



# 2018 ANNUAL REPORT

Maryland Commission  
on Climate Change

Prepared for:

Larry Hogan, Governor  
State of Maryland

and the Maryland General Assembly





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## EXECUTIVE SUMMARY

*A heightened sense of urgency is needed to build upon Maryland's impressive and steady progress on climate change, given the latest scientific information and policy challenges at the national level. The State continues to reduce greenhouse gas emissions, transition to cleaner and healthier environmental solutions, increase local resiliency and preparedness, and improve scientific understanding and public awareness. However, more emphasis is now needed for finding additional, bold innovations in energy, transportation, agriculture, and natural resources management, that will allow Maryland to meet its climate goals while ensuring positive impacts to jobs and the economy, and advance our shared commitment to public health and equity.*

The climate of a region is defined by its long-term average temperature and precipitation trends, which shape many of the physical, chemical, and biological components of ecosystems as they develop. Significant and rapid changes in the climate, therefore, are expected to have pervasive and in some cases devastating impacts to ecosystems, and consequently to the resources and services upon which humans rely {[Ch1.1](#)}. The body of scientific evidence for global climate change is both clear and growing, and has demonstrated with a high degree of certainty that the dominant cause is human activity, particularly the emission of heat-trapping greenhouse gases (GHGs) into the atmosphere {[Ch1.1](#)}.

Maryland is facing a wide variety of consequences from climate change, such as:

- A climate that is trending warmer and wetter, with an increased frequency of summer heat waves and winter/spring precipitation {[Ch 2.1](#)}
- Impacts to our ecosystems, from the Chesapeake Bay to the Appalachian Mountains {[Ch 2.1.1](#)}
- Damage to coastal and inland infrastructure from sea-level rise, storm surge, and heavy rain events {[Ch 2.1.2](#)}
- Climate-driven stressors in agriculture, fisheries and forestry that negatively impact productivity and yields {[Ch 2.2.1](#)}
- Direct and indirect public health impacts from extreme heat and precipitation; changes to air and water quality; and threats to food and energy security {[Ch 2.3](#)}
- Differing experiences of these impacts among Marylanders due to regional and socioeconomic variance {[Ch 2.3.4](#)}

Actions taken now to mitigate greenhouse gas emissions and adapt to the consequences of climate change are integral to the ultimate outcome - to the severity of the risks that Marylanders are exposed to. That is why Maryland is proud to have always been a leader in tackling climate change. Though far from the first steps taken, key reduction goals were established in the Greenhouse Gas Emissions Reduction Acts (GGRA) of 2009 and 2016. Through these acts, Maryland is implementing its multifaceted plan to reduce our GHG emissions 25 percent from 2006 levels by 2020 {[Ch 3.2](#)}; and developing an updated version to achieve or exceed the next benchmark of a 40 percent reduction by 2030 {[Ch 3.4](#)}.

Even as the State moves forward with actions that will reduce GHGs, some consequences of climate change are already underway and will still be realized in the future. Maryland is working to adapt to the anticipated impacts and reduce its climate change vulnerability through both short- and long-term efforts. In 2017 and 2018, significant progress has been made addressing a broad range of issues, including: public health; transportation system risk assessments; and incorporation of resilience in restoration practices and coastal and nuisance flooding [{Ch 3.3}](#).

The Maryland Commission on Climate Change, initially established in 2007, has played a fundamental role in Maryland's efforts to combat climate change, beginning with its 2008 Climate Action Plan that catalyzed the 2009 GGRA [{Ch 1.2}](#). Right now, one of the most significant roles of The Commission is to serve in an advisory capacity to the Maryland Department of Environment and other State entities as they work to develop the 40 by 30 Plan required by the updated 2016 GGRA [{Ch 3.1}](#); [Ch 3.5](#). This role will continue through 2019, following the release of the draft plan, as the final plan is refined and completed at the end of next year.

Over the course of 2018, the Commission's working groups undertook diverse efforts, not only developing but also actively implementing programs and engaging in activities in pursuit of their particular charges. They also conducted discussions related to new or evolving approaches to enhance Maryland's plans for mitigation of and/or adaptation to the impacts of climate change. The working groups spent a significant amount of time hearing from experts on and discussing a number of issues, including: the impact of climate change on the Chesapeake Bay TMDL, the insurance industry, public health, coastal construction, labor and manufacturing, and the agricultural community; updated estimates for sea-level rise; potential GHG reduction benefits from carbon markets, forest and soil management, natural gas fuel conversion, and transportation initiatives; and education/outreach efforts such as green jobs training and the Climate Leadership Academy. The working groups each developed a set of recommendations informed and shaped by these proceedings, and the Commission has chosen to highlight a number of them, which can be found in the final chapter of this report [{Ch 4.1}](#). The working group reports which contain their complete recommendations are additionally included in this chapter [{Ch 4.2}](#). Furthermore, a minority report has been prepared by several members. It includes specific additional recommendations, distinct from those presented by the full Commission in this report. The Commission looks forward to working with the authors of the minority report on these potential recommendations, and has requested that the emission reduction, job creation, and economic analyses that were used to develop each recommendation be shared with other Commission members and the Commission's working groups. The Commission will incorporate the discussions required to fully address these recommendations in the upcoming 2019 working group work plans.

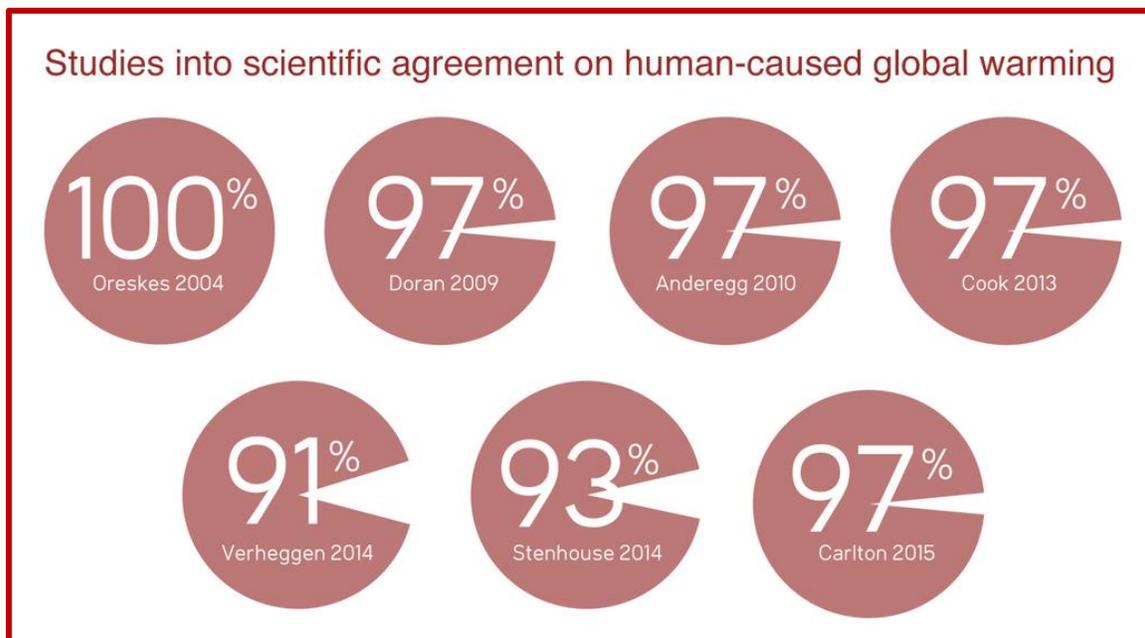
Public involvement is also crucial to the Commission process, especially as work is ongoing in 2019 to refine and finalize the Maryland Department of the Environment's MDE's draft 40 by 30 Plan, due December 31. Stakeholders and members of the public are encouraged to share their thoughts with the Commission expeditiously, to allow ample time for review and consideration, and are welcome to attend meetings of the Commission and its working groups. Meeting information for the Commission and its working groups is posted at [mde.maryland.gov/MCCC](http://mde.maryland.gov/MCCC). Specific stakeholder meetings will also be held throughout 2019 as part of the 40 by 30 draft plan process, and meeting information will be posted on the Air Quality Planning website, at <http://www.mde.state.md.us/programs/Air/AirQualityPlanning/Pages/index.aspx>. Written comments related to the Maryland Commission on Climate Change, its Working Groups, or the GGRA Draft Plan can be sent to [climate.change@maryland.gov](mailto:climate.change@maryland.gov), or mailed to Maryland Department of the Environment, 1800 Washington Blvd, Baltimore, MD 21230.

# 1

## INTRODUCTION

### 1.1 The Science of Climate Change

In its previous reports, beginning in 2008 and continuing through its 2017 Annual Report, the Maryland Commission on Climate Change (“the MCCC”, or “the Commission”) has relied upon the latest and most widely accepted science to guide its evaluations and recommendations. The body of scientific evidence for global climate change is both clear and growing, and has demonstrated with a very high degree of certainty that the dominant cause is human activity [1, 2, 3, 4], particularly the emission of heat-trapping greenhouse gases (GHGs) into the atmosphere [2, 3, 5, 6, 7, 8, 9]. Anthropogenic GHG emissions (including carbon dioxide, methane, and nitrous oxide) have increased considerably since the pre-industrial era, and are currently found at atmospheric concentrations “unprecedented in at least the last 800,000 years” [1]. The Intergovernmental Panel on Climate Change (IPCC) has concluded that human drivers, including GHG emissions, are “extremely likely to have been the dominant cause of the observed warming since the mid-20th century” [1]; recently estimating that human activities have already<sup>1</sup> contributed approximately 1 °C of global warming above pre-industrial levels [10]. Furthermore, experts agree that there is no convincing evidence that natural cycles and variability alone can account for the changes observed over the industrial era [9, 11]. Statements affirming the occurrence, danger, and anthropogenic nature of climate change have been issued by many reputable U.S. scientific organizations and national science academies [12, 5, 13, 7, 14, 15, 16, 8, 17]; and the consensus among experts in the scientific community continues to be reinforced (Figure 1) [18].



**Figure 1.** Expert consensus results among previous studies, published by Cook et al. (2016). Graphic by Skeptical Science, color altered.

<sup>1</sup> From the IPCC Special Report, *Global Warming of 1.5°C*, “‘Present level of global warming’ is defined as the average of a 30-year period centered on 2017, assuming the recent rate of warming continues”.

The climate of a region is defined by its long-term average temperature and precipitation trends [19], which shape many of the physical, chemical, and biological components of ecosystems as they develop. Significant and rapid changes in the climate, therefore, are expected to have pervasive and in some cases devastating impacts to ecosystems, and consequently to the resources and services upon which humans rely. While both eco- and human systems have a certain capacity to adapt to change, these mechanisms operate most effectively over a much longer time scale and may have limited success at the unprecedented speed at which effects are currently progressing. Continuation of society down a “business as usual” path will increase the likelihood and severity of potentially irreversible impacts to the global ecosystems and interconnected human systems [1, 10].

Yet, as very active modifiers of the environment, humans also have the ability to affect the outcome. Actions taken at this time are still capable of lessening the damage of future impacts, while delayed action or inaction will lead to more severe impacts [1, 9, 10]. In October, the IPCC released a special report<sup>2</sup> stating that “future climate-related risks depend on the rate, peak and duration of warming”, emphasizing significantly increasing risks at 1.5 °C and further at 2 °C. The report also notes that future risk can be reduced through considerable multi-sectoral mitigation efforts along with adaptation

### Resiliency and Thresholds

Many of the most fundamental aspects of both ecosystems and human systems have evolved based on a climate which had, until recently, been changing relatively slowly throughout Earth’s history. More rapid changes in temperature and precipitation patterns (and the resulting impacts) can be tolerated only within a certain range, based on the resiliency of a given system. Once this threshold is surpassed, the effects are irreversible and may be devastating to the environment, the economy, and human health.

measures [10]. The U.S. Global Change Research Program’s (USGCRP) 2017 *Climate Science Special Report* similarly concluded that significant reductions in GHG emissions are required to potentially maintain the rise in temperature to 2 °C or less [9]. Though the specifics in timing and magnitude may be uncertain due to basis in a wide range of variables, an urgent response is clearly crucial to minimizing both the costs and risks of climate change [6, 13, 10]. As with any major adjustments, delaying action is expected to necessitate changes that are more dramatic and economically disruptive.

In order to limit the temperature increase to a 2 °C threshold, the IPCC originally calculated that global GHG emissions must be reduced by 40 to 70 percent from 2010 levels by 2050, and further to near or below zero in 2100 [1]. When making their recommendations in 2015, the Maryland Commission

on Climate Change noted that, because these reduction goals were global and the U.S. has far greater per capita emissions than all but a few nations in the world, the U.S. emissions must be reduced at least to the upper end of the range in order to constitute an effective contribution [2]. That trajectory of emissions reductions informed the recommendation of the MCCC that Maryland should adopt a goal and develop a plan to reduce its emissions by 40 percent from 2006 levels by 2030, which in turn provided the basis of the Greenhouse Gas Emissions Reduction Act (GGRA) of 2016. In October 2018, the IPCC released a special report with updates stating that modeled pathways which provide a 66% probability of staying under the 2 °C threshold have global emissions declining by 20% by 2030 (from a 2010 baseline) and reaching net zero by 2075 [10]. This tracks well with Maryland’s existing goals, both

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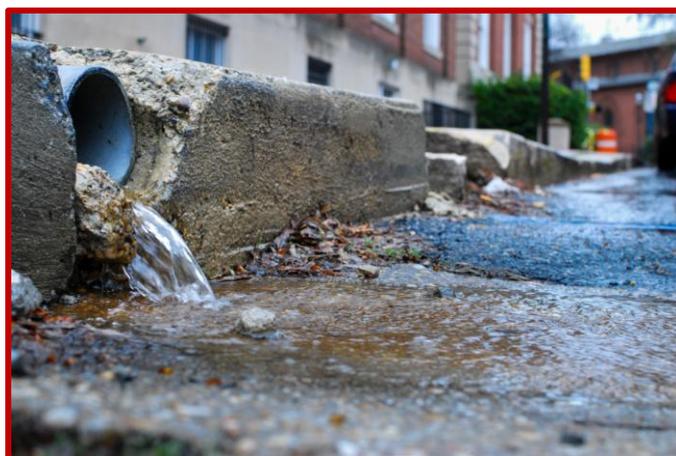
<sup>2</sup> All references are to the approved but copyedit pending version of the “Summary for Policymakers” which was available at the time this report was being written. The individual chapters of the IPCC SR1.5 were available only as final government drafts, not able to be cited, quoted, or distributed.

short and long-term. The report also provided estimates for the more ambitious 1.5°C pathway to further reduce risks from future climate impacts, proposing 45% reductions by 2030 and net zero near 2050, which are more aggressive than Maryland’s existing goal.

Our international obligation to contribute to global mitigation efforts should also result in a net benefit nationally. A 2015 report of the Climate Change Impacts and Risk Analysis project estimated that mitigating action would result in significant avoided costs for the U.S. – both human and economic. For example, global mitigation (compared to a business-as-usual scenario) was projected to avoid 12,000 deaths per year associated with extreme temperature events by the year 2100; save \$4.2 to \$7.4 billion on avoided road maintenance; avoid the loss of 230,000 to 360,000 acres of coldwater fish habitat; and reduce the predicted damages from sea-level rise through 2100 from \$5 trillion to \$810 billion [20].

Although successful mitigation can greatly reduce the risk of climate impacts, it will not eliminate the impacts completely. Some changes are already underway, and the response of the environment to the current levels of anthropogenic GHG emissions is still being realized [1, 21, 22, 9, 10]; therefore, adaptation is required. As noted in the USGCRP *Climate Science Special Report*, “thousands of studies conducted by tens of thousands of scientists around the world have documented changes in surface, atmospheric, and oceanic temperatures; melting glaciers; disappearing snow cover; shrinking sea ice; rising sea level; and an increase in atmospheric water vapor. Rainfall patterns and storms are changing, and the occurrence of droughts is shifting” [9]. In the Northeastern U.S., the rate of sea-level rise already observed is greater than the global average, having increased about one foot since 1990 (average is 8 inches) [23], likely due to increased

Greenland ice loss as well as changes in regional currents and land subsidence [24, 25, 20]. The MCCC’s *2016 Annual Report* provided probabilistic projections of future sea level under scenarios of aggressively restrained and unrestrained GHG emissions, and the Scientific and Technical Working Group is currently working on finalizing their estimates of relative sea-level rise in Maryland over the next century {[Ch 4.2.4](#)}. The annual average temperature in the Northeastern U.S. increased at a rate of approximately 0.16 degrees Fahrenheit (°F) per decade between 1895 and 2011, with seasonal increases ranging from a rate of 0.11 °F per decade in the summer to 0.24 °F per decade in the winter [26]. Maryland has closely followed this regional trend, with a total increase in annual average temperature of 1.5 °F since the beginning of the 20th century, and a winter warming trend reflected in the average of less than one day per year of nights below 0 °F since the mid 1990’s, as compared to an average of two nights per year between 1950 and 1994 [27]. Annual precipitation, though more variable, increased by approximately 0.39 inches per decade in the Northeast during this same time [26], with Maryland’s annual mean precipitation having been above average for the past two decades. The climate in this region is generally expected to continue trending warmer and wetter over the next century, accompanied by an increase in extreme heat waves and precipitation events [20, 27].



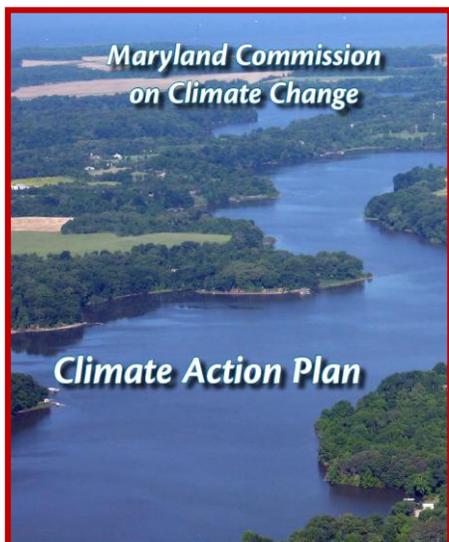
**Photo 1.** Stormwater flows onto a street in Annapolis, MD.  
[Photo by Matt Rath/Chesapeake Bay Program]

These consequences to the physical systems reverberate through biological and human systems, the three of which have co-evolved to exist under current conditions. A thorough understanding of the ramifications which accompany unmitigated climate change, as well as the complexity of costs and benefits (economic, environmental and human) associated with climate action, is essential to the core function of the Maryland Commission on Climate Change. The scientific community is constantly strengthening the models and projections for various emission-reduction scenarios, providing the Commission with increasingly detailed information on which to base its policy and program recommendations. It is the ongoing endeavor of the Commission and its working groups to ensure that Maryland is utilizing the best science available in order to move forward with progress on limiting climate change (or mitigation) and adapting to the changes that do occur, keeping open lines of communication in both directions with the residents of Maryland.

## 1.2 History and Structure of the Commission

Maryland has historically been at the forefront of states taking action to address both the drivers and consequences of climate change, as demonstrated by the State's policy record. Maryland has consistently advanced efforts to combat climate change with legislation and policy initiatives over the past decades. These include, but are not limited to:

- Development of A Sea-level Rise Response Strategy for Maryland in 2000
- Creation of and updates to Maryland's Renewable Portfolio Standard, starting in 2004
- Passage of the Healthy Air Act of 2006
- Passage of and update to the Clean Cars Act (2007 and 2017)
- Participation in the Regional Greenhouse Gas Initiative (2007 to present)
- Creation of the Coast Smart Council and Bay Acidification Task Force in 2014
- Passage and reauthorization of the Greenhouse Gas Emissions Reduction Act (2009 and 2016)
- Passage of the Healthy Soils Act in 2017
- Participation in the U.S. Climate Alliance starting in 2018



**Photo 2.** Cover of the *Climate Action Plan* produced by the MCCC in 2008.

In 2007, the Maryland Commission on Climate Change was established by Executive Order (01.01.2007.07) and charged with developing an action plan and firm timetable for mitigation of and adaptation to the likely consequences and impacts of climate change in Maryland, including strategies to reduce Maryland's GHG emissions to 1990 levels by 2020 and 80 percent of 2006 levels by 2050. As a result of the work of more than 100 stakeholders and experts, the MCCC produced a climate action plan which was the catalyst for the GGRA of 2009. In 2014, a second Executive Order (01.01.2014.14) expanded the scope of the MCCC and its membership to include non-state government participants.

During its 2015 session, the Maryland General Assembly codified the MCCC into law, refining and enhancing its membership, working groups, and responsibilities ([Appendix C](#)). The main charge of the Commission is to "advise the Governor and General Assembly on ways to mitigate the causes of, prepare for, and adapt to the consequences of climate change". It is chaired by Maryland Department of the Environment (MDE)

Secretary Ben Grumbles and consists of 26 members representing State agencies and legislature, local government, business, environmental non-profit organizations, organized labor, philanthropic interests, and the State university system. The work of the Commission is supported by a Steering Committee and four working groups.

The members of the working groups are appointed by the Commission Chair, and embody both public and private interests in climate change. Members include representatives of academic institutions, renewable and traditional energy providers, environmental organizations, government agencies, labor organizations and business interests. The Greenhouse Gas Mitigation Working Group ('Mitigation Working Group', or MWG) focuses on regulatory, market-based and voluntary programs to reduce GHG emissions and increase sequestration capacity while supporting economic development and job creation. The Adaptation and Response Working Group (ARWG) is charged with developing a comprehensive strategy for reducing Maryland's climate change vulnerability, and providing state and local governments with tools to plan for and adapt to climate impacts such as extreme weather and sea-level rise. The Scientific and Technical Working Group (STWG) is responsible for updating and informing the MCCC on the science of climate change. The Education, Communication, and Outreach (ECO) Working Group (created by the 2015 law) assists with the Commission's public outreach and public meetings on climate change as well as educating Marylanders on what the State is doing to address its causes and impacts.

### 1.3 Report Overview

The Maryland Commission on Climate Change Act of 2015 ([Appendix C](#)) requires that the Commission issue a yearly report to the Governor and the General Assembly on the status of the State's efforts to mitigate the causes of, prepare for, and adapt to the consequences of climate change, including future plans and recommendations for legislation, if any, to be considered by the General Assembly. The first report, issued in 2015, provided background and recommendations on key challenges and opportunities related to the status of Maryland's response to climate change [28]. The 2016 and 2017 reports further developed this base, including updates on the science of climate change as well as climate policy and action, and examining potential and realized climate impacts to the State across various sectors [29].

This year's report is another step in what is expected to be a continual process as the State not only works to achieve a 25 percent reduction in GHG emissions by 2020 and 40 percent by 2030 (as mandated by the 2016 GGRA), but also moves toward the anticipated long-term goal of reducing GHG emissions by up to 90 percent from 2006 levels by 2050 (as noted in the original Act's legislative findings, and emphasized by the mandate for the State to develop its 2020 and 2030 plans in recognition of the 2015 IPCC finding that such reductions are needed in developed countries [30, 31]). The report builds on the information provided in previous Commission publications. It contains an update on the science of climate change; how it is already impacting Maryland's ecosystems, infrastructure, and socioeconomic framework; and how it is expected to impact the State in the future. It culminates in progress being made to address these projections and the State's goals at various points along the timeline, and the Commission's recommendations to the State agencies and other State entities to continue the path forward.

In order to protect the State’s economy, the local environment, and the health of Maryland’s citizens, it is crucial that the State maintain its aggressive course of both mitigation and adaptation actions. According to the IPCC, “effective adaptation and mitigation responses will depend on policies and measures across multiple scales: international, regional, national and sub-national” [1]. Adaptation within Maryland has a clear connection to reducing vulnerability and risk in Maryland, but mitigation efforts at the state level are not insignificant. Although it is true that eliminating all GHG emissions from Maryland tomorrow is not enough to mitigate climate change singularly, it is critical for Maryland to continue to do its part and lead by example in order to affect the ultimate transformation required. At the same time, the State must keep working to expand regional efforts to combat climate change. Climate change is a global problem, and Maryland’s programs and policies must be part of a larger climate action plan to be broadly effective at preventing many of the costs of unmitigated climate change to the State. The Commission recognizes that many other states and municipalities are making great strides in similar efforts, and hopes that Maryland’s proactive and economically balanced approach may serve as model to inspire additional action from neighboring states and beyond. With causes and consequences interwoven among nearly all sectors of state and inter-state economy and society, it is also clear to the Commission that national leadership will be imperative to ensure adequate and equitable progress into the future.



**Photo 3.** Young crabbers reflection, summer on the dock in Maryland. *[Photo by Christine Edwards]*



## 2

# STATE OF MARYLAND: PRESENT & FUTURE

The global climate system is complex, and a large number of variables interact to determine the eventual impact of expected changes to various segments of the natural and built environment. While not every individual change is necessarily harmful, the negative consequences of unmitigated climate change will far outweigh those select benefits [25]. The Climate Action Plan prepared by the Commission in 2008 included a *Comprehensive Assessment of Climate Change Impacts in Maryland*. This chapter updates and expands on that assessment in terms of key indicators of climate change currently being analyzed, as well as future projections of particular relevance to the state of Maryland. These projections are typically informed by computer models of the global climate that estimate how temperature, precipitation, or sea level will change under scenarios of future GHG concentrations. Those concentrations, in turn, depend on scenarios describing the rate of GHG emissions over time, which generally include a “reference” or “business-as-usual” scenario (in which emissions continue to grow through the 21st century, based on current policies and trends), and one or more “mitigation” scenarios (in which global emissions decline as related to a given set of policy decisions, or based on a desired ‘end point’). Although projections of impacts under various reference and mitigation scenarios are referred to in this chapter, it is important to note that these are not always fully equivalent as they

### Modeling Climate Change

Models are designed to take a complex system, such as the global climate, and characterize its main functional components and their interactions in a simpler and more easily manipulated representation of reality. Reliable predictive models are developed based on well-documented physical processes; and have been tested and calibrated by running the model using known past variables and comparing the results with actual observations. Climate models which perform well in this respect are considered to produce valid results for future scenarios as well [158]. While there is some uncertainty in all models, and specific climate model projections can vary based on the treatment of natural variability and differences in forcings and feedbacks, climate models do agree on the basics of future climate change, such as rising global temperature, changes in the hydrologic cycle, and rising sea level [159]. Uncertainty within a model is often accounted for by representing results as a range.

may rely on different sets of assumptions or parameters. For example, some earlier projections such as those used in the U.S. Environmental Protection Agency’s (EPA’s) *Benefits of Global Action* study [20] or the *National Climate Assessment* [17] are based on different climate models and emissions trajectories than those used in the 2015 IPCC assessment [1].

Furthermore, the following pieces of information in regards to the modeling and projections referenced in this chapter should be kept in mind. First, reliable predictions are necessarily limited to sectors in which there is a sufficient understanding of the effects that climate change could have, and for which quantifiable data and modeling methodologies exist to support analysis. In addition, areas of focus tend to be limited to those in which economic, iconic or cultural significance can be assigned to impacts or damages [20]. It is likely that many other potential risks from climate change exist, which have not necessarily been assessed or may not even be foreseeable. Finally, Maryland impacts are not isolated - many impacts at the global and national level are expected to affect the daily life of Marylanders. The state brings in electricity, food, and a number of necessities from other states and countries, meaning any impacts felt at the source of these essential goods will create problems for

Marylanders. California’s Central Valley, for example, produces 25 percent of the nation’s food, and already relies heavily on irrigation [32]. The climate in this area is expected to become even hotter and drier which, among other changes, threatens the agricultural yield in the region and the nation’s food supply [33]. The discussion in this chapter is not meant to be taken as an all-inclusive look at climate indicators and risks, but rather as an overview of those that are most high-profile, and generally well-accepted by the scientific community.

