

DRAFT

Proposed Strategy Framework
for the Maine Climate Action Plan

September 15, 2020

Important notes on this draft framework:

This draft framework represents a first draft version of a two-part document to be presented to the Maine Climate Council by staff that includes the recommendations proposed by the six Maine Climate Council working groups in summary form and incorporated into consolidated strategies.

The Maine Climate Council members have not yet taken a position on the draft proposed strategies and framework (and ultimately the Action Plan) which will continue to be refined, clarified, and shaped by the Council process. Public comment in written form will continue to be accepted by the Maine Climate Council through September 24, 2020, for consideration prior to final climate council decision making. The final four-year Maine Climate Action Plan is due to be submitted to the Governor and Legislature on December 1, 2020.

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(See Part 1: Reduce Maine’s Greenhouse Gas Emissions in a separate [draft](#))

DRAFT

Introduction

This draft framework organizes the draft climate actions under consideration by the Maine Climate Council for the state's climate action plan. These draft actions were recommended by the six working groups—(1)Transportation; (2)Buildings, Infrastructure and Housing; (3)Energy; (4)Community Resilience Planning, Emergency Management and Public Health; (5)Coastal and Marine; and (6)Natural and Working Lands—and were presented to the Climate Council at the June 2020 meeting. The details of the working group strategies are available at <https://www.maine.gov/future/initiatives/climate/climate-council/reports>.

The draft strategy framework also references several additional analyses conducted over the last several months. First is an evaluation of the costs and benefits of the various recommended strategies. [*Assessing the Impacts Climate Change May Have on the State's Economy, Revenues, and Investment Decisions*](#), an analysis by Eastern Research Group and Synapse Energy Economics, includes 4 volumes:

- Volume 1, Vulnerability Mapping: A mapping analysis that identifies vulnerable communities, geographies, and economic sectors.
- Volume 2, Cost of Doing Nothing Analysis: Estimates of losses that the State of Maine and its citizens could incur if the State does not take action to prevent or prepare for climate change. The cost of not adapting to a changing climate is large and will accelerate over time, with flooding serving as the largest overall threat.
- Volume 3, Maine Emissions Analysis: An energy use and emissions baseline based on current state and regional policies, as well as an assessment of options for meeting Maine's energy needs (and allowing economic growth) while reducing greenhouse gas emissions.
- Volume 4, Economic Analyses of Adaptation and Mitigation Strategies: Economic analyses to provide context for the majority of the adaptation and mitigation strategies developed by the Maine Climate Council.

Second is a summary of the public input surveys conducted over the summer. More than 4,400 responses were received through feedback survey on the website, climatecouncil.maine.gov. Members of the public were invited to learn about the impacts of climate change on the State, read the strategies recommended by the working groups, and provide feedback through a series of short surveys. Numerous organizations helped amplify the message, and staff and working group co-chairs conducted more than twenty outreach presentations this summer. Residents from more than two-thirds of Maine communities submitted comments. The public input survey effort built on the stakeholder engagement conducted as part of working group process to develop the draft recommendations which was conducted via public and stakeholder outreach meetings, calls, surveys, and individual and organizational input.

Third, the framework references the [executive summary](#) of the draft report, *Strengthening Maine's Clean Energy Economy*, which will be released in mid-September by the Governor's Energy Office and the Governor's Office of Policy Innovation and the Future. This plan will identify pathways and strategies for the advancement of Maine's clean energy economy that includes the development and sustained operations of renewable energy resources and energy efficiency services.

Finally, the report *Assessing the Potential Equity Outcomes of Maine's Climate Action Plan: Framework, Analysis and Recommendations*, an analysis by the University of Maine's Senator George J. Mitchell Center for Sustainability Solutions, is currently being finalized and will be shared with the Climate Council in the coming weeks. The report analyzes how the draft strategies ensure the equitable distribution of the benefits of climate protection efforts, and address inequitable burdens created by climate change and the policies designed to alleviate it.

The Climate Council will meet from September until November to consider and prioritize strategies for the four-year climate action plan, which is due to the Governor and the Legislature on December 1, 2020.

Maine's Climate Goals

Maine has adopted some of the country's most ambitious climate and energy goals. Maine's climate vision and policy envisions achieving our climate goals while creating jobs and growing a more diverse, sustainable economy.

Investing in renewable energy and energy efficiency can create the good-paying jobs of Maine's future, from solar and heat pump installers to engineers and contractors designing and building the offshore wind farms of the future. The steps we take now to prepare and protect our communities, people, and businesses from the impacts of climate change will create jobs and save money in the long-term. These actions will improve public health and protect our environment. The benefits from our climate strategies must benefit all Mainers equitably.

