CHAPTER FIVE

Comprehensive Strategy for Reducing Maryland's Vulnerability to Climate Change

Phase I: Sea-level rise and coastal storms









REPORT OF THE MARYLAND COMMISSION ON CLIMATE CHANGE ADAPTATION AND RESPONSE WORKING GROUP

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MARYLAND DEPARTMENT OF NATURAL RESOURCES

Integration & Application Network

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REPORT OF THE MARYLAND COMMISSION ON CLIMATE CHANGE ADAPTATION AND RESPONSE WORKING GROUP

August 2008





MARYLAND DEPARTMENT OF NATURAL RESOURCES

MDE

MDP Maryland Department of Planning



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Jane Hawkey.

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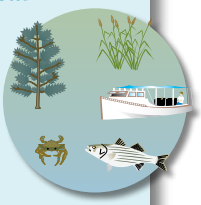
- **Take action now to protect human habitat and infrastructure from future risks.**
  Require the integration of coastal erosion, coastal storm, and sea-level rise adaptation and response planning strategies into existing state and local policies and programs. ***Develop*** and ***implement*** state and local adaptation policies (i.e., protect, retreat, abandon) for vulnerable public and private sector infrastructure. ***Strengthen*** building codes and construction techniques for new infrastructure and buildings in vulnerable coastal areas.



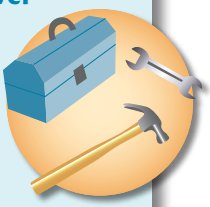
- **Minimize risks and shift to sustainable economies and investments.**
  Develop and ***implement*** long-range plans to minimize the economic impacts of sea-level rise to natural resource-based industries. ***Establish*** an independent Blue Ribbon Advisory Committee to advise the state of the risks that climate change poses to the availability and affordability of insurance. ***Develop*** a *Maryland Sea-Level Rise Disclosure and Advisory Statement* to inform prospective coastal property purchasers of the potential impacts that climate change and sea-level rise may pose to a particular piece of property. ***Recruit, foster,*** and ***promote*** market opportunities related to climate change adaptation and response.



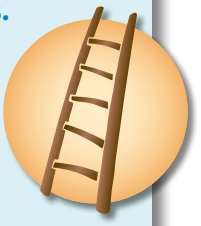
- **Guarantee the safety and well-being of Maryland's citizens in times of foreseen and unforeseen risk .**
  Strengthen coordination and management across agencies responsible for human health and safety. ***Conduct*** health impact assessments to evaluate the public health consequences of climate change and projects and/or policies related to sea-level rise. ***Develop*** a coordinated plan to assure adequacy of vector-borne surveillance and control programs.



- **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. ***Develop*** and ***implement*** a package of appropriate regulations, financial incentives, and educational, outreach, and enforcement approaches to retain and expand forests and wetlands in areas suitable for long-term survival. ***Promote*** and ***support*** sustainable shoreline and buffer area management practices.



- **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. ***Update*** and ***maintain*** state-wide sea-level rise mapping, modeling, and monitoring products. ***Utilize*** new and existing educational, outreach, training and capacity building programs to disseminate information and resources related to climate change and sea-level rise.



- **State and local governments must commit resources and time to assure progress.**
  Develop state-wide sea-level rise planning guidance to advise adaptation and response planning at the local level. ***Develop*** and ***implement*** a system of performance measures to track Maryland's success at reducing its vulnerability to climate change and sea-level rise. ***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.

VISION FOR THE FUTURE

Climate change, sea-level rise, and associated coastal storms are putting Maryland's people, property, natural resources, and public investments at risk. To protect Maryland's future economic well-being, environmental heritage, and public safety, and to guide the fundamental intent of the Comprehensive Strategy for Reducing Maryland's Vulnerability to Climate Change, the Adaptation and Response Working Group recommends that legislative and policy actions be instituted by the Governor and the Maryland General Assembly to:

- ***Promote*** programs and policies aimed at the avoidance and/or reduction of impact to the existing-built environment, as well as to future growth and development in vulnerable coastal areas.
- ***Shift*** to sustainable economies and investments and ***avoid*** assumption of the financial risk of development and redevelopment in highly hazardous coastal areas.
- ***Enhance*** preparedness and planning efforts to protect human health, safety, and welfare.
- ***Protect*** and ***restore*** Maryland's natural shoreline and its resources, including its tidal wetlands and marshes, vegetated buffers, and Bay islands, that inherently shield Maryland's shoreline and interior.

INTRODUCTION

We must take action now to plan for the impacts of climate change

Climate change is among the most daunting environmental problems faced by the world today. The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) shows that no country or region of the world will be unaffected, and in many countries the consequences for human activities will be profound.[1] The IPCC defines *adaptive capacity* as the ability of a system to adjust to climate change, including climate variability and extremes, to reduce potential damages, take advantage of opportunities, and cope with the consequences.[2] The prospect of long-term climate change is now leading decision-makers to do some hard thinking about how this process of adaptation can fit within and serve the broad goals of sustainable development in a country, region, or state.

Adaptation and response planning is crucial to Maryland's ability to achieve sustainability. A 'do-nothing' approach will lead to unwise decisions and increased risk over time. Planners and legislators must realize that the implementation of measures to mitigate climate change and sea-level rise impacts associated with erosion, flooding, and inundation of low-lying lands is imperative to sustainable management, as well as protection of Maryland's coastal resources and communities.

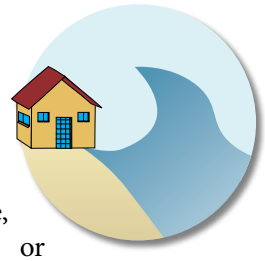
The Adaptation and Response Working Group (ARWG) of the Maryland Commission on Climate Change (MCCC) was charged with developing the *Comprehensive Strategy for Reducing Maryland's Vulnerability to Climate Change*. The Executive Order calls for the Strategy to outline specific policy recommendations for reducing the vulnerability of the state's natural and cultural resources and communities to the impacts of climate change, with an initial focus on sea-level rise and coastal hazards, including shore erosion and coastal flooding.

Adaptation and response planning is crucial to Maryland's ability to achieve sustainability

This report lays out the specific priority policy recommendations of the ARWG to address short-and long-term adaptation and response measures, planning and policy integration, education and outreach, performance measurement, and, where necessary, new legislation and/or modifications to existing laws. For the purposes of this report, the priority policy recommendations have been condensed and a select number of implementation targets identified. Full versions of the priority policy recommendations, which include a detailed discussion of implementation mechanisms, related policies and programs in place, qualitative benefits, and cost assessments and feasibility issues, are contained in Appendix E.

MARYLAND'S VULNERABILITY TO SEA-LEVEL RISE AND COASTAL STORMS

Maryland's people, property, natural resources, and public investments are at risk



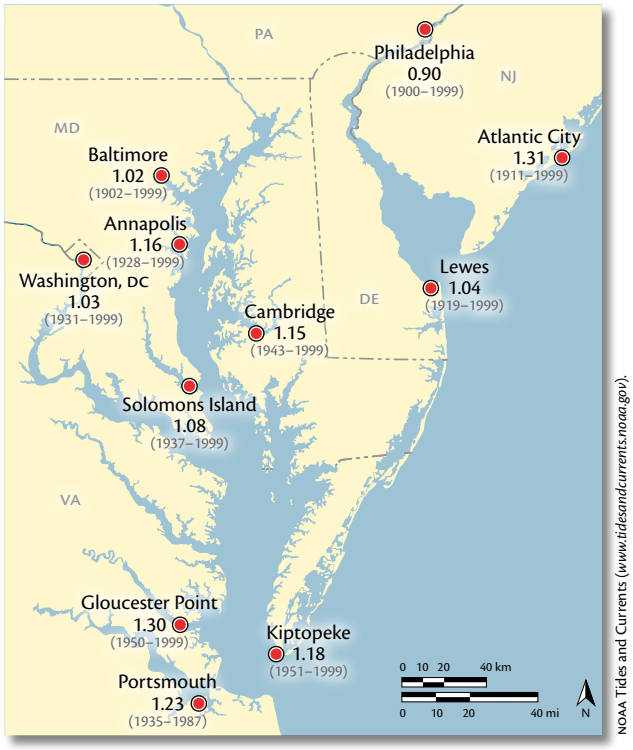
The IPCC defines *vulnerability* as the degree to which a system is susceptible to or unable to cope with adverse effects of climate change, including climate variability or extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity.[2] With over 3,000 miles of coastline, Maryland is poised in a very precarious position when it comes to the impacts of climate change. Maryland's coast is particularly vulnerable to both episodic storm events, such as hurricanes and nor'easters, and chronic hazards associated with shore erosion, coastal flooding, storm surge, and inundation. These coastal hazards are both driven and exacerbated by climate change and sea-level rise.

> Maryland is poised in a very precarious position when it comes to the impacts of climate change
>
> —Governor Martin J. O'Malley

Rising sea levels over the last 20,000 years formed the Chesapeake Bay that we know today. While the rapid rate of sea-level rise that occurred over the past 5,000 years has slowed, historic tide-gauge records show that levels are still rising and have increased by one foot within Maryland's coastal waters in the last 100 years (Figure 1). Such a rate of rise is nearly twice that of the global average over the same time period. Maryland is experiencing more of a rise in sea level than other parts of the world, due to naturally occurring regional land subsidence (Figure 2).

Measurement of sea level at any particular location is *relative*. Relative sea-level rise is the sum of global (eustatic) sea level change plus changes in vertical land movement at a particular location (Figure 3). In support of this report, the MCCC Scientific and

Rates of sea-level rise (feet per century)



NOAA Tides and Currents (*www.tidesandcurrents.noaa.gov*).

Figure 1. Rates of sea-level rise in Chesapeake and Delaware Bays region. Data are from tide gauges and the period of time they cover is in parentheses.

Land subsidence (feet per century)

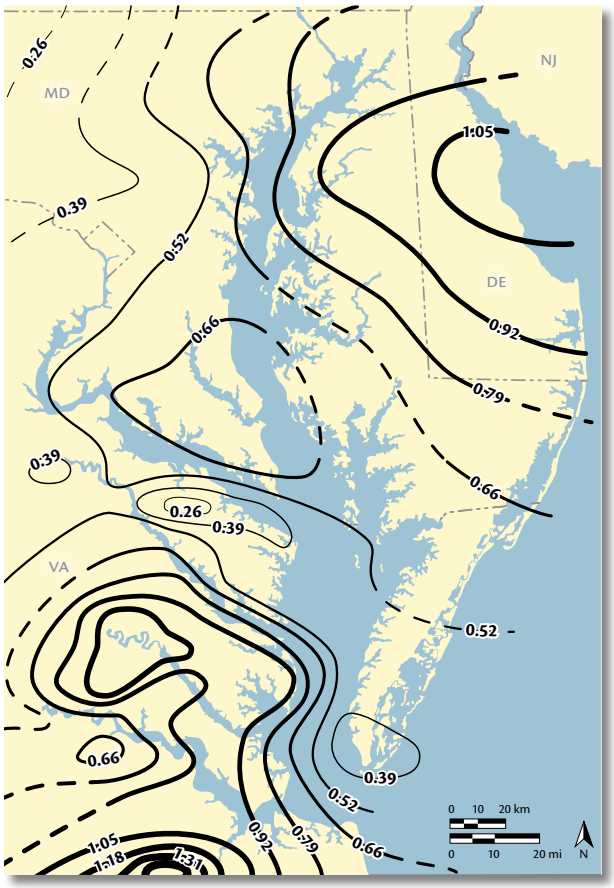


Figure 2. Rates of land subsidence in the Chesapeake Bay region.[4] Subsidence in this region is mostly a result of postglacial rebound or readjustment (sinking) of land elevations since the retreat of the glaciers at the end of the last ice age. Lines are dashed where values are inferred.