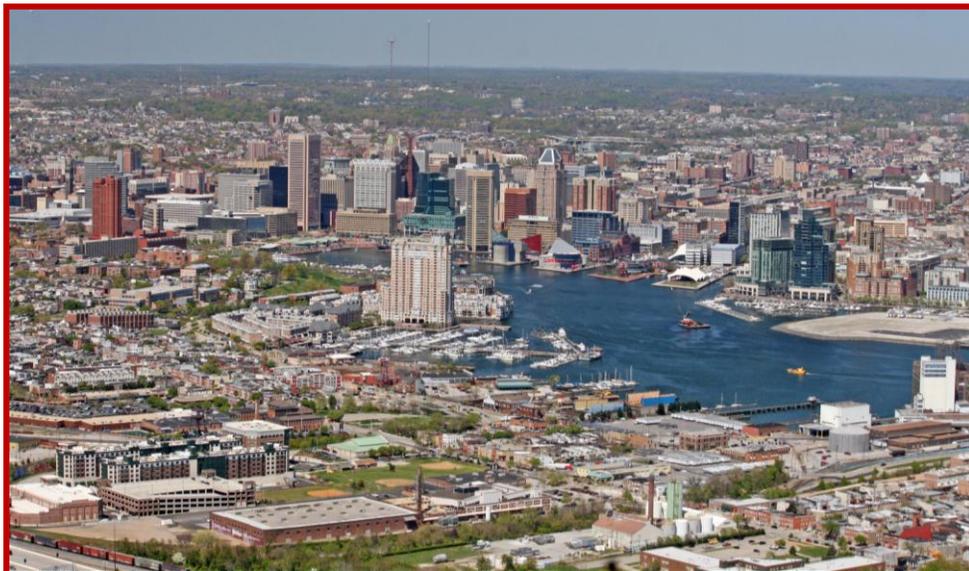
## 2.1 Maryland’s Environment

Ecosystems consist of networks of interactions among the biosphere, atmosphere and geosphere (or – living and nonliving components, including chemical, biological and physical interactions). Human systems, or the “built environment”, can be considered a more recently evolved component which is equally intertwined with and dependent upon these same resources. As noted earlier, the climate in Maryland and the rest of the Northeastern U.S. is currently trending warmer and wetter, a trajectory which is expected to continue. Heat waves are likely to increase in frequency, intensity and duration corresponding directly to increases in emissions; and Maryland is expected to have a notable increase in days with extreme heat (over 90 degrees Fahrenheit) by 2050, as compared to the late 1900’s [23]. The trend in average precipitation is expected to remain seasonal, increasing in the winter and spring, with less change expected in the fall and summer [26]. Combined with the higher summer temperatures, greater evaporation and earlier snowmelt will create the risk of drought during the growing season (significant for both ecosystems and human systems).

### Risk and Vulnerability

Risk is a term used frequently in discussing both present and future scenarios related to climate change impacts. It can be defined as the relationship between the likelihood of exposure to a given hazard, and the damage expected if exposure occurs. A change in either factor due to the influence of impacts associated with climate change alters the overall risk of a particular event or occurrence.

Individuals or groups may be considered more vulnerable, or at increased risk from climate impacts compared to the general population, due to factors that increase either their exposure to climate impacts or expected damage from them.



**Photo 4.** Baltimore cityscape. *[Photo by Jane Thomas]*

Additional impacts in Maryland could include increased frequency and severity of other existing problems such as storms, flooding and forest fires, as well as erosion, saltwater intrusion, and inundation of low-lying areas along the State's shoreline and coast [34]. In general, "climate change increases the risk, frequency, and intensity of certain extreme events like intense heat waves, heavy downpours, flooding from intense precipitation and coastal storm surges, and disease incidence related to temperature and precipitation changes" [17]. The direct impacts to Maryland's ecosystems and built environment are assessed in the following sub-sections.

### 2.1.1 Maryland Ecosystems

Maryland has a wide diversity of ecosystems ranging across the Atlantic coast, the Chesapeake Bay, the Piedmont region and the Appalachian Mountains; all of which are threatened in various ways by the changing climate. Depending on the specific traits of a given population of organisms, and the pressures they are exposed to in the changing environment, the population may experience adaptation (e.g., natural selection or behavioral changes), migration to maintain residence in suitable habitat (e.g., expanding or contracting, or strict directional movement), phenological shifts (i.e., changes in the timing of seasonal life-cycle events), or even local extinction when other mechanisms are not successful [35, 36, 37]. In isolation, rising temperatures are expected to change species distribution by latitude and

#### Ecosystem Services

When attempting to either qualify or quantify the value of ecosystems, a term commonly used is "ecosystem services". These refer to the benefits and resources afforded to people by the normal and healthy functioning of the ecosystem, such as robust fisheries, cleaner air and drinking water, and recreational opportunities [36, 53]. As the introduction highlighted, the success of the ecosystem is intimately connected to the success of the human system [160, 36]. People depend on these ecosystem services, and loss or degradation of the ecosystem will have a negative impact on both the quality of life and the economy in Maryland [53].

elevation, a trend which has already been documented in scientific literature, particularly for temperate locations [38, 39, 40]; however additional factors such as changes in precipitation regimes may also play a role in the directional nature of these shifts [40, 41]. This would not mean that all species in Maryland migrate out of the State - species for which Maryland is in the middle of their range or that are better able to adapt may persist in the area, while the overall composition of the communities they are a part of may change as others migrate or become locally extinct. Variable adaptation within an ecosystem or community via habitat shifting or changes in phenology (such as when flowers bloom or when animals become active in spring) will result in changes to community interactions. This could lead to novel interactions between species which were not previously associated, or asynchronies in the life cycles and distribution of some species which have key interactions, like plant/pollinator and predator/prey [23, 36]. While individual populations may experience many different impacts, positive or negative from the population's perspective, the overall stability and

persistence of the community (i.e., resilience to these changes and ability to adapt its complex network of interactions to maintain its productivity and fundamental identity) is far more significant from a broader perspective [42, 43]; and from the perspective of maintaining ecosystem services. The remainder of this section highlights some ecosystem-specific changes that are already occurring or are predicted for Maryland.

Maryland's Atlantic coast provides ecosystem services such as fisheries, recreational opportunities, and storm-surge protection. The coastal and ocean ecosystems are particularly vulnerable to physical and chemical changes brought about by rising ocean temperatures and sea-level rise (contributed to by the former), as well as ocean acidification, increased precipitation, and increased freshwater inputs from rivers. Global sea surface temperature has demonstrated a warming trend since the 1950's [44], and long-term in the Mid-Atlantic since the late 1800's (with a steady increase since the mid-1960's) [45, 46]; including in the Chesapeake Bay [47]. Higher ocean surface temperatures contribute to sea-level rise via thermal expansion, and have the potential to alter tropical storm activity and weaken circulation patterns [25]. These warmer temperatures are also impacting the species distribution of marine fish and invertebrates. One study of U.S. coasts found that for over 100 species sampled, the average center of biomass has shifted north by approximately 10 miles and deeper by an average of 20 feet since the 1980's [25]. Another study found that the bottom-dwelling Mid-Atlantic marine species specifically show a northeastern shift, noting that the ocean-floor depth in this region is relatively uniform and shallow [48]. Rising global temperatures also impact dissolved oxygen concentrations in water by decreasing oxygen solubility and increasing respiration rates (and oxygen consumption); exacerbated by changing ocean circulation and, in coastal areas, increased nutrient loading from changes in precipitation [49, 9]. Reduced oxygen ultimately impacts productivity and biodiversity through influence over many biological and nutrient-cycling processes [49, 9]. Sea-level rise threatens the coastline and other marginal habitat, such as marshes and tidal wetlands through inundation and exacerbation of erosion, the latter having a particular impact in the sandy coastline of the Mid-Atlantic [50]. In fact, salt water intrusion/inundation has been identified as the primary cause of wetland losses in the Mid-Atlantic region in recent decades [51]. While sea-level has changed in the past and coastal environments have adjusted by shifting location, the speed at which the change is occurring and the prevalence of human development will continue contributing to the likelihood of successful habitat migration and the associated impacts [50]. Where tidal marshes become submerged or are eroded, impacts would likely be seen in the populations of birds, fish and shellfish that utilize tidal marsh habitat for spawning, nursery and shelter areas [50]. Many water bodies are becoming more acidic as the atmospheric concentration of carbon dioxide (CO<sub>2</sub>) rises and a greater amount is absorbed by the ocean, lowering the pH [3]. This has been identified as an issue for coral and shellfish globally, and the National Oceanic and Atmospheric Administration (NOAA) is doing a wide variety of research to determine additional impacts of ocean acidification on coastal ecosystems.



**Photo 5. Chesapeake Bay salt marsh at the Chesapeake Bay Environmental Center in Queen Anne's County, MD. [Photo by Catharine Love]**

The Chesapeake Bay ecosystem is the largest estuary in the United States and an invaluable and iconic part of Maryland, providing a broad range of environmental, recreational, and economic services. Many of the coastal, wetland and marsh impacts discussed in the previous paragraph are clearly also applicable to the Bay, but due to its significance, the Chesapeake Bay has also drawn specific attention



from researchers, and the estuarine system is expected to experience some unique impacts due to climate change. Researchers from the University of Maryland Center for Environmental Science (UMCES), the National Estuarine Research Reserves (NERR) of Maryland and Virginia, and Chesapeake Environmental Communications have compiled and analyzed meteorological data from sites managed by NERR and the National Weather Service going back to 1910; and identified clear climactic trends for this region which are already influencing the Bay's habitats and the species that reside there [52]. One of these trends is a growing season which is expanding at an even greater rate than that of the East coast overall, which has been observed as an issue for some migratory species which reside in the Bay during the spring and summer months, but farther south during the winter. Warmer fall weather means that these species do not begin their migration early enough, lacking the usual indicator of oncoming cold. Then, when the temperature drops suddenly, these species may suffer from cold-shock, resulting in incidents such as the cold-snap-associated death of thousands of Speckled Trout in February of 2014, or 2 million juvenile Spot in 2011 [52]. In addition to temperature changes, an increase in total annual precipitation in the Bay region (12 percent since 1900) is particularly significant due to the correlation between precipitation and nitrogen/sediment pollution brought into the Bay with runoff [52, 36].

Wetlands in the area currently provide ecosystem services that help to mitigate some of the nutrient



**Photo 6.** Underwater grasses in the Susquehanna Flats.  
*[Photo by Will Parson/Chesapeake Bay Program]*

loads, with saltwater marshes in Dorchester and Somerset counties contributing a large portion of the total \$402 million/year value in nitrogen removal benefits provided by wetlands and forests statewide [53]. Excess nutrients that reach the Bay can cause algal blooms, which reduce oxygen levels at the bottom of the Bay as they decompose; and warmer summer temperatures have already exacerbated low-oxygen "dead-zones" [54]. These blooms, while active, also reduce light penetration to the bottom of the bay, and sediment pollution further reduces clarity. Aquatic vegetation, which provides food and habitat for fish, crabs, and waterfowl, tends to be stressed by any combination of these factors (increased temperatures, decreased oxygen, nutrient pollution, and reduced clarity) [52]. Acidification in shallow estuarine environments such as the Bay is further mediated by nutrient availability, as the same algal bloom events which deplete oxygen also increase dissolved CO<sub>2</sub> [55]. Besides generally being

a concern for pH sensitive species, Bay acidification creates a particular issue for shellfish such as crabs and oysters which require specific chemical conditions in order to create and maintain their shells [55]. The Maryland Ocean Acidification Task Force report released in 2015 identified a critical need for enhanced monitoring networks to gain a better understanding of the multitude of complex interactions that causes acidification in shallow, estuarine Bay waters, as well as the effects on the species that inhabit them [55]. Finally, as noted earlier, sea-level rise is expected to have a direct impact on coastal estuaries such as the Chesapeake Bay, "moving estuarine shorelines by inundating lowlands, displacing wetlands, and altering the tidal range in rivers and bays" [56].

In 2017, it was estimated that about 2.5 million acres of Maryland was covered by forest [57]. This ecosystem provides a large number of benefits, include decreasing the total runoff and maximum flow of rivers during storm events, which reduces incidents of riverine flooding; capturing or retaining soil and nutrients from runoff, which helps the State meet its Bay TMDL goals and keeps our drinking water

reservoirs cleaner; acting as a sink for atmospheric carbon; reducing air pollutants; and providing essential habitat for wildlife, and recreational opportunities for people [53]. Quantified, the value of forests in reducing air pollution alone is estimated to be \$140 million/year for the State; and wetlands and forests together provide value for flood prevention and stormwater mitigation at \$3.1 billion/year, and surface water protection at \$246 million/year [53]. Climate change may have direct impacts on the distribution of tree species in the forest, or indirect effects through previously discussed changes to other populations within the ecosystem such as pests and pathogens, with most significant changes expected to appear in the long-term [58, 59]. Whether population can shift successfully depends on the interplay of abiotic, biotic, and ecological variables [60]; and for tree species this may include dispersal capacity and generation time, as well as environmental heterogeneity and succession processes [61, 59]. Maryland has three different forest “ecological provinces”, located in the western, central, and coastal regions of the state [62], each of which is expected to be most impacted by slightly different factors. The coastal forests of Maryland are expected to suffer from similar issues to other ecosystems in that region, including rising sea levels and increased storm surge which cause greater saltwater intrusion and flooding, and may reduce suitable habitat for some species [63]. In western Maryland, habitat is likely to become unsuitable for northern hardwood and conifer species such as eastern hemlock, red spruce, and sugar maple, and species at high elevation or otherwise topographically limited may be unable to shift their range as changes expand beyond their tolerances [63, 58]. Similarly, extinctions of Virginia pine have been predicted for even low-emissions scenarios in the central region [59]. At the same time, habitat in the western region is expected to become more suitable for oak-hickory and in both western and central for southern species like yellow poplar and loblolly pine, changes that will have significant impact on community composition and ecosystem services in the region [59, 58, 63]. Central Maryland’s broadleaf forests are considered by some to be more at risk from changes in hydrology, including more intense precipitation events, that increase the risk of excessive flooding and inundation in low-lying areas as well as stream bank erosion [63]. In addition, warmer winters are shifting the range of some insect pests northwards into the region [63]. Freshwater stream habitat in western Maryland is also at risk from rising temperatures. From 1960 through 2014, the water temperature increased at 79 percent of all stream sites measured in the Chesapeake Bay region, and several stream gauges in Maryland demonstrated a statistically significant increase in temperature of 2 to 4 degrees Fahrenheit during this time [25]. According to the EPA, under a business-as-usual emissions scenario, those sites which are currently coldwater fisheries are projected to become unsuitable for this use by 2100, as is true for most of Appalachia; however, under a 2 degrees Celsius mitigation scenario, this use may be maintained [20].



**Photo 7.** Eastern Box Turtle eating mushrooms in College Park, MD. *[Photo by Catharine Love]*

## 2.1.2 The Built Environment

Projections from the USGCRP's *Third National Climate Assessment* indicate that infrastructure (e.g., roads, bridges, and buildings) in the Northeastern U.S. is expected to be at particularly high risk from the impacts of sea-level rise, coastal flooding, and more intense precipitation events brought by climate change [23]. The East coast infrastructure represents some of the oldest in the U.S., and was designed to a certain standard based on the elements and stressors which it was expected to withstand. Climate

change exposes these already aging structures to increased stress such as more frequent extreme temperatures and weather events which can shorten their useful lifetime, increase maintenance costs, or even render them unusable [64, 65, 17].

### Coastal Resiliency Grant Program: Building Resilience through Restoration

While coastal hazards threaten our communities, natural systems such as coastal forests, wetlands, and dunes can help buffer communities from flooding, stabilize shorelines, and facilitate inland migration as sea levels rise. The Maryland Department of Natural Resources (DNR) conducted a *Coastal Resiliency Assessment* in 2016 to identify areas where coastal habitats provide risk-reduction benefits. Assessment data were integrated into conservation and restoration activities to better target and prioritize nature-based community resilience projects. In 2017, DNR's Chesapeake and Coastal Service launched a *Resiliency through Restoration Initiative* to build resilience to climate impacts through nature-based projects. At least 15 projects will be implemented over a five year period to demonstrate cost-effective restoration techniques that mitigate and accommodate impacts due to storms, precipitation, and sea-level rise. The Initiative supports design, construction and adaptive management of nature-based projects such as living shorelines, wetlands, and stormwater practices that address flooding, erosion, sea level rise and other climate impacts. These projects build community, economic, and ecosystem resiliency by buffering people and infrastructure while enabling nature to be more robust and bounce back following natural or man-made disasters.

As previously noted, the Northeastern U.S. is actually experiencing a rate of sea-level rise greater than the global or national average. In its *2016 Annual Report*, the MCCC projected likely sea-level rise in Maryland between 2.2 and 4.1 feet with unrestrained growth in global emissions, and between 1.4 and 2.8 feet even when emissions were reduced to achieve the 2015 2 °C IPCC mitigation scenario [29]. This puts the people and infrastructure of Maryland's extensive coastline at increased risk of damage from hazards such as flooding, salt-water intrusion, storm surge, and erosion [25]. Though many sites along the U.S. coastline have experienced a greater frequency of flooding since the 1950s, the Mid-Atlantic has experienced a disproportionately large increase [25]. The city of Annapolis is a particularly severe example, with the average number of flood events per year increasing from fewer than 10 over the 50s and 60s to more than 40 in the past decade [25].

For coastal areas, the impacts of storm surge on transportation infrastructure can compound the loss of human life during storm events if major evacuation routes become impassable, and may lengthen the process of community recovery after events, due to a decreased ability to access work or school, or to receive much-needed supplies. Although factors which influence the formation, intensity, and landfall of Atlantic hurricanes are numerous and complex, the ability of scientists to attribute extreme events to climate change has been advancing rapidly [66, 9]. Higher temperatures and greater air moisture are expected to contribute to Atlantic hurricanes with greater precipitation rates, and more frequent occurrences of the most intense storms [9]. Outside of the direct impacts of extreme storms, such disturbances may affect the economic

viability of main harbors, airports, and supply chains in coastal areas, as well as the areas further inland and even nationally which rely upon their goods and services [67, 64]. In 2017, the Port of Baltimore handled 38.4 million tons of international cargo (worth \$53.9 billion), ranking it 9th in all U.S. ports by dollar value; and the Port generates \$310 million in taxes, nearly \$3 billion in annual wages and salaries, and supports 13,650 direct jobs [68]. Imported and exported product is heavily reliant on not only port infrastructure, but also the major highways and railways out of Baltimore city: Domino Sugar alone is estimated to generate 33,000 truck trips and utilize more than 1,100 rail cars per year [69]. Due to Maryland's extensive and vulnerable coastline, much of the early adaptation effort in Maryland has been focused on identifying and addressing these coastal hazards, particularly sea-level rise and coastal storms. This was the focus of the MCCC Adaptation and Response Working Group's Phase I plan, *Comprehensive Strategy for Reducing Maryland's Vulnerability to Climate Change*, initiated in 2008.

While Maryland's coastal areas may be considered particularly vulnerable, many areas of the State have infrastructure susceptible to impacts from climate change. For example, a severe thunderstorm that occurred this May in Frederick County required the rescue of more than 60 stranded motorists and left many roads closed several days later due to flooding, debris, or sinkholes [70]; with one source estimating the damage to public infrastructure at over \$6 million [71]. Non-coastal (riverine and urban) flooding is a result of multiple factors, including those related to the design of the built environment (e.g., river modifications, drainage, and land use) and climate factors such as precipitation [72]. This type of urban flooding is especially likely to occur during high-intensity, heavy rainfall events which have



**Photo 8.** Flooding of the Jones Falls in Baltimore, MD after heavy rains (2008). [Photo by Tim Windsor]

increased in frequency in the Northeast (71 percent from 1958 to 2012), and are expected to continue to increase with unmitigated climate change [3]. According to the 2017 USGRP *Climate*

*Science Special Report*, the increased atmospheric water vapor associated with global warming means that when rainfall occurs, the amount of rain falling in a given event tends to be greater than it would have been under previous conditions [9]. When combined with the low permeability of the majority of urban surfaces, large quantities of runoff may quickly overwhelm the capacity of

stormwater drainage systems [72, 20, 9], affecting homes, businesses, roads, bridges, public railways, and other infrastructure. Inland bridges are particularly vulnerable to increased riverine storm flow and flooding, and the U.S. Geological Survey hydrologic region which includes most of Maryland (Hydrologic Unit Code 02, or HUC02) is expected to experience some of the greatest impacts, with 76 percent (more than 20,000) of inland bridges projected as vulnerable by 2100 without mitigation; while a successful 2 degrees Celsius scenario reduces this number to 35 percent [20]. Across HUC02, the cost of damages from inland flooding under a business-as-usual scenario is projected to be between \$1 and \$2 billion (in 2014 \$) in 2100, significantly different from historic numbers [20]. In addition to damage from flooding and severe weather events, increased average temperatures can have a direct impact on urban infrastructure as well. Unmitigated climate change is projected to increase the cost of road infrastructure maintenance by \$4.2 to \$7.4 billion nationally (in 2100) compared to the 2 °C mitigation

scenario [20]. In the Northeast, the majority of predicted costs were associated with higher temperatures, which necessitate the application of alternative pavement binders to avoid road cracking [20]. While in-depth analysis at the State level is still in the early stages, an increasing amount of work is focused on identifying and analyzing non-coastal risks and developing specific strategies to address them, considered Phase II of the ARWG's 2008 Plan.

## 2.2 Jobs and the Economy

Damages to natural or built systems may necessitate diversion of public funds for the replacement of ecosystem services or infrastructure repairs. Climate impacts can alter the natural resource productivity or availability in a region, and therefore the viability of the various economic sectors that depended on them. More frequent disruptions to urban and coastal infrastructure caused by extreme weather events may indirectly impact the economy of the region by restricting the flow of goods and impacting days worked. Decisions surrounding the adaptive management of various sectors are critical to the eventual outcome, but complicated by mitigation goals, socioeconomic factors, and concerns regarding uncertainty. For example, if regions or communities become unfavorable for an activity or industry which was historically a large part of their economy, they may need to shift or diversify quickly to avoid substantial economic impact. This is likely to be a disproportionate burden on rural communities, which tend to have less diverse economic portfolios [73]. Certainly, new opportunities can arise in the process; however as with many of the other anticipated changes, the speed with which they are occurring is the key factor. Adaptation at a matching pace could be challenging and not always entirely feasible, especially when considering the time and money invested, such as in equipment or training for a particular vocation. Efforts in mitigation are therefore required in addition to plans for adjusting to these changes, to reduce the extent and pace of adaptation that is needed and make it more manageable. This section provides an overview of some of the major economic sectors in Maryland, and the anticipated climate impacts.



**Photo 9.** Kite Hill Farm in Manchester, MD. *[Photo by Katie Rae Warner]*

### 2.2.1 Agriculture, Fisheries and Forestry

Agriculture and forestry are cultivated under human control, yet directly and clearly linked to the impacts of climate change on ecosystems. Common stressors will be experienced among ecosystems, agriculture, fisheries and forestry, such as those caused by general changes in temperature and precipitation regimes; increased extreme weather events; and increased pressures from weeds, diseases and pests. Maryland's Eastern shore farmers will be at particular risk from additional issues such as sea-level rise, coastal storms, and saltwater intrusion. While not all individual impacts are necessarily negative (e.g., the growing season is expected to lengthen in Maryland, which may initially benefit some crops), issues such as increased temperature extremes and pest activity may negate these benefits [74];

and beyond 2050, impacts are expected to be increasingly unfavorable in most situations [75]. The magnitude of the impact will additionally depend in part on the level of adaptation that is achieved at the production level, as well as the response of the global market to these shifts [75].

Although total farm acreage has been decreasing from historic levels [76], agriculture remained the largest single land use (almost one third of total land area) and the largest commercial industry in the State, employing approximately 350,000 Marylanders [77]. According to the U.S. Department of Agriculture (USDA) survey data, Maryland's total production in 2017 included over \$1 billion in broiler chickens, \$699 million in field crops, and \$169 million in milk [78]. In 2016, the market value of all agricultural products was over \$2.3 billion; which, after production costs, translated to a net farm income of about \$370 million (\$42,091 per farm on average) in that year [77]. Poultry farms, the highest grossing agricultural industry in the state, are expected to see increased summer cooling costs, decreased growth rates, increased mortality and increased risk of *Salmonella* with increasing temperatures [74]; challenging slim margins. Increased frequency of summer heat stress has the potential to negatively affect both field crops and milk production yields [75], and may amplify water demand, increasing the risk of over pumping groundwater for irrigation. This latter tendency, combined with sea-level rise, places unconfined aquifers exposed to the freshwater-saltwater interface on the



**Photo 10.** Riverdale Park Farmer's Market in Prince George's County, MD. [Photo by Maryland Department of Agriculture]

Eastern shore at risk from saltwater intrusion. Saline water may also flood fields during storm events, leaving salt behind after evaporation which can alter the soil composition and leach vital trace minerals.

Changes in temperature and precipitation are likely to alter the types of crops that can be grown in a given region, similar to the effects on natural plant populations. Where field crops are grown is generally determined by USDA hardiness zones, and while most of Maryland is currently in zone 7, the USDA predicts that much or part of Maryland may be in zone 8 under various future scenarios, both mid- and late-century [79]. The seasonality of trends in temperature and precipitation is also particularly relevant to the agricultural sector. As noted earlier in this chapter, average precipitation is expected to continue increasing in the winter and spring, with less change expected in the fall and summer [26]. Combined with the higher summer temperatures, this will likely increase the intensity of any droughts during the growing season [27]. Farmers may be able to adapt in part to the impacts of climate change by exploring new crop options or adjusting management practices, but as the *Third National Climate Assessment* notes, "these adaptations are not cost- or risk-free" [23]. Adaptation may pose a further challenge for farmers whose crops are not single season (such as fruit trees and vines), as their life cycles often rely on particular seasonal cues, and because selective breeding would likely take many more years to become effective [75]. These perennial crops may also become more sensitive to hard freezes, as unusually warm winters can de-harden vines, or cause spring growth to begin prematurely only to be later destroyed by a hard freeze [75]. Though introducing varieties from other areas could be an effective form of adaptation, existing orchards and vineyards represent a significant investment, and replacing them with an entirely new stock may not be financially feasible. In 2017, Maryland's apple and peach orchards produced over \$11.5 million utilized for fresh eating and in processing [78]. Additionally, the State has 858 acres of vineyards, 70 percent of which are owned by wineries that sold \$47 million worth of product in 2015 [77].

While the effect on forestry is not predicted to be as substantial as that on agriculture, and increased incidence of wildfires is not expected to be as significant a concern in Maryland as in other regions of the U.S. [20, 23], there are still potential threats and changes to the industry that merit attention. In 2016, the forestry industry generated \$248 million in income for its 5,195 employees, who mostly reside in Garrett and Allegany Counties [80]. This accounts for only some of the estimated 18,000 people who depend either directly or indirectly on the industry for their livelihood [81]. As noted in the ecosystem section, changes in average temperature and precipitation have the potential to impact forest communities, including shifting, shrinking, or expanding the ranges for various tree species such as the yellow-poplar and loblolly pine, and oaks which are prevalent in Maryland [82, 57, 83]. On the Eastern shore, where forestry is the second largest employer [81], sea-level rise, storm surge, and salt-water intrusion were discussed as local concerns. The positive contribution to global forestry production from lengthened growing seasons and increased CO<sub>2</sub> concentrations is unclear; though similarly to agriculture, it is expected that negative climate impacts such as wildfires, insects and pathogens, heat and water stress, and extreme weather events may eclipse these benefits [84, 82]. The Maryland Department of Natural Resources (MDNR) has already noted that pests such as the gypsy moth, Southern pine bark beetle, loblolly pine sawfly, and fall canker worm have begun to threaten forests in recent decades [81]. Not only may a changing climate impact the prevalence of these pests, but it may also stress the trees or otherwise affect defense mechanisms, making them more susceptible to damage [84]. Adjusting management either to accommodate specific impacts or to enhance the overall resiliency of the forest system to change is expected to be an important part of the adaptation of the forestry industry [83]. In addition, forest management will be an important component of mitigation, since forests play a major role as carbon sinks, already having absorbed about 17 percent of anthropogenic CO<sub>2</sub> emissions the past several decades [85]. Depending on the chosen strategies, we may either expand or reduce this capacity.

The Chesapeake Bay fisheries are expected to be impacted by a combination of environmental stressors, including those previously discussed for Bay and coastal ecosystems such as basic water quality issues that include changes in temperature, salinity, and dissolved oxygen, as well as habitat loss due to sea-level rise and projected impacts on submerged grasses. Many commercially important fisheries species are projected to move northward as waters warm and suitable habitats shift; and as previously noted, this shift could also bring new pests or increase the damages done by diseases such as bacteria which thrive in warmer waters [86]. The Maryland seafood industry (not including imports) was responsible for over 7,000 jobs and \$160 million of income in 2015 [87]. Nationally, Maryland was in the top states for harvest of soft clams (306 thousand pounds) and blue crabs (22% of the national catch) in 2016 [88]. Within the State, the blue crab was the most lucrative species by far, accounting for over \$54 million in revenue in 2015, with the oyster coming in second at \$15 million [87]. In addition to concerns regarding ocean acidification, oysters may be at an increased risk of suffocation by sediment loads, exposure to low-oxygen dead zones, and damages from the diseases Dermo and MSX; all of which have contributed to the historic decline of the oyster population [89] and may be exacerbated directly or indirectly by the changing climate as previously discussed. For



**Photo 11.** A scientist holds an adult and a juvenile blue crab. *[Photo by Chesapeake Bay Program]*

blue crabs, a study of current life-cycle variations across their native range (Maryland/Virginia, North Carolina, and Florida) concluded that since the Chesapeake Bay is towards the northern edge, increased temperatures taken independently may provide certain benefits currently experienced by their more southern populations, including: a longer reproductive season with additional broods, increased growth rate and maturation, and decreased deaths over winter [90]. However, the peak summer water temperatures of the three regions studied were very similar, despite the marked differences in temperature the remainder of the seasons, and so the current climates of the southern sites cannot necessarily be considered an accurate representation of those temperature differences expected in the Chesapeake as a result of climate change. Furthermore, many other potential impacts are projected to affect blue crabs negatively, including loss of submerged grass habitat and expanded dead zones [90].