Goal 1: Create jobs and economic opportunity

The [executive summary](#) of the draft report, *Strengthening Maine's Clean Energy Economy* finds that the State of Maine is poised to significantly grow and expand its clean energy economy. Research shows that 41 states including Maine have reduced their energy-related carbon dioxide emissions while increasing gross domestic product (GDP). From the executive summary:

“Innovative developments and the use of forest products and biofuels in the energy sector provide unique opportunities for Maine, particularly in the rural areas of the State. Energy efficiency investments and programming have already proven greatly successful throughout Maine, with integration across the State to reduce energy consumption and provide energy cost savings to Maine consumers. Simultaneously, Maine is facing an economic downturn and related challenges as a result of the COVID-19 pandemic. As Maine charts the course for economic recovery, clean energy should be a key component of economic development as it creates good paying, long-term jobs, spurs economic growth, all while helping to reduce the State's climate impacts.”

Our strategies to prepare Maine communities for climate change impacts can also create new economic opportunity for Maine. We know that because of climate change, we are going to experience more frequent severe storms and flooding of our streams and rivers. Sea level increases will cause more frequent coastal flooding. Many communities and state agencies have identified vulnerabilities and are planning for necessary improvements to reduce flood and other hazard risks to community, business and transportation infrastructure. Investments in climate-ready infrastructure like working waterfronts, roads and bridges, and water treatment systems, will create good paying jobs while making our communities more proactively resilient against future climate impacts and potentially reduce future expenditures on climate response measures.

Goal 2: Reduce Maine's greenhouse gas emissions

Maine's Climate Action Plan must put us on a trajectory to reduce greenhouse gas emissions by 45% by 2030 and at least 80% by 2050. Reducing Maine's emissions is core to our state's effort to contribute meaningfully to national and international efforts to slow emissions, and as a result, to slow global climate change. Human activities have already caused approximately 1.0°C (1.8°F) of warming globally (IPCC, 2018), with Maine warming 3.2°F since 1895. If global climate warming is kept at or below 1.5°C (2.7°F) above the pre-industrial average, climate-related risks to humans and natural environments are lower than at 2°C of warming or above. Maine has committed to scientifically rigorous emissions reductions goals recommended by the Intergovernmental Panel on Climate Change to help keep global climate change within the warming level of 1.5°C and do our part to reduce the effects of climate change.

In addition to greenhouse gas emission reduction goals, Maine has committed to reach carbon neutrality by 2045. Our working forests, farmlands, and natural areas, including coastal and marine environments, already store carbon long-term, and they could store more, while continuing to provide critical economic, recreation, habitat and drinking water protection benefits. Balancing reducing emissions and increased carbon storage (sequestration) will allow Maine to reach our goal of sequestering at least as much carbon as our state emits.

Goal 3: Prepare Maine residents, businesses and communities for climate change impacts

From increasing land and ocean temperatures, to rising sea levels, more frequent severe storms, increased environmental damage, and public health risks, Maine scientists have catalogued the significant effects of rising greenhouse gases and climate change on our State.

Maine's Climate Action Plan must ensure Maine people, environment, industries, and communities are more resilient to the impacts of climate change. These efforts should include supporting transitions for communities, businesses, families and workers who will be most impacted by climate impacts. And it should support both planning and adaptation to help Maine's communities and people better withstand the current and future impacts of climate change.

Goal 4: Ensure that Maine's climate strategies are equitable

Maine's climate strategies can help address inequities that are exacerbated by the effects of climate change. We must ensure that we protect our most vulnerable communities from the impacts of climate change, and that all Mainers benefit from the economic, quality of life, and public health benefits of our climate strategies. This includes engaging diverse groups of Maine people and communities in the development and implementation of effective climate solutions, especially those most impacted.

Proposed Climate Strategy Framework

The following sections present six proposed strategies to achieve Maine’s climate and energy goals. They are:

Part 1: Reduce Maine’s Greenhouse Gas Emissions

- A. Bring the Future of Transportation to Maine
- B. Modernize Maine's Buildings: Energy Efficient, Smart and Cost-Effective Homes and Businesses
- C. Drive Innovation to Reduce Carbon Emissions in Maine's Energy and Industrial Sectors

Part 2: Prepare for Climate Change Impacts

- D. Build Healthy and Resilient Communities
- E. Invest in Climate-Ready Infrastructure
- F. Protect Maine’s Environment and Natural Resource Economies and Promote Natural Climate Solutions

The actions recommended within each of the proposed strategies represent science-based and detailed information provided by the six Working Groups. They include cost-benefit considerations from the Cost-Benefit and Modeling Analysis conducted by the Maine Climate Council consultants Eastern Research Group and a summary of the feedback from the public surveys conducted by the Governor’s Office of Policy Innovation and the Future during the summer of 2020. They also refer to the impacts of climate change described in the *Scientific Assessment of Climate Change and Its Effects in Maine*, from the Maine Climate Council's Scientific and Technical Subcommittee. These reports as well as the June 2020 Working Group reports are available at <https://www.maine.gov/future/initiatives/climate/climate-council/reports>.