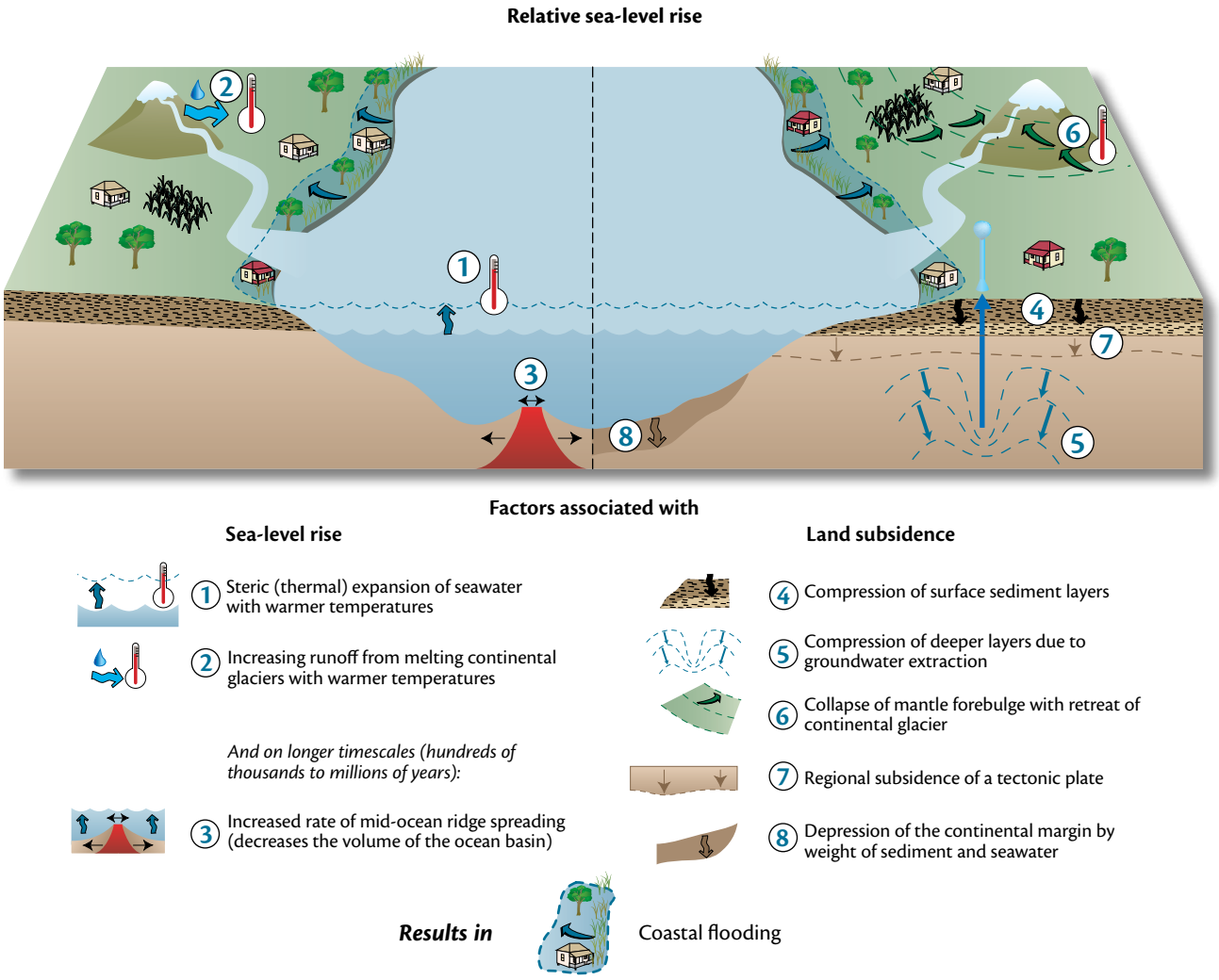


Figure 3. Relative sea-level rise is a result of a combination of factors. Sea-level rise is the combination of the increase in volume of water as a result of global warming and decrease in size of the ocean basins due to mid-ocean ridge spreading. Land subsidence is a consequence of various factors which result in the land surface sinking, reducing elevation. Sea-level rise and land subsidence combine to result in relative sea-level rise.

Technical Working Group (STWG) assessed the 2007 IPCC global sea-level rise projections, along with regional land subsidence variables, and provided a conservative estimate that by the end of this century, Maryland may experience a relative sea-level rise of 2.7 feet under a lower-emission scenario, and as much as 3.4 feet under the higher-emission scenario (Figure 4).

Due to its geography and geology, the Chesapeake Bay region is considered the third most vulnerable to sea-level rise, behind Louisiana and southern Florida. See Figure 5 for a graphical illustration of low-lying land areas in Maryland that may likely be subject to sea-level rise inundation and coastal flooding over the next 100 years. In fact, sea-level rise impacts are already being detected all along Maryland's coast.

Shore erosion. Erosion is a significant problem currently facing Maryland's diverse coastal

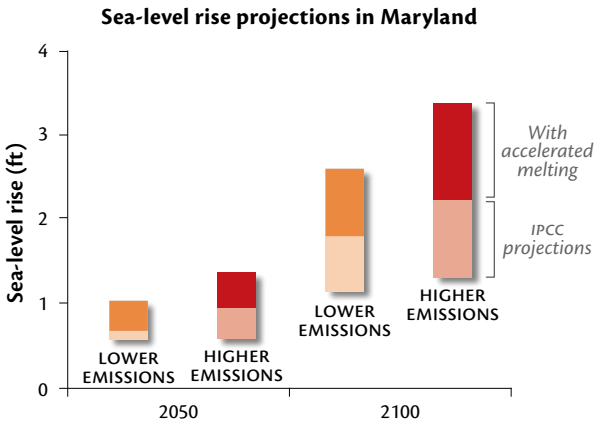


Figure 4. When including coastal Maryland subsidence rates, relative sea-level rise as little as 0.6 ft (probably unlikely because this is scarcely above the 20th century rate) to much as 1–1.3 ft could be experienced along Maryland's coast by the middle of the century. By the end of the century, accelerated melting could produce a relative sea-level rise of 2.7 ft under the lower emissions scenario to 3.4 ft under the higher emissions scenario.[5,6,7,8]

environment. Approximately 31% of Maryland's coastline is currently experiencing some degree of erosion, with some areas losing as much as 8 ft of upland per year. State-wide, approximately 580 acres of land is lost per year due to shore erosion processes. Sea-level rise is a causal force which influences the on-going coastal processes that drive erosion, in turn making coastal areas ever more vulnerable to both chronic erosion and episodic storm events.

Coastal flooding. As demonstrated by Tropical Storm Isabel in 2003, Maryland's coast is extremely vulnerable to coastal flood events. Sea-level rise increases the height of storm waves, enabling them to extend further inland. In low-lying coastal areas, a one-foot rise in sea level translates into a one-foot rise in flood level, intensifying the impact of coastal flood waters and storm surge. The risk of damage to properties and infrastructure all along Chesapeake Bay and the Atlantic coast will be heightened as sea level continues to rise.

Inundation. For many coastal areas, slope is the primary variable controlling the magnitude and range of sea-level rise impact over time (Figure 6). In areas such as Maryland's Eastern Shore where elevation change may only be as much as one foot per mile, gradual submergence of a large geographic area, including large expanses of tidal wetlands,

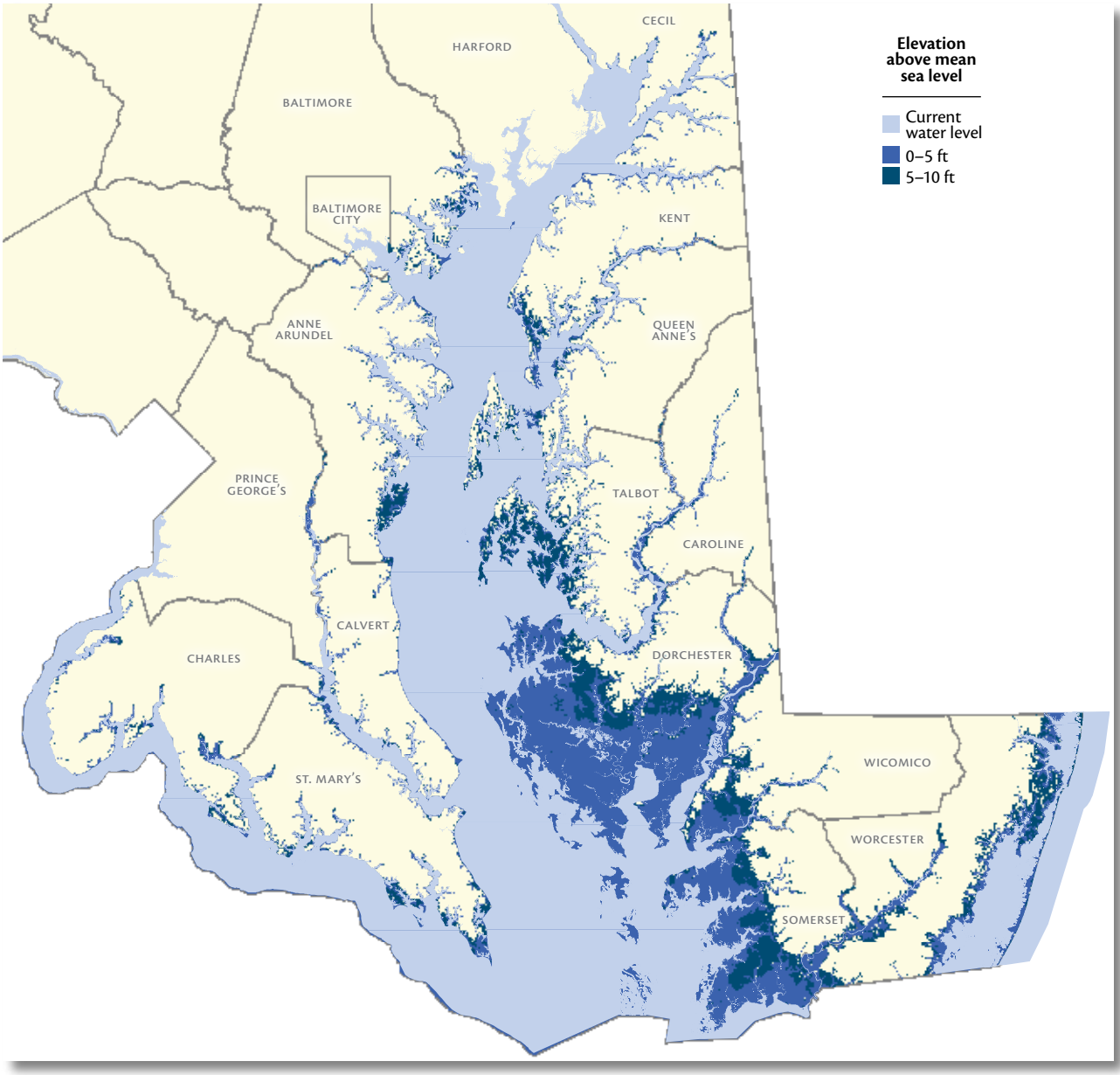


Figure 5. Sea-level rise vulnerability in the coastal areas of Maryland, calculated using LIDAR elevation data. Note: LIDAR elevation data were not available for Baltimore City, Harford County, and Prince George's County. Therefore, vulnerability data do not exist for those areas and cannot be shown on this map.

is quite likely over time. Land inundation due to sea-level rise is already occurring along low-lying coastal areas in Dorchester and Somerset Counties.

Impacts to barrier and bay islands. Barrier islands are highly dynamic coastal landforms, under constant pressure from the driving forces of waves, wind, ocean currents, and storm surge. These forces, coupled with rising sea levels, act to continually reshape barrier islands, as well as to advance landward migration of the island itself (Figure 7). Fenwick and Assateague Islands form the barrier between Maryland's mainland and the Atlantic Ocean. Extensive development in Ocean City, located on Fenwick Island, restricts the natural process of barrier island migration and in turn puts billions of dollars of public and private infrastructure at risk. Islands, such as James Island in Chesapeake Bay (Figure 8), are also extremely vulnerable to sea-level rise. Thirteen charted Chesapeake Bay islands have completely disappeared beneath the water's surface.[3]

Higher water tables and salt water intrusion. As sea level rises, the groundwater table, in general, will also rise and salt-water will begin to intrude into fresh water aquifers. Evidence of these gradual processes has already started to appear along Maryland's Eastern Shore. Analysis of aerial photography taken over the last 50 years confirms that large expanses of upland areas in Dorchester County are being converted to nontidal wetlands and, as the mean high tide has begun to encroach further inland, these freshwater wetlands are becoming infiltrated with saline water. Over time, these impacts will grow to be ever more

Flooding vs. inundation

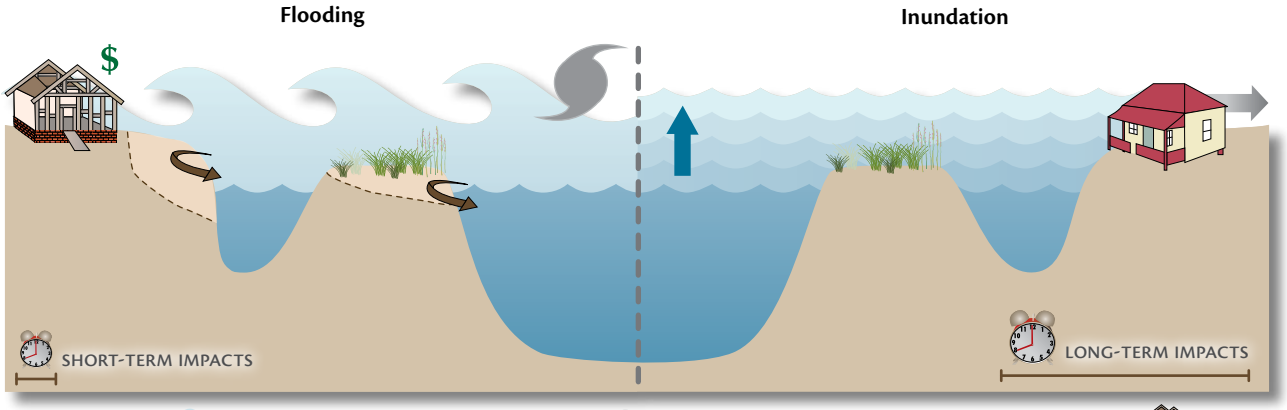


Figure 6. Flooding from stronger and more frequent storms results in erosion and expensive property damage $. Inundation from sea-level rise, which occurs over a long period of time, includes land loss and disappearing islands. Inundation threatens buildings in coastal areas. These buildings may need to be relocated to higher elevations.

