at both state and local scales. This is an important first step to ensuring climate issues are during infrastructure planning, design, construction and budget processes.

MADE-CLEAR

University of Maryland Center for Environmental Science, Maryland State Department of Education

The recently funded Maryland and Delaware Climate Change Education, Assessment and Research (MADE CLEAR) program will bring together university faculty, middle school and high school teachers and informal educators to develop training opportunities in climate education across Maryland and Delaware. The goal will be to ensure that students graduating from Maryland schools understand the science behind climate change, the choices available to mitigate and adapt to a changing climate, and



Maryland and Delaware Climate Change Education Assessment and Research

professional opportunities related to the green job market. For more information on MADE-CLEAR, visit: <http://www.madeclear.org/>

Incorporation of climate change into education initiatives

Department of Natural Resources

In 2011, the DNR assembled a series of talking points on climate impacts in Maryland to be utilized by its education staff. The next step will involve incorporating climate change into existing education and outreach programs. Messages of most relevance to citizens will be used as appropriate in outreach programs aiming to encourage stewardship actions; while more direct coastal education programs and materials are being developed for use in classroom settings.

Climate Change Adaptation Needs Assessment, Training and Technical Assistance

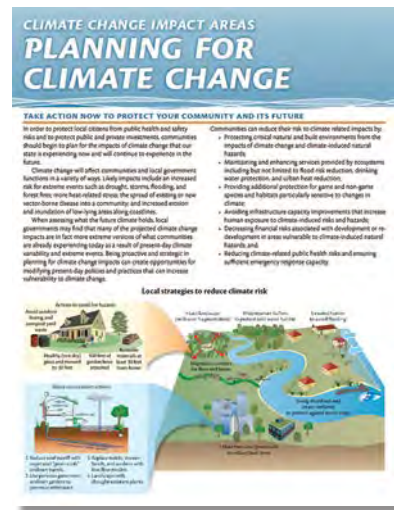
Department of Natural Resources

In 2012, the Chesapeake Bay National Estuarine Research Reserve's Coastal Training Program, DNR's Chesapeake and Coastal Program and Maryland Sea Grant initiated a needs assessment to better understand the training and technical needs of local governments to help them adapt to the impacts of climate change. The needs assessment was completed in the spring of 2012. Results of the needs assessment will be used to deliver targeted training and technical assistance to communities in order to better prepare them for climate change, coastal flooding and storm inundation through the Coast Smart Communities Initiative.

Information Dissemination

Department of Natural Resources/University of Maryland Center for Environmental Science

Information on both the Phase I and II adaptation strategies have been widely disseminated and presented at a variety of conferences, workshop and stakeholder events. Topic and sector-based fact sheets have been developed and are available online (<http://www.dnr.maryland.gov/climatechange/>). DNR and UMCES are both working to widely disseminate climate change-related data and information to agencies, stakeholders, and the public via existing networks and social media outlets.



A factsheet to help local governments plan for climate change was distributed in the fall of 2012.

CONCLUSIONS

The information presented in this Adaptation Update is not intended to be a final work product or strategy on climate change adaptation for the State of Maryland. It should be viewed as “living document” that provides a snapshot of where the state currently stands in terms of implementing its broad scale climate change adaptation planning efforts. The chapter is intended to provide the basis for guiding and prioritizing future state-level activities with respect to both climate science and adaptation policy within short to medium-term time frames (i.e., 1–5 years). It is also envisioned that it will also serve as a framework not only to direct state-action, but also to engage policy-makers and stakeholders, and facilitate collaboration among federal, regional and local partners.

Adaptation planning efforts at the state-level will be routinely reviewed and updated new climate science and information becomes available and we gain a better understanding of how to adapt to climate change. State agencies leads, as well as internal and external partners will remain key to advancing climate change adaptation planning here in Maryland. In closing, it goes without saying that further detailed planning, stakeholder engagement, and funding will be required to build Maryland's ecological, societal and economic resilience to the impacts of climate change. For more information, visit the Department of Natural Resources website: dnr.maryland.gov/climatechange and climatechangemaryland.gov.