Part 2: Preparing for Climate Change Impacts

Maine must ensure that our people, industries and communities are resilient to the impacts of climate change.

From increasing land and ocean temperatures, to rising sea levels, more frequent severe storms, increased environmental damage, and public health risks, Maine scientists have catalogued the significant impacts from climate changes on our state in [the report](#), “Scientific Assessment of Climate Change and its Effects in Maine,” by the Maine Climate Council’s Scientific and Technical Subcommittee .

Specific Maine communities, economic sectors, and infrastructure are especially vulnerable to the impacts of climate change.

Communities with high social vulnerability may have more difficulty preparing for and recovering from natural disasters and other types of disruptions made more frequent by climate changes. A community’s *social vulnerability* is influenced by factors including socioeconomic status, minority status, household composition and disability, and housing and transportation. The vulnerability mapping conducted by Eastern Research Group (ERG) looked at communities that are both socially vulnerable and vulnerable to climate risks such as sea level rise, riverine flooding, and high heat.

The Scientific and Technical Subcommittee recommends that the Maine Climate Council consider *committing to manage* for 1.5 feet of relative sea level rise by 2050, relative to the year 2000, and 3.9 feet of sea level rise by the year 2100.

Additionally, the STS recommends that the Climate Council consider *preparing to manage* for 3.0 feet of relative sea level rise by 2050, and 8.8 feet of sea level rise by the year 2100.

The analysis found that for sea level rise, a number of highly vulnerable communities are located along the coast of Washington and Hancock Counties and the eastern edge of Aroostook County. Lower topography and more erodible shorelines put low-lying beaches in southern Maine at higher risk in the next several decades. However, socioeconomic factors amplify risk for Downeast communities in later decades, despite more favorable topographies.

For riverine flooding (specifically the 1 percent annual chance, a flood that statistically has a 1-percent chance of occurring in any given year, also known as the 100-year flood), the analysis identified areas across the state where the impacts of flooding would be compounded by social vulnerability.

Populations vulnerable to high heat include people over 65 and living alone, children under 5 years of age, and those residents lacking air conditioning or living in areas with low population density where they are more likely to live further from community cooling centers. The ERG

analysis found that communities more vulnerable to high heat are generally concentrated in Washington County and eastern Aroostook County.

The vulnerability mapping also looked at the intersection of communities lacking municipal planning capacity and with high social vulnerability. The most vulnerable communities in this analysis include coastal communities as well as communities spread across central Maine.

In examining the vulnerability of Maine’s economic sectors to climate change, ERG estimated the potential job loss and associated annual Gross Domestic Product (GDP) loss from sea level rise and riverine flooding. Sea level rise puts jobs at risk because places of employment along the Maine coast and near inland tidally influenced rivers will be increasingly prone to flooding in the future. Similarly, the analysis looked at jobs located within the 100 year and 500 year floodplains. Overall, Maine’s statewide GDP could face annual losses from \$119 million to \$1.4 billion under different flood hazard scenarios. The analysis notes that sea level rise impacts to jobs may be felt far upstream in communities located near Maine rivers (e.g., Bangor), because of tidal connections to the ocean.

Among Maine’s natural resource sectors, projected job losses were highest in the tourism economy across all the sea level rise and riverine flooding scenarios.

Table 1: Statewide annual GDP loss from job loss due to flooding

Flood Hazard Scenario	Climate Projection	Potential Statewide Annual GDP Loss (Millions of 2019\$)
Highest astronomical tide (HAT) + 1.6 feet of sea level rise (coastal)	Likely range 67% probability sea level rise is between 1.1 and 1.8 feet in 2050	\$119
HAT + 3.9 feet of sea level rise (coastal)	Likely range 67% probability sea level rise is between 3.0 and 4.6 feet in 2100	\$665
HAT + 8.8 feet of sea level rise (coastal)	Central estimate for a high sea level rise scenario for 2100	\$2,415
1% annual chance flood (coastal and riverine)	Present	\$1,197
0.2% annual chance flood (coastal and riverine)	Present	\$1,449

Maine’s buildings, transportation infrastructure, and wastewater treatments plants are also vulnerable to flooding.