Sea level rise and Maryland's Coastal Bays

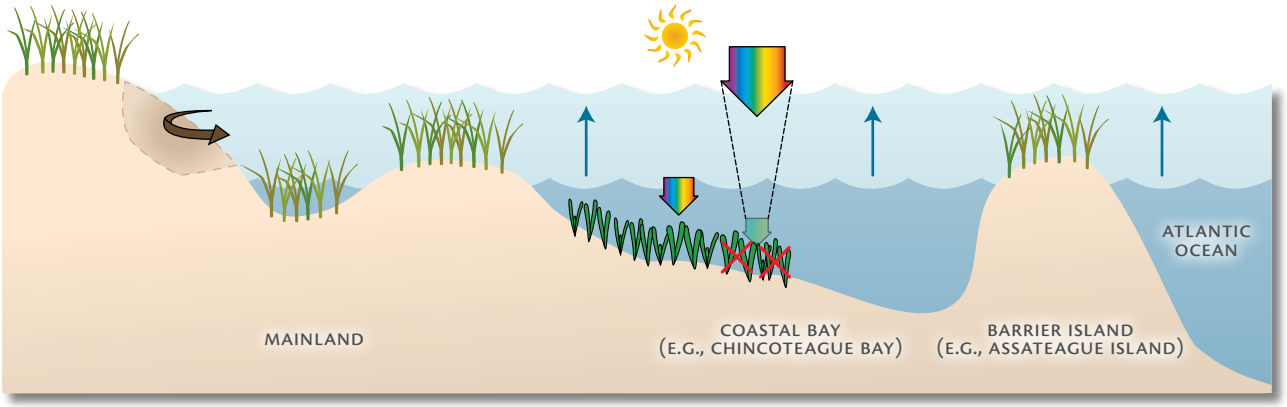
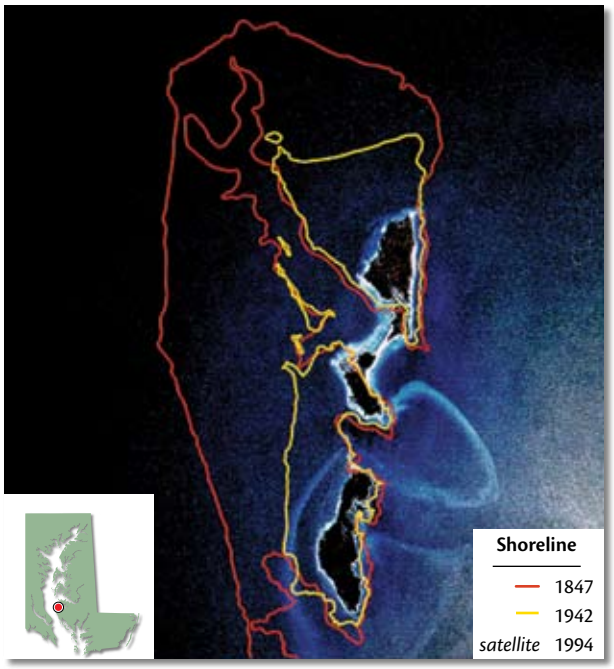


Figure 7. Sea level rise will flood coastal lagoons, which in turn drowns islands and increases coastal erosion. Increased water depth caused by sea level rise reduces the amount of light available to seagrass. The reduced light availability will cause seagrass to decline.

James Island shoreline, 1847–1994



Maryland Department of Natural Resources.

Figure 8. James Island shoreline in 1847, 1942, and 1994 (satellite image). Thirteen Chesapeake Bay islands have disappeared due to sea-level rise over the past century.[3]

problematic as fresh water drinking water supplies are diminished, septic tanks and associated drain fields begin to fail, and non salt-tolerant plants and crops start to die off in surrounding agricultural fields and forests.

Two to three feet of additional sea-level rise will result in a dramatic intensification of coastal flood events, increase shore erosion, cause the intrusion of salt-water into freshwater aquifers, and submerge thousands of acres of tidal wetlands, low-lying lands and Chesapeake Bay's last inhabited island community in Maryland—Smith Island (Figure 9). Sea-level rise poses a significant threat to resources and infrastructure in Maryland's coastal zone. As growth and development continues, especially within low-lying Eastern Shore communities, these impacts are likely to escalate. In the short-term, coastal areas already under natural and human-induced stress are most vulnerable. Of these, barrier and bay islands and the lower Eastern Shore of Chesapeake Bay are in critical need of protection. However, much larger portions of Maryland's coast will become threatened over time.[3]

Chesapeake Bay vulnerability to sea-level rise and storm surge

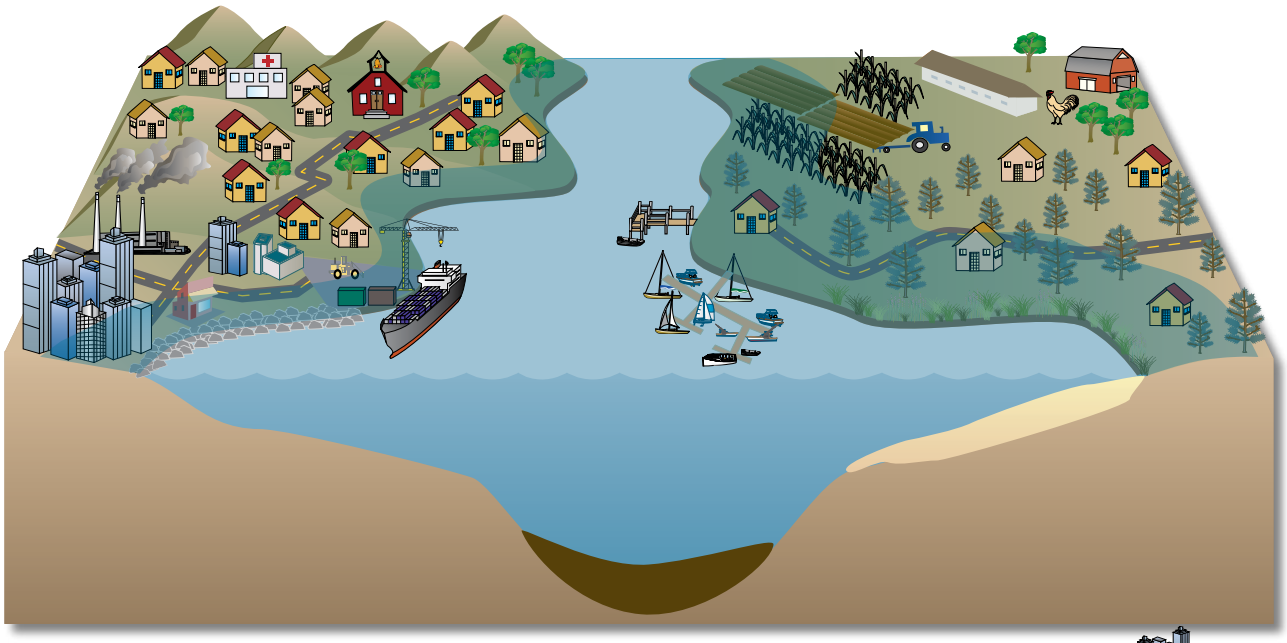
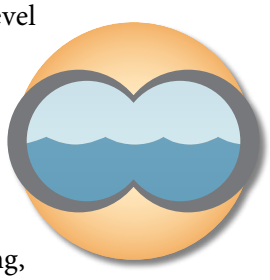


Figure 9. Chesapeake Bay is vulnerable to sea-level rise and storm surge. The western shore has a dense built environment, including industry and ports. The grade of slope affects shoreline movement, so areas with steep slopes, such as Calvert Cliffs, will have a slower rate of shoreline movement than flatter areas. The Eastern Shore's flat landscape contains low-lying roads, animal feeding and agricultural operations, marinas, marshes, and forests.

VISION/STATEMENT OF INTENT

Protect Maryland's future economic well-being, environmental heritage, and public safety



Climate change, sea-level rise, and associated coastal storms are putting Maryland's people, property, natural resources, and public investments at risk. To protect Maryland's future economic well-being, environmental heritage, and public safety, and to guide the fundamental intent of the Comprehensive Strategy for Reducing Maryland's Vulnerability to Climate Change, the ARWG recommends that the Governor and the Maryland General Assembly take legislative and policy actions to:

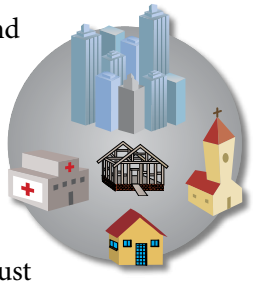
- Promote programs and policies aimed at the avoidance and/or reduction of impact to the existing-built environment, as well as to future growth and development in vulnerable coastal areas.
- Shift to sustainable economies and investments and avoid assumption of the financial risk of development and redevelopment in highly hazardous coastal areas.
- Enhance preparedness and planning efforts to protect human health, safety, and welfare.
- Protect and restore Maryland's natural shoreline and its resources, including its tidal wetlands and marshes, vegetated buffers, and Bay islands, that inherently shield Maryland's shoreline and interior.



Smith Island—Maryland's last inhabited Chesapeake Bay island community—is vulnerable to sea-level rise. Photo by Tom Darden.

REDUCTION OF IMPACT TO EXISTING AND FUTURE GROWTH AND DEVELOPMENT

Take action now to protect human habitat and infrastructure from future risks



Leadership by state and local governments of Maryland is imperative to reduce Maryland's vulnerability to climate change, sea-level rise, and coastal storms. Maryland's state agencies and its local governments must take action now to protect human habitat and infrastructure from future risks. The state can accomplish this by taking steps to effectively *reduce* the impact to existing-built environments by requiring that public and private structures be elevated and designed to reduce damage, and to *avoid* future impact by directing new growth and development away from vulnerable coastal areas.

Leadership by state and local governments of Maryland is imperative

Priority policy recommendations

Integrated planning: Require the integration of coastal erosion, coastal storm, and sea-level rise adaptation and response planning strategies into existing state and local policies and programs.

Planning for sea-level rise and its associated impacts is extremely complex. There is no single methodology, management strategy, or regulatory program that can be used by state or local governments to respond. Instead, efforts to reduce vulnerability can be greatly advanced by integrating sea-level rise planning into existing state and local planning, policy, and management efforts (Figure 10). This policy recommendation includes two sets of targets: (1) Integration of adaptation strategies into *local* comprehensive plans and implementing codes and ordinances; and (2) Integration of adaptation strategies into *state* plans and underlying management and regulatory programs.

Integrated sea-level rise adaptation and response



Figure 10. Due to the variation, range, and magnitude of sea-level rise impacts expected to occur, there is not a single means of response, nor is there one entity that can effectively implement all adaptation planning activities. Sea-level rise adaptation and response planning is most effective if integrated into existing sector- or issue-based planning, management, and regulatory programs.

Local government components

Maryland Planning Article 66B amendments. Maryland Planning Article 66B, §3.06(b) of the Annotated Code of Maryland should be amended to expand sensitive areas, and/or add a Sea-Level Rise Planning Element under county comprehensive plans and/or local hazard mitigation plans.

Chesapeake and Atlantic Coastal Bays Critical Area Act. Local Critical Area Program should be amended to modify current Critical Area buffer provisions to enhance sea-level rise adaptation and response. Options include: (1) expanding the distance of vegetated buffers in areas experiencing significant erosion (2+ ft per year); and/or (2) developing criteria to enable the designation of wetland migration corridors and natural shore erosion areas within Critical Area buffers.

Guidance development and selection of plan mechanisms. Planning guidance should be developed jointly by state and local governments to ensure consistency and clarity and facilitate the integration of the Sea-Level Rise Planning Element with existing comprehensive planning and zoning requirements.

Local capital planning projects. Planning efforts for new or modified capital projects, such as transportation planning, stormwater management, and infrastructure siting, should assess sea-level rise and storm surge vulnerability in the planning process.

Emergency management and mitigation plans. Effective approaches should be developed to communicate appropriate responses that protect human health during large-scale floods, storms, and storm surges. Of particular concern are

communication systems and plans that address health issues associated with low-income and underserved populations and other vulnerable groups. Plans should be developed for moving critical acute and longer-term care facilities that are vulnerable to sea-level rise or coastal storm surge.

State agency components

Designation of areas of critical state concern. State Finance and Procurement Article, Title 5, Subtitle 6 establishes the authority for the Maryland Department of Planning (MDP) to define areas of critical state concern. State and local governments should work together to define the geographic limits of areas potentially impacted by sea-level rise, coastal erosion, and storm surge. Once defined, these areas should be formally designated as areas of critical state concern.

Planning and policy integration. Maryland has emerged as a national leader in sea-level rise adaptation and response planning and should continue to lead by example by integrating sea-level rise issues into state agency policy and planning and implementing sound sea-level rise adaptation measures on state lands through the allocation of state fiscal resources. Targeted activities should include the following:

- Utilize Geographic Information Systems (GIS) technology to analyze areas vulnerable to sea-level rise in combination with jurisdictional and regulatory mandates of existing management programs, including but not limited to Green Infrastructure, Smart Growth, and Resource Conservation Areas.
- Align State Smart Growth strategies, including Priority Funding Area requirements, to reflect population growth and development patterns in relation to areas vulnerable to sea-level rise and coastal hazards.
- Integrate planning for climate change and sea-level rise into the Maryland State Development Plan, currently under development.
- Direct existing land conservation programs, such as Green Infrastructure, Rural Legacy, Program Open Space, the Conservation Reserve Enhancement Program, and the Coastal and Estuarine Land Conservation Program, to consider the use of conservation easements and other land conservation initiatives as a means to protect key coastal areas vulnerable to sea-level rise and to provide sufficient lands for wetland migration.
- Evaluate state natural resource management practices and advocate the means for enhanced protection through such efforts as the promotion of 'living shorelines', tidal marsh restoration, increased vegetative buffers, bay island restoration, and land conservation.

State capital planning projects. Establish a directive and means to review all state-funded projects to determine the cost-effectiveness of minor alterations in the setback and/or design standards based on life expectancy of proposed structures in relation to projected levels of sea-level rise. Potential changes include increasing building setbacks to accommodate a change in the shoreline position due to erosion or inundation, designing structures to accommodate more frequent storm events, such as a 25-year vs. 100-year flood, and elevating structures in tidal floodplains two or more feet above the 100-year base flood elevation.

Implementation

Local components: Implementation of several local government components will require legislative action. The lead agencies, the Department of Natural Resources (DNR) and MDP, with support from the Maryland Emergency Management Agency (MEMA) and the Maryland Department of the Environment (MDE), will begin working together immediately to assess local government capacity and identify specific state and local plans, programs, and policies where climate change and sea-level rise response planning should be integrated. Within one year, the lead agencies will prepare proposed administration legislation for the 2010 session. The lead and supporting agencies will then work together to develop planning guidance to help local governments achieve integration of a Sea-Level Rise Element into



Jane Thomas.