### 2.2.2 Tourism

Businesses involved in the State’s tourism sector are also likely to feel the impact of climate change. In 2016, Maryland visitors spent \$17.3 billion dollars, more than 60 percent of which was in the industries of transportation, food and beverage, and lodging [91]. Tourism in the State supported 146,012 direct full-time equivalent jobs in that year, bringing in wages of approximately \$6 billion; while visitor spending generated over \$2.3 billion in state and local taxes [91, 92]. The Maryland Office of Tourism Development often touts Maryland as “America in miniature”, with the wide array of regional activities: skiing, boating, and mountain scenery in the west; national sports, restaurants, and shopping in the cities; winery tours, fishing, and historic and natural history in the central and southern regions; and seafood, beaches, and marshlands on the Eastern Shore [93]. Without action, all of the various activities and the natural beauty of the State could suffer the effects of climate change, depriving Maryland residents and visitors of this wealth of experiences.



**Photo 12.** Tourists at the National Aquarium in Baltimore’s Inner Harbor. The Aquarium attracts over 1.3 million visitors to the area annually, a majority from out of state [162]. *[Photo by Lindley Ashline]*

Snow sports such as skiing are at obvious risk from rising temperatures and longer growing seasons, especially for lower-elevation resorts such as those in Maryland [94]. Wisp Mountain Park is a four-season resort but more significantly a winter sports destination whose employment jumps from 220 to 600 during the winter ski season, ranking it among the top employers in Garrett County [95]. In late December of 2015, the resort reported that only one of their 35 trails was open, having been unable to keep snow on the ground due to temperatures consistently above freezing [96]. In 2016, winter sports closed for the season at the end of February after a consecutive 72 day winter season (the shortest in 10 years) “due to the historic, unseasonably warm rainy weather”<sup>3</sup> [97]. Though there have always been bad seasons, and individually these are not specifically attributable to climate change, they do demonstrate how important dependably cold weather is to the resort’s seasonal functionality, which

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<sup>3</sup> The park did experience a brief revival for a few weeks at the end of March.

increasing global temperatures could debilitate. The resort is also a good example of how diversification may become significant, potentially increasing its attractions in the other three seasons to make up for lost revenue in winter. This year it advertised off-season events and activities such as golf, white water rafting, a beer and music festival, and Escape Games (new in 2017) [98].

Maryland's sizable sport fishing industry has an estimated economic impact of nearly 7,000 jobs and \$300 million in income across the State; with 352,000 anglers (nearly half of the total) coming from out-of-state in 2015 [87]. Similarly to commercial fisheries, key species will face increasing risks brought by higher temperature surface water, changes in precipitation, and other indirect effects. Maryland's



**Photo 13.** Visitors to Ocean City, MD. [Photo by Hannah Brubach]

beaches will be susceptible to more extreme weather events as well as sea-level rise, and are difficult to protect from storms and erosion without negatively impacting their aesthetics [94]. Ocean City generated around \$60 million in tourism-related taxes each year during 2014, 2015, 2016 and 2017 (60 percent during the months of June, July, and August) [99]. *Maryland's Greenhouse Gas Reduction Act Plan* from 2012 stated "it is estimated that beaches will move inland at a rate 50 to 100 times faster than the rate of sea-level elevation and that the cost of replenishing the coastline after a 20-inch rise in sea level would be between \$35 and \$200 million" [100]. Even tourism in cities and

urban centers is expected to be impacted by climate change, experiencing the effects of extreme heat and precipitation events as discussed surrounding the built environment.

### 2.2.3 Energy

The energy sector tends to be thought of in terms of the potential impact of its emissions; however it is also at risk from negative impacts due to increasing temperatures, decreasing water availability, and increasing storms, flooding, and sea-level rise associated with climate change [101]. Particularly in the Northeast, hotter summer temperatures are expected to increase peak electricity demand in this season due to increased use of air conditioning units [20]. Overall, the increased demand is anticipated to outweigh the decreased need for heating in winter [20]. This makes it more difficult and potentially more expensive for utilities to meet the immediate peak demand, and also increases the risk of system failure precisely when it is most needed [23]. In a scenario where global average temperature increases by 3.5 to 5 °C, it is estimated that a 10 to 20 percent increase in total U.S. electric generating capacity will be required by 2050 [102]. Beyond mitigation, programs for adaptation such as enhanced urban tree canopies can help increase resiliency by providing shade relief to buildings during the summer, which helps alleviate the demand for electric cooling.

In addition to changes in demand, the extreme weather events which threaten coastal and urban infrastructure include direct threats to electricity infrastructure (e.g., transmission lines) throughout the state; as well as indirect impacts such as issues with fuel extraction, processing, and delivery [103, 101]. The majority of thermoelectric power plants (e.g., nuclear, coal, oil, and natural gas) are specifically located near bodies of water since they require constant cooling, and are therefore expected to become more susceptible to flooding. Furthermore, as atmospheric temperatures increase, the temperature of

surface water also increases and the water being used for this purpose becomes a less effective coolant, reducing the efficiency of thermoelectric generation [101]. Warmer water would also be discharged back into the Bay, with potentially negative impacts on the ecosystem.

### 2.3 Public Health and Equity

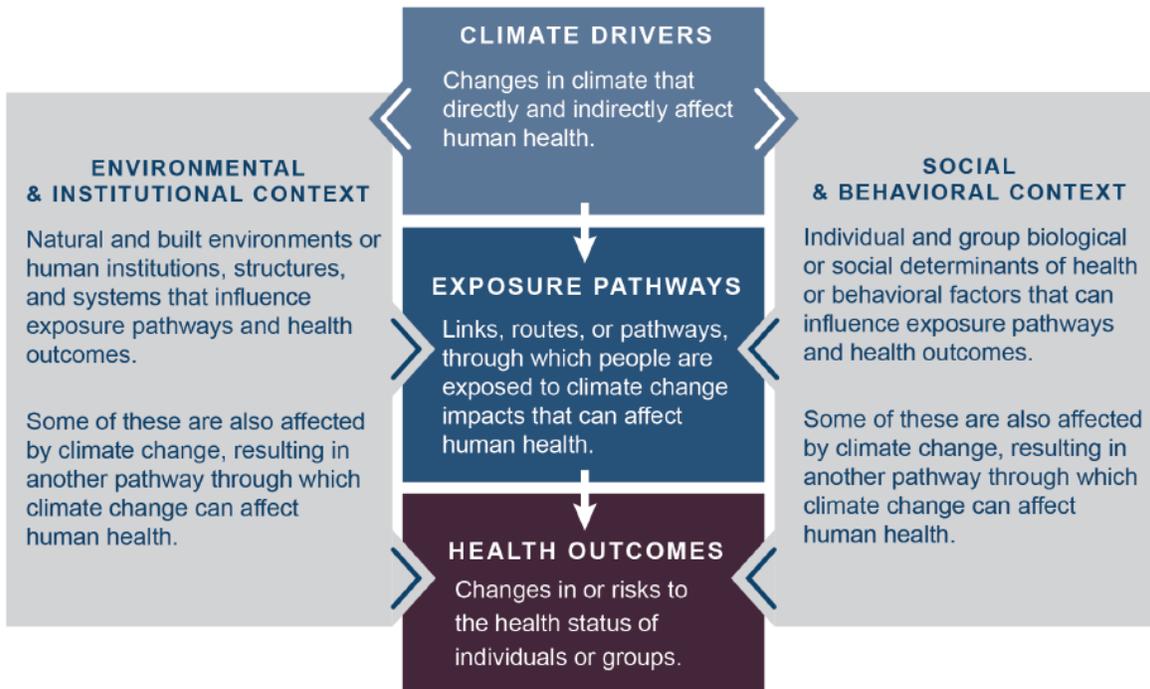
Climate change is expected to alter the severity, frequency, and distribution of health problems which are affected either directly or indirectly by temperature and precipitation [20, 104]. Impacts may be related to changes in the natural or built environment, including effects on our food and water supply, air quality, and extreme weather events [20, 104]. Not all individuals and communities will be equally at risk, however. Health outcomes are ultimately influenced by a variety of social and institutional factors that may increase the likelihood of exposure to an impact of climate change, or the probability of a negative outcome from that exposure (Figure 2). Climate change may even impact one or more of these factors, altering the ability of a community or an individual to respond to health concerns, rendering them unable to take appropriate measures to prevent or treat an illness or injury [104]. For example, a prolonged heat wave may simply mean one family changes their weekend plans from playing ball at the park to staying inside and watching a movie in their air conditioned home. This family had access to resources that included information about the dangers of heat waves, the option to stay indoors, and access to air conditioning, all of which allowed them to avoid exposure to the hazard. The same heat wave may have an entirely different health outcome for a middle-aged man who works outdoors and takes a heart medication which places him at increased risk of heat stroke (Figure 2b).

In 2009, under section 202(a) of the Clean Air Act, the EPA Administrator issued an endangerment finding which stated that “based on careful consideration of the full weight of scientific evidence and a thorough review of numerous public comments” the cumulative impacts of GHGs endanger the public’s health and welfare [105]. This section provides an overview of the major health impacts anticipated due to a changing climate (i.e., the cumulative impacts of GHGs); as well as the inseparable issues of vulnerability, equity, and environmental justice.

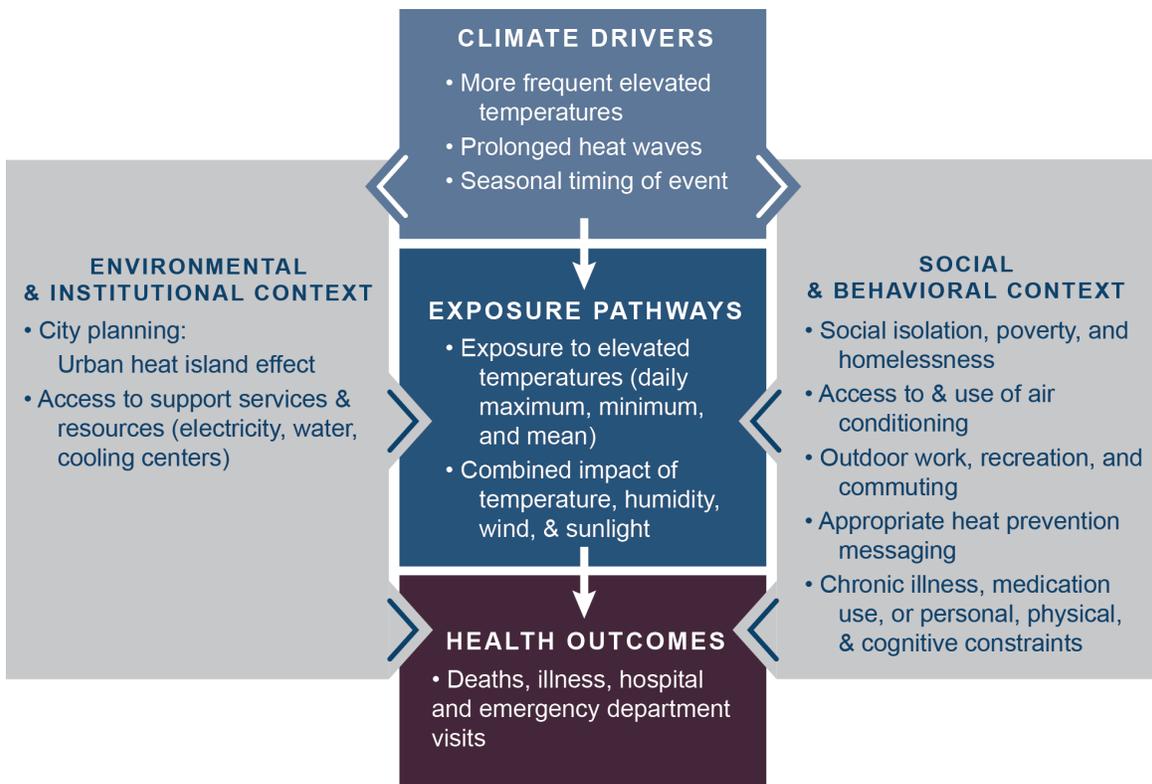
*The Administrator finds that six greenhouse gases taken in combination endanger both the public health and the public welfare of current and future generations.*

*-- U.S. EPA  
Endangerment Finding, 2009*

(a) Understanding the Exposure Pathway Diagrams



(b) Climate Change and Health - Extreme Heat



**Figure 2.** Exposure pathways diagrams from the U.S. Global Change Research Program report, *Impacts of Climate Change on Human Health in the United States*. Figure (a) demonstrates the general layout of exposure diagrams, which show how health outcomes are ultimately influenced by a variety of social and institutional factors that affect exposure to an impact of climate change. Figure (b) provides an example of this using “extreme heat” as the climate driver

### 2.3.1 Extreme Heat and Air Quality

Extreme heat events have been increasing in frequency over the past several decades at the national level [25], and between 2050 and 2100 the incidence is expected to more than triple under a business-as-usual scenario [20]. These events are directly associated with a greater risk of illness or death due to conditions such as heat stroke, cardiovascular disease, and respiratory disease [20, 25], even if only small differences in average seasonal temperature occur [104]. Factors related to vulnerability which are expected to increase exposure include lack of access to air conditioning or having an outdoor job; while individuals at already increased risk of health problems from extreme heat, such as children and the elderly, are more likely to experience a negative health outcome if exposure occurs [104, 25]. The *Maryland Climate and Health Report* released in 2016 found that, between 2000 and 2012, extreme summer heat events (95th percentile for the baseline day) increased the risk of hospitalization for heart attack by 11 percent statewide and by up to 43 percent in some areas; and increased the risk of hospitalization due to asthma by 22 percent [106].

Air quality is also projected to decline under a business-as-usual scenario, especially in the Eastern U.S. [20], which increases the risk of cardiovascular and respiratory issues [104]. Increased atmospheric temperatures increase the rate of chemical reactions, such as the formation of ground-level ozone, when the pollutants that participate in these reactions (NO<sub>x</sub> and VOCs) are present in sufficient quantities. All else equal, increased temperatures will make it more difficult for cities in particular to achieve or maintain compliance with ozone standards, and the risk of health impacts associated with non-attainment, including reduced lung function, asthma attacks, and premature death, will increase [20, 104]. Mitigation (2 °C scenario) is projected to avoid 13,000 premature deaths in 2050 and 57,000 in 2100 nationwide due to impacts from ozone and particulates<sup>4</sup>, with an estimated economic benefit of \$160 billion and \$930 billion respectively [20].

Additionally, climate change and even increased CO<sub>2</sub> concentrations alone may impact seasonal plant-based allergies through several pathways: altering the distribution of plants, lengthening the growing season, and altering the dispersion or allergenicity of the pollen [107, 108]. The season for ragweed pollen, for example, has already begun to lengthen in a large percentage of locations where the trend has been studied, and is expected to continue exhibiting higher pollen counts due to earlier springs, increasing temperatures, later fall frosts, and increased CO<sub>2</sub> concentrations [25]. Another recent study

#### Increasing Urban Trees to Capture Carbon

As noted in the section on energy, enhanced urban tree canopies can help decrease the demand for electric cooling in the summer by providing shade relief to buildings. Beyond that, this measure has additional adaptation and mitigation benefits. Decreasing the amount of electricity used decreases associated CO<sub>2</sub> emissions; and since trees take in atmospheric carbon and convert it to biomass as they grow, this sequesters some existing atmospheric CO<sub>2</sub> as well. Maryland's Department of Natural Resources (DNR) manages the *Increasing Urban Trees to Capture Carbon* program, which also notes air quality co-benefits of slowing the formation of ground-level ozone and the evaporation of fuel from motor vehicles. The program is supported by several other Maryland laws and programs, including MDE's green infrastructure and stormwater initiatives, and has the goal of planning 12.5 million trees in urban areas through the Forest Conservation Act, Marylanders Plant Trees, Tree-Mendous Maryland, and 5-103 State Highway Reforestation Act planting programs. Almost 6 million trees have been planted

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<sup>4</sup> This analysis assumed no change in emissions of traditional air pollutants from current levels, and is based on projected impacts from increased ozone and fine particulate matter.

predicted increased emergency room visits in the Northeast due to allergic asthma caused by oak pollen under several future climate scenarios that worsened with the severity of change [108]. Increased pollen exposure in general is expected to increase incidence of asthma in sensitive groups, especially when compounded by other air-quality issues [25, 17].

### 2.3.2 Water Quality, Extreme Precipitation, and Infectious Disease

As previously stated, changes to precipitation in the Chesapeake Bay region are expected to increase the pollutant load to the Bay, a trend which is generally true for other water bodies in the State as well. Combined with increasing atmospheric temperatures, these changes will negatively impact water

*Extreme precipitation events have been statistically linked to increased levels of pathogens in treated drinking water supplies and to an increased incidence of gastrointestinal illness in children.*

*-- U.S. Global Change Research Program, 2016*

quality parameters and potentially change the viable uses of surface water, such as recreation or human consumption [20]. Warmer winters and springs are associated with increased occurrence of *Vibrio* bacteria, including *V. cholerae*, which causes cholera, and *V. vulnificus*, which can cause similar symptoms or infect open wounds. Over the past century, the likelihood of encountering these bacteria in the Bay has already increased as conditions become more favorable to them [52]. Overall, increased temperatures and nutrient loads are expected to expand suitable habitats for toxic freshwater and marine algae, increasing the likelihood of exposure which can occur through consumption of

contaminated seafood or drinking water, or via direct contact in recreational waters [104]. Another potential exposure from seafood consumption is accumulated heavy metals, especially methylmercury, which is taken up at greater rates in warmer waters [104].

Extreme precipitation poses a threat to drinking water supplies, and may be one of the largest climate threats to water quality, having preceded 68 percent of waterborne disease outbreaks between 1948 and 1994 [104]. Such events may overburden stormwater and drainage systems, which can cause discharge of untreated sewage into waterways or back-ups into basements in cities with combined storm and sewer systems (e.g., Cumberland) [20], creating a potential for exposure to human pathogens such as those that cause diarrhea. In cities with aging infrastructure, even those with separate storm drains and sewers may still be vulnerable to overflows during periods of heavy or prolonged rainfall. In Baltimore, this occurs frequently as stormwater infiltrates the sewer pipes and excess volume is released through structured overflows, or damage from storm debris causes ruptures and leakage [109, 110, 111, 112, 113]. Adaptation measures which update aging infrastructure in such cases are crucial, and in Baltimore, those already underway are expected to alleviate 83% of the overflow volume by 2021 under the Sanitary Sewer Consent Decree Program [114]. Private wells can also be contaminated by extreme precipitation events, such as by livestock manure carrying the bacteria *E. coli* [104]. In other cases, flooding events may cause direct injury to those caught in its path, or damage to infrastructure which leads to increased growth of mold or bacteria which can aggravate allergies and asthma [25]. Adaptation or upgrades to stormwater management systems to accommodate for increased peak flow and nutrient



**Photo 14.** Loch Raven Reservoir, which serves Baltimore City and County, has a watershed that occupies almost the entire central portion of Baltimore County [163]. *[Photo by Mike]*

removal, or decrease the amount of overland flow (such as by reducing the amount of impervious land-cover in a watershed), may help alleviate some of these impacts.

As with other plants and animals, climate influences the habitat, population, and active season of ticks that spread Lyme disease and mosquitoes that spread West Nile virus and other pathogens [104]. According to one recent review, the gulf coast tick (which had a historic range suitable to its name) has expanded its geographic distribution northwards, including into the piedmont and coastal areas of Maryland [115]. The specific influence of climate change on disease incidence is, however, difficult to predict owing to the large number of other factors which also influence the spread of these diseases [104]. For example, it has been determined that the recent increase in Lyme disease cases in the Northeast is driven by multiple factors [25], though geographic location and seasonal climate variability are very likely to be significant factors in determining when and where exposure is most likely [104]. Adaptation of the human population to this increased risk should, again, have a strong influence on the eventual outcome of infection rates [104]. This includes broader vector-control measures such as spraying programs, as well as factors related to the vulnerability of individuals, like access to air conditioning.

### 2.3.3 Food and Energy Security

Climate change is expected to increase the exposure of food and consumers to pathogens, toxins, and chemical contaminants, and to increase the risk of disruptions to distribution systems (Figure 3) [104]. Changes to precipitation patterns in the Mid-Atlantic region are likely to increase overland flow and therefore the chemicals and other contaminants discharged into bodies of water, including those used as sources used for irrigation or fisheries [104]. Flooding caused by extreme precipitation further increases the likelihood that fields or fisheries are contaminated by pathogens, such as those released by overwhelmed sewer systems or carried from livestock manure, as noted in the previous section. Climate change may alter the ranges of bacterial and fungal pathogens which normally affect crops and farm animals; and higher temperatures may improve growing conditions, increasing the concentration of pathogens already typical during various stages of food production and storage [104]. Changes to the climate can increase risk of damage from pests and competitors; and in an effort to deal with these threats, many farmers may find it necessary to increase pesticide and herbicide use, thereby increasing the level of exposure to consumers [104]. Increased CO<sub>2</sub> levels may even decrease the nutritional content of crops, and has been shown to alter the ratio of macronutrients (decreasing protein concentrations) as well reduce the concentrations of micronutrients (e.g., iron, magnesium and zinc) per calorie [104]. Climate change also threatens the overall yields from agriculture, and decreased yield in other states or countries can still have a significant impact in Maryland. As mentioned in the introduction to this chapter, the State's economy and the other systems on which we rely are not isolated within Maryland. According to an analysis done by the Johns Hopkins Center for a Livable Future, the amount of vegetables produced in Maryland accounts for little more than 10 percent of consumption; dairy production is estimated to fill almost 30 percent; and fruit approximately 20 percent [116]. Key agricultural import sources for the U.S. include Mexico and Canada (almost 40 percent by USD in 2016 combined), followed by the European Union (another 18 percent), China, Brazil, Australia, Chile and Indonesia, among others [117]. These imports are, for the most part, processed goods such as coffee, wine, and cocoa (the top



**Photo 15.** Corn infected with fungi and potentially contaminated by mycotoxins.  
*[Photo by Jourdan Bell, Texas A&M AgriLife]*

three by USD in 2016), however staples such as beef, grains, fruits, vegetables and dairy products also make the top 25. Furthermore, in the event that prices are driven up by decreased supply, household food security may become a concern. The USDA estimated that around 11.8 percent of U.S. households (15 million) were food insecure in 2017, meaning at some time during the year, they did not have the resources to provide adequate food to all family members [118]. Although Maryland tends to fare better than the national average (about 10.4 percent average 2015 to 2017) [118], that is still a large number of households in the State that are likely vulnerable to further climate impacts.

## Farm to Table The Potential Interactions of Rising CO<sub>2</sub> and Climate Change on Food Safety and Nutrition



**Figure 3.** Diagram demonstrating the impacts of increased CO<sub>2</sub> concentrations and changes in temperature and precipitation which affect the quality and distribution of food, as well as food safety and nutrition [104].

Extreme weather events are likely to disrupt infrastructure, and while transportation was discussed at length, this also includes electricity, food and water, and communication services that are important not only to daily life, but also emergency response services; reducing capacity to respond to and recover from an event [104]. An extended loss of electricity may impact human health by restricting access to clean water (pumping stations, water treatment plants, and household well pumps), temperature control (A/C units, fans, and electric heating), safe food storage and preparation (refrigerators, freezers, and electric stoves), and certain emergency medical services [65, 104].

### 2.3.4 Equity

Communities that live in areas which are particularly vulnerable to the impacts discussed in this chapter are clearly more likely to be exposed to such events and scenarios; and individuals who may be inherently more sensitive or have a reduced adaptive capacity for responding to the scenarios have a higher probability of experiencing a negative outcome if exposure occurs. As noted previously, both factors are integral to describing the overall risk involved. While a few examples of vulnerable individuals and communities have been identified throughout this chapter, it is worth revisiting in a more cohesive manner. Sectors such as agriculture, fisheries and tourism were discussed in terms of jobs and the economy, for example, but it must not be overlooked that negative impacts to these industries have a very real and direct impact to individuals and families whose livelihoods depend on their yearly success.



**Photo 16.** Maryland woman with her great-granddaughter. [Photo by Christie Davis]

The U.S. Global Change Research Program refers to vulnerable groups as “populations of concern,” and identifies that this includes “those with low income, some communities of color, immigrant groups (including those with limited English proficiency), Indigenous peoples, children and pregnant women, older adults, vulnerable occupational groups, persons with disabilities, and persons with preexisting or chronic medical conditions” [104]. Furthermore, some communities may have less ability to respond to climate impacts and climate-change-related events based on socioeconomic status. Since all Marylanders are not starting out on equal footing, it is essential that these differences and disadvantages are taken into account during decision-making regarding resource allocation and prioritization of actions.

*The impacts of climate change will not affect Americans equally. In addition to regional differences in impacts, socioeconomic factors (e.g., income, education) affect adaptive capacity and can make some communities more vulnerable to impacts*

*-- U.S. EPA, 2015*

The State gives full consideration to climate change impacts as they relate to community concerns, and engages this issue through multiple avenues, including the Commission of Environmental Justice and Sustainable Communities (CEJSC), the legislation of the GGRA, and through the recommendations provided by the Commission. It is one of the charges of the Commission to address any disproportionate impacts of climate change, and it is also integral to the Commission’s work to consider unintended consequences of adaptation and mitigation efforts on these communities.

# 3

## POLICY & PROGRESS

### 3.1 The 2016 Greenhouse Gas Emissions Reduction Act (GGRA) – Reauthorization

As noted in the introductory chapter, the GGRA of 2009 was created based on the recommendations of the MCCC’s 2008 Climate Action Plan. The original law required Maryland to achieve a 25 percent reduction in statewide GHG emissions from 2006 levels by 2020. MDE’s *2015 GGRA Plan Update*, showed that Maryland was on target to not only meet but exceed this level of emissions reduction; and that it was being accomplished with an estimated economic benefit between \$2.5 and \$3.5 billion in increased economic output by 2020 as well as creation and maintenance of between 26,000 and 33,000 new jobs [119]. The *2015 GGRA Plan Update*, along with the MCCC’s *2015 Annual Report*, informed a review of the State’s progress that occurred at the end of that year. This review by the Governor and General Assembly was mandated by the original law, and culminated in a reauthorization of the GGRA in 2016. The updated law includes the same balanced requirements and safeguards as the original, such as protection of jobs and the economy, additional reporting, and a mid-course reaffirmation of goals by the General Assembly. The most significant enhancement was a new benchmark requiring a 40 percent reduction of emissions from 2006 levels by 2030. This additional benchmark was included in order to ensure continued progress after 2020 towards the State’s long-term GHG emission reduction goals; as indicated in the text of the 2009 and 2016 GGRA, which notes both reduction plans shall be designed “in recognition of the finding by the Intergovernmental Panel on Climate Change that developed countries will need to reduce greenhouse gas emissions by between 80 percent and 95 percent from 1900 levels by 2050” [31].



**Photo 17.** Signing of the Greenhouse Gas Emissions Reduction Act Reauthorization (SB 323) on April 4, 2016.  
[Photo by Joe Andrucyk]

MDE is currently working on a draft of the 40 by 30 plan, which is due to be presented to the Governor and the General Assembly by December 31, 2018. The final plan must be adopted in 2019, and has the same requirements as the 2012 plan, including: consideration of the impacts implementation may have on all segments of the community (rural, low-income, minority) as well as various sectors of the economy (agriculture, manufacturing); ensuring reliable and affordable electrical service; producing a net economic benefit for Maryland and a net increase in jobs in the State; encouraging new “green jobs” in Maryland; and special provisions protecting the manufacturing industry. MDE will also submit a report in 2022 describing the State’s progress toward achieving both the currently mandated GHG reductions (40 by 30), and the long-term goals as defined by the most up-to-date science regarding emissions reductions needed by 2050 to avoid the most dangerous impacts of climate change [31].

An independent study on the economic impacts of these GHG reduction goals is to be performed by an institution of higher education in Maryland, and overseen by the Commission. This report is due to the Governor and General Assembly in 2022, and will supplement the MDE progress report to inform the General Assembly’s decision regarding continuation or augmentation of the 40 by 30 goals, as well as the special manufacturing provisions. The law will terminate in 2023 if not reauthorized [31].

### 3.2 Progress towards the 2020 Goals

In the *2015 GGRA Plan Update*, MDE reported that the 2012 GGRA Plan was expected to result in an estimated \$2.5 to \$3.5 billion in increased economic output by 2020, and help create and maintain between 26,000 and 33,000 new jobs. At that time, the State was projected to be on target to exceed the emission reduction goal of 34.66 million metric tons of CO<sub>2</sub> equivalent (MMTCo<sub>2</sub>e, based on the global warming potential of other gases compared to CO<sub>2</sub>) by nearly 4 MMTCo<sub>2</sub>e. MDE is currently engaged in modeling for the draft 40 by 30 Plan, which estimates that Maryland will be within 1-2% of meeting our 2020 goals. Additionally, the State is in the process of updating its past emissions trajectory based on the 2017 GHG Emissions Inventory data, which will be available at the end of 2018. These combined pieces of information should provide a relatively complete picture of where the State expects to be in 2020, with the 2020 inventory (available end of 2021) to be the final confirmation of whether the goals were met.