ERG’s analysis considered two types of flooding scenarios: one-time or 1 percent annual chance floods and inundation flooding from sea level rise. In one-time flood scenarios, water levels ultimately recede, and infrastructure can continue to operate after addressing damages. In scenarios with inundation flooding from sea level rise, the analysis assumes a complete loss of facilities, as flood waters will not recede and facilities are permanently inundated and thus inoperable.

Building losses include both repair and replacement costs for building damage based on building type (i.e., residential versus industrial), and content loss such as furniture and inventory damage. Building loss due to riverine flooding can amount to major financial impacts in rural areas and smaller towns. Projected building losses due to coastal flooding are highest along the southern Maine coast.

Table 2: Cumulative Building Loss due to Sea Level Rise and Riverine flooding

Flood Hazard Scenario	Climate Projection	Combined Loss (2018\$) [a]
HAT + 1.6 ft sea level rise (coastal)	Likely range 67% probability sea level rise is between 1.1 and 1.8 ft in 2050	\$512,097,000
HAT + 3.9 ft sea level rise (coastal)	Likely range 67% probability sea level rise is between 3.0 and 4.6 ft in 2100	\$671,024,000
HAT + 8.8 ft sea level rise (coastal)	Central estimate for a high sea level rise scenario for 2100	\$1,280,389,000
1% annual chance flood (coastal, still water elevation)	Present	\$610,090,000
1% annual chance flood (inland riverine)	Present	\$1,805,784,000

[a] Combined loss = building loss + contents loss + inventory loss (Hazus outputs)

Many miles of Maine roads and rail lines lie within flood zones. For example, under a scenario of highest astronomical tide plus 3.9 feet of sea level rise, 116 miles of public roads and 23 miles of rail lines are directly exposed to flooding, as well as parts of the Portland and Eastport port facilities. In addition, miles of transportation infrastructure may become unusable, especially where the route depends on a single access point that is flooded.

Maine also has many wastewater treatment plants vulnerable to sea level rise. ERG quantified their vulnerability by presenting lower and upper amounts for replacement costs for each treatment plant. For example, it would cost between \$14.3 million and \$43 million to replace the Saco Wastewater Treatment Plant if it were impacted by sea level rise inundation flooding and the Plant currently is among those plants at the greatest risk in the state. The Emergency Management Working Group has identified 10 wastewater treatment plants for priority action based on their significant risk profiles.

Using the specific vulnerabilities of Maine’s communities, economic sectors, and infrastructure to the impacts of climate change, ERG then quantified some of the costs that the State of Maine and its citizens could incur from damage incurred by climate-related hazards. ERG also estimated the as well as losses in greenhouse gas emissions sequestration due to potential climate hazards, such as the loss of blue carbon opportunities.

The “Cost of Doing Nothing” analysis makes clear if Maine does not adapt to climate change, losses are expected to be significant to communities, individual property and business owners, and the state. Doing nothing, or putting off much-needed efforts to adapt key infrastructure, will not save money but rather is likely to cost the state and its communities far more in significant property and economic damage losses; straining health care systems during times of crisis due to access issues; and diminishing or compromising disaster responses.

For example, if sea level rises by 1.6 feet in Maine by 2050, the analysis projects the following losses, among many others:

- Based on simulating damage over a 30-year period, the cumulative impact of building damage and content losses due to permanent sea level rise (1.6 feet in 2050) and repeated storm surge is approximately \$16.9–\$18.2 billion.
- \$118.8 million in annual GDP is vulnerable at 1.6 feet of sea level rise (an annual GDP loss of 0.2 percent).
- Between 2020 and 2050, 11,344 to 23,880 jobs (1.2 to 2.6 percent of total employment) will be lost due to the combined effects of permanent sea level rise and repeated storms.

Tourism will be significantly impacted by sea level rise. In one example, tourism spending in the Maine Beaches in York County region could drop by \$1.67 billion annually with 8.8 feet of sea level rise. That amount of sea level rise could lead to a 97 percent dry beach area loss across Maine’s coast, an 85 to 100 percent dune inundation, and 13.2 million fewer visitors to the region.

In addition to their value to tourism, Maine beaches and dunes offer a variety of ecosystem services such as water filtration, carbon storage, protection from flooding and coastal erosion, and essential habitats to endangered shorebird species such as piping plover and least terns. ERG estimates that the lost value of those dune ecosystem services due to sea level rise could equal an additional \$71.8 million or more in losses annually.