Waterfront properties, such as those in Ocean City and Fenwick Island, are vulnerable to sea-level rise and storm surge.

comprehensive plans. The guidance document will be part of the MDP Models & Guidelines series.

State components: Several state agencies are already undertaking efforts or implementing programs that are consistent with the goals of this policy option. MDP will be integrating relevant components related to land use and planning into the State Development Plan to be implemented by MDP, the Smart Growth Subcabinet, and all state agencies. Components of the policy recommendation that are not currently being addressed can be implemented by Executive Action.

Adaptation of vulnerable coastal infrastructure: Develop and implement state and local adaptation policies (i.e., protect, retreat, abandon) for vulnerable public and private sector infrastructure.

Maryland has thousands of miles of developed waterfront property along Chesapeake Bay, the Atlantic Coastal Bays, and the ocean coast. Much of the state's coastal areas contain public and private sector infrastructure that will be adversely impacted by sea-level rise and the intensification of coastal storm events. Locations like the City of Annapolis, Shady Side Peninsula in Anne Arundel County, and the Town of Crisfield in Somerset County have considerable amounts of infrastructure vulnerable to sea-level rise (Figure 11). The state must take action to reduce the vulnerability of Maryland's public and private sector infrastructure to impacts associated with sea-level rise and increased severity of coastal storm events. There is a clear need to identify impacted public and private sector infrastructure, determine a feasible set of adaptation options and strategies, and formulate strategies to integrate action plans at the federal, state, and local levels.

As sea level continues to rise and storm surge intensifies, both state and local governments, as well as many other public and private property owners, are facing the very real and hard decision about how to adapt and at what expense. Decisions about how to adapt to the impacts of sea-level rise will be different for varying land uses, and must take into account the value of the land, public opinion, public safety and risk, ecosystem survival, environmental factors, and development opportunities.

Adaptation options including protection, relocation, or abandonment can all be utilized to respond to sea-level rise. Protection of vulnerable coastal infrastructure can be accomplished by use of structural bulkheads, seawalls, or revetments, which are the least desirable means. It may not be

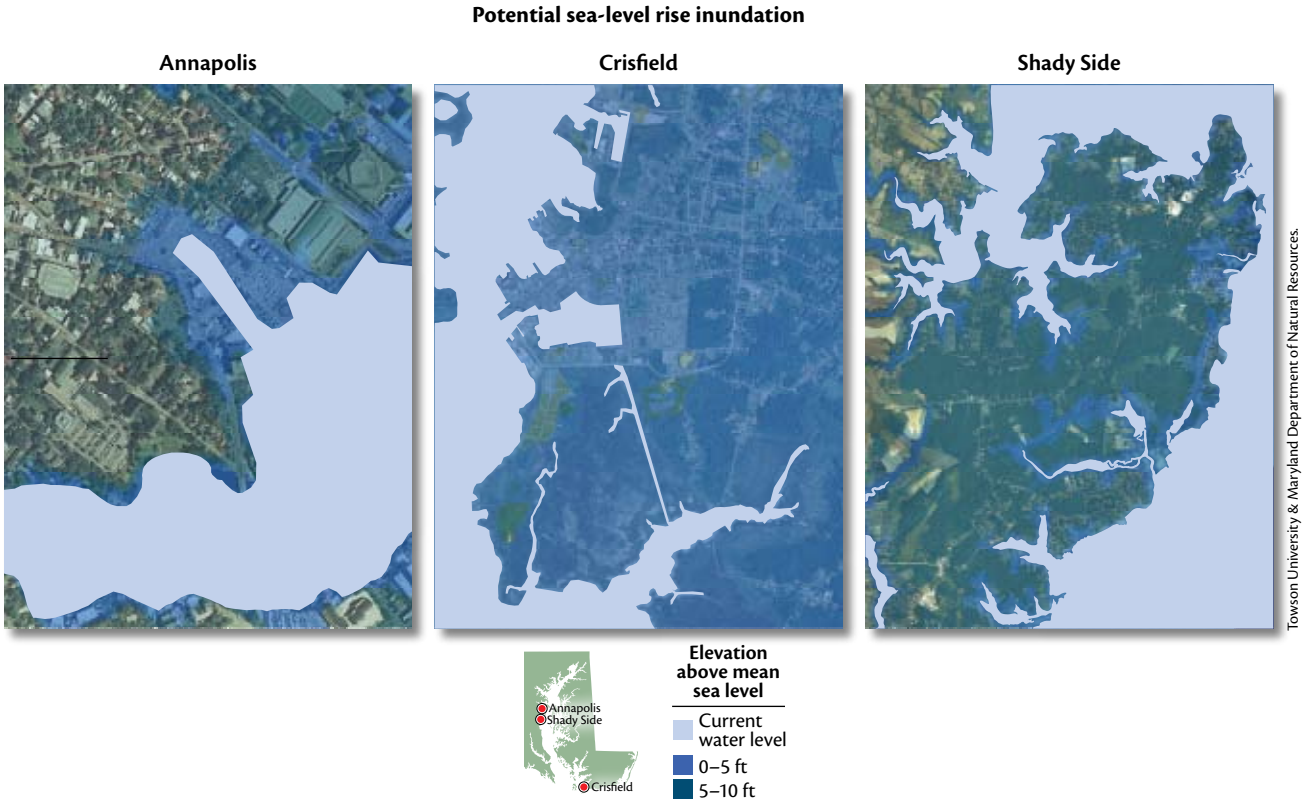


Figure 11. Areas of Annapolis, Crisfield, and Shady Side that would be inundated with various sea-level rise scenarios.

feasible or environmentally beneficial, however, to protect all vulnerable coastal infrastructure—some will undoubtedly have to be relocated or abandoned. Developing a framework for making protection, abandonment, and retreat/relocation decisions must be done in combination with other comprehensive planning and emergency management decision-making processes at both state and local levels.

Implementation

The lead state agencies, DNR and the Maryland Department of Transportation (MDOT), have already initiated efforts consistent with the goals of this policy option. Over the next one to two years, MDOT and the affected agencies will begin an assessment of Maryland's critical transportation facilities and systems' vulnerability to projected sea-level rise and extreme weather damage. That assessment will provide the information necessary to evaluate the options for dealing with potential impacts to infrastructure and connectivity. With the results of the assessment, MDOT will formulate adaptation policies for existing and planned transportation facilities and ultimately develop a long-term strategic plan for system adaptation that can account for the uncertainty of future climactic conditions.

Over the next year, DNR's Chesapeake and Coastal Program will begin identifying vulnerable sea-level rise inundation areas along Maryland's shoreline using newly acquired topographic data and will start assessing public and private sector infrastructure within these vulnerable areas. DNR will work with other state agencies, including MDP and the Maryland Historical Trust, to identify the types of infrastructure that will be included in the inventory of potentially impacted infrastructure. An update on the efforts of MDOT and DNR, along with a more detailed implementation plan, will be presented to the MCCC at its Spring 2009 meeting.

Building code revisions and infrastructure design standards: Strengthen building codes and construction techniques for new infrastructure and buildings in vulnerable coastal areas.

Many existing building codes were originally intended to ensure the safety of new residential and commercial construction; therefore, implementation of this recommendation will involve evaluating existing codes and design standards with respect to their proven effectiveness in past storm events, identifying causes of failure, and recommending and implementing changes to improve performance in the future. In addition to past performance, codes and standards should be reviewed and strengthened by taking into account future increased hazards caused by sea-level rise and the associated possible increase in storm intensity caused by climate change.

All types of building development, including residential, commercial, institutional, etc., and public infrastructure, such as roads, bridges, water and sewer, etc., should be analyzed. Standards for piers, wharves, and other marine-related structures should be included in this review as well. In addition to the overall evaluation and strengthening of codes, the entire development process must change to allow for an integrative process that recognizes and takes into account potential impacts of sea-level rise and climate change at all stages, including early design and decision-making. Design professionals must look for ways to reduce future impacts, and local governments must increase plan review, inspection, and enforcement efforts.

The State of Maryland has adopted, with modifications for Maryland law, the International Building Code (2006) and the International Residential Code (2006) as the Maryland Building Performance Standards (MBPS or Standards). As of July 2007, the Standards apply to all building structures within Maryland for which building permit applications are received by a local jurisdiction. Each local jurisdiction may, by local amendment, modify the provisions of the Standards to address issues relevant to that jurisdiction. Many jurisdictions have, in fact, made amendments in addition to the MBPS. Therefore, any review must include an evaluation of the MBPS as well as local building code ordinances. Reviews should include, but not be limited to, the following targets:

- *Elevation of buildings*. Require two or more feet of freeboard for structures located in tidally influenced floodplains. Freeboard is an elevation above a designated high-water level (base flood elevation; Figure 12). For example, the bottom of the lowest horizontal structural member should be elevated a minimum of two feet (or more) above the base flood elevation. This is especially pertinent with regard to sea-level rise, since base flood elevations will be higher in the future.
- *Foundation design.* Certain types of foundations are more effective in flood situations than others. Deep pile or column

foundations are desired if significant erosion is possible in oceanfront locations as well as bay locations where the following conditions exist: erodibility of the soil; exposure to damaging waves (greater than 1.5 ft); potential for velocity flow; potential for flood-borne debris; and required resistance to wind forces. These locations include V-zones, as well as A-zones, that are identified under the National Flood Insurance Program (NFIP).

- *Long-duration flood impacts*. Long-duration flooding, which may be a result of sea-level rise in the future, can cause extensive damage to interior contents and building materials. Moisture entrapment within walls and floors can impact structural integrity and cause biological and chemical contamination. Elevation will reduce this problem, as will the use of flood-resistant building materials above the minimum elevation.
- *Debris impact*. Substantial damage can be caused by floating or wind-driven debris in a flood or storm event. Current codes and construction standards should be evaluated with regard to debris resistance.
- *Building envelope*. A 'building envelope' is the entire exterior surface of a building, including walls, windows, doors, and roofs. All parts of the building envelope must provide protection from wind, wind pressure, and wind-borne debris. Building codes are very specific regarding these issues, but they should continually be reviewed and improved as needed.
- *Capital project design*. Design of future public projects, including roads, bridges, tunnels, landfills, water, and wastewater treatment plants, etc., should consider the effects of climate change and sea-level rise. In addition, standards should be developed for the modification of existing facilities in response to sea-level rise.
- *Abandoned facilities*. Provisions should be made to minimize the negative impacts of both public and privately maintained structures, facilities, and utilities that may be abandoned due to sea-level rise. Such impacts may include social, economic, navigational, and environmental hazards.

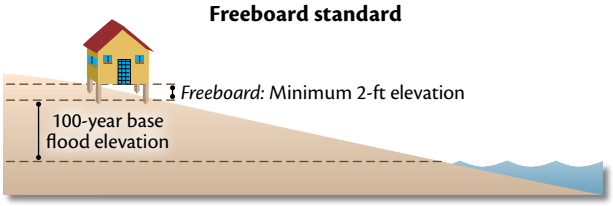


Figure 12. Freeboard is an elevation above a designated high water level (base flood elevation). For example, the bottom of the lowest horizontal structural member should be elevated a minimum of two feet (or more) above the 100-year National Flood Insurance Program base flood elevation. This is especially pertinent with regard to sea-level rise, since base flood elevations will be higher in the future.

Implementation

Implementation of this recommendation will initially involve an evaluation of existing codes and regulations with specific regard to the threats associated with climate change and sea-level rise. If deficiencies are found, changes to codes, regulations, and laws should be pursued. Legislative action will be necessary to amend the Maryland Flood Hazard Management Act of 1976 (Environment Article, Title 5) to require that all counties adopt standards requiring two or more feet of freeboard in tidally influenced floodplains. Over the next year, MDE will conduct a policy analysis of the Maryland Flood Hazard Management Act and will take the lead role in developing any necessary legislation or regulatory amendments to remedy policy deficiencies.

This policy recommendation dovetails with certain requirements of House Bill 1353 of the 2008 session of the Maryland General Assembly. Under the Omnibus Coastal Property Insurance Reform Act, the Maryland Department of Housing and Community Development (DHCD) is charged with reviewing current state-wide building codes and developing enhanced building codes for coastal regions of the state that promote disaster-resistant construction. DHCD is required to report their findings and recommendations to the Senate Finance Committee and House Economic Matters Committee on or before October 1, 2010. DHCD will fulfill its obligations under this Act and at the same time implement the recommendation as discussed above.