The programs listed in this chapter are being specifically tracked for their contribution to the State’s GHG reduction efforts; and most information is taken directly from the annual reports submitted by State agencies regarding GGRA progress. A more thorough overview of these programs can be found in the *2015 GGRA Plan Update* (Table 1). In addition to the programs noted here, there are many other State initiatives that directly and indirectly impact mitigation and adaptation efforts, whether designed for such purposes or as a co-benefit.



**Photo 18.** MDE Secretary Ben Grumbles gives a tour of the Chalk Point Power Plant to officials from China’s Ministry of Ecology and Environment, to share Maryland’s experience with monitoring and policy enforcement practices for air emissions. [photo by Hannah Brubach]

**Table 1.** Key strategies and programs listed in the 2015 GGRA Plan

GGRA POLICY / PROGRAM
A. EmPOWER Maryland
B. The Maryland Renewable Energy Portfolio Standard (RPS)
C. The Regional Greenhouse Gas Initiative (RGGI)
D. Other Energy Programs
E. Transportation Technologies
F. Public Transportation
G. Pricing Initiatives
H. Other Innovative Transportation Strategies
I. Forestry and Sequestration
J. Ecosystems Markets
K. Building and Trade Codes in Maryland
L. Zero Waste
M. Leadership-By-Example
N. Maryland's Innovative Initiatives
O. Future or Developing Programs
P. Land Use Programs
Q. Outreach and Public Education

### 3.2.1 EmPOWER Maryland

Enacted in 2008, the EmPOWER Maryland Energy Efficiency Act (EmPOWER) set a target to reduce both Maryland's per capita total electricity consumption and peak load demand by 15 percent below 2007 levels by 2015. The program includes numerous State- and utility-managed energy efficiency and conservation programs, some of which are noted later in this section. EmPOWER is funded in part by the Regional Greenhouse Gas Initiative, but also by a line-item on utility ratepayer bills. While the Maryland Energy Administration (MEA) is the lead on non-utility EmPOWER programs, the Public Service Commission (PSC) is responsible for ensuring that the utilities meet their goals. A 2017 order by the PSC extended the utility programs for 2018-2020, approving several new programs, pilots, and enhancements to the suite of energy efficiency portfolios [120]. By increasing energy efficiency across the State, the amount of electricity required for "business-as-usual" activity is decreased, thereby reducing demand for electricity and GHG emissions from the electricity sector.

### 3.2.2 The Maryland Renewable Energy Portfolio Standard

Recognizing the economic, environmental, fuel diversity, and security benefits of renewable energy resources, Maryland became one of the first states to adopt a Renewable Energy Portfolio Standard (RPS) in 2004. The Legislature intended the RPS law to establish support for development of renewable electricity generation within Maryland and the PJM region, by requiring that power providers procure Renewable Energy Credits from renewable sources. The Maryland legislature updated the original legislation in 2017, to increase the goal to 25 percent of retail electricity sales by 2020, replacing the 20 percent by 2022 target. This includes a 2.5 percent carve-out specifically for solar energy. The RPS legislation has a clear and direct impact on GHG emissions from the electricity sector, by increasing the percentage of electricity that comes from zero emission generation sources.

### 3.2.3 The Regional Greenhouse Gas Initiative

The Regional Greenhouse Gas Initiative (RGGI) is a cooperative effort by Maryland and eight partner states to reduce CO<sub>2</sub> emissions from the electricity generation sector. Maryland formally joined RGGI in 2007, and its participation is managed by MDE and the PSC. Maryland Secretary of the Environment, Ben Grumbles, chairs the program. RGGI is based on a “cap and invest” strategy, with a collective 91 million ton cap set for all participating states in 2014 declining by 2.5 percent annually until 2020, and then by another 30 percent from 2020 to 2030. The states are allocated a portion of the total cap, and sell most of their emission allowances at quarterly auctions. Auction proceeds fund various programs which promote energy efficiency, renewable energy, or other consumer benefits. Maryland invests auction revenue in the Strategic Energy Investment Fund (SEIF), which is administered by MEA. SEIF is used in part to fund EmPOWER Maryland projects, including energy efficiency upgrades for low-to-moderate income families; and is also allocated for direct bill assistance and projects that promote affordable, reliable, and clean energy across Maryland. According to the most recent update by MDE, the potential emissions reductions over the lifetime of the RGGI program are estimated to be 3.60 MMTCO<sub>2</sub>e by 2020; and the program is anticipated to continue driving emissions reductions into the future.

In 2017, the RGGI states announced a series of improvements to the program that build on past successes and continue to reduce GHG emissions after 2020 through innovative approaches. Maryland played a leading role in forging this bipartisan consensus to strengthen and broaden the groundbreaking program with a number of proposed improvements. During the program review, the states established a 30 percent reduction in the carbon cap from 2020 to 2030 and the Emissions Containment Reserve, which will secure additional environmental progress if emission reductions are less expensive than anticipated. In addition, the Cost Containment Reserve, which protects consumers by releasing additional allowances when costs are significantly higher than expected, will remain in effect.

During 2018, RGGI has seen many successes. First, RGGI hosted its 40th allowance auction and celebrated the program’s successful year. Second, the RGGI program collaborated with two new states, New Jersey and Virginia, to build relationships and help the states initiate participation in the program. Both states officially announced that they will be proposing regulations to participate in the program in 2020. The RGGI program plays an important role in Maryland’s statewide climate change efforts, and is a significant component of the GGRA program as it generates both environmental and economic benefits for the State.

Updates, including information on upcoming stakeholder meetings, news, and auction results, can be found at <https://www.rggi.org/>.

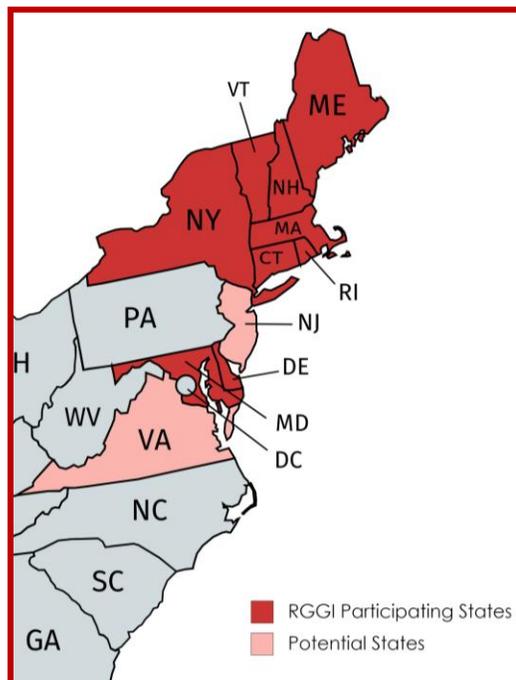


Figure 4. RGGI participants and potential participants. [Image created with mapchart.net]



### 3.2.4 Other Energy Programs

The mission of the Maryland Energy Administration is to promote affordable, reliable, and cleaner energy for the benefit of all Marylanders. MEA manages a portfolio of energy efficiency, renewable energy, and transportation programs that reduce energy consumption and produce cleaner energy for Maryland residents and businesses, many of which are linked to EmPOWER, the RPS, and RGGI. As these programs tend to have broad reaches, the Administration often works in partnership with other agencies to accomplish the full scope. Furthermore, several agencies work through programs managed by the Federal government to provide energy efficiency and renewable energy benefits to Marylanders. The Maryland Department of Housing and Community Development (DHCD), for example, manages several energy conservation and retrofit programs that specifically reduce energy costs and address critical health and safety hazards for low-income Maryland residents. Many of these energy projects, by their nature, build sustained GHG savings over time. A number of State programs for energy efficiency and renewable energy are highlighted below.

#### Energy Efficiency

- The *Combined Heat and Power (CHP) Grant Program* is offering \$4 million in FY 2019 for projects at commercial, industrial, institutional, and critical infrastructure facilities, in order to encourage the further implementation of CHP technologies in Maryland [121].
- The *Commercial and Industrial Grant Program* provides incentives for these groups to implement projects that reduce electricity usage by 15 percent or more, such as building insulation and envelope improvements, lighting and controls, and HVAC upgrades [122].
- The *Data Center Energy Efficiency Grant Program* is designed to support the robust and growing information technology sector in Maryland by providing grants on a competitive basis to encourage the implementation of cost-effective energy efficiency measures in data centers around the State.



**Photo 19.** The MEA team and Governor Hogan at Peninsula Regional Medical Center in Salisbury, MD for the dedication of their new Combined Heat and Power (CHP) system. This \$6 million investment was supported by State and utility-level grants, as well as fiscal and construction support from corporate partners, and the system generates 26 million KWh per year. [Photo by Maryland Energy Administration]

- The *Boiler Maximum Achievable Control Technology* (MACT) rule, administered by MDE, requires certain industrial, commercial and institutional boilers to conduct tune-ups that improve efficiency, minimize fuel consumption, and reduce emissions.
- The *Weatherization Assistance Program*, managed by DHCD, helps eligible low-income households across the State of Maryland with the installation of energy conservation measures in their home. These measures reduce the consumption of energy, GHG emissions, and the cost of maintenance for the homes. Funding is provided by the U.S. Department of Energy (DOE) and SEIF.
- The *EmPOWER Low Income Energy Efficiency Program* and the *Multifamily Energy Efficiency and Housing Affordability Program* help low-income households and affordable housing managers with installation of energy conservation measures in their homes and buildings. Funding is provided by the EmPOWER program.
- The DHCD manages a *BeSMART Home Loan Program*, which offers financing to homeowners across the State for energy efficient replacements and/or upgrade of appliances as well as heating, cooling, and ventilation systems; and for whole house envelope improvements. The BeSMART platform grew over 2017/2018 to support a new *Net Zero Construction Loan Program* for projects which are Net Zero or Net Zero Ready (Home Energy Rating System score of 50). The first project, anticipated to be completed this year, was deployed at Perry Point – an affordable housing rehabilitation that will serve veterans.

### Renewable Energy

- The *Parking Lot Solar PV Canopy with EV Charger Grant Program* combines Maryland's RPS goal for solar with the State's ongoing support of electric vehicle (EV) infrastructure by providing incentives for the installation of solar PV canopies in combination with EV-charging stations at Maryland parking lots. This program also maximizes the efficient use of land area by utilizing existing parking lot space in the State.
- MEA's *Clean Energy Grant Programs* offer incentives to Maryland homeowners, businesses, nonprofits, State departments and agencies, and local governments for the installation of a variety of qualifying clean energy technologies to support the State RPS.
- The *Animal Waste Technology Fund*, managed by Maryland Department of Agriculture (MDA), provides incentives for farm projects that provide alternative strategies for managing animal manure, \$2 million of which is carved out for renewable energy projects in FY 2019 [123]. Additionally, MEA is providing \$6 million in FY 2019 to businesses, government agencies, and non-profits in Maryland for assistance installing *Animal Waste to Energy Projects* [124]. This is intended to encourage pilot or on-farm projects as well as larger community/regional facilities.
- The *Offshore Wind Workforce Development Grant Program* provides funding for new or existing workforce development training centers that provide technical education related to development, manufacturing, construction, installation, operations and maintenance of offshore wind energy projects [125]. This program is designed to prepare a workforce for the development of an offshore wind industry in Maryland.



**Photo 20.** Llamas grazing near the solar panels on a farm in Carroll County, Md.  
[Photo by Hannah Brubach]

### 3.2.5 Transportation Initiatives

State programs, many of which are managed by Maryland Department of Transportation (MDOT), focus on the GHG emissions from on-road vehicles. Levers to impact emissions from aviation, marine, rail, and non-road sources are indirect and primarily focused on operations within the boundaries of the Port of Baltimore and Maryland's airports; excluding the remainder of commercial operations. MDE works with MDOT, the Baltimore Regional Transportation Board (BRTB), the Metropolitan Washington Council of Governments (MWCOCG), the Wilmington Area Planning Council (WILMAPCO), and other state agencies and stakeholders to evaluate proposed major transportation projects for potential growth in vehicle miles traveled (VMT) which may cause increases in transportation-related GHG emissions.



**Photo 21.** MDE Secretary Ben Grumbles, the president of the Maryland Motor Truck Association Louis Campion, and the president of Cowan Systems signed a pledge to work to reduce unnecessary idling in MD, as part of the Idle Free MD program. This is one of Maryland's many transportation-related programs, and has both air and water-quality benefits, including GHG emissions reduction. *[Photo by Maryland Department of the Environment]*

#### Maryland Clean Cars Program

Maryland's Clean Cars Program is designed to lower emissions from vehicles and is implemented by MDE. The program adopted California's strict vehicle emission standards in November 2007, implementing the California Low Emission Vehicle Standards II (CALEV II) for all model year 2011 vehicles. It works on a macro level; rather than applying to individuals it sets a standard based on fleet-wide emission averages. The purpose of the Clean Cars Program is to reduce a number of vehicle emissions, including volatile organic compounds (VOCs) and nitrogen oxides (NO<sub>x</sub>); but it directly regulates CO<sub>2</sub> emissions as well. The Clean Cars Program is mandated by the Maryland Clean Cars Act of 2007 and has been fully implemented through regulations codified in COMAR 26.11.34, the Low Emissions Vehicle Program, adopted and enforced by MDE.

In 2017, the program was updated to maintain consistency with the California Program, adopting changes designed to:

- Streamline testing for the alternative fuel conversion certification procedure and reduce the burden for small volume manufacturers;
- Provide greater flexibility to intermediate volume manufacturers to meet the Zero Emission Vehicle (ZEV) requirement;
- Align the CALEV III program and test procedures with the Federal Tier 3 program;
- Align the medium and heavy-duty GHG regulations with the EPA's Phase 1 GHG regulations; and
- Improve compliance flexibility and strengthen the performance requirements of the On-Board Diagnostics II (OBD II) regulation.

### Electric and Alternative Fuel Vehicles

A key component of reducing GHG emissions from the transportation sector is increasing the use of EVs. Maryland's Electric Vehicle Infrastructure Council (EVIC), established in 2011, continues to build opportunities for and remove barriers to plug-in EVs in Maryland. Additionally, in 2013, Maryland joined a multi-state ZEV Task Force which works to support the implementation of each state-run ZEV program and move towards their collective goal of 3.3 million ZEVs operating on these state's roads by 2025



**Photo 22.** New EV charging stations at the I-95 Maryland House Travel Plaza.

*[Photo by Maryland Transportation Authority]*

“EV ready” designation<sup>5</sup> from the Federal Highway Administration for portions of I-95, I-83, I-81, I-70/I-68, I-270, I-695, I-495, US 50, and US 301 [130, 131]. As of September 2018, the total number of battery-electric and plug-in hybrid electric vehicles registered in Maryland was approaching 15 thousand.

Maryland, as a beneficiary of the Volkswagen Settlement Agreement, is eligible to receive approximately \$75.7 million to use on specific projects intended to reduce emissions from the transportation sector. MDE partnered with MDOT and MEA to develop a Draft Mitigation Plan, focused on reducing NO<sub>x</sub>

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<sup>5</sup> This designation includes DC Fast Chargers and Level 2 with publicly accessible stations less than five miles from the highway and less than 50 miles between stations.

emissions which is in keeping with the settlement agreement [132]. By implementing the measures in the Draft Plan, Maryland will also experience significant co-benefits such as reductions in GHGs. The project guidelines allow for up to 15% of the funds to be used for electric vehicle charging infrastructure. Maryland intends to utilize the full 15% (approximately \$11.3 million) for installing a mix of charging and fast charging stations. This part of the Draft Plan will be coordinated with other existing electric vehicle infrastructure initiatives to maximize the benefits of the State's investment. Installing charging stations across the State will help facilitate the growth of the electric vehicle market in Maryland and assist in meeting GHG goals.

### Public Transportation

Increasing public transportation use is one of the many ways to reduce both VMT and congestion, by reducing the number of cars on the road. The multi-year planning process and deployment of BaltimoreLink in 2017 was a major effort and investment of \$135 million, resulting in the reconfiguration of local and commuter bus service throughout Baltimore. BaltimoreLink aimed to create a more reliable, efficient, and accessible system, with high-frequency service available to approximately 130,000 (32 percent) more people<sup>6</sup> [133]. In June 2018, approximately one year into the reboot, the Maryland Transit Authority (MTA) reported that local and CityLink buses are hitting timed targets approximately 70 percent of the time; up from its previous rate of 59.5 percent [134]. There are also plans for additional improvements in 2019 such as mobile ticketing and real-time GPS tracking of bus service [134]. Numerous additional public transit projects are in the planning or construction phases, and these are discussed further in later sections. The relationships and priorities of policies and investments that advance public transportation and those that promote roads and vehicular traffic will remain an area of active public debate. Requirements to substantially reduce our GHG must be incorporated into existing considerations for personal convenience and choice, growth and development, and congestion and efficiency.



**Photo 23.** Baltimore light rail after the 2017 BaltimoreLink redesign of the area's core transit system.  
*[Photo by BeyondDC]*

### **3.2.6 Managing Natural and Working Lands**

Land conservation and sustainable management offers an important mechanism for mitigating and adapting to climate change. Healthy and vigorous forests and grasslands not only provide direct benefits in GHG reduction but keeping them intact also helps to avoid or diminish additional GHG emissions which would be associated with development. Climate change is projected to have multiple and potentially severe impacts to the agricultural and forestry sectors; shifting the optimum growth ranges for various species, and increasing direct and indirect stressors such as heat and pests. The State's programs in land management work on all these fronts – to mitigate by increasing sequestration capacity and avoiding future emissions, and also adapt by taking steps that make Maryland more resilient to direct and indirect climate change impacts.

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<sup>6</sup> The service is considered “available” to people living within a quarter-mile of the transit system.



## Forestry and Wetlands Management

There are an estimated 2.5 million acres of forest land in Maryland. Though long-term data show decreases since the 1963 inventory, the net volume of trees on forest land has increased since 2011, and in 2017, the total annual growth of all live trees on timberland outpaced total removals by a ratio of 2.3:1, further improved from 1.9:1 in 2016 [135, 57]. MDNR acts as state lead in *Managing Forests to Capture Carbon*. This program promotes sustainable forestry management practices which enhance productivity and increase carbon sequestration in existing Maryland forests on both public and private lands. The goals of this program are to improve sustainable forest management on 30,000 acres of private land annually and on 100 percent of State-owned resource lands, and ensure 50 percent of State-owned forest lands will be third-party certified as sustainably managed. Enhanced forestry management in Maryland should contribute a total 1.8 MMTCO<sub>2</sub>e cumulative reduction in the State's GHG emissions in 2020. In addition to management of existing forest lands, MDNR is leading efforts on *Planting Forests in Maryland*. Planting trees expands forest cover and associated carbon stocks by regenerating or establishing healthy, functional forests through practices such as soil preparation, erosion control, and supplemental planting, to support optimum forest growth. By 2020, the implementation goal of this program is to achieve the afforestation and/or reforestation of 43,030 acres in Maryland; and over 38,000 acres have been planted thus far (between 2006 and 2017). This program is expected to achieve 1.79 MMTCO<sub>2</sub>e of cumulative sequestration in 2020.

In addition to forests, wetlands are known to be very efficient at sequestering soil carbon; though their contribution to Maryland's GHG emissions can be difficult to quantify due to the methane generated by anaerobic decomposition. A variety of wetlands and waterways programs managed by MDNR help the State meet both water- and air-quality goals. For example, in 2017 alone The *Natural Filters Program* restored 149.4 acres of wetlands and planted 56.17 acres of streamside forest buffers on state and public lands. To date this and other wetland and waterway projects have restored 2,384 acres of wetland and 1,184 acres of riparian buffers. Since both forests and wetlands can be a source or a sink of GHGs, depending on their management, it will be particularly important to continue these programs and retain sequestration benefits into the future.

## Agricultural Land Conservation



**Photo 24.** Farm in Carroll County, MD that is managing land as part of the CREP program.  
[Photo by Hannah Brubach]

The Maryland Department of Agriculture (MDA) seeks to safeguard Maryland's network of natural areas, agricultural lands, and coastal zones through its established conservation programs and practices. MDA has pursued policies and programs that curb the conversion of agricultural lands and encourage the conservation of natural resources, working with its partners at MDNR and Maryland Department of Planning (MDP) in these efforts and to promote the preservation and restoration of forested, grassed, and wetland areas on agricultural lands. Two MDA programs that have long been key to these efforts are the *Maryland Agricultural Land Preservation Foundation (MALPF)* and the USDA's *Conservation Reserve Enhancement Program (CREP)*. MALPF, which purchases permanent preservation easements, was established in 1977 and is one of the most successful programs of its kind in the country.

Besides maintaining prime farmland and woodland as a viable local base of food and fiber production, the protection of agricultural land reduces random urban development, safeguards wildlife habitat, and enhances the ecology of the Chesapeake Bay and its tributaries. As of this June, MALPF alone has preserved a total of 312,667 acres, but when added to other qualified State easement programs, over 640,000 acres have been protected. Maryland has participated in CREP since 1997 to target high-priority conservation concerns by offering rental payments for 10 to 15-year set-aside contracts and other incentives to agricultural producers to protect environmentally sensitive lands, improve wildlife habitat, and reduce nutrient and sediment loss. While enrollment has generally been declining, most of the funded areas have maintained their conservation measures. Furthermore, these CREP areas are being targeted for *permanent* protection under MDNR's Easement Program, and nearly 11,500 acres have been converted so far.

### 3.2.7 Land Use Development

Maryland's GGRA Plan includes two programs designed to minimize GHG emissions through the management of future land development: (1) Reducing Emissions through Smarter Growth; and (2) Land Use/Location Efficiency and Priority Funding Area Related Benefits. MDP is the lead agency for these efforts, which involve the private sector as well as various agencies and commissions at all levels of government within the State. Overall, land use development trends in Maryland have moved in the direction of more compact development, with at least 75 percent compact development from 2011 through 2017, a marked improvement from 62.5 percent compact development between 2001 and 2010. Despite implementation of the land use programs, market, economic, and other forces invariably have an impact on the location and intensity of new development. This, in turn, impacts the GHG emissions prevented.

MDP provides data analysis and forecasting as part of its technical assistance to State and local governments, to promote smart growth and land-use efficiency. They utilize a variety of data sets and analytical tools, such as MDP's parcel database, U.S. Census information, land use/land cover data, and modeling. By better managing growth, local communities can maximize the efficiency of their development patterns and contribute to a reduction in Maryland's GHG emissions. Smart growth promotes compact, mixed-use development that maximizes mobility and housing choices; and encourages new development (or redevelopment) in areas with existing or planned infrastructure, to reduce sprawl. This helps preserve vegetated/forested lands and protect agriculture, while helping to increase the economic competitiveness and fiscal performance of local communities. Many local governments in Maryland are increasingly implementing these kinds of land use and transportation policies and programs. The following are a few examples of programs and initiatives managed by MDP which support these efforts.



**Photo 25.** In the town of Berlin in Worcester County, MD, businesses and town leaders actively engaged to ensure that recent redevelopment and reinvestment were completed strategically. For example, county officials created mixed-use zoning laws that allowed for dwellings above first-floor commercial properties, to help encourage smart growth [164].  
[Photo by Philip N Young]

- The Maryland Smart Growth Subcabinet makes recommendations to the Governor regarding changes in State law, regulations, and procedures needed to create, enhance, support, and revitalize Sustainable Communities across Maryland. It also facilitates interagency coordination to ensure successful statewide community reinvestment and compact development initiatives through implementation of the recommendations from the Maryland Sustainable Commission’s *Reinvest Maryland 2.0* report (released in May 2018), and development of new strategies associated with the new State development plan, *A Better Maryland*.
- The Maryland Sustainable Growth Commission identifies regional growth and development issues for the Governor's Smart Growth Subcabinet, and recommends opportunities for collaboration on these issues between the State and local governments. It also reviews statewide efforts to implement the state growth plan and the state plans for transportation and housing. This includes review of state programs and development of tools and recommendations to assist Maryland’s counties, towns, and communities to meet the goals of the *Reinvest Maryland 2.0* initiative.
- Maryland has designated Priority Funding Areas to influence smarter, more sustainable growth and development; and legislation directs the use of State funding for roads, water and sewer systems, economic development, and other growth-related needs toward these areas.

### 3.3 Adaptation

Even as the state moves forward with actions that will reduce greenhouse gases (GHGs) and ultimately result in increased energy efficiency, a more sustainable economy, and cleaner air, climate impacts will still be felt into the future. The climate is already changing and Maryland is seeing an increase in extreme flooding and extreme heat events, presenting new adaptation challenges in both the coastal and non-coastal zones. As efforts to advance climate adaptation in Maryland have evolved over the past decade, the scope and scale at which progress is being made also continues to change. In order to reduce Maryland’s climate change vulnerability, short- and long-term actions are being undertaken to plan for and implement projects and programs aimed at addressing diverse impacts of climate change.

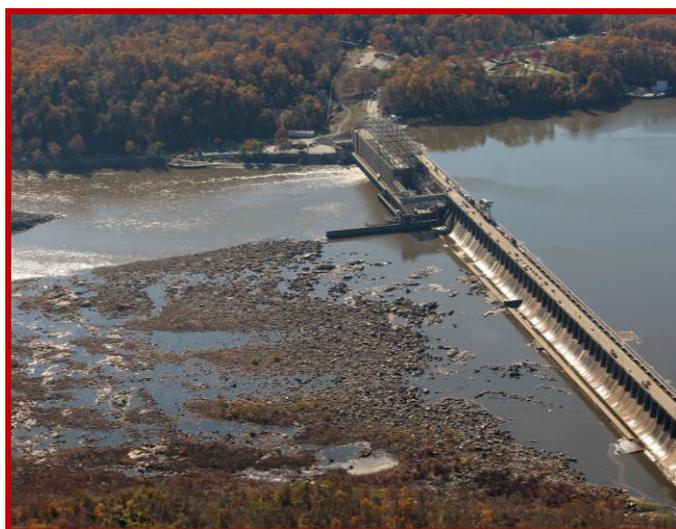


**Photo 26.** Maryland DNR's Chesapeake and Coastal Service work to establish a living shoreline in Havre De Grace, MD. Living shorelines are one type of nature-based project being undertaken by the State to help increase coastal resiliency and reduce climate impacts.

[Photo by Stephen Badger, Maryland Department of Natural Resources]

Progress over the past year has embraced a broadened adaptation scope to meet these climate adaptation needs. 2017-2018 saw significant progress addressing issues ranging from public health, to transportation system risk assessments, to incorporation of resilience in restoration practices and coastal and nuisance flooding. A number of programs advancing climate adaptation are highlighted below.

All Chesapeake Bay states are now required to incorporate climate change into their Chesapeake Bay nutrient reduction *Watershed Implementation Plans (WIPs)*, which include the implementation strategies for achieving the Chesapeake Bay nutrient and sediment TMDLs required under the federal Clean Water Act. As discussed earlier in this report, climate change is expected to make the nutrient reduction goals more challenging. To confront this challenge, members of the Principals' Staff Committee, who represent the Bay-state governors, agreed to a three part climate strategy in March 2018 [136]. First, states will include a narrative strategy in their 2019 Phase III WIPs to address climate change. Second, the Bay Program Partnership will sharpen its understanding of the impacts of climate change on the Bay, identify research needs, and refine nutrient and sediment load estimates for each Bay jurisdiction by March 2021. Third, Bay States will account for additional nutrient and sediment loads, as well as improved understanding of the behavior of pollution control practices under climate change conditions, beginning in September 2021. These strategies will be reflected in a Phase III WIP addendum and/or 2022-2023 two-year milestone commitments. The framework of the Phase III WIP is strongly aligned with the overall dual-pronged approach and adaptive management strategies that Maryland is committed to employing, which will be critical to the long-term success of climate and TMDL efforts.



**Photo 27.** The Conowingo Dam traps much of the Susquehanna's upstream sediment before it flows into the Chesapeake Bay. [Photo by Dylan Taillie]

The *Coast Smart Construction Program* includes guidelines and other directives applicable to the preliminary planning and construction of proposed capital projects to address sea level rise and coastal flood impacts. This includes a requirement that the lowest floor elevation of proposed structures located within a Special Flood Hazard Area be built at an elevation of at least 2 feet above the base flood elevation [137]. The program is intended to be used by all Maryland agencies that design and build facilities, or that prepare programs and budgets for the design and construction of facilities. It is specifically created for project managers, capital planners, and the professionals who will design and operate State-owned facilities [138]. The Program will be reviewed annually by the Council and revised as necessary to address issues which may occur as the building of State facilities and knowledge of Coast Smart building practices evolves.

In support of the MCCC's Adaptation and Response Working Group's effort to determine the local capacity for climate change adaptation planning, MDP conducted a *Comprehensive Plan Review* for the 23 counties and the City of Baltimore, as well as the Montgomery County Climate Protection Plan and the City of Baltimore's Disaster Preparedness and Planning Project Plan, to determine if and how current plans are addressing climate change. This information will assist the state in tailoring adaptation planning assistance based on an understanding of the current local capacity.