Public health will also be significantly impacted by climate change. Based on global greenhouse gas projections, Maine can expect 36 high heat index days (over 90°F) per year by 2100, compared to one average high heat day per year from 1971 to 2000. Health care costs for heat illness were \$224,000 in 2019 due to 200 emergency department visits and 15 hospitalizations in Maine for heat-related illness. Health care costs will be nine to 14 times higher in 2050 (costing \$1.9 to \$3.2 million annually) and 13 to 36 times higher (costing \$2.9 to \$8.1 million annually) in 2100 if hospital visits are directly proportional to the number of days with a heat index over 90°F.

Tick-borne diseases, including Lyme disease, have been growing in geographic extent and case numbers since the early 1980s and are another major public health concern in Maine. Increased incidences of Lyme disease are associated with range expansion of the deer tick, which is attributed to expanding white-tailed deer populations, suburban development in forested areas, and warmer/shorter winters—with the change in winter season caused by climate change (Fernandez et al., 2020). In 2018, Lyme disease cost \$11.5 million to treat 1,405 cases in Maine. Those costs are expected to increase as case numbers increase.

Maine’s aquaculture and fishing industries are also vulnerable to climate change impacts. Maine’s lobster industry generated \$485 million in landings in 2019, and the industry is both

economically and culturally vital to the state. Aquaculture harvesting of fish, shellfish, and macroalgae added another 622 jobs, with harvests valued at about \$88 million. If ocean temperatures rise above their current levels, Maine's lobster industry could experience less lobster and more potential species health impacts. Lobster population productivity has taken advantage of warmer, more optimal environmental conditions in eastern Maine, driving an increase in landings over the past decade. Continued ocean warming could reduce that amplified productivity and therefore reduce the Maine fishing stock from current levels in the future.

Working waterfront and shorefront industries such as aquaculture and fishing will also be heavily disrupted by increased coastal flood frequency.

Finally, the "Cost of Doing Nothing" analysis also estimated the potential loss of carbon sequestration from forests, fields and wetlands if they are not protected from development. Forests in Maine, including working forests, sequester, or store, an amount of carbon equal to 75 percent of Maine's annual carbon emissions, making forest conservation an essential strategy to fight climate change. Each year, around 10,000 acres of natural and working lands are developed, and the rate of development is expected to grow over time, to 15,000 acres a year starting in 2030 and 20,000 acres starting in 2050. By 2100, Maine will have lost the potential to sequester 543,394 metric tons of carbon since 2020.

Coastal "blue carbon" is the carbon that is sequestered by coastal resources such as salt marshes and eelgrass beds. These resources also provide other important ecosystem values such as flood protection and habitat support for key marine species and aquaculture. Maine's coastal natural lands are an important contributor to carbon sequestration, but Maine's eelgrass and salt marshes are vulnerable to sea level rise. As these resources are lost, so too are important co-benefits such as flood-control, water quality improvements, wildlife habitat, and mitigation of coastal erosion.

D. Build Healthy and Resilient Communities

Objective: *Support Maine communities in being proactive about understanding climate risk, planning, and taking actions to safeguard their citizens from the impacts of climate change.*

Maine's communities have adapted to change for centuries, resulting in experiences rich in ingenuity, self-reliance, and resilience. As Maine reduces greenhouse gas emissions that *cause* climate change, our people, businesses, and natural resources must also be protected from the *effects* of climate change now occurring. Communities will need to draw confidence from our collective experience as we now confront the challenges of preparing for and thriving in a world defined by climate change.

Communities are already coping with a variety of difficult and threatening challenges. Some are climate-related, others like COVID-19 are not; some are acute disasters like a major flood or the economic crisis, others are chronic like increases in Lyme disease infections or a declining winter snowpack. Maine people are already experiencing hotter summers (in particular, hotter summer nighttime temperatures) and shorter winters. Coastal communities are seeing more "sunny-day" nuisance flooding that blocks roadways and degrades infrastructure, shoreline erosion that shrinks beaches or endangers bluffs, and changes in ocean temperatures and chemistry that affect commercial fisheries. Inland communities are seeing increased heavy rainstorms and seasonal shifts affecting everything from growing seasons to winter recreation.

Increased asthma rates from high heat and high ozone days and fishing closures due to pollution and toxic algae blooms, and rising rates of a variety of tick-borne diseases are also concerns. In almost all of these examples, social vulnerabilities compound the climate vulnerabilities. Low-income residents and communities in Maine feel the impacts of climate change more severely and have fewer resources to alleviate their hardship (see Volume 1: Vulnerability Mapping for more information). In many cases, local governments and community-based organizations are the first responders to these challenges, often without the benefit of time to prepare or the resources to respond. This places communities in the position of being reactive rather than proactive.

To thrive within continuous change and multiple, overlapping crises, communities must become proactive in understanding their risks, planning, and taking actions to safeguard their citizens.