FINANCIAL AND ECONOMIC WELL-BEING

Minimize risks and shift to sustainable economies and investments

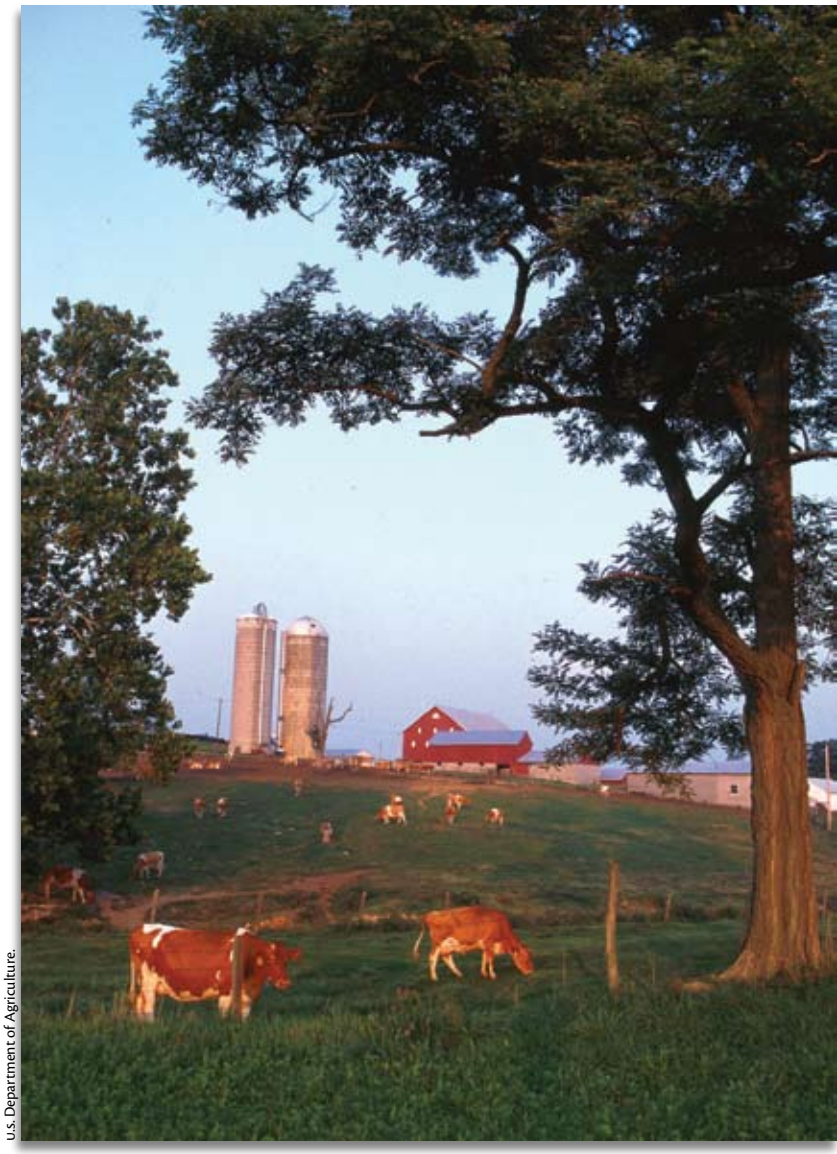


Maryland's people, property, natural resources, and public investments are all vulnerable to climate change and sea-level rise and, at some point, the inevitability of climate change will require critical actions to protect them rather than purposeful foresight and preparedness planning. Two to three feet of sea-level rise would inundate thousands of properties in low-lying areas and expose millions of dollars' worth of public infrastructure to the threat of submergence and/or storm surge. Billions of dollars more of public and private investments are at risk. Over time, federal, state, and local governments will not be able to afford to assist all in need—the costs will be just too high. Maryland should begin a sweeping shift to develop sustainable economies and investments, and at the same time, must work hard to avoid assumption of the financial risk of development and redevelopment in highly hazardous coastal areas.

Priority policy recommendations

Resource-based industry economic initiative: Develop and implement long-range plans to minimize the economic impacts of sea-level rise to natural resource-based industries.

Resource-based industries, such as forestry, agriculture, commercial and recreational fishing, and sportsmen's activities, represent the economic backbone of rural Maryland. These industries are heavily dependent on the health and vitality of the Atlantic Coastal Bays and Chesapeake Bay ecosystems. While potential climate change impacts to these industries are widespread, including changes in salinity, temperature, rainfall, disease, and invasive species, sea-level rise and coastal storms will specifically impact areas where the current primary land use supports these industries. Adaptation and response strategies that investigate all possible impacts should be addressed, recognizing that many will fall outside the focus of this phase of adaptation planning.



U.S. Department of Agriculture.

Impacts to resource-based industries such as farming and agriculture need to be minimized.

Baseline information regarding the impacts of climate change, including sea-level rise and associated coastal hazards, on the economics of varying sectors of resource-based trades and industries is lacking. Research within each respective field should aim to identify these potential impacts, and lead to developing an appropriate strategy to buffer such effects, as well as identifying potential opportunities for expansion and development. State agencies, in cooperation with the private sector, should develop and implement long-range plans, such as fishery management plans, forestry management plans, marine sensitive

Two to three feet of sea-level rise would inundate thousands of properties in low-lying areas

areas initiatives, and agriculture land use plans, that institute protection mechanisms to minimize the economic impacts of sea-level rise on natural resource-based industries. These plans should be flexible enough to adjust to ongoing and future change.

Implementation

Several lead agencies, including DNR, the Maryland Department of Agriculture (MDA), and the University System of Maryland, will work together to implement this recommendation. Implementation will occur over several phases. Phase 1 will focus on research and data collection, followed by Phase 2, which will be a strategic planning exercise. The first step in this process will be the development of several research teams, each comprised of individuals with expertise in sector-based issue areas. These teams will be coordinated by the lead agencies and will work over a two-year timeframe to evaluate key vulnerabilities and potential economic impacts of climate change on resource-based industries (fisheries, forestry, aquatic, and agriculture) and to develop appropriate adaptation and response strategies. A more detailed implementation plan will be presented at the MCCC Spring 2009 meeting.

Climate change insurance advisory committee: 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.

Due to sea-level rise and a likely increase in the intensity of coastal storm events, climate change will significantly impact the financial status of insurers and reinsurers, their ability to pay future claims, and consequently, the availability and affordability of insurance to Maryland's households and businesses. Maryland must take a proactive approach to risk reduction and take steps to maintain the insurability of financial investments.

Maryland must take two important steps to assess its options for state regulation of insurance in the face of climate change. First, there is a need for information on the risks posed by climate change. An independent Blue Ribbon Advisory Committee should be established to advise the State Insurance Commission and the Governor of the risks that climate change poses to the availability and affordability of insurance for Maryland citizens and businesses. The Blue Ribbon Advisory Committee should assess the following targets:

- The adequacy of data availability to insurers to assess risks posed by climate change, including sea-level rise, and recommend steps to improve data where it is deficient.
- The degree to which adaptive options, such as zoning that recognizes risks of building in high-risk areas and improved building codes to protect against more severe weather and flooding, may mitigate insured losses due to climate change, and whether insurance rate structures could be constructed that provide incentives for early adaptive actions.
- Options to promote partnerships with policyholders for loss mitigation.

It is also essential to have a focused assessment and a strategy for managing the ramifications of climate change risks and uncertainties. The State Insurance Commission should undertake a study on the costs and benefits of requiring greater disclosure of the risks posed by climate change to investors on the part of all insurance companies operating in the State of Maryland.



Bhaskaran Subramanian.

Agriculture is a vital component of Maryland's economy.

Implementation

The Maryland Insurance Commissioner will convene a Climate Change Insurance Advisory Committee on or before September 15, 2008. Membership will be composed of citizens, business owners, members of civic and conservation organizations, representatives from the insurance industry, and local and state government representatives. Additionally, membership may consist of members from Maryland's Coastal and Watershed Resources Advisory Committee. The

Insurance Advisory Committee will provide an initial report to the Commissioner on or before January 1, 2009. An interim report will be due on or before July 1, 2009 and the final report will be completed on or before January 1, 2010.

Disclosure: Develop a *Maryland Sea-Level Rise Disclosure and Advisory Statement* to inform prospective coastal property purchasers of the potential impacts that climate change and sea-level rise may pose to a particular piece of property.

Maryland should develop a *Sea-Level Rise Disclosure and Advisory Statement* that would be applicable to all real-estate transactions taking place within Maryland counties bordering the Atlantic Ocean and the Chesapeake and Coastal Bays. The *Maryland Sea-Level Rise Disclosure and Advisory Statement* should contain general information about risks associated with sea-level rise, coastal storms, and/or shore erosion, as well as disclose property owner knowledge of any flooding, avulsion, erosion, or other damage that has occurred to a particular piece of property.

The *Maryland Sea-Level Rise Disclosure and Advisory Statement* would build upon the precedent of requiring residential property sellers to provide information regarding lead and lead-based paint. Federal and state law require both require persons selling or leasing most residential housing built before 1978 to provide purchasers and renters with a federally approved lead hazard information pamphlet and to disclose known lead-based paint and/or lead-based paint hazards in the sales contract. Information contained in the *Maryland Sea-Level Rise Disclosure and Advisory Statement* should be made available in as many stages of the property transaction and ownership as possible, including but not limited to the notification of potential buyers in the listing of the property, a disclosure notice at settlement, and recording on the plat maps, zoning maps, or with the title and deed.

The analogy to sea-level rise, erosion, storm surge, and other climate change-related risks is straightforward. First, the state may require property owners or managers to provide general information on climate-related risks, similar to the general notice regarding lead. This notice requirement could be triggered particularly for vulnerable properties. For lead, that includes residential buildings built before 1978. For sea-level rise, it could include houses in coastal counties or those located in areas specifically identified as vulnerable to sea-level rise, erosion, storm surges, and other related risks. Second, to the extent that a property owner or manager has knowledge regarding the risk to that particular property, the law would also require the property owner or manager to disclose that information.

Implementation

Within 180 days of the release of the *Climate Action Plan*, both DHCD and DNR, as lead agencies, will assemble a small group of key state agency staff to discuss accuracy, insurance, and legal issues that need to be resolved during the development of a disclosure and advisory statement relating to the transfer of real property. In addition, the group will address the pros and cons of different forms of communicating those statements and the timing and targets of those statements. Within one year, a public discussion of the proposed recommendations will take place in a forum to be determined by DHCD and DNR. The lead agencies will work together to draft new/revised legislation, as necessary, for the 2010 legislative session.

Green economic development initiative: Recruit, foster, and promote market opportunities related to climate change adaptation and response.

Maryland should take immediate steps to capture the emerging economic opportunities in climate change adaptation and response fields. While some greenhouse gas reduction strategies require new costs, many of these strategies and the expertise and technologies involved also offer tremendous opportunities for economic growth. Maryland is well-situated to capitalize on the state's expertise in environmental issues to become a leader in the 'green-collar' job creation and economic development while meeting the challenges of climate change. Maryland's efforts should encompass the development of new green businesses as well as the greening of more traditional businesses to improve their economic, social, and ecological performance.

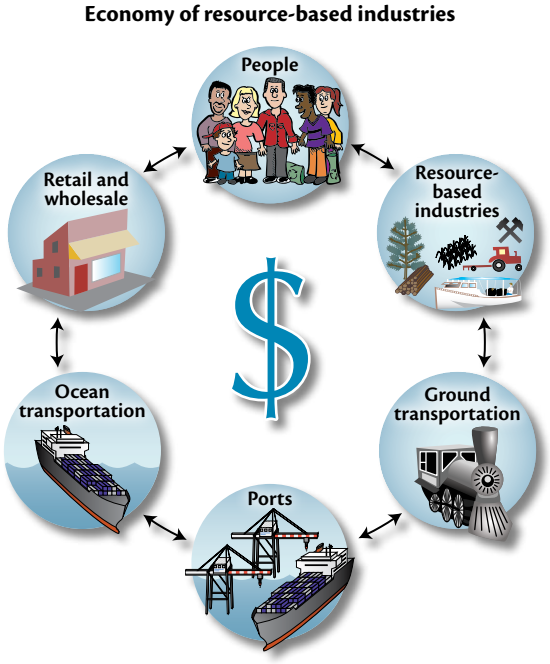
A Task Force should be established to identify priority initiatives and refine implementation strategies to establish strong capacity to recruit, foster, and promote market opportunities related to climate change adaptation and mitigation. The Maryland Department of Business and Economic Development (DBED) and other agencies with programs in business

development and trade promotion should play a major role in this effort. Green economic opportunity targets include the following:

- Build public and business awareness of why a green, sustainable economy is good for Maryland.
- Promote the 'greening' of existing Maryland businesses.
- Use Maryland government investment to 'prime the pump' for green economic growth.
- Develop adaptation decision support services and tools for businesses.
- Market Maryland as a leader in adaptation and mitigation strategies.
- Build a 'green-collar' entrepreneurial workforce through education, training, and outreach.
- Create an environment to foster green business and markets.
- Support the development of sustainable resource-based industries.

Implementation

The lead agencies, DBED and DNR, will work together to implement this policy recommendation in coordination with implementation of the MCCC's Mitigation Working Group (MWG) policy option CC-9, which is aimed at promoting economic development opportunities associated with reducing greenhouse gas emissions in Maryland. DBED and DNR will convene and coordinate the efforts of the Task Force, as identified above. A more detailed implementation plan will be prepared by the lead agencies for presentation to the MCCC at its Spring 2009 meeting.



Sea-level rise does not just affect coastal areas. It can affect all aspects of resource-based industries' economy, from production through transportation to consumption.

PROTECTION OF HUMAN HEALTH, SAFETY, AND WELFARE

Guarantee the safety and well-being of Maryland's citizens in times of foreseen and unforeseen risk



Sea-level rise will impact both the coastline and some interior portions of Maryland and will change the way health-related infrastructure and programs are maintained and managed in the future. The general population may take for granted that clean and adequate water supplies are available, waste water is cared for and properly disposed of, and that our population is generally safe from the impact of coastal flood events and vector-borne illnesses. However, with a projected growing population in Maryland, mostly in coastal areas, protecting human health and safety will become an increasing large responsibility for state and local governments. With that responsibility, new tools and adequate resources will be needed in order to protect Maryland's communities—both large and small.

Priority policy recommendations

Inter-agency coordination: Strengthen coordination and management across agencies responsible for human health and safety.

The Maryland Department of Health and Mental Hygiene (DHMH), Office of Preparedness and Response should undertake a gap analysis, in cooperation with MEMA and other target agencies to determine if there is adequate management, procedures, and coordination of county- and city-level options to ensure consistency in and capacity for adaptation and response to health-related impacts of climate change across boundaries. This gap analysis should evaluate state and local government capacity to respond to large-scale floods and storms, ensuring the safety and protection of drinking water sources and septic systems/waste treatment, and infectious disease outbreaks. Additional components should include: (1) organization of the response; (2) benchmarking; (3) capacity inventory; (4) information technology and communications; (5) needs analysis; and (6) state law and policy amendments. For example, a conclusion of the analysis might be that counties and municipalities be encouraged to adopt well and septic provisions, including water and sewer plans and re-mapping of zoning for areas that are at-risk for inundation due to gradual sea level rise or coastal flooding and storm surge.