MDOT is conducting an ongoing *State Highway Vulnerability Assessment* to determine the current and future impacts of climate change on the transportation network. Data from the vulnerability assessment will be integrated into all aspects of planning, programming and design to ensure resilient and reliable transportation is available for counties to utilize [139]. MDOT's programs focus on an integrated and multimodal approach, leveraging public-private partnerships and ensuring equity to accomplish these goals.

Dam safety is also an important part of adaptation efforts related to riverine flooding; and MDE administers the State's *Dam Safety Program* as part of stormwater management. Recent legislation requires owners of dams, which have been assessed as hazardous, to maintain a detailed Emergency Action Plan, which includes information on monitoring weather and conditions during emergencies, and actions to protect lives and property downstream [140].

The *Maryland Climate Change Health Adaptation Program* (MCCHAP) at the Maryland Department of Health (MDH) has begun development of an Environmental Public Health Climate Adaptation Tracker (EPHCAT). The EPHCAT will be an online portal that highlights climate adaptation around the State of Maryland that includes a health adaptation component. The tracker will host relevant information (organization, purpose, outcomes of interest, health component, and timeline) as well as supplemental content information as deemed relevant. It aims to begin filling a gap that exists around awareness of climate and health adaptation work in Maryland and will be populated with assistance of the MCCC working groups. MCCHAP is expanding the educational and training adaptation program 'Climate Change and Community Health Workers' to include chronic disease management and emergency preparedness. This training program is the result of a partnership with the University of Maryland Extension. MCCHAP is holding a round of community health worker (CHW) trainings across the state during the summer/fall of 2018. Additional effort is made to align goals and approaches with similar adaptation programs that fall under a Climate Ambassador umbrella. The Climate Ambassador umbrella is an attempt by ECO at bringing together similar programs to increase the understanding of, evidence base around, and communication about adaptations taking place across Maryland.

### 3.4 Long-Term Goals: Beyond 2020

Maryland has always been a leader in tackling climate change. We are on track to meet or exceed existing goals, and well-positioned to continue this progress and maintain our leadership role into the future. Many of the control programs in Maryland's 25 percent by 2020 Plan are not tailored to a 2020 endpoint, but designed to generate deeper reductions as they are implemented through 2030 and beyond. For example, mobile source emission reductions will occur as fleets turn over and older vehicles are replaced by newer models with more stringent requirements and updated technology, decreasing the total pollution burden. Energy sector reductions related to RGGI, Maryland's RPS, and supply and demand-side energy efficiency measures should also continue to decrease total GHG emissions. In addition to existing efforts and emerging strategies being considered by the State, MDE is keeping track of broader trends such as energy demand, fuel usage, and travel trends which are expected to impact the additional reductions needed.

Modeling is currently being conducted to update both emission and economic impacts of programs moving forward, as well as a variety of policy scenarios, all of which will inform the State’s 40 by 30 Plan. MDE has been working with both the MWG and the Commission on these modeling scenarios to better assist the development of the Plan in a transparent manner. To date, the Commission has been presented with information from both the reference case (baseline scenario) and Policy Scenario 1, which utilized on-the-books policies as well as several new concepts consistent with proposed legislation. Other model runs being developed include a more aggressive policy run with new programs (Policy Scenario 2), and a run developed by the MWG which focused on carbon pricing policies. In aggregate, the scenarios encompass existing policies, more aggressive versions of existing policies, new policies discussed by the MWG and the Commission, and more long-term policies with 2050 in mind. Results from this broad range of scenarios will help educate Maryland on the options available to meet the GGRA goals with consideration for emissions, economics, and employment.

As this information is compiled, MDE will be able to determine not only whether critical adjustments *need* to be made in order to ensure a successful 40 by 30 Plan, but also what adjustments *can* be made to achieve even deeper reductions while still maintaining net economic progress and jobs growth. The complete suite of proposed programs and initiatives will be drafted and available to stakeholders for review in MDE’s Draft Plan at the end of 2018, in conjunction with the most recent update of the GHG Inventory. Program evaluation will include consideration of the full scope of expected emissions reductions into the future, so that the plan might be compatible with long-term emission reduction goals; and to comply with the 2016 GGRA requirement that plans “be developed in recognition of the finding by the IPCC that developed countries will need to reduce GHG emissions by between 80 percent and 95 percent from 1990 levels by 2050. Throughout the process, this modeling information and analysis will continue to be shared with the Commission. While the final Plan is a State product, the Commission is an integral stakeholder. Such open lines of communication enhance the capabilities of the Commission to perform their mandate, and allow the State to make best use of the diverse expertise therein. This framework will generate the substantive feedback necessary for Maryland to put forth a robust final Plan in 2019, with careful consideration for inventory data, modeling, and stakeholder input, to ensure that Maryland has everything in place to meet or, if feasible, to exceed its ambitious reduction goals.



**Photo 28.** Wetlands in New Germany State Park, Garrett County, MD. [Photo by Matt Tillett]

### 3.4.1 Potential Upcoming Programs and Projects

The following represent just a few of the programs or projects that are being researched, analyzed, planned, and developed as potential contributors to the State's 40 by 30 and long-term goals. Some of these programs are newly emerging, and others have been in the works for some time, but for varying reasons have not been fully realized in the 25 by 20 time frame.

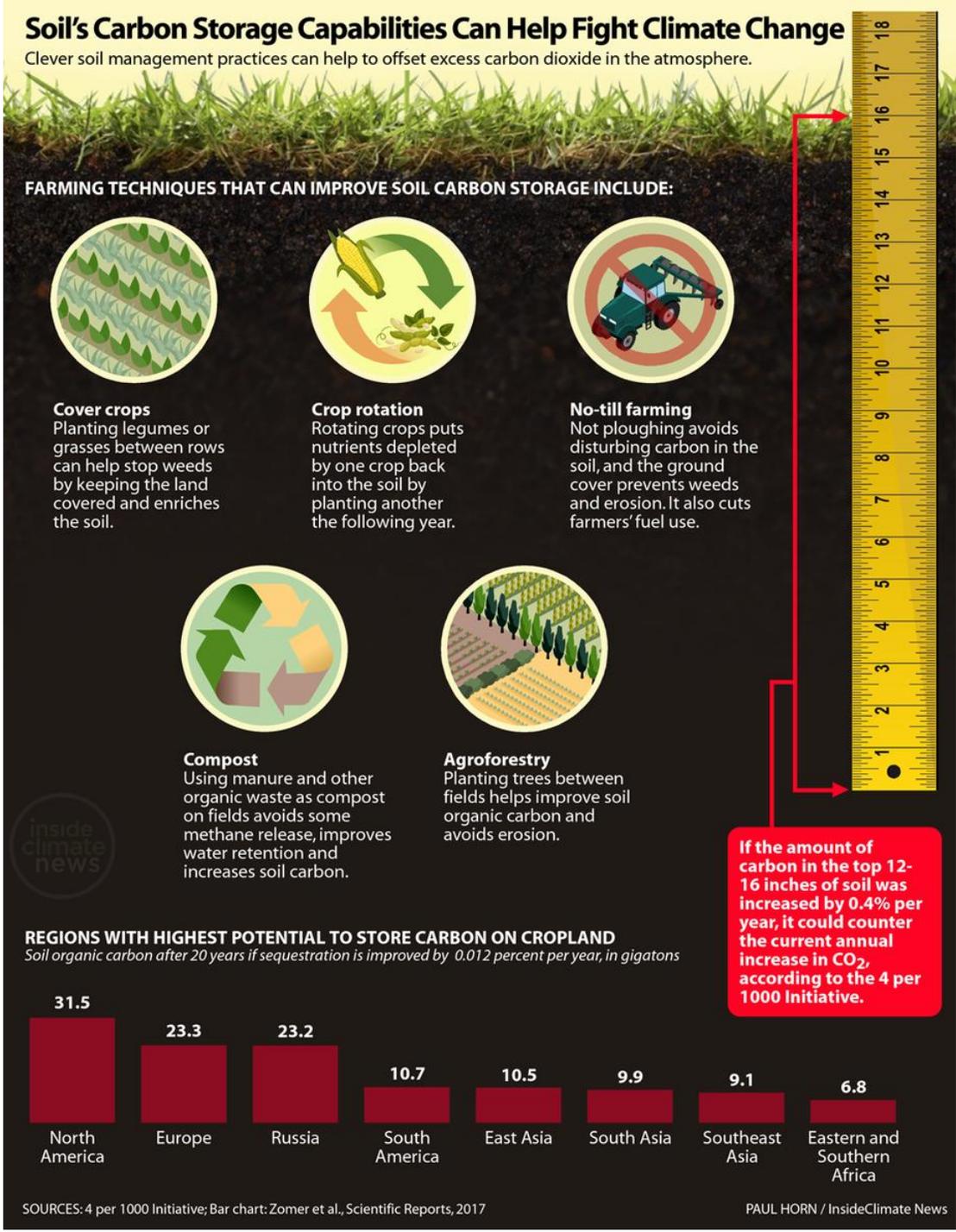
#### Sequestration in Agricultural Soils

In addition to their proven success in reducing nutrient and sediment flows into the Chesapeake Bay and its tributaries, many of the agronomic and conservation practices already used by Maryland's farmers have the potential to make a significant contribution to the State's climate change goals by sequestering carbon and other GHGs. Under the auspices of the Healthy Soils Initiative and the Healthy Soils Act, MDA has collaborated with participants in the Healthy Soils Consortium to complete a comprehensive scientific literature review to identify those practices that are most effective in building soil carbon stocks. The next steps will be to create a menu of Maryland-specific practices, determine the metrics and tools that will be used to quantify soil carbon, and develop a new incentive program to encourage the adoption of more climate-friendly practices. While some refinements will be necessary, estimates based on early data indicate that Maryland's agricultural soils can sequester enough carbon to reduce GHGs by 0.75-1.0 MMTCO<sub>2</sub>e annually [141].

Figure 5 on the next page illustrates a number of practices that can improve soil storage capacity, as well as some of their co-benefits. Estimates vary for the percentage increase in both organic matter needed and the resulting atmospheric reductions produced, but France's "4 per 1,000" initiative suggests that a mere 0.4% annual improvement in global soil carbon levels could offset the total amount of CO<sub>2</sub> sent into the atmosphere every year. Although this is may not be a realistic target, it certainly demonstrates the potential contribution of agriculture to combating climate change [142].

#### Geological Opportunities to Store Carbon

Multiple entities are currently engaged in research to develop technology that captures CO<sub>2</sub> generated by fossil fuel combustion before it enters the atmosphere, and either transforms it for an alternative use, or stores (sequesters) it indefinitely. MDNR is lead on identifying and assessing such geological storage opportunities in the State. To facilitate this, Maryland is a part of the Midwest Regional Carbon Sequestration Partnership, one regional segment of a national (DOE) effort to study carbon-sequestration options for mitigating climate change. So far, the partnership has identified more than 10 gigatonnes of storage capacity within terrestrial Maryland, and an unquantified but potentially larger amount of storage offshore. MDNR is working with a number of institutes of higher education and the surrounding Mid-Atlantic states to further evaluate this offshore potential, including information on geologic characterization, capacity evaluations, injectability, and risk analyses. This type of thorough evaluation is particularly important to ensure that if Maryland pursues geologic sequestration, it is a permanent solution. As noted in last year's report, there are still concerns regarding this technology and method, including the potential for leaks which would release large amounts of CO<sub>2</sub> back into the atmosphere. Currently, MDNR reports that this method is cost-prohibitive, though cost has been slowly decreasing as technology improves.



**Figure 5.** Infographic showing some best management practices that can improve soil carbon storage [161].

### Biomass for Energy Production

Maryland is working to promote the use of locally produced woody biomass for generation of thermal energy and electricity. Energy from forest by-products can be used to offset fossil fuel-based energy production and associated GHG emissions. The goal of this program is to develop policies that recognize wood as a preferred renewable energy source, recognize wood as the largest source of biomass to energy potential in Maryland, and offer incentives to utilize locally produced wood to meet thermal energy needs. Awareness of wood energy technology is the primary barrier to this program. In particular, it will be important to adequately convince the managers of commercial and institutional spaces of the opportunities to save money while improving environmental outcomes that are offered by the simple switching of wood fuels.



**Photo 29. Fall forest in Baltimore County, MD.**  
*[Photo by Catharine Love]*

### Water Quality Trading and Ecosystem Markets

Maryland's Water Quality Trading Program is a partnership between MDE and MDA. Since many of the agronomic, land use, and structural practices promoted by the Trading Program also store carbon and lower other GHG emissions, the existing nutrient marketplace could provide a platform for the addition of a voluntary carbon component. Just like the nutrient and sediment markets, carbon trading offers entities under regulatory requirements a potentially more cost-effective means to maintain their limits by acquiring credits or offsets generated from reductions elsewhere. Carbon credits would be "stacked" onto existing nitrogen, phosphorus, and sediment credits as tradable commodities, thereby increasing the potential value of the total credit package and taking another incremental step toward building a comprehensive environmental marketplace. Encouraging cross-sector trades between nonpoint sources, such as agricultural operations and permitted point sources (including for the first time, entities operating under Municipal Separate Storm Sewer System (MS4) permits) would not only improve water quality, but also create new opportunities for GHG reductions, provide supplemental income for farmers and foresters, and promote the preservation of natural and working lands.

MDNR invests in ecological restoration to achieve water quality goals through programs like the Chesapeake and Atlantic Coastal Bays Trust Fund and regularly acquires new state lands through initiatives such as Program Open Space. The potential for carbon sequestration is among the factors the Department considers when selecting restoration projects to fund and lands to acquire. Tools such as MDA's Nutrient Tracking Tool and the Department's GreenPrint online mapper have been created to assist the state and its partners quantify carbon sequestration benefits of best management practices and land conservation.

### Expansion of Cap-and-Invest Carbon Markets

A highly successful regional cap-and-invest system already exists for the electric sector under RGGI, and numerous ways to build upon the success of this program's achievements have been discussed in a wide variety of forums at the state, local, and regional level. As discussed above, MDNR and MDA are working to utilize carbon markets in the context of nutrient loading and ecosystems, and both indicate that these

programs could benefit from being part of a more comprehensive carbon market. Additionally, discussions have been ongoing at the Transportation Climate Initiative (TCI), a regional collaboration which Maryland participates in with 11 other Northeast and Mid-Atlantic states that works to reduce carbon emissions from the transportation sector [143]. Expansion of a cap-and-invest program into other sectors of the economy will face many challenges, and is most successful at a regional or national level, however the State is continuing to explore opportunities to do so in a way that avoids issues with leakage or shifting of emissions, has an equitable distribution of costs, and benefits the Maryland economy and jobs market.

### Zero Waste Initiative

Sustainable materials management (SMM) is another important part of improving the efficiency with which resources and energy are used, which in turn reduces GHG emissions from life-cycle processes such as the extraction of natural resources, and production, transportation and disposal of food and goods. A 2009 analysis by the EPA showed that materials management accounted for 42 percent of GHG emissions nationwide [144]. On June 27, 2017, Governor Hogan signed Executive Order 01.01.2017.13, *Waste Reduction and Resource Recovery Plan for Maryland*. The Order adopted a first-ever SMM policy for Maryland that aims to minimize the environmental impacts of a materials' use throughout the entire lifecycle. The policy emphasizes environmentally and economically sustainable methods to capture and reinvest resources into our economy, rather than simply dispose of them – including everything from metals and plastics to energy, nutrients, and soil. This approach recognizes that SMM efforts require collaboration, and as MDE initiates the new partnerships and consultation processes, it will work to better quantify the GHG emissions benefits and jobs impacts of the initiatives for inclusion in the 40 by 30 Plan.

### Transportation Initiatives

In 2017, construction began on the \$100 million I-270 Innovative Congestion Management Project which is targeting projects that eliminate bottlenecks and adds new lanes, real-time traffic communication signs, and intelligent signals that deliver dynamic traffic management along the corridor. While this project is still underway, it is expected to reduce the commute from Frederick by up to 30 minutes [145, 146]. Construction has also begun on the new Purple Line light rail route, a 16-mile project connecting Bethesda, Silver Spring, Takoma/Langley Park, University of MD College Park, and New Carrollton, along with numerous existing public transit routes [147].



**Photo 30.** I-270 in Montgomery County, MD [Photo by Doug Kerr]

Supported by two TIGER Grant awards from the U.S. Department of Transportation, the MTA is working with Baltimore City to deliver the *North Avenue Rising* project, and with Montgomery County to deliver the *US 29 Bus Rapid Transit* project. North Avenue Rising is a collaboration between the State and City of Baltimore, designed to increase mobility and access for corridor residents to economic opportunities throughout the city [148]. Construction is expected to begin in fall 2019, and be completed by the end of 2021. The US 29 Project will bring a rapid transit bus line along US 29 into DC, including a Purple Line Light Rail stop. This project is currently being designed, and expected to begin operations in 2020 [149].

Supported by two TIGER Grant awards from the U.S. Department of Transportation, the MTA is working with Baltimore City to deliver the *North Avenue Rising* project, and with Montgomery County to deliver the *US 29 Bus Rapid Transit* project. North Avenue Rising is a collaboration between the State and City of Baltimore, designed to increase mobility and access for corridor

### 3.5 The Role of the Maryland Commission on Climate Change

The Maryland Commission on Climate Change has been actively involved in efforts to mitigate, adapt to, enhance local scientific knowledge of, and educate on climate change for about a decade. As has been noted, the 2008 Climate Action Plan produced by the Commission was instrumental to informing the development and passage of the 2009 GGRA. More recently, the 2015 MCCC Report supported the new 40 by 30 goals, and helped to inform the decision of the Governor and General Assembly, explicitly recommending “that the State adopt a goal and develop a plan to reduce Maryland's GHG emissions 40 percent from 2006 levels by 2030, with continued inclusion of safeguards, exemptions... and other relevant language contained in the 2009 Act” [28]. This endorsement by the Commission was informed by STWG calculations which were based on the IPCC’s conclusion that global emissions must be reduced 40 to 70 percent from 2010 levels by 2050 in order to minimize the impacts of climate change <sup>7</sup> [28, 1].

This year, the Commission continued its role as a major stakeholder involved in creating recommendations for the 40 percent by 2030 Draft Plan, which can be found in the following chapter. Additionally, the Mitigation Working Group was involved in designing one of the policy scenarios for modeling, which will inform the Draft Plan policy decisions. The Commission is expected to have further input once the Draft Plan is released at the end of the year, during the public comment, review, and finalization in 2019.

The full Commission meets at least four times per year, and in 2018 it convened in April, June, September, October, and November. These meetings are open to the public, and a portion of each meeting is set aside for public comment. The Steering Committee for the MCCC met regularly to review and guide Working Group progress in the interim. The four Working Groups held numerous meetings in 2018 to advance each of their contributions to the Commission goals. Details of the meetings and activities of the MCCC and its working groups can be found at:

<http://mde.maryland.gov/programs/Marylander/Pages/mccc.aspx>

### 3.6 United States Climate Alliance

In January 2018, Governor Hogan committed Maryland to participation in the United States Climate Alliance (“the USCA” or “the Alliance”). The Alliance is a bipartisan group of 17 states and territories committed to meeting their obligations under the Paris Climate Agreement, while continuing to grow their economies [150]. The Alliance states collaborate to reduce the impacts of climate change through work on: reducing emissions of short-lived climate pollutants, increase carbon sequestration on natural and working lands, strive to decarbonize the transportation sector, coordinate state adoption of energy efficiency standards, and increase state resiliency to climate impacts. Throughout the past year, Maryland has actively participated in the Alliance, contributing our available knowledge and research. Many participating states have looked to Maryland to learn from our efforts with the Transportation Climate Initiative, Healthy Soils, the Climate Leadership Academy, and the Regional Greenhouse Gas Initiative. The Maryland Commission on Climate Change endorses Maryland’s participation in the USCA and the support that the group provides to Maryland as they work towards common goals.

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<sup>7</sup> The STWG utilized the upper end of the reduction range for their calculations, in consideration of the large per capita emissions in the U.S.

### 3.7 Federal Efforts

Since the transition to a new Federal administration in 2017, this administration has altered, set-aside, or challenged many federal policies that would limit global climate change and allow the nation to adapt to its consequences. Maryland has 3,100 miles of shoreline and is one of the states potentially most vulnerable to sea-level rise associated with climate change. For this reason, and for those noted in the preceding chapters, the Maryland Commission on Climate Change is concerned about these policies. The need for continued aggressive action has been made clear throughout this report, and support at the Federal level is important to the success of individual State goals, in part due to the global nature of the problem. Furthermore, Federal efforts would create unanimity, which allows businesses to feel secure in the decisions they make and prevents a lack of effort in neighboring states from negating the climate policy actions of Maryland.

While Federal actions taken thus far do not prevent Maryland from moving forward with its own efforts to limit climate change, they do make state-based goals more difficult to meet. Maryland is a leader in the RGGI program and is dedicated to reducing in-state emissions through the cap-and-invest program; however, through the GGRA, Maryland must also account for emissions from imported electricity generated out-of-state (which supplied approximately 42 percent of consumption in 2014 [151]). As noted in the Commission’s 2017 Annual Report, the Federal Clean Power Plan (CPP) would have helped Maryland meet its GGRA goals by requiring similar emission reductions from neighboring states which supply this electricity, reducing the overall emissions from the power sector. Furthermore, the CPP improves the economic prospects of in-state power plants, since all generators selling electricity into the regional market will be following similarly stringent regulations. In October of 2017, the EPA proposed a rule repealing the CPP [152], and in August 2018, they announced the proposal of the CPP replacement rule, the Affordable Clean Energy (ACE) Rule [153]. As MDE stated in its January 2018 letter to the EPA, Maryland is adamant that any Federal rule be at least as stringent and enforceable as the RGGI program, and ACE is not.



**Photo 31.** MD Secretary of the Environment Ben Grumbles traveled to Bonn, Germany in November 2017 for the COP23 conference.

[Photo by Maryland Department of the Environment]

Federal rollbacks in other sectors will further undermine Maryland’s work to reduce GHG emissions. In April 2018, the EPA announced that they will be revising GHG emission standards for cars and light trucks (model years 2022-2025), stating that existing standards were set too high [154]. Because cars move easily between states, Federal action is necessary to regulate and enforce fuel-economy standards and penalties, and the stringency of these regulations has a direct impact on Maryland’s related transportation-sector emissions. As noted earlier, Maryland has adopted California’s strict vehicle emission standards through the *Maryland Clean Cars Program*. The waiver that allows California and Maryland to adopt these stricter standards is also currently being examined by the EPA under the administration’s leadership [154]. Further reducing federal efforts to address climate change the EPA proposed a rule to limit “the Agency’s recent approach to regulating appliances containing substitute refrigerants such as hydrofluorocarbons (HFCs) by proposing to rescind the November 18, 2016 extension of the leak repair provisions to appliances using substitute refrigerants” [155].

The proposed rule would step-back action the EPA previously took to phase-out HFCs under the Kigali Agreement. Maryland is still working to make progress, however, as MDE will be working with other U.S. Climate Alliance participants to develop regulations that phase out the use of certain HFCs in foam products as well as refrigeration [156].

There are also less direct changes which may impact Maryland's ability to utilize the strongest and most complete scientific information possible when addressing climate change. In April, the EPA proposed a rule that would limit their ability to use scientific data that is not publicly available [157]. This would restrict the EPA's consideration of the peer reviewed health studies frequently used to write climate regulations, as they necessarily omit personally sensitive health data. Additionally, the EPA's revision of scientific methods used to estimate net carbon sequestration from land use, land-use change, and forestry will set back Maryland's sequestration estimates.

Maryland is making significant efforts to compensate for the Federal push to roll back environmental regulations aimed at slowing climate change. Through updating the GGRA Plan, Maryland will set goals to reduce emissions 40 percent by 2030. The Commission is committed to encouraging Maryland in their effort to address climate change, despite federal rollbacks.

However, Federal support is particularly crucial to the State's long-term goal of even deeper reductions, especially during the critical final phases. As surrounding states also begin to internalize the environmental costs of electricity generation, for example, it will become more practicable for Maryland to make even deeper reductions while remaining competitive in this market. As with other issues of interstate commerce, a Federal standard will likely become essential as we move forward with decarbonization. The Commission fully recognizes the need for regional and national leadership and action on the global challenge of climate change, and encourages the Federal government to take note of the proactive and economically beneficial approach taken by Maryland to address this substantial and pressing issue.

# 4

## RECOMMENDATIONS

The recommendations in this year's report demonstrate efforts made by the working groups to continue building on the progress towards our 2020 and 2030 interim goals, while maintaining a long-term focus on what must be achieved in the decades to follow. This year's report has a broad range of recommendations; however there is a noticeable focus due to the timing, being released immediately preceding the Draft 40 by 30 Plan from MDE. In general, it is the expectation of the Commission that the contents of this year's report will provide the Governor and General Assembly with guidance to aid in making informed policy and program decisions which benefit all Marylanders now and in the future.

### 4.1 Commission Recommendations

The Commission has decided to provide the following recommendations to the State agencies and other parties identified in each. These recommendations are drawn from those provided by the Working Groups, and have been highlighted as priorities by the group chairs and Commission members. They are presented here in no particular order. The complete Working Group reports, including the full suite of recommendations, can be found in Chapter 4.2.

- The State's 40 by 30 Draft Plan should build upon effective existing programs and consider new and evolving programs, including those discussed by the MWG (see MWG work plan in [Appendix B](#)). GHG emissions reductions and economic benefits of these programs should be quantified where feasible, and conveyed qualitatively (descriptions, pros and cons) where not. This information will be valuable to the Commission as it discusses the final GGRA Plan in 2019.
- The State's 40 by 30 Draft Plan should include explicit discussions of uncertainty, need, and urgency raised by the IPCC report released in October of 2018, which could be considered in efforts to raise the 40 by 30 emission reduction goal to 45 by 30 prior to or no later than required by statute.
- The State's 40 by 30 Draft Plan should include a section that is explicitly focused on 'social and environmental justice'. This section should be developed through outreach and in partnership with urban and rural communities that have experienced particular socio-economic disadvantage and environmental burden. It should specifically identify (a) proposed strategies, programs, and actions specifically designed to address equity and advance social and environmental justice objectives; (b) the objectives that these strategies, programs, and actions are expected to advance; and (c) the process by which progress towards these objectives will be assessed. This section should also include information and analysis on how the other proposed strategies in the Plan are expected to impact such objectives, including equitable distribution of costs and benefits related to public health, the environment, the economy, and jobs.
- The State's 40 by 30 Draft Plan should include specific goals, objectives, action plans, and evaluation and reporting protocols related to (a) ensuring the production of sustainable economic benefits from climate action strategies, policies, and programs; (b) addressing economic dislocations caused by climate strategies, policies and programs (e.g., a "just transition" for fossil-fuel-dependent workers); and (c) improving the response of vulnerable communities to stressors and shocks.

- The Sea Level Rise Inundation and Coastal Flooding - Construction, Adaptation, and Mitigation Act (House Bill 1350 / Senate Bill 1006) passed in 2018. In addition to making changes to the Maryland Coast Smart Council, over the next two years work will move ahead through state agency, local jurisdiction and other partners to establish plans to adapt to saltwater intrusion and nuisance flooding; and, with the Board of Public Works and in conjunction with MDNR, MDE, and the Maryland Emergency Management Agency (MEMA), partners will establish criteria to evaluate whether state funds may be used to mitigate hazards associated with sea level rise inundation and coastal flooding. The Commission recommends that the agencies listed in the legislation work through the Maryland Coast Smart Council and the Adaptation and Response Work Group to provide guidance and assistance to local jurisdictions to comply with the requirements set forth in this act.
- In June 2018 MDNR launched the Maryland Climate Leadership Academy, the nation's first state-sponsored institution providing continuing education and executive training programs specifically designed for government officials, business leaders, and infrastructure executives. The Commission recommends that the Academy's programming be coordinated with Maryland state agencies, universities and community colleges, and other convening organizations, to deliver training programs statewide. This programming should target local governments (municipal and county) to support their efforts to respond to climate change impacts, including programming on data, tools, and technical assistance to support climate adaptation efforts.
- House Bill 1063 passed during the 2017 legislative session established a Healthy Soils Program and requires MDA to provide incentives, including research, education, technical assistance, and subject to available funding, financial assistance to farmers to implement the management practices that promote soil health and sequester carbon. The Commission recommends that MDA, MDNR, and MDE work together through the Adaptation and Response and Mitigation Work Groups, as well as the Healthy Soils Consortium, to identify long-term sources of funding to support the purposes of the Healthy Soils Act.
- Every five years UMCES is charged with updating the relative sea level rise projections in Maryland and a panel of regional experts was convened in 2018. Based on *preliminary* estimates considering the latest science, Maryland should plan for a relative sea level rise of between 0.8-1.6 ft by 2050 and 1.6-3.4 ft by 2100 – considerably more if GHG emissions are not stabilized. Increasing rates of sea level rise are expected to cause even greater shoreline erosion and deterioration of tidal wetlands; saline contamination of low-lying farm fields; and “nuisance” tidal flooding. Maps that indicate these vulnerable areas of the State should be updated. Development within this zone should be weighed in coastal hazard planning as this area may also be vulnerable to future storm surges.
- Innovation and technology need to be further explored to enhance resilience of Maryland's agricultural economy including: solutions to reducing the impacts of salinity intrusion; mitigating the increased variability in precipitation and temperature patterns on animal and plant production; cost-effective management of animal waste including capturing methane from lagoons; and practices that increase carbon sequestration in agricultural soils to enhance resiliency and reduce nutrient transport from fields.