"Resilient" communities are ready to withstand the effects of climate change, and have worked with their citizens, businesses, health systems, and their regional neighbors and partners and assessed the vulnerability of their infrastructure to prevent costly climate-related damage. Resilience will have slightly different meanings to each community, but generally the foundation of community resilience includes: 1) Planning and decision-making processes that absorb information about climate and health risks and evaluate options for action; 2) Individuals, committees, or offices in municipal government who are responsible for planning, implementing, and monitoring activities that reduce climate risk, improve health, and build the community's capacity to manage crises; and 3) Community dialogue and participation that

ensures the voices and needs of the most vulnerable citizens are elevated and prioritized. If communities can make progress on these foundational goals in climate change context, they may also find themselves better prepared to manage unexpected challenges like pandemics and economic crises.

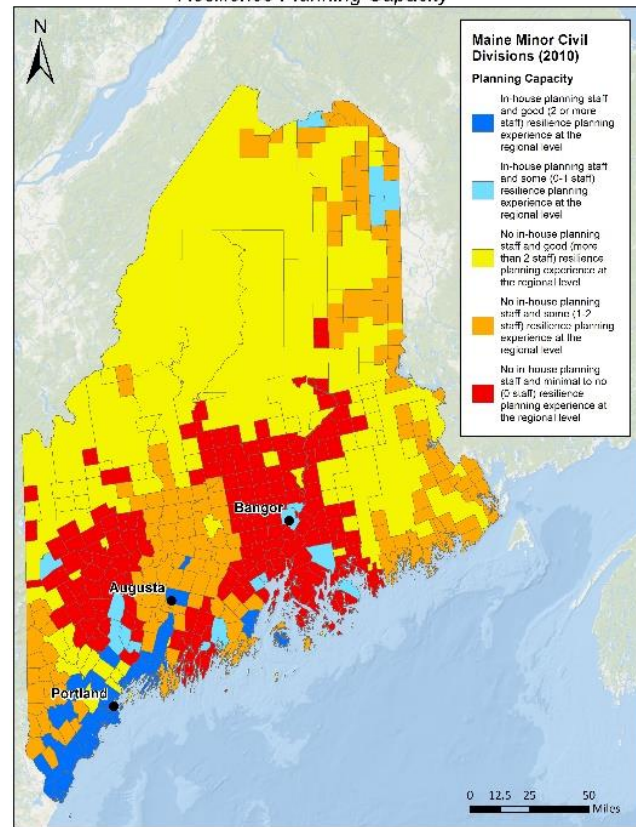
Actions to support Maine communities in becoming resilient include:

- 1) Enhance and coordinate assistance and funding for community resilience activities;
- 2) Improve the planning and legal tools communities use to build resilience;
- 3) Invest in public health monitoring and education; and
- 4) Protect water sources from contamination due to high intensity weather events.

Action 1: Enhance and Coordinate Assistance and Funding for Community Resilience Activities

State government has been providing resilience planning assistance and funding to Maine towns and cities for years, which has led to successful municipal projects that assess vulnerabilities, support planning ideas, implement local policy changes, and undertake infrastructure upgrades. The assistance provided to towns –technical assistance from agencies as well as state grant programs like the Coastal Communities Grant Program, the Shore and Harbor Improvement Program, and the Stream Crossing Upgrade Grant Program and others– includes scientific information on sea level rise and flood risk, mapping, stream crossing inventories for roads, public process facilitation, and policy guidance, to name a few examples. Without this support, communities do not have ready or affordable access to Maine-specific technical information or the tools and funding to make sound policy or investment decisions related to climate resilience.

Maine Minor Civil Divisions
Resilience Planning Capacity



Unfortunately, state government’s current capacity for assistance and financial support to towns is significantly undersized compared to the need. Lack of capacity, expertise, and funding are consistently cited by municipalities as reasons why they are not able to address their

climate risks. Only 11% of communities in Maine have a town planner on staff, while 72% have no local planner and insufficient or no regional resilience planning support.

At least 39 Maine coastal communities have completed climate change vulnerability assessments yet many lack the capacity to secure funding or manage the next steps in their response. Few inland communities have undertaken similar efforts. Furthermore, Maine's current grant programs are only meeting a fraction of the requested assistance each year and are falling particularly short in supporting resilience activities for inland communities.

Regional planning organizations, councils of governments, regional economic development commissions, and non-governmental organizations provide assistance to towns in some parts of the state but not in others. Despite these current gaps in regional capacity, communities in Maine do have a long history of regional cooperation in planning, economic development, and emergency management. This experience offers an opportunity to build regional capacity for climate resilience assistance. Sharing capacity across a region is more cost effective than each town hiring a resilience planner. A regional approach can also help spread good practices and provide much needed coordination among neighboring towns.