Recommendations resulting from the proposal will recognize and account for differences in response capacity between counties and recommend mitigation and augmentation options to minimize disruption in services due to lack of capacity. The recommendations will be of benefit for all aspects of agency operations and coordination, as well as for specific responses to climate change. Implementation of this recommendation will increase the adaptive capacity of state institutions by increasing coordination and collaboration and raising awareness of how to appropriately address the health risks of climate change.

> Protecting human health and safety will become an increasingly large responsibility

Implementation

The DHMH, Office of Preparedness and Response and MEMA will immediately begin the process to undertake the recommended gap analysis. The gap analysis should be coordinated with the 2008 Federal Gap Analysis, as applicable. The gap analysis should be completed by September 2009. A progress update and preliminary findings will be presented to the MCCC at its Spring 2009 meeting.



Zoë Johnson.

Protecting human safety during coastal flood events is an essential part of climate change planning.

Health impact assessments: Conduct health impact assessments to evaluate the public health consequences of climate change and projects and/or policies related to sea-level rise.

Health consequences for residents of Maryland may arise from the implementation of climate change adaptation and response options across all sectors. Health Impact Assessments (HIAs) should be used to assess the public health consequences of climate change and policies and measures related to sea-level rise prior to their adoption. HIAs are a proven approach to ensuring that potential public health concerns are identified and addressed before they become a problem. A HIA should be conducted, at a minimum, whenever an Environmental Impact Assessment is required or if a proposed policy is expected to have a health-related and/or safety impact. HIAs also can be used to identify the co-benefits of smart growth and development policies.

HIAs will increase the adaptive capacity of state institutions by incorporating consideration of possible public health considerations at the beginning of the policy process, rather than waiting for adverse consequences to be recognized and mitigated at the end of the policy or implementation process. Recognizing possible adverse health consequences early in the process will help prevent injuries and illnesses before they occur and result in less costly solutions. In addition, the cross-department and agency collaborations developed as a result of HIAs will increase the capacity of the state to prepare for and respond to climate change and sea-level rise risks.

Implementation

The lead agencies, DHMH and MEMA, will work to implement this policy recommendation in coordination with MWG policy option CC-11, which recommends the evaluation of climate change policy options to determine projected public health risks, costs, and/or benefits. DHMH and MEMA will work together to coordinate and participate in the efforts of the Maryland Climate Change Environmental Health and Protection Advisory Council.

Vector-borne surveillance and control: Develop a coordinated plan to assure adequacy of vector-borne surveillance and control programs.

One of the consequences of climate change may be alteration of the geographic distribution and intensity of transmission of vector-borne and zoonotic diseases. As the climate warms, the range of several insect- and arthropod-borne diseases is likely to expand northward. DHMH, along with DNR and MDA, is responsible for conducting vector-borne disease surveillance and control programs. A working group should be established between the departments to develop a coordinated plan to assure adequacy of the surveillance program given increased demand associated with climate change. In addition, there would be collaboration with agencies responsible for water storage, storm water management, etc., to ensure that these programs achieve their goals without increasing breeding sites for disease-carrying vectors.

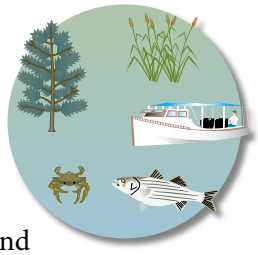
Vector and disease surveillance programs already exist within the state that could meet some, but not all, of the demands associated with increased monitoring of vector-borne diseases as a result of climate change. Significant increases in personnel and resources may be required if surveillance programs are to be expanded. Vector surveillance requires specialists trained in the collection of specimens, laboratory analysis, and GIS or other spatial analysis. While not immediately required, the long lead-time required to recruit and/or train the personnel necessary to fill these specialized positions necessitates advance planning and dedication of resources. Improving surveillance and control activities will need to include educational programs so that individuals do not over-spray when vector-borne diseases are identified, as using excessive amounts of insecticides has adverse health and environmental consequences.

Implementation

DHMH, along with the MDA and DNR, is responsible for conducting vector-borne disease surveillance and control programs. These lead agencies will convene a working group within 180 days of the release of the *Climate Action Plan* to develop a coordinated plan assuring adequacy of the surveillance program given increased demand due to climate change. This plan will be developed by the working group and should be completed within a one-year timeframe.

NATURAL RESOURCE PROTECTION

Retain and expand forests, wetlands, and beaches to protect us from coastal flooding



Maryland's natural resource lands provide critical wildlife habitats, have regional significance for migratory birds, sequester large amounts of carbon, provide sediment and nutrient water quality benefits, and generate economic benefits through farming, forestry, fishing, and passive recreation. Natural resources, particularly coastal wetlands and barrier and bay islands, also play a vital role in protecting Maryland's shoreline and interior by absorbing the damaging impact of coastal floods, heavy winds, and strong waves (Figure 13). Identifying undeveloped lands and ecologically and economically important lands will be critical for targeted conservation and coordinated restoration in response to sea-level rise and its associated effects. Preserving undeveloped, vulnerable lands also offers a significant opportunity to avoid placing people and property at risk to sea-level rise and associated hazards including storm surge, coastal flooding, and erosion in the future.

Priority policy recommendations

Natural resource protection areas: Identify high priority protection areas and strategically and cost-effectively direct protection and restoration actions.

Conservation and restoration of natural resource lands are currently facilitated through a number of state agencies and programs. To date, significant state resources have been invested to establish various assessments for identifying and prioritizing targeted lands. These existing assessments, however, are sometimes utilized independently of one another and do not consider sea-level rise and its associated effects. Rising sea levels will undoubtedly impact coastal ecosystems and natural resource lands; therefore, the criteria for which these lands are prioritized and targeted for strategic management will need to shift in order to account for associated impacts.

Natural resources play a vital role in protecting Maryland's shoreline and interior

The state should establish a scientific and technical framework to develop and test new and existing criteria for identifying priority protection and restoration areas in the context of sea-level rise. To the extent possible, the framework should use

Protective natural resources

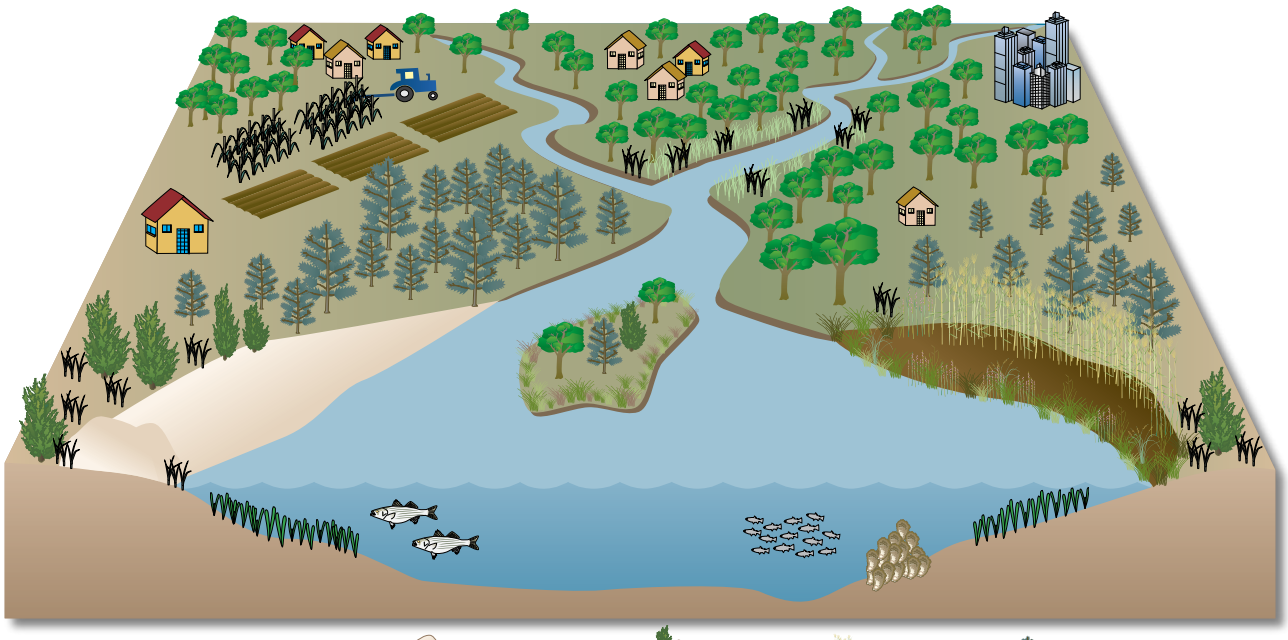


Figure 13. Natural barriers such as beaches , dune vegetation , wetlands , coastal forests , and vegetated stream buffers protect residential areas and urban areas from flooding, erosion, and inundation. Natural barriers also protect crops and agricultural areas .

existing assessments, such as Green Infrastructure and Blue Infrastructure, in order to identify high-priority ecological and economic natural resource lands and aquatic habitats in the coastal zone. Mapping and modeling data gaps and needs should also be identified and addressed. It is recommended that the framework be developed as a peer-reviewed model to graphically illustrate the potential location of wetland migration corridors, areas where accretion may keep pace with sea-level rise, and areas that are not suitable for migration and need active management to be sustained (Figure 14). Potential field sites should be identified in order to test site-scale suitability criteria for various restoration practices in response to sea-level rise.

The information generated from the model will enable programs to strategically and cost-effectively direct and implement specific conservation, restoration, and growth management actions. Undeveloped coastal land areas of high priority for targeted action include those identified as potential wetland migration corridors, those essential in maintaining ecosystem integrity and connectivity, those crucial in supporting farming, forestry, and fisheries industries, and those positioned to confer risk reduction to coastal communities in response to projected sea-level rise inundation and coastal flooding scenarios.

Implementation

Several state agencies, including DNR and MDE, are already undertaking efforts or implementing programs that are consistent with the goals of this policy option. Early analysis of natural resources protection and restoration priorities will be initiated immediately by these lead agencies using existing inundation maps and natural resource assessments. By September 2009, the lead agencies, along with input from other state agencies, will develop a comprehensive plan to integrate various models, identify data gaps, and evaluate sea-level rise and marsh migration models. Targeting priorities as recommended by the MWG for carbon sequestration will be incorporated, where possible.

Forest and wetland protection: Develop and implement a package of appropriate regulations, financial incentives, and educational, outreach, and enforcement approaches to retain and expand forests and wetlands in areas suitable for long-term survival.

Forest and wetland conservation will, without doubt, become increasingly complex in the face of climate change and sea-level rise. If sea level increases by three feet, by the year 2050, 21% of coastal forests and 66% of tidal marshes in Dorchester County will be lost (Table 1). These habitats are pivotal to Maryland's ability to adapt to climate change, as forests and wetlands provide a buffer to storm surge and have the ability to sequester carbon, reduce shoreline erosion, and mitigate peak runoff during storm events. Side benefits include improved water and air quality, enhanced wildlife and natural resource habitats, increased 'green' renewable construction

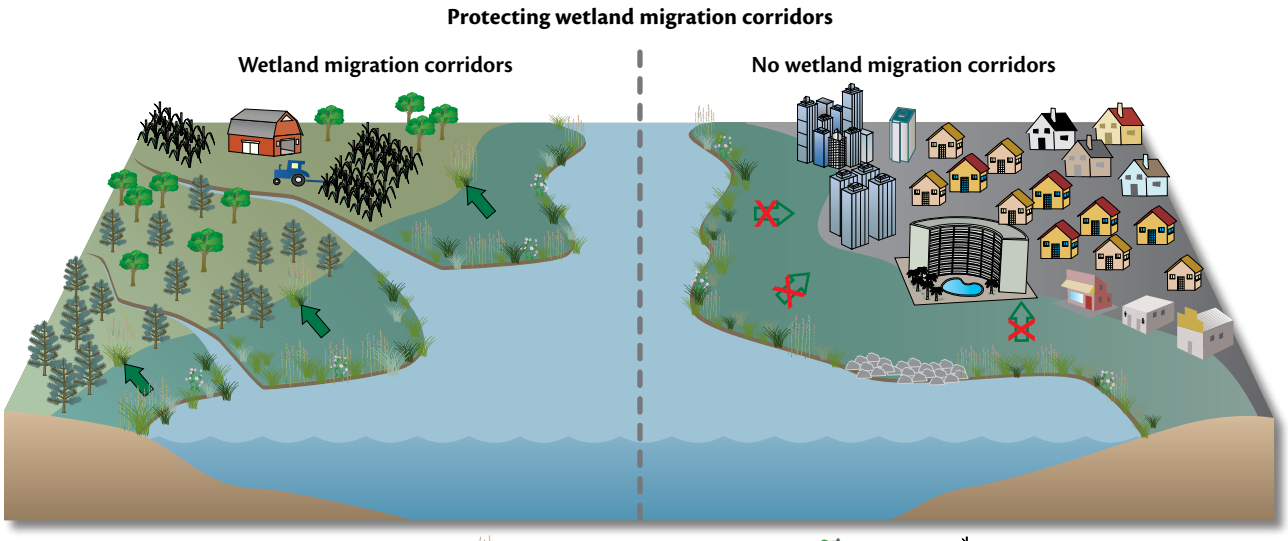


Figure 14. As sea level rises, wetlands may migrate into open spaces such as forests and fields. However, wetlands cannot migrate into areas with man-made barriers such as hardened shorelines and heavy development such as urban, commercial, and residential areas.

and fuel forestry products, and expanded resource-based industry jobs.