- Preliminary assessments have identified priority uncertainties in the State’s greenhouse gas emission assessment, that should be refined in future updates in 2019 that will inform the State’s Greenhouse Gas Reduction Plan. Improved estimates include better quantification of the role of tidal wetlands, forests, and landscapes in the sequestration (and release) of GHG across Maryland. The STWG will work with MDE to refine projections of GHG emissions for a range of future scenarios particularly related to changes in population, land use, and transportation.
- The State should seek ways to provide materials to the public to inform and educate on climate change through common points of entry to state and local government and state facilities, in order to leverage existing contact between the State and the public. To the extent possible, the State should look for similar opportunities with private organizations that have widespread interaction with the public.

## 4.2 Working Group Reports and Recommendations

### 4.2.1 Adaptation and Response Working Group

The Adaptation and Response Working Group (ARWG) is chaired by the Secretary of the Maryland Department of Natural Resources with administrative support provided by MDNR staff. The ARWG is charged with implementing a comprehensive strategy for reducing Maryland’s climate change vulnerability, as well as providing the State and local governments with tools to plan for and adapt to the more extreme weather and rise in sea levels anticipated as a consequence of climate change. The working group advances its work through the active involvement of and leadership from other working group members, agencies and stakeholders.

The ARWG and its members are actively implementing work on recommendations that have been adopted since the group began its early work a decade ago. The ARWG members are squarely in implementation mode – working to ensure that a broad variety of Phase I and II Strategy recommendations about sea-level rise and climate impact are advancing. The working group has relied upon and recommends continued collaboration and conversations with stakeholders to determine when, how and if implementation of adaptation measures move forward. The recommendations set forth below will continue to be guided and informed in this manner as they move forward.

**Saltwater Intrusion** - Part IV of Senate Bill 1006 / House Bill 1350 requires that on or before December 15, 2019, MDP, in consultation with MDNR, MDE, and MDA, shall establish a plan to adapt to saltwater intrusion. The Commission recommends that MDP facilitate a state agency-level workgroup and gather information from subject matter experts to develop the content for the plan, including collecting data on the spatial extent of saltwater intrusion in Maryland, identifying data gaps regarding the spatial extent of saltwater intrusion in Maryland, forecasting how the spatial extent of saltwater intrusion in Maryland could change in the future due to sea-level rise, and developing recommendations for how to fill the data gaps. As this plan is developed, the Commission recommends that MDP and the subject matter experts consider and discuss the range of impacts to various sector’s best management practices and how those topics could be addressed in required future saltwater intrusion plan updates.

**Nuisance Flooding** - Part VI of Senate Bill 1006 / House Bill 1350 requires that on or before July 1, 2019, a local jurisdiction that experiences nuisance flooding shall develop a plan to address nuisance flooding. The Commission recommends that MDNR facilitate a workgroup comprised of MDNR, MDE, MDP, MEMA, and local governmental and non-governmental partners to provide guidance and assistance to local jurisdictions to comply with this requirement.

**Climate Leadership Academy** - The Commission recommends that MDNR establish a community of climate-smart local government and infrastructure leaders through the Maryland Climate Leadership Academy. The Commission recommends the Academy's programs and planning efforts be informed by an advisory council that includes senior leadership from Maryland state agencies in order to ensure continuity and coordination with the Commission. The Commission also recommends that the Academy's programming be coordinated with universities and community colleges throughout the state, as well as other convening organizations, to deliver training programs statewide.

**Public Health** - The Commission recommends that the Commission work groups assist MDH in populating an online inventory of climate adaptation efforts across the state that focus on health adaptation, or that use health as a major component of the adaptation effort/justification. In addition, as work groups continue to provide and expand data/tools/technical assistance to local communities or other agencies to support climate adaptation efforts, the Commission recommends that public health be integrated in community forums that address climate adaptation efforts.

**Phase III WIP** - The Commission recommends that the MCCC work groups collaborate with Maryland's Chesapeake Bay Program Phase III WIP teams to ensure that climate change is reflected in the draft Phase III WIP that Maryland will develop and deliver to the Environmental Protection Agency in 2019.

**Evaluation of Adaptation Strategies** - The Commission recommends the ARWG continue to review its Phase I and Phase II Comprehensive Strategy recommendations to identify progress on the existing suite of recommendations, highlight any gaps or needs, and present a review of the strategies in the summer of 2019 to inform priority setting and recommendations for 2020.

**Healthy Soils Initiative** - House Bill 1063, passed during the 2017 legislative session, established a Healthy Soils Program and requires MDA to provide incentives, including research, education, technical assistance, and subject to available funding, financial assistance to farmers to implement the management practices that promote soil health and sequester carbon. MDA, MDNR, and MDE should work together through the Adaptation and Response and Mitigation Work Groups, as well as the Healthy Soils Consortium, to identify long-term sources of funding to support the purposes of the Healthy Soils Act.

**Environmental Justice** - Environmental justice (EJ) remains an important part of climate change work. If a related recommendation(s) is included in the 2018 report it should be representative of any overarching EJ goals that the MCCC has as a whole. For reference, the 2017 report included three EJ-related recommendations.

#### **4.2.2 Education, Communication and Outreach Working Group**

ECO supports the education, communication and outreach goals of the Commission by providing expertise on best practices around outreach and education to stakeholders on climate change and state actions to address its causes and impacts. In 2018, ECO has worked to strategically reach out to stakeholder groups on their specific interests and via existing channels of communication. ECO has developed several recommendations and urges the state to use strategies similar to the recommendations for outreach.

In general, ECO's work is related to three specific charges in the MCCC law: (1) communicating with and educating citizens about the urgency of acting to reduce the impacts of climate change; (2) addressing any disproportionate impacts of climate change on low-income and vulnerable communities; and (3) developing broad public and private partnerships with local, State, and Federal agencies.

ECO is committed to considering the impacts of climate change on vulnerable communities such as those who may experience increased flooding, sea level rise and other climate-driven effects, as well as those with less ability to respond to these events based on socioeconomic status. ECO, the Commission, and the State should continue work to give full consideration to climate change impacts alongside community concerns. Likewise, it is important to identify and collaborate with existing trusted messengers in communities vulnerable to climate change to implement these efforts.

**Recommendations:**

1. MDE and other State agencies should include activities and plans around climate change outreach in the 2018 Draft GGRA 40x30 Plan order to facilitate collaboration and coordination on outreach efforts. This includes, but is not limited to, existing and new programs being implemented by MDH, MDNR, MEA, MDOT, MSDE, and MDP.
2. The State should provide outreach and information to local governments (municipal and county) to support their efforts to respond to and educate about climate change via the Climate Leadership Academy and other agency efforts.
3. The State should continue to support efforts to train individuals and organizations to educate on climate change; and recognize and leverage efforts by private organizations to address climate change. This includes efforts such as training the trainer and the Maryland Green Registry's Climate Champion Contest.
4. The State should seek ways to provide materials to the public to inform and educate on climate change through common points of entry to state and local government and state facilities, in order to leverage existing contact between the State and the public. To the extent possible, the State should look for similar opportunities with private organizations that have widespread interaction with the public.
5. The State should develop an outreach plan around the 2018 GGRA draft plan that incorporates best practices for communication, education and outreach. The plan should reach various stakeholders throughout the State in order to seek diverse opinions about the final plan that is due at the end of 2019. The State should collaborate with state and industry partners in developing this outreach plan.

**4.2.3 Mitigation Working Group**

The MWG is co-chaired by three balanced commission members (State agency, business representative, and environmental advocate), with administrative support provided by MDE staff. The MWG focuses on regulatory, market-based and voluntary programs to reduce GHG emissions while supporting economic development and job creation.

This year, the group heard from expert panels on a number of topics as determined by the 2018 Work Plan, followed by discussions to develop recommendations based on the information provided. Many of these recommendations address the plan that MDE is currently developing under the 2016 Greenhouse Gas Emissions Reduction Act (GGRA), to reduce the State's greenhouse gas (GHG) emissions 40% by 2030 from a 2006 baseline (the 40 by 30 Plan). During this past year, the MWG engaged with MDE in discussions regarding modeling for this draft plan, including the development of one of the model scenarios. The draft of the 40 by 30 Plan is due December 31, 2018, and the final plan is due December 31, 2019. Currently, and through 2020, the State is following the plan developed under the first GGRA to reduce emissions 25% by 2020 (the 25 by 20 Plan). The following recommendations were approved by the MWG. Several other recommendations were submitted, discussed, and not approved.



## Recommendations:

1. The State's 40 by 30 Plan should build from the many programs already contained in the final 25 by 20 Plan that are expected to continue generating reductions beyond 2020, following an internal review of implementation to date.
2. The State's 40 by 30 Plan should continue to examine measures that may be critical for meeting long-term goals, such as an 80%-90% reduction in GHG emissions or carbon neutrality by 2050, and should ensure that proposed programs are compatible with achieving these goals.
3. The State's 40 by 30 Plan should include new programs that have been discussed by the MWG and may have been finalized by State or legislative action. For programs that have been finalized, the GHG reductions and economic benefits should be quantified and included in the 2018 draft plan. For evolving programs that have been discussed but not adopted, the 2018 draft plan should provide available information as well as pros and cons on each of these measures, and ask for specific comment.
4. The State's 40 by 30 Plan should include explicit discussions of uncertainty. Examples may include emission reduction quantification, economic and job creation analysis, life-cycle emissions and the potency of short-lived climate pollutants. To the extent possible, these uncertainties should factor into efforts to exceed the 40 by 30 emission reduction goal.
5. The State's 40 by 30 Plan should include information and analysis on efforts to address social equity, and how proposed strategies impact underserved and environmental justice communities, including equitable distribution of both costs and benefits. This should address public health, environmental, economic, and job creation impacts.
6. The State's 40 by 30 Plan should include a section that is explicitly focused on 'social and environmental justice'. This section should be developed through outreach and in partnership with urban and rural communities that have experienced particular socio-economic disadvantage and environmental burden. This section should specifically identify (a) the strategies, programs, and actions in the Plan that are expected to advance social and environmental justice objectives; (b) the objectives that these strategies, programs, and actions are expected to advance; and (c) the process by which progress towards these objectives will be assessed.
7. The State's 40 by 30 Plan should include specific goals, objectives, action plans, and evaluation and reporting protocols related to (a) ensuring the production of sustainable economic benefits from climate action strategies, policies, and programs; (b) addressing economic dislocations caused by climate strategies, policies and programs; and (c) improving the response of vulnerable communities to stressors and shocks.
8. The State's 40 by 30 Plan should include analysis and information on efforts designed to ensure a just transition for fossil-fuel-dependent workers, and other workforce-related issues linked to the State's efforts to reduce GHG emissions.
9. MDE, in collaboration with other State agencies, should seek relevant assistance from and work with Maryland academic institutions to develop a robust evaluation component as part of the 40 by 30 Plan. A sound evaluation component would include goals, objectives, indicators, metrics, implementation benchmarks, timelines, and reporting protocols that would allow for 'clear and complete understandings of the strengths, weaknesses, successes, and shortcomings of the strategies and programs that the state is employing'.
10. The 2020 manufacturing study required by the GGRA should explore the overall costs and benefits (both economic and environmental) of the Maryland GGRA on the manufacturing sector.

11. The 2020 manufacturing study required by the GGRA should explore the general feasibility of, and mechanisms for (a) potential modifications or enhancements to the current “buy local” provisions in the GGRA Plan, including the use of domestic iron, steel, and manufactured products in energy-related construction; (b) "Buy USA-Made" policies; and (c) the development of an in-state supply chain to create lasting manufacturing and other jobs related to renewable energy infrastructure, including committing additional funding for state-certified or otherwise accredited apprenticeship programs to support the workforce needs of clean energy industries, and collaborating proactively with industry and unions to develop local manufacturing capacity for offshore wind and solar industries.
12. As part of the process to meet the State's current light-duty zero emission vehicle (ZEV) goals and projections, the Maryland Electric Vehicle Infrastructure Council (EVIC) should specifically assess: (a) bolstering the State's consumer purchasing incentives for ZEVs, and regulatory and financial incentives for high power/speed ZEV infrastructure installation, including particular attention to investments and incentives for challenging areas; (b) policies that employ Maryland's public utilities to aid in efforts to rapidly and equitably expand EV infrastructure in Maryland, with specific targets in rural areas; and (c) policies that make it easier to install EV charging infrastructure at multi-family housing locations with attention to high density, urban populations.
13. MDOT should continue to research and evaluate the GHG emission reduction potential of vehicle and infrastructure technologies, including: connected and autonomous vehicles; EVs and other ZEVs; transportation network companies/shared rides; and system operations. The evaluation effort should include consideration of safety, congestion, and equity issues including public health, economic, and workforce impacts.
14. MDOT should continue to enhance travel demand management strategies, land use/smart growth, active transportation, and inter-city travel strategies, in collaboration with MDP and other State agencies and stakeholders.
15. MDOT should develop tracking of key indicators of GHG reduction strategies to monitor progress of achieving goals. Examples include state facilities and fleet adoption of renewable/low-emissions energy sources, ZEV penetration, equity indicators to track participation, congestion levels, per capita VMT, mobility access, and adoption of low-emissions vehicle technology for personal use.
16. MDOT, MDE, MEA, Department of Budget and Management and the Department of General Services should review state fleet procurement procedures and practices and provide direction on procurement of EVs and other ZEVs, and associated charging/filling station installation guidance and targets, by October 2019.
17. MDOT should work with other appropriate agencies and stakeholders to examine the costs and benefits of supporting deployment opportunities of ZEV school and transit buses in Maryland. The analysis should include: (a) capital, maintenance and operating cost comparisons; (b) research into the viability of ZEVs as well as hybrid and alternative fuel technologies; (c) emissions reduction benefit summaries; and (d) potential goals to fully electrify bus transport in the State, including targets for deployment and provisions for low-interest financing.
18. MDE, MDNR, and MDA should utilize best available scientific data on land-based carbon sequestration and GHG emissions for existing GGRA programs, in collaboration with the University of Maryland/NASA Carbon Monitoring System program, the US Forest Service, and the MCCC Scientific and Technical Working Group.
19. MDNR should add a program on the carbon benefit of land conservation and avoided forest conversion through compliance with Maryland’s Forest Conservation Act.

20. MDNR and MDE should continue tracking progress of wetland restoration and biomass to energy, but not project a carbon reduction associated with these programs, due to uncertainty in wetland methane emissions and establishment of new biomass to energy facilities in the state.
21. MDE, MDNR, and MDA should adopt the term “Natural and Working Lands” to refer to all GGRA programs concerning land-based carbon sequestration and avoided emissions of carbon or other GHGs. This will allow Maryland to better align with the effort coordinated by the US Climate Alliance.
22. House Bill 1063, passed during the 2017 legislative session, established a Healthy Soils Program and requires MDA to provide incentives, including research, education, technical assistance, and subject to available funding, financial assistance to farmers to implement the management practices that promote soil health and sequester carbon. MDA, MDNR, and MDE should work together through the Adaptation and Response and Mitigation Work Groups, as well as the Healthy Soils Consortium, to identify long-term sources of funding to support the purposes of the Healthy Soils Act.
23. Maryland should expand its wholesale-rate, net-metering benefit for combined heat and power (CHP) in accordance with PJM's pending recommendations.
24. Maryland should create a statewide CHP stakeholder working group, led by MEA, to discuss key issues and develop standardized processes across the State of Maryland, and to engage in outreach to smaller utilities in order to provide technical support for CHP projects.

#### **4.2.4 Scientific and Technical Working Group**

The Scientific and Technical Work Group (STWG) of the Maryland Commission on Climate Change focused on several issues in the past year to support the activities of the MCCC Working Groups. The priority issues explored in 2018 included (1) an update of the 2013 Report on Sea Level Rise predictions for Maryland, (2) a preliminary evaluation on what scientific information could contribute to an improved understanding of the effects of climate change on Maryland’s agriculture and how these effects could be mitigated, and (3) identification of the primary uncertainties in the modeling of sources and sinks of greenhouse gases that are being used at MDE to assess progress in meeting the Greenhouse Gas Reduction Act goals.

##### *1. Updated Projections for Sea Level Rise*

Due to Maryland’s 3,100 miles of tidal shoreline along the Chesapeake Bay, Atlantic Ocean and the Coastal Bays, it is one of the most vulnerable States to sea level rise. Therefore, the MCCC has given particular attention to sea level rise as a significant threat. Prior to the 20<sup>th</sup> century, rising sea levels were due primarily to the slow sinking of the land since Earth’s crust is still adjusting to the melting of large masses of ice following the last glacial period. Over the 20<sup>th</sup> century, however, the rate of rise of the average level of tidal waters with respect to land, or relative sea level rise, has increased as a result of several factors, including global warming.

The Maryland Commission on Climate Change Act of 2015 specifically requires that “the University of Maryland Center for Environmental Science [UMCES] shall establish science-based sea level rise projections for Maryland’s coastal areas and update them at least every 5 years.” The Act further specifies that these projections shall include maps that indicate the areas of the state that may be most affected by storm surges, flooding and extreme weather events, and shall be made publicly available.

UMCES convened a 15-member panel comprising of sea level rise experts from Maryland, Virginia, Delaware, and New Jersey, to review projections using a range of methodologies. The projection methods for relative sea level rise are probabilistic and include estimates of a central trend (such as a mean or median) as well as probability distributions around those central tendencies. These probabilistic projections allow for reproducible integration of disaggregated lines of scientific evidence. Furthermore, these projections are explicitly tied to the greenhouse emissions pathways that are used in Intergovernmental Panel on Climate Change (IPCC) assessments. This same method has already been widely used for coastal planning in places such as Boston, New York City, Southeast Florida, the Olympic Peninsula, and several states including New Jersey, Oregon, California and Delaware.

The report includes the most recent 2018 observations and analyses and the final report is under review. The **preliminary** findings indicate that Maryland should plan for an increase in sea level in Baltimore of 1.2 feet above 2000 levels with the expectation that the rise will be between 0.8 and 1.6 ft. If greenhouse gas emissions stabilize, the best estimate for sea level rise by 2100 is 2.4 feet with a likely scenario that it would be between 1.6-3.4 ft. However, if greenhouse gases are still increasing, the estimates for sea-level rise are greater. These estimates were made based on the various contributors to sea level rise: thermal expansion of ocean volume as a result of warming, the melting of glaciers and Greenland and Antarctic ice sheets, changing ocean dynamics such as the slowing of the Gulf Stream, and vertical land movement. Deep uncertainties persist about the future of the ice sheets in Antarctica and Greenland. Therefore, it is prudent for Maryland to continue to track assessments and publications on factors contributing to sea-level rise.

The following effects of increased sea level rise in Maryland are already apparent, but are expected to get worse:

- shoreline erosion and deterioration of tidal wetlands;
- saline contamination of low-lying farm fields;
- the frequency of "nuisance" tidal flooding is increasing;
- greater challenges in draining low-lying areas; and
- surges resulting from storms are spreading farther and higher.

## *2. Impact of Climate Change on Maryland's Agriculture*

In the 2015 enabling legislation of the MCCC specifically mentioned that assessments of climate change on Maryland's agriculture should be conducted. There have been significant new research programs focused on the global, regional and state impacts of climate change on agriculture. In order to explore where science could best contribute to the efforts of Maryland, STWG hosted a forum that included scientists, agency resource experts, and stakeholders. The current status of research on the impacts of climate change on agriculture in Maryland, its implications, and potential solutions were presented.

The workshop focused on carbon sequestration; salt water intrusion and planning; agricultural best management practices in the context of a changing climate, developing Watershed Implementation Plans (WIP) and meeting the Total Maximum Daily Load; survey of crops under different climate change scenarios; and agricultural biomass, bioenergy, and manure treatment technologies. The final report is expected to be released in early 2019.

The **preliminary** key findings include:

- Warmer temperatures coupled with more variable and wetter precipitation will likely lead to changes in crop and animal production and new challenges associated with pest management. Maryland farmers may have to consider different crop species that are more tolerant to wet and drought or more resistant to pests.. Farmers will likely face increased costs associated with the summer cooling of poultry and livestock and the need for a rapid response to variable precipitation and pest infestation.
- *Rising sea levels are threatening agricultural lands.* A ribbon of agricultural lands, particularly along the shoreline are more vulnerable to salt water intrusion. Once land is inundated by salt water, it is very difficult to flush the salt due to limited freshwater, poor drainage and evaporation of salt water that concentrates salt in the soil. As the soil gets saltier, production decreases and the selection of crops may change or under more extreme cases the land may transition to salt marshes, thus taking the land out of production. Detailed mapping of the projection of changes in sea levels and salinity in vulnerable areas are critical to giving the landowners and/or farmers advance warning. This approach allows impacted landowners and communities that rely on agriculture for jobs and sustaining local economies several decades to plan and define future options.
- More intense water management and increased technical and financial support for agricultural transitions will help boost resilience. Changing climate is very likely to cause changes for farmers and their communities. Agricultural productivity, profitability, investment in new technologies, timing of planting and harvesting, use of irrigation systems and the cooling of animal production facilities are among some of the factors facing agriculture. As farmers adapt to remain competitive, state and local governments will need to provide resources and training to help alleviate the costs and risks associated with these changes.
- *Farmers need new information tools to support decisions regarding environmental and economic conditions.* Increased investment in improved monitoring and forecasting tools would increase a farmer's ability to prevent, rather than react to, adverse impacts.
- *Increase biodiversity and sequestration in agricultural soils.* Regenerative and healthy soils is a system of farming principles and practices that increases biodiversity, enriches soil, improves watersheds, and enhances ecosystem services. These practices increase soil carbon storage and can be a net sink reducing emissions. This is part of the current MDA Healthy Soils Program.
- *Current and new best management practices should take into account a warmer and wetter climate.* To meet the Chesapeake Bay's Total Maximum Daily Load (TMDL), Maryland is developing Watershed Implementation Plans (WIPs) based on the current understanding of best management practices. Some of these practices may become less effective while others may become more practical. For example, the use of bioenergy associated with waste management systems would be more viable in a warmer and wetter climate. These systems would capture methane and produce bioenergy reducing greenhouse gas emissions but also using it as a local energy source thus reducing generation from other sources.
- *Maryland is developing expertise around agricultural adaptation to climate change.* Maryland is advancing BMPs and assessment tools to anticipate climate change and reduce nutrient loading to the receiving waters of Chesapeake Bay. Consideration could be given to marketing Maryland's agricultural products in a way that promotes the environmental sensitivity to climate and the environment.

### 3. Estimates and Uncertainties Associated with Emissions and Uptake of Greenhouse Gases

The STWG received an initial briefing on the model used by MDE to account for total greenhouse gas emissions. This review identified several uncertainties listed below that could be refined to improve projects and will be a focus in 2019. The STWG will work closely with MDE to evaluate:

- *Emission Estimates.* MDE's inventories of greenhouse gas emissions are estimated directly from electricity and fuel indirectly estimated for transportation. These three categories make up approximately 90% of the total emission. Transportation estimates vary with the type of infrastructure improvements implemented and these assumptions will be reviewed. In addition, there are significant uncertainties in the emission estimates associated with forests, agriculture, wetlands and waterways.
- *Net Sinks of Greenhouse Gases.* Estimation of the net sinks are generalized for forest carbon flux and organic biomass storage. While wetlands, waterways, and agricultural soils can be important sinks they can also be sources of emissions depending upon prevailing conditions.
- *Land Use and Land-Cover Estimates.* Growth simulation modeling suggests that Maryland will confront significant land-use and land-cover changes by 2030 and beyond. This has quantitatively significant implications for net greenhouse gas emissions (including sequestration) from forests, agricultural lands, and wetlands, as well as for VMT and, consequently, on-road vehicle emissions.



# 5

## STATEMENT & MINORITY REPORT

Treasurer Nancy Kopp Statement – 2018 Maryland Commission on Climate Change Annual Report

This 2018 Report of the Maryland Climate Change Commission clearly and strongly sets forth the urgency of our present situation and the need to take immediate actions to confront the impact of climate change on Maryland. It is a clarion call to us all. The scientific case is clear, the impacts are already visible and increasing, and the actions we have taken thus far – both to mitigate and to adapt to this crisis—are clearly insufficient. The reprehensible actions of the Trump administration, as the Report makes clear, are only exacerbating this crisis.

Despite diligent and serious efforts of talented staff and leaders in government and the private sector across the State --and despite the fact that Maryland has been a leader among states -- if we adopt only the proposals in the Recommendation section of this Report, we will not reach the goals set in law, much less the higher goals we must meet by 2050 and beyond. Indeed, even the additional recommendations in the minority report will not be sufficient to meet those essential goals. Nonetheless, I strongly urge that all these recommendations, including those in the minority report, be thoroughly and seriously evaluated, altered if necessary, and adopted. Then we must continue and increase our efforts. This will be hard and involve difficult choices and sacrifice, but it is essential.

Across the State and in every sector from energy, transportation, and agriculture, to housing, land use planning, and economic development, we have to reach higher. And this fight must be sustained over decades. It cannot be the typical political short-term battle. It will involve a broad change in culture and priorities, both personal and community-wide. But, it is a challenge that, if met and joined by others, can lead to a livable earth and a stronger, sustainable economy and community for all Maryland.

## MARYLAND CLIMATE CHANGE COMMISSION MINORITY NOTE

We very much appreciate the diligent work of the MDE staff in developing the Annual report and the proposed Maryland Climate Change Commission recommendations. Our decision to prepare a minority report does not represent any criticism or concerns about the work of the MDE staff.

Our decision to prepare a minority report is instead motivated by our view that the levels of ambition and accountability reflected in the proposed recommendations are simply incommensurate with the Commission's leadership responsibilities at this pivotal moment.

The Commission's 2018 Annual report will be released at a historical moment at which the IPCC has just communicated its most urgent and dire assessments to date, and the Trump Administration is accelerating its unforgivable retreat from the greenhouse gas reduction commitments and investments of the Paris Agreement and the Obama Administration. We are at a decisive juncture, and it is incumbent upon those Marylanders who would lay claim to climate leadership to fiercely and consistently address themselves to the most urgent challenges and opportunities for decarbonizing our state's economy.

We do not believe the proposed recommendations sufficient to achieve this standard. The recommendations propose no specific new programs or policies to reduce carbon, and they make few specific recommendations for improvements to existing programs and policies. There is no specific reference to securing emissions reductions from the transportation sector, nor any specific reference to measures to reduce and better calculate methane emissions. The recommendations urge no specific steps to increase the climate resilience of vulnerable communities, or to insure that the benefits and burdens of climate action are equitably distributed across the state's population. Finally, the recommendations are silent about present or proposed state investments that would lock us into continued fossil fuel dependence, just as they are silent about state investments that can accelerate our emancipation from such dependence. Clearly more is needed.

Rather than proactively engaging these mission-critical items, the recommendations focus on the upcoming draft 40 by 30 plan (recommendations 1 – 3). Rather than focusing on the state's most powerful levers for transforming our energy system, the recommendations encourage state agencies to provide support for existing training, technical assistance, and communications programs (recommendations 4,5,6, and 10). Rather than emphasizing action and initiative, the recommendations urge 'further exploration' and a 'refinement of projections' (recommendations 8 and 9).

To be clear, we do not object to these recommendations. We do, however, strenuously object to the idea that they should stand, alone, as the sum total of 2018 guidance that the Commission provides to the Governor and the General Assembly for how the state should address the causes and consequences of climate change.

We do recognize that the Annual report contains a variety of additional recommendations that have been prepared by the Commission working groups and provided to the Commission. While the working group recommendations do not meet the leadership standard we've set out above, some of them do offer more specificity and ambition than the Commission's own recommendations. Unfortunately, the impact of the Commission report – should it have any – will surely rely on the recommendations that are presented as Commission recommendations.

## MARYLAND CLIMATE CHANGE COMMISSION MINORITY NOTE

We also recognize that some may choose to settle for neutral and insufficiently ambitious recommendations in the hope or expectation that the Administration's upcoming draft 40 by 30 plan will address the important items that the draft Climate Change Commission recommendations have not. If so, we believe this will be tantamount to choosing to postpone assuming our leadership responsibility until after the Department of Environment staff makes choices in their Draft Plan, and then, perhaps, reacting to those choices next year. While some may see this to be a prudent approach, we view it as an abdication of responsibility.

A good portion of the time of the Commission and its working groups has been devoted to discussions of the draft 40 by 30 plan, but the Commission's responsibilities are in no way confined to providing input to that plan. It would be a shame for us to allow our preoccupation with a draft plan that we've not seen, and on which we are therefore poorly positioned to comment, to distract us from our responsibility to directly engage critical ongoing challenges to and opportunities for accelerating Maryland's clean energy transformation. Rather, the Climate Change Commission Report and the draft 40 by 30 Plan should be seen together as two separate, but essential parts of Maryland's program to reduce and adapt to the impacts of climate change.