An enhanced statewide assistance and funding program should:

- meet the needs of Maine's small towns, large cities, coastal and inland communities, while emphasizing support for rural, low-income, and socially vulnerable communities;
- make consistent and actionable climate data, tools, and guidance accessible to towns across the state;
- focus on climate hazards including coastal and riverine flooding, high heat, extreme storms, public health threats, and impacts to infrastructure, vulnerable populations historic downtowns and waterfronts, and economic engines and workforces;
- fund planning, implementation, and performance evaluation of resilience activities;
- work with towns' existing planning, governance, and decision-making processes rather than create new ones;
- leverage advantages offered by regional forms of assistance as well as non-governmental partners from academia, nonprofit organizations, and the private sector;
- guide and incentivize towns toward activities that support community resilience; and
- facilitate the transfer of information and best practices across the state.

This assistance and funding should be led at the Governor's cabinet level by a state resilience officer and should coordinate across state agencies through an interagency body consisting of resilience leads designated for each agency. This structure's mission should be to ensure that assistance and funding are consistent across state government; oriented to community and regional outcomes; and prioritize the equitable distribution of resources and outcomes.

Cost-Benefit Analysis

The primary benefits of enhanced assistance and funding for community resilience are improved public safety during a disaster and the avoided damage to infrastructure, buildings, businesses, and natural resources. These benefits are typically realized only after a crisis. However, the leadership, networks, processes, policies, and actions generated along the path to resilience have recognizable ongoing benefits that improve public health, alleviate social inequities, strengthen the local economy, protect natural resources, and help communities weather non-climate crises. There are also additional job creation benefits of climate resilience activity, especially in the design, construction, management, operation, and maintenance of implementation projects. These are all benefits that help communities thrive in a changing world.

Public Input Survey

Offering communities technical assistance to respond to climate change was deemed a “great fit” or “good fit” for their community by approximately 88 percent of respondents to the Community Resilience Planning, Public Health and Emergency Management Working Group survey.

For more information on this action, see the [Community Resilience Planning Subgroup’s Strategies #2 and #3](#).

Action 2: Improve the Planning and Legal Tools Communities Use to Build Resilience

Maine is a “home rule” state, which in a climate context means that municipal governments have the authority and responsibility for planning and implementing most activities for community resilience (in Maine’s unorganized territories, the state’s Land Use Planning Commission serves the planning function). Many of the tools that communities utilize are delegated to municipalities through state statutes, particularly the land use tools used to reduce future flood risk. These tools include comprehensive planning, zoning, site location of development, and floodplain management ordinances.

Most of Maine’s planning laws and tools were established in the previous century and, with a few exceptions, were not designed with climate change in mind. Some were intended to give communities the ability to manage growth and development proactively, others were intended to safeguard water quality and other environmental priorities. Floodplain management was intended specifically to reduce flood risk but did not anticipate sea level rise or increasing precipitation trends. Furthermore, these laws and tools often have definitions and language that are inconsistent or outdated.

It is time that these laws and tools be improved to: consider climate hazards; contain more consistent and scientifically sound definitions; provide more utility to communities for building climate resilience; decrease the burden on applicants, permitting staff, and planning boards and

code enforcement officers; modernize the regulatory review process for activities related to climate resilience; and support new development (or economic activity) in areas less vulnerable to climate impacts.

The Community Resilience Planning Subgroup recommended important ways to improve seven statutes or rules which include:

- Site Location of Development Act (“Site Law”) Regulations and Rules,
- Stormwater Management & Erosion and Sedimentation Control Regulations and Rules,
- Comprehensive Planning Statute and Rules,
- Shoreland Zoning Statute and Rules,
- Floodplain Management Model Ordinance,
- Land Use Planning Commission regulatory changes, and
- Natural Resources Protection Act statute and rules.

Additionally, the Subgroup recommended authorizing municipalities to designate a “sea level resilience overlay zone” as a tool to identify areas at risk and plan for permanent inundation.

These tools and the suggested improvements are closely linked to the assistance and funding provided by Action 1 above. The roll out of statutory or rule changes should be coordinated with robust technical assistance and training for state agencies, regional service providers, and municipalities. The state’s assistance program should create guidance and funding incentives for communities to employ these tools where appropriate.

Cost-Benefit Analysis

Detailed economic analysis will be needed if statutory review and revision could have impact on landowners or make some properties unbuildable (changing the tax base).

Public Input Survey

Updating and modernizing land use regulations were deemed a “great fit” (60 percent) or “good fit” (25 percent) for their community by 85 percent of respondents to the Community Resilience Planning, Public Health and Emergency Management Working Group survey.