In light of sea-level rise, the state should establish new criteria, where appropriate, for identifying priority natural resource protection and restoration areas in order to integrate and streamline conservation, restoration, and growth management programs across state agencies and local governments. The costs of forest and wetland conservation and expansion are associated primarily with capital costs of land purchases and/or easements in areas identified as critical to buffering against the impacts of sea-level rise. Current state funding sources and incentives are limited and are not likely to be a leading instrument in executing this option. Funding programs and policies must be increased to be comparable with land values for development in order to be effective.

The state should develop and implement a package of appropriate regulations, financial incentives, and educational, outreach, and enforcement approaches to retain and expand forests and wetlands in areas suitable for long-term survival. Select targets may include the following:

- expanding priorities for existing land conservation to promote horizontal marsh migration or vertical accretion, where feasible;
- expanding financial incentives that encourage private forest and waterfront and riparian landowners to favor the retention of forests and other native habitats over development and conversion;
- managing forests and wetlands to enhance ecological services and storm impact reduction benefits;



Bhaskaran Subramanian.

'Living shorelines' involve using non-structural shoreline stabilization measures. Living shorelines provide erosion control benefits while also enhancing the natural shoreline habitat. They often allow for natural coastal processes to remain through the strategic placement of plants, stone, sand fill, and other structural and organic materials.

- identifying and developing programs to enhance and protect wildlife corridors and maintain connectivity of green forest core areas across the landscape; and
- achieving other land use goals.

Implementation

Implementation of this policy recommendation is tied to the process of identifying Natural Resource Protection Areas as outlined in the previous recommendation. In the interim period, the lead agencies, DNR and MDE, will work together to review existing programs and funding across all state, federal,

Table 1. Forests and wetlands of Dorchester County that will be lost in 25 and 50 years with sea-level rise rates of one and three feet per century.[9]

AREA INUNDATED BY SEA-LEVEL RISE OF ONE FOOT PER CENTURY (CURRENT RATE)					
		After 25 years		After 50 years	
	Current acreage	*Inundated*	*% loss*	*Inundated*	*% loss*
Forest	118,717	1,679	1.4%	4,943	4.2%
Wetlands	91,002	7,035	7.7%	18,164	20.0%
AREA INUNDATED BY SEA-LEVEL RISE OF THREE FEET PER CENTURY					
		After 25 years		After 50 years	
	Current acreage	*Inundated*	*% loss*	*Inundated*	*% loss*
Forest	118,717	8,737	7.4%	24,933	21.0%
Wetlands	91,002	29,314	32.2%	59,708	65.6%

and county agencies that can be focused on addressing both adaptation and mitigation options related to sea-level rise and carbon sequestration. Phase 1 of the implementation plan will be to use the initial results of the Natural Resource Protection Area assessment to target existing programs to high priority areas. Phase 2 will entail the identification of new policies, programs, regulations, and financial incentives that are needed to advance forest and wetland protection efforts. Phase 2 will be completed within a two-year timeframe and be followed by the development of new/revised state and local policy and regulation, as necessary.

Shoreline and buffer area management: Promote and support sustainable shoreline and buffer area management practices.

Shoreline management is facilitated through a network of programs housed in the Maryland Departments of the Environment (MDE) and Natural Resources (DNR) and also through local government Critical Area and erosion and sediment control activities. Involvement among these partners varies with respect to agency mandate, jurisdictional boundaries, and level of activity, whether through regulation, technical assistance, or project implementation. In light of the fact that problems associated with erosion will heighten as a result of sea-level rise, there is a need to more comprehensively address shore erosion management from a state-wide perspective.



Town of Ocean City Tourism Office.

Natural resources such as seafood are an essential part of Maryland's culture and economy.

Passage of the Living Shorelines Protection Act of 2008—which requires the use of non-structural, 'living shoreline' shoreline stabilization measures that preserve the natural environment, except in areas mapped by the state as being appropriate for structural stabilization measures—and the strengthened provisions of the Chesapeake and Atlantic Coastal Bays Critical Area Protection Program in 2008 were huge steps in the direction of sustainable shoreline and buffer area management. Implementing the statutory changes of these two bills passed during the 2008 General Assembly will be the initial step in executing a comprehensive approach to shoreline management planning. Additional targets include the following:

- Reorient DNR's Shoreline Conservation and Management Program to promote the installation of innovative shore protection techniques that maximize habitat restoration and enhancement and accommodate for projected sea-level rise.
- Develop a general permit that streamlines the rebuilding process of storm-damaged tidal marshes, including the placement of additional clean sandy fill, plants, and temporary, biodegradable structures to protect rebuilt areas.
- Direct a joint effort of state agencies to standardize design and construction methods and protocols employed for new, retrofitted, or replacement shore erosion control structures that consider climate adaptive strategies for coastal environments subject to sea-level rise, erosion, and storm hazards.
- Integrate mapping and modeling products into state and local planning and implementation efforts.
- Update the Maryland Comprehensive Shoreline Inventory to include type and quantity, location, and conditions of shore erosion control structures on a routine basis, possibly every 5–10 years.
- Expand current outreach and educational programs directed at the public and marine contracting professionals to help ensure a smooth transition toward broader implementation of non-structural and hybrid techniques.

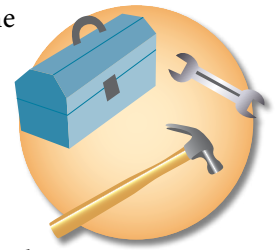
Implementation

Several state agencies, including DNR and MDE, are already undertaking efforts or implementing programs that are consistent with the goals of

this policy option. Specifically, DNR and MDE are currently working together to implement regulatory components of the Living Shoreline Protection Act of 2008, as well as the strengthened provisions of the Chesapeake and Atlantic Coastal Bays Critical Area Protection Program. For those elements of this policy option not related to those two pieces of legislation, DNR and MDE will start working together immediately to initiate implementation. A final implementation plan will be developed by DNR and MDE and be presented to the MCCC at its Spring 2009 meeting.

ADAPTATION AND RESPONSE TOOLBOX

Give state and local governments the right tools to anticipate and plan for sea-level rise and climate change



Over the last 10 years, the State of Maryland has made significant progress acquiring new technology and data, including state-wide high resolution topographic data (as depicted in Figure 15), and has utilized these data to undertake state-of-the-art sea-level rise mapping and research. The state has also been proactively working with select state agencies and coastal counties to provide the necessary funding and technical assistance to build capacity to integrate data and mapping efforts into decision-making processes and to identify specific opportunities, such as statutory changes, code changes, or comprehensive plan amendments, that will advance climate change and sea-level rise adaptation planning. These efforts have made Maryland a national leader in sea-level rise modeling, research, and response planning.

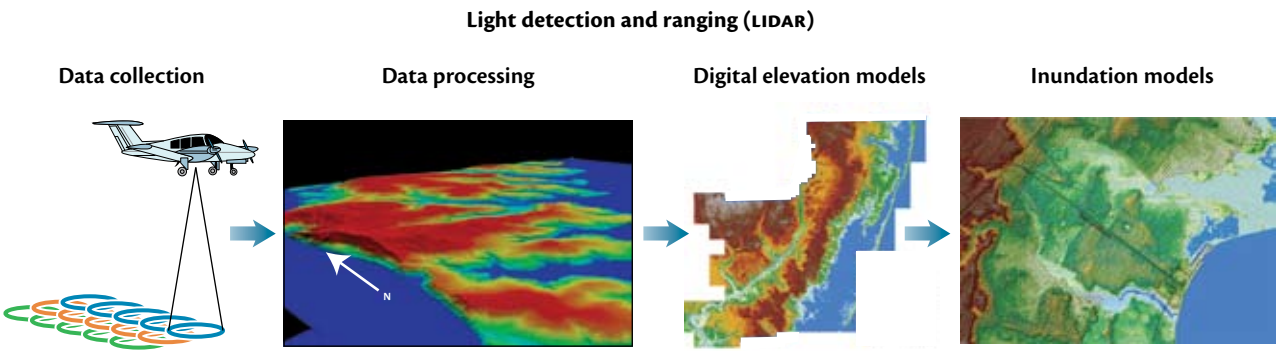
A continued commitment on the part of both state and local governments is still essential

To adequately plan and respond to sea-level rise, it is imperative that both state and local governments have access to the right tools at the right time. Maryland is well on its way to providing the tools, technical resources, and educational programs; however, a continued commitment on the part of both state and local governments is still essential.

Integrated observation systems: 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.

The State of Maryland relies heavily on information obtained from existing federal, state, local, and regional integrated observation systems located throughout the Mid-Atlantic region to support ongoing sea-level rise adaptation and response planning efforts. Information and data gathered from observational networks is also used to evaluate and measure the effectiveness of related coastal resource management and restoration programs. There is a need, however, to strengthen and better integrate a number of the system components already in place within natural and urban settings to detect biological, physical, and chemical changes and responses due to direct and indirect effects of climate change. The state should focus its efforts on the following targets to strengthen and enhance integrated observation systems:

- Enhance federal, state, local, and regional integration and coordination of observation systems that detect trends in coastal water levels, elevation and/or subsidence, shoreline change, wetland loss, and tidal influence on estuaries and water supplies.
- Assess the suitability of vertically controlled tide gauges and investigate the feasibility of installing additional tide gauges in particular locations.
- Investigate the need for the installation of additional surveillance equipment in coastal areas where current public and private infrastructure is potentially vulnerable to small increases in sea level.



Maryland Department of Natural Resources.

Figure 15. LIDAR is a method of collecting and processing high-resolution elevation data to inform models and predictions of flooding and inundation.

- Assess the adequacy of Surface Elevation Tables (Figure 16) to measure whether marsh accretion is keeping pace with erosion/inundation and examine opportunities to add more Tables in select locations.
- Observe and record changes for a set of leading indicators of specific climate change impacts. This should include indicators that are representative of specific geographic ranges, behaviors, or population characteristics of certain species, including plants, birds, mammals, and insects, that are known to be sensitive to sea-level rise and other climatic changes.
- Enhance the utilization of the Maryland Geological Survey Groundwater Quality Network to conduct well water quality assessments in areas where saline intrusion adjacent to tidal waters is known to occur.
- Evaluate the need to expand the Maryland Geological Survey Subsidence Studies Program to assess the risk of elevation declines due to groundwater withdrawals, which would exacerbate any impacts of sea-level rise.

Implementation

A number of federal, state, and local government partners are already working to undertake efforts or are implementing programs that are consistent with the goals of this policy recommendation. DNR will work with these agencies to inform them of the *Climate Action Plan* recommendations and, where possible, work to partner on implementation of specific components. Implementation of several components can be undertaken immediately. For those that cannot, DNR will work with specific partners, including the Maryland State Geographic Information Committee, to develop an implementation plan for presentation to the MCCC at its Spring 2009 meeting.



Maryland Department of Natural Resources/Maryland National Estuarine Research Reserve/Patricia Delgado.

Figure 16. Surface Elevation Table established at the Jug Bay freshwater tidal marsh to measure sediment elevation.

GIS mapping, modeling, and monitoring: Update and maintain state-wide sea-level rise mapping, modeling, and monitoring products.

The effectiveness risk and vulnerability reduction strategies will depend on state and local access to high-quality information about climate change, sea-level rise, and their related risks. Maryland's state agencies have been aggressively acquiring and analyzing various data and technological resources to both gain a better understanding of sea-level rise vulnerability and increase state and local government capacity to adapt and respond. One of these products was the Worcester County Sea-Level Rise Inundation Model, developed cooperatively between DNR, the U.S. Geological Survey, and Worcester County in 2004. Outputs from the model are shown in Figures 17 (Ocean Pines) and 18 (Public Landing). However, more work in the following areas is needed to complete state-wide sea-level rise modeling and develop mapping and monitoring products to support both state and local sea-level rise planning efforts:

- Utilize Maryland iMap, an internet-based interactive map currently under development for use by state agencies, local governments, and the public, to house and display existing and future sea-level rise data and spatially based information.
- Complete state-wide sea-level rise inundation and storm surge modeling at a scale appropriate for both state and local planning.
- Adopt a production and maintenance schedule for mapping and modeling activities including the data necessary for both activities. This schedule should include anticipated costs, financing options, data sources, and increasing the accuracy of predicted results.
- Review institutional and organizational data management practices and make

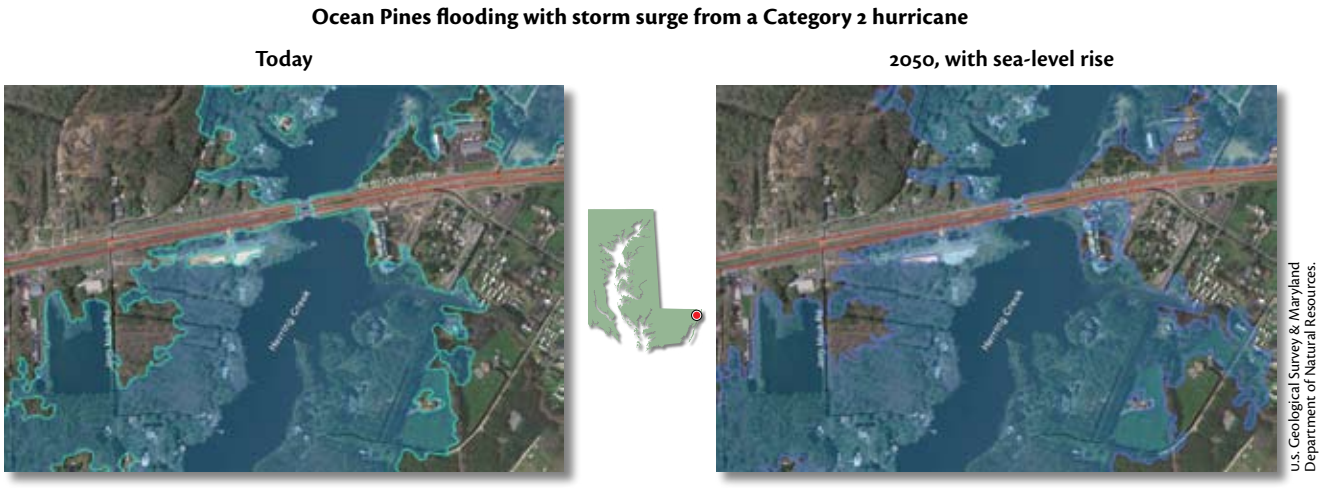


Figure 17. Areas of Ocean Pines that would be flooded by 1.5 m (4.9 ft) storm surge from a Category 2 hurricane today (left) and in 2050 after sea-level rise of 15 cm (0.5 ft), which is the current rate of sea-level rise (right).[10] However, the rate of sea-level rise is projected to increase above the current rate in the future, so this map likely underestimates the extent of flooding in 2050.