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**We** believe that the Climate Commission should function as a force for ambition and accountability. We believe that the Commission's leadership responsibility requires us to strive to focus the state's attention on the most urgent and important climate and clean energy challenges and opportunities. At the same time, we recognize that a reliable power grid and continued energy to power our economy is essential. We believe that the following recommendations would best discharge that responsibility:

1. We recommend that the General Assembly and the Governor increase the state's Renewable Energy Portfolio Standard to at least 50% by 2030, with the highest possible carve outs for in-state solar and for offshore wind (as deemed technically feasible). It should also include an appropriately sized dispatch able energy storage capacity target. A carbon fee, in some form, should be evaluated as one method of reaching this goal.
2. We recommend that MDE in 2019 initiate the production of annual greenhouse gas emissions inventories that utilize a leak rate of at least 2.3% and a 20-year and 100 - year global warming potential estimate for methane, and also account for all out of state methane emissions associated with the production, processing, transmission, and distribution of natural gas consumed in Maryland.
3. We recommend that the General Assembly and the Governor charge MDE, MDP, MDA, MEA, and the Public Service Commission to collaborate with each other and public stakeholders in the development of a Solar Plan for the state that would describe goals and a preferred path for the state's solar build-out. This plan should include recommendations for the optimal blend of rooftop, community solar, and utility scale solar; as well as recommendations for preferred sites and siting considerations. This plan should get the state to 20% in-state solar by 2030.
4. We recommend that by the end of 2020 the General Assembly and the Governor work with public stakeholders to develop and finalize a responsible and specific plan for transitioning from

## MARYLAND CLIMATE CHANGE COMMISSION MINORITY NOTE

Maryland's six large-scale coal electricity generators over the ensuing decade, while maintaining reliable power, and for the establishment of programs that protect and support communities and workers traditionally reliant on these fossil fuel facilities before those coal plants are closed.

5. We recommend that the General Assembly and the Governor require the development of a responsible plan to phase out use of natural gas without carbon capture in the electricity sector by 2040 and in buildings by 2050 (exempting some industrial processes). Again, maintaining reliable power is essential.
6. We further recommend that MDE analyze and report on the health benefits of the reduction of air pollution that would accompany the measures recommended here, both in terms of reduced morbidity and mortality and in terms of the reduced health care expenditures, with special emphasis on the communities that bear a disproportionate share of the burden of pollution today.
7. We recommend that the General Assembly and the Governor alter the distribution of Strategic Energy Investment Fund resources such that all solar investments be directed to low income households and communities.
8. We recommend that the Maryland Department of the Environment (MDE) include strategies and programs in the state's next Greenhouse Gas Reduction Plan that will be sufficient to increase average daily public transportation ridership in each major transit center in the State by 2% or more per year through 2035. We further recommend that MDE specifically assess an expansion of public transportation investments including existing WMATA and MTA funding as well as in projects that integrate transportation and more sustainable land use planning (e.g. Corridor Cities Transit, Red Line, MARC expansion initiatives).
9. We recommend that the General Assembly and the Governor enact legislation requiring the ramping up of efficiency in the EmPOWER Maryland program to 3% per year by 2025, and maintain that pace at least until 2030. This efficiency target should be exclusive of conversion of fossil fuel transportation and fossil fuel heating in buildings to efficient electric systems for which a separate efficiency and GHG reduction accounting should be done.
10. We recommend that the General Assembly and the Governor, working with local governments as appropriate, enact legislation requiring stricter building code and other energy efficiency upgrades, including the establishment of annual residential and commercial building retrofit targets (e.g. 100% commercial building compliance by 2040), the requirement that all new residential and commercial buildings be carbon neutral by 2030; and an expansion of government and utility supported efficient electric heating and cooling system policies and programs.
11. We recommend that the General Assembly and the Governor require the Public Service Commission to model a policy or program that drives at least \$100 million in the 2020 – 2025 period to incentives for switching from oil, propane, or natural gas heating systems to efficient electric heat pumps in the residential and light commercial building sectors. If analysis of the model proves out, it should be implemented.

## MARYLAND CLIMATE CHANGE COMMISSION MINORITY NOTE

12. We recommend that the General Assembly and the Governor enact, by 2020, a sustainable agricultural land preservation law which permits/facilitates the deployment of joint renewable energy and regenerative agriculture development, in order to simultaneously maximize the reduction and sequestration of carbon emissions while improving soil health.
13. We recommend that the General Assembly and the Governor require net forest and tree canopy gains in Maryland by 2025 through the enactment of various forest management and tree planting programs and initiatives; including a strengthened Forest Conservation Law.
14. We recommend that the General Assembly and the Governor enact, by 2022, more aggressive and explicit compact development and sustainable growth incentive and management programs and regulations.

Stuart Clarke  
C. Richard D'Amato  
Nancy K. Kopp  
Senator Paul G. Pinsky  
Delegate Dana Stein  
Deni L. Taveras  
Mike Tidwell

# Appendices

## Commission and Working Group Rosters

### Maryland Commission on Climate Change

#### Commission Leadership

<b>Secretary Ben Grumbles</b>	Commission Chair
<b>Anne Lindner</b>	Commission Co-Chair
<b>Stuart Clarke</b>	Commission Co-Chair

#### Governor Appointed and Standing Members

<b>Secretary Ben Grumbles</b>	Department of the Environment
<b>Nancy K. Kopp</b>	Maryland State Treasurer
<b>Karen Salmon</b>	Superintendent of Maryland Schools
<b>Secretary Joseph Bartenfelder</b>	Department of Agriculture
<b>Secretary Mark Belton</b>	Department of Natural Resources
<b>Secretary Ellington Churchill</b>	Department of General Services
<b>Secretary Pete Rahn</b>	Department of Transportation
<b>Secretary Robert McCord</b>	Department of Planning
<b>Mary Beth Tung</b>	Maryland Energy Administration
<b>Peter Goodwin</b>	President of UMCES
<b>Chucky Fry</b>	Agriculture Community Representative
<b>Charles Deegan</b>	Chair of Critical Area Commission
<b>Dr. Russell Dickerson</b>	Climate Change Expert
<b>Dr. Jane Kirschling</b>	Public Health Expert

#### Senate President Appointed Members

<b>Senator Paul G. Pinsky</b>	Member of the Senate
<b>Stuart Clarke</b>	Philanthropic Organization Representative
<b>Lori Arguelles</b>	Environmental NPO Representative
<b>Jim Strong</b>	Organized Labor Representative
<b>Michael Powell</b>	Business Community Representative

#### House Speaker Appointed Members

<b>Delegate Dana Stein</b>	Member of the House of Delegates
<b>Mike Tidwell</b>	Environmental NPO Representative
<b>Anne Linder</b>	Business Community Representative
<b>C. Richard D'Amato</b>	Philanthropic Organization Representative
<b>Gerald Jackson</b>	Organized Labor Representative

#### Local Government Appointees

<b>Councilwoman Deni Taveras</b>	Maryland Association of Counties
<b>Commissioner Michael Bibb</b>	Maryland Municipal League

## Maryland Commission on Climate Change Steering Committee

### Steering Committee

<b>Secretary Ben Grumbles</b>	Department of the Environment
<b>Anne Lindner</b>	Business Community Representative
<b>Stuart Clarke</b>	Philanthropic Organization Representative
<b>Secretary Mark Belton</b>	Department of Natural Resources
<b>Secretary Joseph Bartenfelder</b>	Department of Agriculture
<b>Secretary Pete Rahn</b>	Department of Transportation
<b>Mary Beth Tung</b>	Maryland Energy Administration
<b>Nancy K. Kopp</b>	Maryland State Treasurer
<b>Tad Aburn</b>	Department of the Environment
<b>C. Richard D'Amato</b>	Philanthropic Organization Representative
<b>Michael Powell</b>	Business Community Representative
<b>Peter Goodwin</b>	President of UMCES
<b>Mike Tidwell</b>	Environmental NPO Representative
<b>Lori Arguelles</b>	Environmental NPO Representative

## Adaptation and Response Working Group

### Leadership

<b>Secretary Mark Belton</b>	Chair	Department of Natural Resources
<b>Catherine McCall</b>	Coordinator	Department of Natural Resources
<b>Kim Hernandez</b>	Coordinator	Department of Natural Resources
<b>C. Richard D'Amato</b>	Commission Liaison	Philanthropic Organization Rep.

### Public Sector Representatives

<b>Fredrika Moser</b>	Maryland Sea Grant
<b>Brian Ambrett</b>	Eastern Shore Land Conservancy
<b>Eric Myers</b>	Conservation Fund

### **Maryland General Assembly Members**

<b>Dana Stein</b>	State Delegate
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### State-Agency Adaptation Sector Leads

<b>Matt Rowe</b>	Department of the Environment
<b>Don Van Hassent</b>	Department of Natural Resources
<b>Mark James</b>	Maryland Emergency Management Agency
<b>Bruce Michael</b>	Department of Natural Resources
<b>Clifford Mitchell</b>	Department of Health
<b>Jason Dubow</b>	Department of Planning
<b>Sandy Hertz</b>	Department of Transportation
<b>Susan Payne</b>	Department of Agriculture
<b>Catherine McCall</b>	Department of Natural Resources

Technical Advisors

<b>Katherine Charbonneau</b>	Critical Area Commission
<b>Scott Zacharko</b>	Department of the Environment
<b>Lisa Lowe</b>	Department of Information Technology
<b>Nell Ziehl</b>	Department of Planning
<b>Sasha Land</b>	Department of Natural Resources
<b>Kevin Wagner</b>	Department of the Environment
<b>Shawn Kiernan</b>	Maryland Port Administration
<b>Susan Gore</b>	Department of Budget and Management
<b>vacant</b>	Local Government Representative
<b>Megan Granato</b>	Department of Natural Resources
<b>Elizabeth Habic</b>	State Highway Administration
<b>Joy Hatchette</b>	Maryland Insurance Administration
<b>Matthew Flemming</b>	Department of Natural Resources
<b>vacant</b>	Department of General Services
<b>JaLeesa Tate</b>	Maryland Emergency Management Agency
<b>Andrew Asgarali-Hoffman</b>	Maryland Emergency Management Agency

**Education, Communication and Outreach Working Group**Leadership

<b>Kris Hoellen</b>	Co-Chair	B&O Railroad Museum
<b>John Kumm</b>	Co-Chair	EA Engineering, Science and Technology
<b>Lori Arguelles</b>	Commission Liaison	Alice Ferguson Foundation

Public Sector Representatives

<b>Ashley Pennington</b>	Johns Hopkins Office of Sustainability
<b>Dannielle Lipinski</b>	Maryland League of Conservation Voters
<b>Denise Robbins</b>	Chesapeake Climate Action Network
<b>Grant Samms</b>	Washington College Center for Environment and Society
<b>Isaac Hametz</b>	Mahan Rykiel Associates
<b>Joelle Novey</b>	Interfaith Power and Light
<b>Pat Harcourt</b>	UMCES/MADE-CLEAR

Private Sector Representatives

<b>Michele Peterson</b>	Honeywell
<b>Kevin Rudolph</b>	Maryland Chamber of Commerce

State Government Representatives

<b>Allison Gost</b>	Department of Health
<b>Colleen Turner</b>	Department of Transportation
<b>Donna Balado</b>	Maryland State Department of Education
<b>Julie Oberg</b>	Department of Agriculture

State Government Representatives, Cont.

<b>Kaymie Owen</b>	Maryland Energy Administration
<b>Mark Shaffer</b>	Department of the Environment
<b>Sara Luell</b>	Department of Housing and Community Development
<b>Cindy Etgen</b>	Department of Natural Resources

Technical Advisors

<b>George (Tad) Aburn</b>	Department of the Environment
<b>David Costello</b>	IEER
<b>John Coleman</b>	Department of Planning

**Greenhouse Gas Mitigation Working Group**Leadership

<b>Stuart Clarke</b>	Co-Chair	Town Creek Foundation
<b>Michael Powell</b>	Co-Chair	Gordon Feinblatt, LLC
<b>Tad Aburn</b>	Work Group Lead	Department of the Environment

Representatives of Environmental Organizations

<b>Joe Uehlein</b>	Labor Network for Sustainability
<b>Jana Davis</b>	Chesapeake Bay Trust
<b>Arjun Makhijani</b>	Institute for Energy and Environmental Research
<b>Tamara Toles O’Laughlin</b>	Maryland Environmental Health Network

Representatives of Academic Institutions

<b>Gerrit Knaap</b>	University of Maryland, National Center for Smart Growth
<b>Ben Hobbs</b>	Johns Hopkins University

Representatives of Renewable and Traditional Energy Providers

<b>Anne Lindner</b>	PEPCO Holdings, Exelon
<b>R. Daniel Wallace</b>	Bithenergy
<b>Tom Weissinger</b>	Talen Energy
<b>Tom Dennison</b>	Southern Maryland Electric Cooperative

Representatives of Business Interests and Labor Organizations

<b>Tom Ballentine</b>	NAIOP - Real Estate Development
<b>Mike Remsberg</b>	Trinity Consultants
<b>Drew Cobbs</b>	American Petroleum Institute
<b>Colby Ferguson</b>	Maryland Farm Bureau
<b>Jim Strong</b>	United Steelworkers
<b>Gerald Jackson</b>	Maryland and DC AFL-CIO

Representatives of State and Local Government Agencies

<b>Colleen Turner</b>	Department of Transportation
<b>Chris Rice</b>	Energy Administration
<b>Christine Conn</b>	Department of Natural Resources
<b>Susan Payne</b>	Department of Agriculture
<b>Tom Walz</b>	Department of Housing and Community Development
<b>Les Knapp</b>	Maryland Association of Counties
<b>Lisa McNeilly</b>	Baltimore Office of Sustainability

Mitigation Working Group Steering Committee

<b>George “Tad” Aburn</b>	Maryland Department of the Environment
<b>Michael Powell</b>	Gordon Feinblatt, LLC
<b>Stuart Clarke</b>	Town Creek Foundation
<b>Colleen Turner</b>	Maryland Department of Transportation
<b>John Fiastro</b>	Maryland Energy Administration
<b>Elliott Campbell</b>	Maryland Department of Natural Resources
<b>Susan Payne</b>	Maryland Department of Agriculture

**Scientific and Technical Working Group**Leadership

<b>Peter Goodwin</b>	Chair	President, University of Maryland Center for Environmental Science
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Representatives of Academic Institutions

<b>Adel Shirmohammadi</b>	College of Agriculture and Natural Resources, UMCP
<b>Amir Sapkota</b>	School of Public Health, UMCP
<b>Belay Demoz</b>	Joint Center for Earth Systems Technologies, UMBC
<b>David A. Vanko</b>	Fisher School of Science, Towson University
<b>Eric A. Davidson</b>	Appalachian Laboratory, UMCES
<b>Eric D. Wachsman</b>	University of Maryland Energy Research Center, UMCP
<b>Fernando Miralles-Wilhelm</b>	Earth Science Interdisciplinary Center, UMCP
<b>Gerrit J. Knaap</b>	National Center for Smart Growth Research and Education, UMCP
<b>Ghassem Asrar</b>	Joint Global Change Research Institute
<b>Jane M. Kirschling</b>	School of Nursing, University of Maryland Baltimore
<b>Russell R. Dickerson</b>	Department of Atmospheric and Oceanic Sciences, UMCP
<b>Jason Keppler</b>	Maryland Department of Agriculture
<b>Donald Boesch</b>	University of Maryland Center for Environmental Science

## Working Group 2018 Work Plans

These draft Work Plans were approved by the Maryland Commission on Climate Change in April of 2018. While they served as guidelines, decisions were made by the working groups/leadership throughout the year as necessary to maintain their function and purpose. The plans as shown below also do not include schedules or appendices which may have been in the original. For a full review of the complete work plans, as well as all meeting minutes and materials from 2018, please refer to the working group pages on the Commission website, <https://mde.maryland.gov/MCCC>.

### Adaptation and Response Working Group

#### Purpose

The Maryland Commission on Climate Change (MCCC) is charged with advising the Governor and General Assembly on ways to mitigate the causes of, prepare for, and adapt to the consequences of climate change and maintaining and strengthening the state's existing Greenhouse Gas Reduction Plan (GHG Plan). The Commission is supported by a Steering Committee and for working groups. The Adaptation and Response Working Group (ARWG) is charged with developing a Comprehensive Strategy for Reducing Maryland's Climate Change vulnerability. The Strategy includes both short- and long-term measures that State and local governments may undertake in planning for and adapting to diverse impacts of climate change.

Even as the state moves forward with actions that will reduce greenhouse gases (GHGs) and ultimately result in increased energy efficiency, a more sustainable economy, and cleaner air; climate impacts will still be felt into the future. Therefore, adaptation, together with mitigation, is necessary to address climate change. The Maryland Commission on Climate Change (MCCC) has charged the Adaptation and Response Working Group (ARWG) with implementing solutions for reducing Maryland's Climate Change vulnerability.

#### 2017 Progress

In early 2017 the ARWG developed a two-year work plan to guide ARWG efforts through the end of 2018. The 2017 MCCC Annual Report, published December 2017, outlines new priorities for the ARWG in 2018 that were not in the original 2017-2018 work plan. To address these new MCCC recommendations, this document provides an update to the 2017-2018 ARWG work plan, including specifics about progress made in 2017 and what the ARWG will be focusing on in 2018.

1. *Evaluating New Sea Level Rise Science:* Since the 2013 STWG report updates and the October 2016 STWG 6-pager, new literature, studies, data and other science have been issued. In 2018 the ARWG will work with the STWG to better understand the climate science that should be used in adaptation and communication efforts, and work with ECO to incorporate this information into trainings, tools and all disseminated information.
2. *Broadening the Adaptation Scope:* (1) The ARWG continues to work with the Coast Smart Council on infrastructure siting and design criteria and also with its members to understand what areas beyond sea level rise and flooding could be advanced. Through this joint work, the groups proceeded with work to use the Coast Smart assessment and certificate to review proposed projects in non-coastal areas. (2) The ARWG staff worked with the Mid Atlantic Regional Council on the Ocean on a report titled "Climate Change Vulnerabilities in the Mid-Atlantic Region." This report, prepared jointly by the Center for the Blue Economy of the Middlebury Institute of International Studies at Monterey and the Marine Policy Center of the Woods Hole Oceanographic Institution, highlights vulnerabilities to our marine transportation, fisheries and fishing communities, and ecosystem services. The findings of this report will be

presented to the ARWG in 2018. (3) There still exists a need to define 'vulnerable populations' from the perspective of the MCCC and ARWG. In 2018 and beyond the ARWG will work closely with the Steering Committee, other working groups and the Maryland Commission on Environmental Justice to assist in defining vulnerability for ARWG efforts.

3. *Healthy Soils Initiative:* (1) In January 2018 the Maryland Department of Agriculture was awarded a \$1 million Regional Conservation Partnership Program (RCPP) grant by the U.S. Department of Agriculture's Natural Resources Conservation Service to utilize and demonstrate a suite of soil health practices on Maryland farm fields. (2) In 2018, the Maryland Department of Natural Resources will continue exploring a partnership with the Harry Hughes Center to use department owned agricultural land to pilot implementation precuts that increase the concentration of carbon in the soil. (3) On March 27, 2018 a "Healthy Soils Farm Visit and Roundtable Discussion" will be held to visit conventional and organic farm operations and discuss opportunities for soil carbon sequestration. This event is being sponsored by the ARWG, MDA, MDNR, UMD Extension, the Alice Ferguson Foundation, Future Harvest and the Town Creek Foundation in direct response to initial 2017 meetings and conferences about "Healthy Soils" or "Carbon Farming." These three initiatives will go a long way towards fulfilling the state's Healthy Soils Initiative and improving natural resource management.
4. *Local Comprehensive Plan Adaptation Research:* The Maryland Department of Planning completed its first phase of comprehensive plan research on addressing climate issues and presented this work at the December 2017 ARWG meeting. The ARWG will use this review and information to guide the Regional Adaptation Meetings, discuss additional opportunities to extend such a review to other plans (e.g. Hazard Mitigation Plans) and Local Government Climate Academy work.
5. *Resilience Financing Stress Test:* In fall 2017 the Maryland Department of Natural Resources contracted with the Environmental Finance Center (EFC) at the University of Maryland College Park to develop a Community Resilience Financing Tool. The tool will help communities determine the actions they can take to become more resilient to climate hazards as well as accelerate and scale the financing efforts needed to implement those projects. The City of Salisbury and the City of Annapolis have agreed to partner as the communities that will trial the tool once it is developed and have been given a resilience assessment and financing tool template as a starting point for engaging in the development process.
6. *Metrics for Tracking Progress:* Work is being undertaken by the Chesapeake Bay Program Climate Resiliency Workgroup to develop indicators of adaptation. ARWG members are engaged in this effort to determine if this work and/or the indicators could be relevant to the ARWG. Follow up in 2018 will focus on the suite of potential indicators of adaptation to identify which might be relevant to the ARWG. Staff will coordinate with Chesapeake Bay Program staff in 2018 to hold future discussion about these resilience indicators.
7. *Georgetown Climate Center Recommendations:* The ARWG will be exploring with the other working groups the value of a research agenda, a GCC recommendation that was included in the MCCC Annual Report. Additional clarity on the interest of a research agenda from the MCCC/Steering Committee will be sought in 2018.

### **New 2018 Priorities**

In addition to continuing the progress on the ARWG priorities listed above from the 2017-2018 work plan, the ARWG will also be undertaking the following in 2018:

8. *Regional Adaptation Meetings:* In the 2017 Annual Report the MCCC added an additional recommendation for the ARWG to "convene regional meetings by the end of 2018 to solicit local and regional climate adaptation priorities and support local adaptation efforts." The ARWG

began to discuss this goal at the December 2017 meeting, and since then a Planning Committee has formed and will work diligently to achieve this goal in 2018. Two meeting options were discussed and vetted at the March 2018 meeting.

9. *Local Government Climate Academy*: The Maryland Department of Natural Resources has partnered with the Association of Climate Change Officers (ACCO) to develop and deliver a competency framework and climate change training for local governments. Throughout 2018, ACCO, MDNR and the ARWG will be working to develop training modules specific to the needs and issues facing Maryland's local communities. Staff will explore opportunities with the ARWG to deliver climate resources and training through the development of the Local Government Climate Academy.
10. *Reviewing Phase I and II Comprehensive Strategy*: In 2018 the ARWG will review its Phase I and II Comprehensive Strategy recommendations to identify progress, highlight any gaps or needs, and consider revising as needed.

## **Education, Communication and Outreach Working Group**

### **Purpose**

During its 2015 session, the Maryland General Assembly codified the Maryland Commission on Climate Change (MCCC) into law, and charged the Commission with advising the Governor and General Assembly on ways to mitigate the causes of, prepare for, and adapt to the consequences of climate change. The MCCC is chaired by the Secretary of the Maryland Department of the Environment, and consists of 26 members representing diverse interests in the State.

The Education, Communications, and Outreach (ECO) Working Group is one of four working groups that support the objectives of the Commission. The Commission is responsible for prioritizing working group activities, including the following activities noted in the governing legislation that are especially relevant to the ECO working Group:

- Developing broad public and private partnerships with local, State, and federal agencies;
- Communicating with and educating citizens about the urgency of acting to reduce the impacts of climate change; and
- Addressing any disproportionate impacts of climate change on low-income and vulnerable communities.

To support education, communication, and outreach among diverse stakeholders on the causes of climate change, its potential impacts to Marylanders, and mitigation and adaptation strategies, the ECO Working Group has the following core strategies:

- Advising on effective communications strategies and best practices for education, communication and outreach to diverse stakeholders;
- Identifying and advising on opportunities for stakeholder engagement in Commission and State activities, or for State and Commission support of existing community activities; and
- Engaging the network of Commission members (inclusive of working groups) to coordinate and provide capacity for such initiatives, as feasible.
- Leveraging the interests and initiatives of public and private sector organizations outside of the Commission, to advance the Commission's objectives.

## Process

The ECO Working Group has access to a wide variety of internal and external assets, including the expertise and resources of ECO members, various State agencies, and the three other working groups of the Commission. This last portion is especially important to ECO as it works to coordinate Commission efforts on education, communication, and outreach. Starting in 2018, ECO will send a representative to each of the Adaptation and Response, Scientific and Technical, and Mitigation Working Group meetings to identify opportunities for collaboration and support. In addition, ECO members will work within their networks to contribute to the public facing “Environment, Public Health and Climate Change in Maryland” calendar of events maintained by the Maryland Department of Health; as well as to enhance the visibility of this and other similar platforms.

ECO will be tracking its efforts on outreach in order to quantify its efforts and use this information to inform future work.

## 2018 Priorities

Each working group is charged to establish a comprehensive and accountable annual plan that sets goals and performance benchmarks for the year; prioritizing new and existing climate change actions and initiatives. The following items represent those actions and initiatives which ECO has determined to be a priority in the 2018 year, and those members that have been assigned to take the lead on each are indicated. This work plan may be adjusted as is appropriate to maintain the group’s purpose as new events and opportunities arise during the 2018 year, and furthermore is subject to the approval and will of the Commission.

### *Climate Ambassador Program*

*Pat Harcourt, Steve Pattison*

In 2017, ECO members facilitated the development of a pilot Climate Ambassador Program which partners MDE and Bon Secours in Baltimore, to be launched over the winter of 2017/2018. This program utilizes a train-the-trainer approach, and incorporates materials on climate change into an existing framework. ECO will attempt to identify additional opportunities to use this strategy in 2018 and beyond, as capacity exists.

### *Commission Fact Sheets*

*Kris Hoellen, Michele Peterson*

In 2017, ECO collaborated with MDE and the Hatcher Group to create five fact sheets and an infographic that connect climate change impacts in Maryland across the sectors and workgroups. The original topics for the fact sheets include The Commission, The Greenhouse Gas Reduction Act, Resiliency to Climate Change, Sea-Level Rise and Flooding, and the Health Impacts of Climate Change. In 2018, ECO plans to work on coordinating the dissemination of these products and how to best increase their utilization in appropriate platforms.

### *Increase external awareness of State climate change work*

*John Kumm, Lori Arguelles*

In 2018, ECO aims to increase external awareness of the Commission and the State’s work on climate change, with a goal of increasing stakeholder engagement in the upcoming 40 by 30 Draft Plan and the 2018 Commission Report which will also address the Draft Plan’s release.

ECO will produce a brief guide to accompany the 2018 Report (to be posted online in conjunction with or shortly after the report), which may include (1) information on appropriate educational usage and application of the Report; (2) FAQs about the Report; (3) ways to keep up-to-date on the State’s climate change efforts; and/or (4) a timeline of upcoming events related to the State’s climate change efforts, including expected opportunities for public engagement.

Finally, ECO will work to identify new communities to work with in increasing awareness of State climate change work. It will be a priority of ECO to ensure underserved communities are included in outreach efforts throughout the year.

*Recognition of Climate Change Action – Climate Champions Program* Donna Balado, Kaymie Owen

In 2017, ECO worked with MDE to incorporate recognition of climate change action taken by businesses, as part of the existing Maryland Green Registry program. In 2018, ECO plans to engage the Chamber of Commerce or community organizations to see if it would be feasible to hold a “climate change mitigation business day/week” where businesses can show off what they are doing to save energy or reduce GHG emissions. ECO also plans to work with MSDE to develop a program which recognizes schools engaged in efforts to reduce their GHG emissions, educate on climate change, or otherwise contribute to the State’s climate goals. MEA’s Smart Energy Community Grant and MDH’s Community Ambassadors Program will be followed as well.

These items will be assigned to sub-groups of the ECO Working Group:

*Maryland Climate Photo Essay*

Grant Samms

During 2017, ECO members worked to develop a campaign packet and timeline for the Climate Change in Maryland Photo Event - a multi sector effort to engage the public to share what climate change looks like through social media platforms using specific hashtags. In 2018, discussions will continue to coordinate the launch of the campaign among members and stakeholders.

*Facilitation of existing outreach and listening sessions* Allison Gost

In 2018, ECO will continue to provide support for existing outreach through working group and state agency efforts as requested. This includes, but is not limited to: (1) identifying communities most vulnerable to climate change in which outreach might occur, and existing trusted messengers in those communities; (2) identifying underserved communities in which outreach might occur, and existing trusted messengers in those communities; (3) identifying locally relevant topics related to climate change and its impacts which might best address the concerns of a given community; and (4) identifying emerging methods and best practices for the process of community outreach and engagement.

**Future Priorities**

While certain priorities were established for 2018, based on timing and capacity, the following items are still on the docket for 2019 or as ECO or State Agency capacity becomes available.

*Climate Education ToolBox*

ECO will work to continue its 2017 work to identify and compile existing resources and tools for climate education targeted at diverse sectors and literacy levels. These resources should draw from products created by environmental education experts like MSDE, MAEOE, MADE-CLEAR, and the National Aquarium, as well as State agencies and other partners. ECO recommends that the resulting Climate Education ToolBox, once properly vetted, reside on the updated Commission website to be launched in 2018.