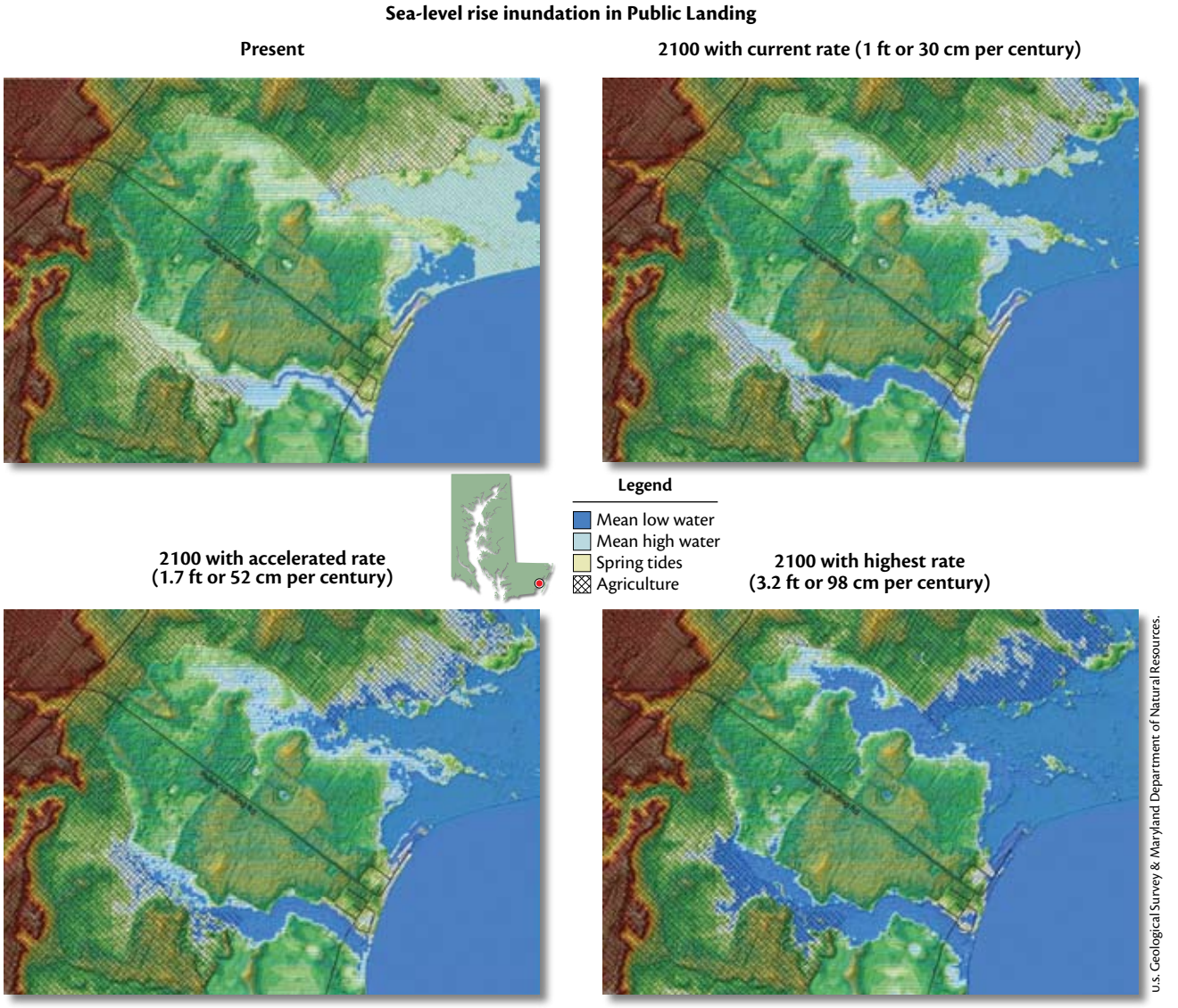


Figure 18. Areas of Public Landing that would be inundated by 2100 under various sea-level rise scenarios.[10] Data and maps such as these are important for visualizing and understanding potential impacts. Note that the highest rate (3.2 ft per century) is the maximum rate considered here, but is less than the maximum possible rate reported in the scientific literature.

recommendations to enhance efficiency and cost-effectiveness of data gathering, sharing, maintenance, and processing efforts and to minimize duplication of effort and data and modeling redundancies.
- Create a digital, spatial inventory of infrastructure potentially impacted by sea-level rise, including the identification of public and private systems and facilities and threatened historical structures. This database should be maintained relative to sea-level rise projections and scenarios.
- Utilize GIS systems to model and monitor specific 'leading indicators' of climate change impacts.
- Encourage federal agencies to factor climate change and sea-level rise risk into NFIP floodplain mapping efforts.

Implementation

A number of federal, state, and local government partners are already working together to undertake efforts and/or implementing programs that are consistent with the goals of this policy option. Specifically, DNR is currently working to facilitate the use of Maryland iMap to house and display spatially-based information, including existing and future sea-level rise data. Using existing communication lines and working relationships with local governments, MDP and DNR will ensure access and delivery of all relevant climate change planning data needed for land use planning efforts. For those elements of this policy option that cannot be implemented immediately, DNR will work together with other partners to develop an implementation plan for presentation to the MCCC at its Spring 2009 meeting. This implementation plan will include a schedule and the estimated cost for completing state-wide sea-level rise inundation and storm surge modeling at a scale appropriate for both state and local planning.

Public awareness, outreach, training, and capacity building: Utilize new and existing educational, outreach, training, and capacity building programs to disseminate information and resources related to climate change and sea-level rise.

Sea-level rise and increases in the intensity of flooding and storm surge are expected to have complex and far-reaching consequences for Maryland's residents, businesses and trades, and local governments. Better preparation, through the modification of existing law and policy and the implementation of new strategies and policies, will reduce the impacts experienced. There is a significant need, however, to increase public awareness of the risks and appropriate responses among those responsible for preparation and response, as well as those likely to be affected, including the media and non-governmental organizations.

Two key sets of activities to improve targeted public awareness, outreach, training, and capacity building have been identified: 1) development of coordinated and cohesive communication messaging, and 2) effective distribution of the messaging to a wide variety of people and professions across all levels of government, sectors, and organizations. Of particular concern is the development of communication plans to reach low-income and under-served populations. Implementation of the following targets will increase the ability of residents, businesses, and local governments to understand the potential climate change risks, gather the information necessary to make informed decisions, and to work with partners to identify solutions.

- Work with Public Information Officers of relevant federal, state, and local agencies to develop a communication framework and to ensure clear, consistent, and cohesive messaging.
- Identify and engage all licensing, training, and capacity-building programs that currently exist in areas at serious risk from sea-level rise and extreme storm events.
- Target educational, outreach, training, and capacity building to specifically address the needs of low-income and under-served populations.
- Develop specific educational programs to achieve the following:
  - Inform the public of appropriate behavior before, during, and following extreme storm events.
  - Increase awareness of the risks of vector- and water-borne diseases in a warmer climate.
  - Inform private landowners of the availability of applicable wetland and forest protection programs.
  - Train marine contractors on the design and installation of 'living shoreline' shore erosion control practices.
  - Educate local elected officials about climate change and sea-level rise dynamics and

what local governments can do to promote adaptation and response planning.

- Create greater public awareness of the integral relationship between Chesapeake Bay restoration actions and climate change and sea-level rise adaptation and response activities.

Implementation

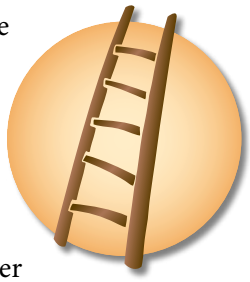
DNR's Coastal Training Program and its Chesapeake and Coastal Program will coordinate agency efforts to implement this policy recommendation. These Programs will coordinate implementation with the MWG's Education and Outreach Work Group (See MWG Policy Option CC-5). For those elements of this policy option that cannot be implemented immediately, DNR will work together with the Education and Outreach Work Group and other agency partners to develop an implementation plan for presentation to the MCCC at its Spring 2009 meeting.



In 2006, the Maryland Chesapeake and Coastal Program worked with Maryland Sea Grant to develop four Coastal Hazard Public Outreach Panels to promote public awareness on the impacts of sea-level rise, coastal erosion, storms, and coastal flooding to coastal communities around the state. The panels are displayed in tourist access areas throughout the Maryland portions of Chesapeake Bay.

FUTURE STEPS AND DIRECTION

State and local governments must commit resources and time to assure progress



Planning for climate change and sea-level rise is extremely complex—there are many potential impacts and no single remedy. While climate change and sea-level rise are both gradual processes occurring slowly over time, the impacts of both are already being detected. Maryland's state and local governments must take specific action now to plan for inevitable impacts. The recommendations laid out in this report are intended to guide adaptation activities over the next five years and along the way, Maryland's state and local governments must measure and track progress, keeping in mind that many of the implementation strategies must be adaptable to change. Progress will take time, fiscal resources, flexibility, and continual commitment.

Local government planning guidance: Develop state-wide sea-level rise planning guidance to advise adaptation and response planning at the local level.

The ARWG identified a specific need to improve the capacity of local governments to plan for and adapt to sea-level rise, and where that capacity does not currently exist, to develop guidance to assist with identifying specific measures, such as local land use regulations and ordinances, to adapt to sea-level rise and increasing coastal hazards.

Written guidance should be developed to address the following four phases of sea-level rise response planning: 1) vulnerability and impact assessment; 2) long-range and comprehensive planning; 3) code, regulation, and development standards; and 4) public education and outreach. The guidance should specifically lay out the process, methodology, including draft language, and a proposed timeline for incorporating sea-level rise and coastal hazard response planning into local planning processes and frameworks. It should also provide recommendations for sequencing and integrating the four planning phases and identify financial and technical assistance needs.

Implementation

DNR is already working to support the needs identified in this policy recommendation. DNR's Chesapeake and Coastal Program is currently providing funding to Dorchester, Somerset, and Worcester Counties to develop written sea-level rise planning guidance. Following completion of these projects in September 2008, DNR, MDP, and MDE, and other state agencies as appropriate, will work together to develop the state-wide local government sea-level rise adaptation and response planning guidance. Implementation will be coordinated with the development of the written guidance for the Sea-Level Rise Elements of comprehensive plans. It is projected that completion of this project will take two years.

Progress will take time, fiscal resources, flexibility, and continual commitment

Adaptation-Stat: Develop and implement a system of performance measures to track Maryland's success at reducing its vulnerability to climate change and sea-level rise.

Maryland's state agencies with programs, policies, or activities affected by issues related to sea-level rise should immediately begin to review and respond to the recommendations contained in the *Climate Action Plan*. Specifically, respective agencies should report on how these issues and recommendations affect their missions and programs, provide action plans for integrating relevant issues into their

BayStat is a powerful new state-wide tool created by Governor Martin O'Malley in February 2007 to assess, coordinate, and target Maryland's Bay restoration programs and inform our citizens on progress. BayStat allows Maryland state agencies to work more effectively by coordinating efforts and programs, basing decisions on the best available science, targeting resources to get the biggest 'bang for the buck', and to be more open and accountable to Maryland citizens.

planning programs and activities, and participate in the development of performance measures.

Performance measures should be reported annually to track process and progress in adaptation to sea-level rise and associated hazards. In their initial evaluation report, agencies should consider opportunities for integration with existing programs, new programmatic efforts, and barriers to response. Topics for evaluation programs, policies, standards, and activities include: engineering, design, and construction; siting and planning; funding; coastal zone management activities, including permitting of shoreline activities and monitoring; staff training programs; and educational and outreach programs.

Implementation

The MCCC Executive Order calls for annual reporting on the *Climate Action Plan* to the Governor and General Assembly on or before November 1 of each year, including an update on implementation timetables and benchmarks. Adaptation and response performance measures will be a component of this reporting requirement. Additionally, performance measures will be implemented through BayStat and/or StateStat, powerful new statewide tools, created by Governor Martin O'Malley to make Maryland state government more accountable and efficient and to assess, coordinate, and target Maryland's Bay restoration programs. DNR and MDE will work together to implement this policy recommendation.

Future adaptation strategy development: 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.

The MCCC should continue to evaluate adaptation strategies in addition to sea-level rise and coastal vulnerability over the next year and beyond. The sector-based impact and issue assessments provided by the STWG (see Chapter 2) will serve as a useful basis for evaluation of adaptation strategies appropriate for Maryland in the areas of human health, water resources, forest management, and the restoration of the Chesapeake and Atlantic Coastal Bays.

Implementation

Phase II of the *Comprehensive Strategy to Reduce Maryland's Vulnerability to Climate Change* should be initiated within one year. Sector-based working groups, comprised of a broad array of stakeholders and issue experts, will be necessary to fulfill this task.

Chairs of the ARWG and STWG will begin working immediately to develop a more detailed implementation plan for development of Phase II and will present the plan to the Commission for its consideration at its Spring 2009 meeting.

ENDNOTES

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