*Environmental Literacy*

ECO plans to identify efforts such as Project Green Classrooms and the Chesapeake Bay Program which make connections between climate change and environmental literacy. Once identified, ECO will work to support these programs by communicating on events and progress, and collaborating as feasible. Schedule of Meetings The ECO Working Group meets monthly to further the priorities laid out in the previous section. Appendix C of [the ECO 2018 Work Plan] provides a summary of ECO Working Group meetings scheduled for 2018, as well as tentative topics and action items.

## Purpose

During its 2015 session, the Maryland General Assembly codified the Maryland Commission on Climate Change (MCCC) into law, and charged the Commission with advising the Governor and General Assembly on ways to mitigate the causes of, prepare for, and adapt to the consequences of climate change. The MCCC is chaired by MDE Secretary Ben Grumbles and consists of 26 members representing diverse interests in the State.

The Mitigation Working Group (MWG) is one of four working groups that support the objectives of the Commission. The purpose of the MWG is to recommend regulatory, market-based and voluntary programs to reduce greenhouse gas (GHG) emissions. These strategies are to be designed in support of a strong economy and job creation in Maryland.

## 2018 Priorities

The MWG is partially driven by the schedule set by the 2016 Greenhouse Gas Emissions Reduction Act (GGRA) legislation, which requires MDE to present a draft plan to the Governor and General Assembly by the end of 2018 outlining specific strategies to achieve the most recent benchmark GHG emission reduction requirement (40 percent reduction from 2006 levels by 2030). Furthermore, the Plan is being developed in recognition of the IPCC's finding that developed countries must reduce GHG emissions between 80 to 90 percent below 1990 levels by 2050. The MWG agrees that such considerations for reductions beyond 2030 are important to achieving long-term emission reduction goals, especially when it comes to actions which may take longer to achieve results. Due to the significance of the Draft Plan for the State's climate change mitigation targets in 2030 and beyond, the MWG intends to provide guidance and assistance to MDE both during the development process and after the draft plan is released, prior to finalization at the end of 2019. Accordingly, the 2018 MWG Work Plan focuses on refining and finalizing the recommendations the group has been building during 2016 and 2017, and taking actions to move these forward as appropriate, in order to support the Draft Plan and produce robust recommendations for the Commission's 2018 Annual Report. Appendix C [of the MWG 2018 Work Plan] contains more detail on the expected meeting topics, taken from both the MWG and Commission's 2017 recommendations, as well as discussion at the working group.

1. Discussion to prioritize additional analyses or specific methodology that the MWG may request of MDE or other State entities related to the 40 by 30 Draft Plan or GHG Inventory due in 2018.
2. Discussion regarding GHG emissions reduction opportunity from natural gas fuel conversion.
3. Discussion on jobs and the economy, especially related to labor and manufacturing in Maryland.
4. Discussion regarding the economic and environmental costs and benefits of a carbon market approach in various sectors, or a carbon fee and dividend.
5. Discussion related to the mitigation of GHG emissions from the transportation sector.
6. Discussion on ways to incorporate healthy soils into the 40 by 30 Draft Plan.
7. Active incorporation of considerations for environmental justice into each topical discussion.
8. Updates from MDE on the 40 by 30 Draft Plan.
9. Updates from MEA on the QECB and Commercial PACE sub-groups.

## Process

The MWG has access to a wide variety of internal and external assets, including the expertise and resources of MWG members, various State agencies, and the three other working groups of the Commission. The past two years, the MWG regularly sourced subject matter experts to inform its analyses and discussion, and plans to continue doing so in 2018. The MWG will also coordinate with the Scientific and Technical Working Group (STWG), the Adaptation and Response Working Group (ARWG) and the Education, Communication and Outreach Working Group (ECO) on cross-cutting issues as

appropriate. More specific opportunities for collaboration are laid out in the Proposed Meeting Schedule (Appendix D [of the MWG 2018 Work Plan]).

### **Scientific and Technical Working Group**

The STWG plans to hold 2-3 technical workshops that will assist in summarizing key issues that would help understand the greenhouse gas emissions from landscapes, the impact of climate change on agriculture, and potentially updating the sea level rise estimates for the State.

- 1. Approaches to quantifying and reducing net GHG emission from landscapes.** Assemble an expert group to identify critical uncertainties in and methods to improve the estimation of greenhouse emissions from forests, agriculture, wetlands and waterways. In 2017, an STWG member prepared a presentation on approaches to improve inventory estimates for net greenhouse gas emissions from forests, fields and wetlands that would help identify potential source reductions and increases in carbon sinks. The STWG found the overview useful for framing a more in-depth assessment under STWG auspices, one that would indicate the level of confidence in estimates and the best opportunities for reducing emissions and enhancing sequestration.
- 2. Assessment of emissions from and climate change impacts on agriculture.** Assemble an expert group to provide an assessment of emissions from and climate change impacts on Maryland agriculture as called for in the Maryland Commission on Climate Change Act [Maryland Environment Code Ann. §2-1303(d)]. STWG assessment is important not only for improving the emissions inventory and evaluating the scientifically realistic potential of carbon sequestration through the Healthy Soils initiative, but also for addressing the requirement for "assessing the impacts that climate change may have on agriculture in the state." Initial STWG assessment indicated that there has been a downward trend in emissions from Maryland agriculture from 2003 to 2013 based on the U.S. Department of Agriculture's Greenhouse Gas Inventory.
- 3. Estimating sea level rise over the next century.** Assemble an expert group to provide an estimate of sea level rise as called for in the Maryland Commission on Climate Change Act [Maryland Environment Code Ann. §2-1303(d)]. These estimates were last completed in 2018. At that time, they estimated for 2050 and 2100. Those seem like reasonable dates for next estimate.

The STWG plans to hold these three workshops in 2018, completing at least 2 of the report prior to year's end.

## Maryland Commission on Climate Change Legislation

### *Code of Maryland – Environment Article*

#### §2–1301.

(a) There is a Commission on Climate Change in the Department to advise the Governor and General Assembly on ways to mitigate the causes of, prepare for, and adapt to the consequences of climate change.

(b) The Department and the Department of Natural Resources shall jointly staff the Commission.

#### §2–1302.

(a) The Commission’s membership shall consist of the following members:

- (1) One member of the House of Delegates, appointed by the Speaker of the House;
- (2) One member of the Senate, appointed by the President of the Senate;
- (3) The State Treasurer, or the State Treasurer’s designee;
- (4) The Secretary of the Environment, or the Secretary’s designee;
- (5) The Secretary of Agriculture, or the Secretary’s designee;
- (6) The Secretary of Natural Resources, or the Secretary’s designee;
- (7) The Secretary of Planning, or the Secretary’s designee;
- (8) The State Superintendent of Schools, or the State Superintendent’s designee;
- (9) The Secretary of Transportation, or the Secretary’s designee;
- (10) The Secretary of General Services, or the Secretary’s designee;
- (11) The Director of the Maryland Energy Administration, or the Director’s designee;
- (12) The President of the University of Maryland Center for Environmental Science, or the President’s designee;
- (13) The Chair of the Critical Area Commission for the Chesapeake and Atlantic Coastal Bays, or the Chair’s designee;
- (14) One member appointed by the Farm Bureau representing the agriculture community;
- (15) One member appointed by the Maryland Association of Counties and one member appointed by the Maryland Municipal League to represent local governments;
- (16) One member appointed by the President of the Senate and one member appointed by the Speaker of the House of Delegates to represent the business community;

(17) One member appointed by the President of the Senate and one member appointed by the Speaker of the House of Delegates to represent environmental nonprofit organizations;

(18) One member appointed by the President of the Senate and one member appointed by the Speaker of the House to represent organized labor, one of whom shall represent the building or construction trades and one of whom shall represent the manufacturing industry;

(19) One member appointed by the President of the Senate and one member appointed by the Speaker of the House to represent philanthropic organizations;

(20) One climate change expert appointed by the Governor representing a university located in Maryland; and

(21) One public health expert appointed by the Governor representing a university located in Maryland.

(b) The Secretary of the Environment or the Secretary's designee shall chair the Commission.

(c) (1) Subject to paragraph (2) of this subsection, the term of an appointed member is 2 years.

(2) The Governor, President of the Senate, and Speaker of the House of Delegates shall stagger the terms of the initial appointed members.

(3) At the end of a term, a member continues to serve until a successor is appointed and qualifies.

(4) A member who is appointed after a term has begun serves only for the remainder of that term and until a successor is appointed and qualifies.

(5) The Governor may remove an appointed member for incompetence, misconduct, or failure to perform the duties of the position.

(d) A member of the Commission may not receive compensation, but is entitled to reimbursement for expenses under the Standard State Travel Regulations, as provided in the State budget.

§2-1303.

(a) The Commission shall establish:

(1) A Scientific and Technical Working Group;

(2) A Greenhouse Gas Mitigation Working Group;

(3) An Adaptation and Response Working Group; and

(4) An Education, Communication, and Outreach Working Group.

(b) The Commission may establish other working groups as needed.

(c) The Chair of the Commission shall appoint working group members who represent both public and private interests in climate change, including representatives of:

(1) Academic institutions;

- (2) Renewable and traditional energy providers;
  - (3) Environmental organizations;
  - (4) Government agencies;
  - (5) Labor organizations; and
  - (6) Business interests, including the insurance and real estate industries.
- (d) The Commission shall prioritize working group actions, including:
- (1) Strengthening and maintaining existing State climate action plans;
  - (2) Developing broad public and private partnerships with local, State, and federal agencies;
  - (3) Communicating with and educating citizens about the urgency of acting to reduce the impacts of climate change;
  - (4) Maintaining an inventory of Maryland's greenhouse gas emissions sources and carbon sinks;
  - (5) Addressing any disproportionate impacts of climate change on low-income and vulnerable communities;
  - (6) Assessing the impacts that climate change may have on the State's economy, revenues, and investment decisions;
  - (7) Assessing the needs for utilities and other public and private service providers throughout the State to adjust their operating practices and investment strategies to mitigate the impacts of climate change on their customers and the public;
  - (8) Assessing the impacts that climate change may have on agriculture in the State;
  - (9) Recommending short- and long-term strategies and initiatives to better mitigate, prepare for, and adapt to the consequences of climate change;
  - (10) Assisting local governments in supporting community-scale climate vulnerability assessments and the development and integration of specific strategies into local plans and ordinances;
  - (11) Establishing comprehensive and accountable annual working group work plans that set annual goals and performance benchmarks and prioritize new and existing climate change mitigation and preparedness actions and initiatives;
  - (12) Maintaining a comprehensive action plan, with 5-year benchmarks, to achieve science-based reductions in Maryland's greenhouse gas emissions;
  - (13) Convening regular working group and full Commission meetings to ensure that sufficient progress is being made across all sectors and communities in Maryland; and
  - (14) Considering other related matters as the Commission determines to be necessary.

## §2-1304.

On or before November 15 of each year, the Commission shall report to the Governor and General Assembly, in accordance with § 2-1246 of the State Government Article, on the status of the State's efforts to mitigate the causes of, prepare for, and adapt to the consequences of climate change, including future plans and recommendations for legislation, if any, to be considered by the General Assembly.

## §2-1305.

(a) (1) Each State agency shall review its planning, regulatory, and fiscal programs to identify and recommend actions to more fully integrate the consideration of Maryland's greenhouse gas reduction goal and the impacts of climate change.

(2) The review shall include the consideration of:

- (i) Sea level rise;
- (ii) Storm surges and flooding;
- (iii) Increased precipitation and temperature; and
- (iv) Extreme weather events.

(b) Each State agency shall identify and recommend specific policy, planning, regulatory, and fiscal changes to existing programs that do not currently support the State's greenhouse gas reduction efforts or address climate change.

(c) (1) The following State agencies shall report annually on the status of programs that support the State's greenhouse gas reduction efforts or address climate change, in accordance with § 2-1246 of the State Government Article, to the Commission and the Governor:

- (i) The Department;
- (ii) The Department of Agriculture;
- (iii) The Department of General Services;
- (iv) The Department of Housing and Community Development;
- (v) The Department of Natural Resources;
- (vi) The Department of Planning;
- (vii) The Department of Transportation;
- (viii) The Maryland Energy Administration;
- (ix) The Maryland Insurance Administration;
- (x) The Public Service Commission; and
- (xi) The University of Maryland Center for Environmental Science.

(2) The report required in paragraph (1) of this subsection shall include:

- (i) Program descriptions and objectives;
- (ii) Implementation milestones, whether or not they have been met;
- (iii) Enhancement opportunities;
- (iv) Funding;
- (v) Challenges;
- (vi) Estimated greenhouse gas emissions reductions, by program, for the prior calendar year; and
- (vii) Any other information that the agency considers relevant.

§2-1306.

(a) The University of Maryland Center for Environmental Science shall establish science-based sea level rise projections for Maryland's coastal areas and update them at least every 5 years.

(b) The science-based sea level rise projections shall include maps that indicate the areas of the State that may be most affected by storm surges, flooding, and extreme weather events.

(c) The science-based sea level rise projections required under this section shall be made publicly available on the Internet.

## Greenhouse Gas Emissions Reduction Act Legislation

### *Code of Maryland – Environment Article*

§2–1201.

The General Assembly finds that:

(1) Greenhouse gases are air pollutants that threaten to endanger the public health and welfare of the people of Maryland;

(2) Global warming poses a serious threat to the State’s future health, well-being, and prosperity;

(3) With 3,100 miles of tidally influenced shoreline, Maryland is vulnerable to the threat posed by global warming and susceptible to rising sea levels and flooding, which would have detrimental and costly effects;

(4) The State has the ingenuity to reduce the threat of global warming and make greenhouse gas reductions a part of the State’s future by achieving a 25% reduction in greenhouse gas emissions from 2006 levels by 2020 and by preparing a plan to meet a longer-term goal of reducing greenhouse gas emissions by up to 90% from 2006 levels by 2050 in a manner that promotes new “green” jobs, and protects existing jobs and the State’s economic well-being;

(5) Studies have shown that energy efficiency programs and technological initiatives consistent with the goal of reducing greenhouse gas emissions can result in a net economic benefit to the State;

(6) In addition to achieving the reduction established under this subtitle, it is in the best interest of the State to act early and aggressively to achieve the Maryland Commission on Climate Change’s recommended goals of reducing greenhouse gas emissions by 10% from 2006 levels by 2012 and by 15% from 2006 levels by 2015;

(7) While reductions of harmful greenhouse gas emissions are one part of the solution, the State should focus on developing and utilizing clean energies that provide greater energy efficiency and conservation, such as renewable energy from wind, solar, geothermal, and bioenergy sources;

(8) It is necessary to protect the public health, economic well-being, and natural treasures of the State by reducing harmful air pollutants such as greenhouse gas emissions by using practical solutions that are already at the State’s disposal;

(9) Cap and trade regulation of greenhouse gas emissions is most effective when implemented on a federal level;

(10) Because of the need to remain competitive with manufacturers located in other states or countries and to preserve existing manufacturing jobs in the State, greenhouse gas emissions from the manufacturing sector are most effectively regulated on a national and international level; and

(11) Because of the need to remain competitive with other states, greenhouse gas emissions from certain other commercial and service sectors, including freight carriers and generators of electricity, are most effectively regulated on a national level.

## §2-1202.

(a) In this subtitle the following words have the meanings indicated.

(b) “Alternative compliance mechanism” means an action authorized by regulations adopted by the Department that achieves the equivalent reduction of greenhouse gas emissions over the same period as a direct emissions reduction.

(c) “Carbon dioxide equivalent” means the measurement of a given weight of a greenhouse gas that has the same global warming potential, measured over a specified period of time, as one metric ton of carbon dioxide.

(d) “Direct emissions reduction” means a reduction of greenhouse gas emissions from a greenhouse gas emissions source.

(e) “Greenhouse gas” includes carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride.

(f) “Greenhouse gas emissions source” means a source or category of sources of greenhouse gas emissions that have emissions of greenhouse gases that are subject to reporting requirements or other provisions of this subtitle, as determined by the Department.

(g) “Leakage” means a reduction in greenhouse gas emissions within the State that is offset by a corresponding increase in greenhouse gas emissions from a greenhouse gas emissions source located outside the State that is not subject to a similar state, interstate, or regional greenhouse gas emissions cap or limitation.

(h) (1) “Manufacturing” means the process of substantially transforming, or a substantial step in the process of substantially transforming, tangible personal property into a new and different article of tangible personal property by the use of labor or machinery.

(2) “Manufacturing”, when performed by companies primarily engaged in the activities described in paragraph (1) of this subsection, includes:

(i) The operation of saw mills, grain mills, or feed mills;

(ii) The operation of machinery and equipment used to extract and process minerals, metals, or earthen materials or by-products that result from the extracting or processing; and

(iii) Research and development activities.

(3) “Manufacturing” does not include:

(i) Activities that are primarily a service;

(ii) Activities that are intellectual, artistic, or clerical in nature;

(iii) Public utility services, including gas, electric, water, and steam production services; or

(iv) Any other activity that would not commonly be considered as manufacturing.

(i) “Statewide greenhouse gas emissions” means the total annual emissions of greenhouse gases in the State, measured in metric tons of carbon dioxide equivalents, including all emissions of greenhouse gases from the generation of electricity delivered to and consumed in the State, and line losses from the transmission and distribution of electricity, whether the electricity is generated in-State or imported.

§2-1203.

(a) On or before June 1, 2011, the Department shall publish:

(1) An inventory of statewide greenhouse gas emissions for calendar year 2006; and

(2) Based on existing greenhouse gas emissions control measures, a projected “business as usual” inventory for calendar year 2020.

(b) The Department shall review and publish an updated statewide greenhouse gas emissions inventory for calendar year 2011 and for every third calendar year thereafter.

§2-1204.

The State shall reduce statewide greenhouse gas emissions by 25% from 2006 levels by 2020.

§2-1204.1. IN EFFECT

// EFFECTIVE UNTIL DECEMBER 31, 2023 PER CHAPTER 11 OF 2016 //

The State shall reduce statewide greenhouse gas emissions by 40% from 2006 levels by 2030.

§2-1205.

(a) The State shall develop plans, adopt regulations, and implement programs that reduce statewide greenhouse gas emissions in accordance with this subtitle.

(b) On or before December 31, 2018, the Department shall:

(1) Submit a proposed plan that reduces statewide greenhouse gas emissions by 40% from 2006 levels by 2030 to the Governor and General Assembly;

(2) Make the proposed plan available to the public; and

(3) Convene a series of public workshops to provide interested parties with an opportunity to comment on the proposed plan.

(c) (1) The Department shall, on or before December 31, 2012, adopt a final plan that reduces statewide greenhouse gas emissions by 25% from 2006 levels by 2020.

(2) The Department shall, on or before December 31, 2019, adopt a final plan that reduces statewide greenhouse gas emissions by 40% from 2006 levels by 2030.

(3) The plans shall be developed in recognition of the finding by the Intergovernmental Panel on Climate Change that developed countries will need to reduce greenhouse gas emissions by between 80% and 95% from 1990 levels by 2050.

(d) The final plans required under subsection (c) of this section shall include:

(1) Adopted regulations that implement all plan measures for which State agencies have existing statutory authority; and

(2) A summary of any new legislative authority needed to fully implement the plans and a timeline for seeking legislative authority.

(e) In developing and adopting a final plan to reduce statewide greenhouse gas emissions, the Department shall consult with State and local agencies as appropriate.

(f) (1) Unless required by federal law or regulations or existing State law, regulations adopted by State agencies to implement a final plan may not:

(i) Require greenhouse gas emissions reductions from the State's manufacturing sector; or

(ii) Cause a significant increase in costs to the State's manufacturing sector.

(2) Paragraph (1) of this subsection may not be construed to exempt greenhouse gas emissions sources in the State's manufacturing sector from the obligation to comply with:

(i) Greenhouse gas emissions monitoring, recordkeeping, and reporting requirements for which the Department had existing authority under § 2–301(a) of this title on or before October 1, 2009; or

(ii) Greenhouse gas emissions reductions required of the manufacturing sector as a result of the State's implementation of the Regional Greenhouse Gas Initiative.

(g) A regulation adopted by a State agency for the purpose of reducing greenhouse gas emissions in accordance with this section may not be construed to result in a significant increase in costs to the State's manufacturing sector unless the source would not incur the cost increase but for the new regulation.

§2–1206.

In developing and implementing the plans required by § 2–1205 of this subtitle, the Department shall:

(1) Analyze the feasibility of measures to comply with the greenhouse gas emissions reductions required by this subtitle;

(2) Consider the impact on rural communities of any transportation related measures proposed in the plans;

(3) Provide that a greenhouse gas emissions source that voluntarily reduces its greenhouse gas emissions before the implementation of this subtitle shall receive appropriate credit for its early voluntary actions;

(4) Provide for the use of offset credits generated by alternative compliance mechanisms executed within the State, including carbon sequestration projects, to achieve compliance with greenhouse gas emissions reductions required by this subtitle;

(5) Ensure that the plans do not decrease the likelihood of reliable and affordable electrical service and statewide fuel supplies;

(6) Consider whether the measures would result in an increase in electricity costs to consumers in the State;

(7) Consider the impact of the plans on the ability of the State to:

- (i) Attract, expand, and retain commercial aviation services; and
- (ii) Conserve, protect, and retain agriculture; and

(8) Ensure that the greenhouse gas emissions reduction measures implemented in accordance with the plans:

- (i) Are implemented in an efficient and cost-effective manner;
- (ii) Do not disproportionately impact rural or low-income, low- to moderate-income, or minority communities or any other particular class of electricity ratepayers;
- (iii) Minimize leakage;
- (iv) Are quantifiable, verifiable, and enforceable;
- (v) Directly cause no loss of existing jobs in the manufacturing sector;
- (vi) Produce a net economic benefit to the State's economy and a net increase in jobs in the State; and
- (vii) Encourage new employment opportunities in the State related to energy conservation, alternative energy supply, and greenhouse gas emissions reduction technologies.

§2-1207.

(a) (1) An institution of higher education in the State shall conduct an independent study of the economic impact of requiring greenhouse gas emissions reductions from the State's manufacturing sector.

(2) The Maryland Commission on Climate Change shall oversee the independent study required by this section.

(b) On or before October 1, 2022, the institution of higher education responsible for the independent study shall complete and submit the study to the Governor and, in accordance with § 2-1246 of the State Government Article, the General Assembly.

§2-1208.

(a) A greenhouse gas emissions source in the State's manufacturing sector that implements a voluntary greenhouse gas emissions reduction plan that is approved by the Department on or before January 1, 2012, may be eligible to receive voluntary early action credits under any future State law requiring greenhouse gas emissions reductions from the manufacturing sector.

(b) A voluntary greenhouse gas emissions reduction plan may include measures to:

- (1) Reduce energy use and increase process efficiency; and
- (2) Facilitate industry-wide research and development directed toward future measures to reduce greenhouse gas emissions.

§2-1209.

(a) On or before October 1, 2015, the Department shall submit a report to the Governor and, in accordance with § 2-1246 of the State Government Article, the General Assembly that includes:

- (1) A summary of the State's progress toward achieving the 2020 emissions reduction required by the plan under § 2-1205 of this subtitle;
- (2) An update on emerging technologies to reduce greenhouse gas emissions;
- (3) A review of the best available science, including updates by the Intergovernmental Panel on Climate Change, regarding the level and pace of greenhouse gas emissions reductions and sequestration needed to avoid dangerous anthropogenic changes to the Earth's climate system;
- (4) Recommendations on the need for science-based adjustments to the requirement to reduce statewide greenhouse gas emissions by 25% by 2020;
- (5) A summary of additional or revised regulations, control programs, or incentives that are necessary to achieve the 25% reduction in statewide greenhouse gas emissions required under this subtitle, or a revised reduction recommended in accordance with item (4) of this subsection;
- (6) The status of any federal program to reduce greenhouse gas emissions and any transition by the State from its participation in the Regional Greenhouse Gas Initiative to a comparable federal cap and trade program; and
- (7) An analysis of the overall economic costs and benefits to the State's economy, environment, and public health of a continuation or modification of the requirement to achieve a reduction of 25% in statewide greenhouse gas emissions by 2020, including reductions in other air pollutants, diversification of energy sources, the impact on existing jobs, the creation of new jobs, and expansion of the State's low carbon economy.

(b) The report required under subsection (a) of this section shall be subject to a public comment and hearing process conducted by the Department.

§2-1210.

On review of the study required under § 2-1207 of this subtitle, and the reports required under § 2-1211 of this subtitle, the General Assembly:

- (1) May act to maintain, revise, or eliminate the 40% greenhouse gas emissions reduction required under § 2-1204.1 of this subtitle; and
- (2) Shall consider whether to continue the special manufacturing provisions in § 2-1205(f)(1) of this subtitle.

## §2-1211.

The Department shall monitor implementation of the plans required under § 2-1205 of this subtitle and shall submit a report, on or before October 1, 2022, and every 5 years thereafter, to the Governor and, in accordance with § 2-1246 of the State Government Article, the General Assembly that describes the State's progress toward achieving:

(1) The reductions in greenhouse gas emissions required under this subtitle, or any revisions conducted in accordance with § 2-1210 of this subtitle; and

(2) The greenhouse gas emissions reductions needed by 2050 in order to avoid dangerous anthropogenic changes to the Earth's climate system, based on the predominant view of the scientific community at the time of the latest report.

## Acronyms

<b>ACE</b>	Affordable Clean Energy Rule
<b>ARWG</b>	Adaptation and Response Working Group
<b>BRTB</b>	Baltimore Regional Transportation Board
<b>CALEV</b>	California Low Emission Vehicle Standards
<b>CEJSC</b>	Commission of Environmental Justice and Sustainable Communities
<b>CHP</b>	Combined Heat and Power
<b>CHW</b>	Climate Health Worker
<b>CO<sub>2</sub></b>	Carbon Dioxide
<b>COMAR</b>	Code of Maryland Regulations
<b>CPP</b>	Clean Power Plan
<b>CREP</b>	Conservation Reserve Enhancement Program
<b>DHCD</b>	(Maryland) Department of Housing and Community Development
<b>DOE</b>	(U.S.) Department of Energy
<b>ECO</b>	Education, Communication and Outreach (Working Group)
<b>EJ</b>	Environmental Justice
<b>EPA</b>	(U.S.) Environmental Protection Agency
<b>EPHCAT</b>	Environmental Public Health Climate Adaptation Tracker
<b>EV</b>	Electric Vehicle
<b>EVIC</b>	Electric Vehicle Infrastructure Council
<b>FY</b>	Fiscal Year
<b>GGRA</b>	Greenhouse Gas Emissions Reduction Act
<b>GHG</b>	Greenhouse Gas
<b>HUC02</b>	Hydrologic Unit Code 02
<b>HVAC</b>	Heating, ventilation, and air conditioning
<b>IPCC</b>	Intergovernmental Panel on Climate Change
<b>MACT</b>	Maximum Available Control Technology
<b>MALPF</b>	Maryland Agricultural Land Preservation Foundation
<b>MCCHAP</b>	Maryland Climate Change Health Adaptation Program
<b>MCCC</b>	Maryland Commission on Climate Change
<b>MDA</b>	Maryland Department of Agriculture
<b>MDE</b>	Maryland Department of the Environment
<b>MDH</b>	Maryland Department of Health
<b>MDNR</b>	Maryland Department of Natural Resources
<b>MDOT</b>	Maryland Department of Transportation
<b>MDP</b>	Maryland Department of Planning
<b>MEA</b>	Maryland Energy Administration
<b>MEMA</b>	Maryland Emergency Management Agency

<b>MMTCO<sub>2e</sub></b>	Million Metric Tons Carbon Dioxide Equivalent
<b>MTA</b>	Maryland Transit Authority
<b>MWCOG</b>	Metropolitan Washington Council of Governments
<b>MWG</b>	Mitigation Working Group
<b>NASA</b>	National Aeronautics and Space Administration
<b>NOAA</b>	National Oceanic and Atmospheric Administration
<b>NO<sub>x</sub></b>	Nitrogen Oxides (NO and NO <sub>2</sub> )
<b>NPO</b>	Non-Profit Organization
<b>OBD</b>	On-Board Diagnostics
<b>PSC</b>	(Maryland) Public Service Commission
<b>RGGI</b>	Regional Greenhouse Gas Initiative
<b>RPS</b>	Renewable (Energy) Portfolio Standard
<b>SEIF</b>	Strategic Energy Investment Fund
<b>SMM</b>	Sustainable Materials Management
<b>(Solar) PV</b>	(Solar) Photovoltaics
<b>STWG</b>	Scientific and Technical Working Group
<b>TIGER</b>	Transportation Investment Generating Economic Recovery
<b>TMDL</b>	Total Maximum Daily Load
<b>UMCES</b>	University of Maryland Center for Environmental Science
<b>USCA</b>	U.S. Climate Alliance
<b>USD</b>	U.S. Dollars
<b>USDA</b>	U.S. Department of Agriculture
<b>USGCRP</b>	U.S. Global Change Research Program
<b>WILMAPCO</b>	Wilmington Area Planning Council
<b>WIP</b>	Watershed Implementation Plan
<b>TCI</b>	Transportation Climate Initiative
<b>VMT</b>	Vehicle Miles Traveled
<b>VOCs</b>	Volatile Organic Compounds
<b>ZEV</b>	Zero Emission Vehicle

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