For more information on this action, see the [Community Resilience Planning Subgroup’s Strategies #1](#).

Action 3: Invest in Public Health Monitoring and Education

While climate change is not the cause of the pandemic, it does, and will continue to, exacerbate inequitable responses in Maine, the U.S., and around the world. According to the World Health Organization, “climate change may indirectly affect the COVID-19 response, as it undermines environmental determinants of health, and places additional stress on health systems. More generally, most emerging infectious diseases, and almost all recent pandemics, originate in

wildlife, and there is evidence that increasing human pressure on the natural environment may drive disease emergence.”

The Institute of Medicine (now the National Academy of Medicine) defined *public health* as “what we as a society do collectively to assure the conditions in which people can be healthy.” As COVID-19 has demonstrated so starkly, the ability to assess and understand the current state of wellbeing in our communities is critical to forming an effective response to stressors that threaten individual and collective health.

Public health monitoring, defined as “the regular collection of data on relevant components of health in the population,” therefore is the foundation of a successful and equitable public health system.

Climate-related public health threats in Maine include vector-borne diseases transmitted by ticks and mosquitoes; water-borne diseases resulting from water pollution and higher water temperatures; bacterial contamination of seafood and shellfish beds; increase in heat related illnesses; and increases in illnesses related to poor air quality like asthma. Maine currently has just two vector-control programs, both of which are town-based programs in York County.

Under Maine’s current air quality monitoring system, eight of Maine’s 16 counties (representing 34% of the state’s population) lack particulate matter monitoring and six counties (15% of the population) lack ozone monitoring.

High heat offers an example of the need for monitoring and education. Extreme heat is linked to many illnesses including heatstroke, renal failure, and exacerbations of many preexisting health conditions. Maine people are particularly vulnerable because residents of cooler climates are less physiologically adapted to extreme heat. Furthermore, air conditioning is far less prevalent in Maine than in warmer states and often not available to low-income people who may also have preexisting health conditions.

As described in the Cost of Doing Nothing analysis, compared to an average of just one high heat index day per year between 1971 and 2000, Maine can expect nine to fourteen days above 90°F per year in 2050, with related healthcare costs of approximately \$2-3 million.

Robust monitoring of public health impacts from climate change should:

- Implement air allergen, particulate matter, and ozone monitoring in all Maine counties.
- Invest in monitoring systems for water-borne disease, particularly the illness-causing bacteria *Vibrio* and freshwater harmful algal blooms (HAB) and conduct modeling in large lakes and public water supplies.
- Invest in monitoring systems for vector-borne diseases (especially ticks and mosquitoes) and the spread of problematic pests like browntail moths.
- Collect, analyze, and report public health monitoring data disaggregated by age, race, ethnicity, gender, disability, geography, and other demographic factors – enabling the

identification of socially vulnerable populations and, accordingly, the strategic deployment of interventions.

Improved monitoring systems feed information into education and outreach that will raise public awareness with the goal of improving public health.

Informing Maine people about health risks from climate change will help them understand why it is important to protect themselves and their families. Expanding public education about how climate change affects health and the resources available will help communities manage risks. Education efforts should include:

- air quality alerts,
- high heat and cold warnings,
- water contamination and health advisories,
- private well water testing, and
- awareness building of water- and vector-borne diseases,

Cost-Benefit Analysis

Action to limit Lyme and Eastern equine encephalitis can avoid treatment costs. By helping residents address risks the risks from high heat index days, Maine can avoid an estimated \$1.9–\$3.2 million annually in healthcare costs in 2050.

Public Input Survey

Monitoring and educating the public about the health impacts of climate change was deemed either a “great fit” (75 percent) or “good fit” (12 percent) for their community by approximately 87 percent of respondents to the Community Resilience Planning, Public Health and Emergency Management Working Group survey.

For more information on this action, see the [Public Health Subgroup’s Strategies #1 and #2](#).

Action 4: Protect Water Systems from High Intensity Weather Events

Maine has nearly 2,000 public drinking water systems that rely on groundwater and surface water sources. Nearly half of Maine people are served by public water systems that rely on surface water bodies like lakes and rivers as the source of drinking water. (Maine CDC, 2018 Drinking Water Program Report)

A warmer atmosphere holds more water vapor, fueling heavier rainstorms and a higher risk of flooding. Heavy rainstorms and flooding wash contaminants and pollution into drinking water sources. Once contaminants enter a drinking water source, it can be extremely expensive to remove them from the source or to treat the drinking water before it arrives at the faucet.

Every \$1 spent on source water protection saves \$27 in future water treatment costs (US EPA, Economics and Source Water Protection, 2012), so there is an enormous economic advantage to taking proactive actions that prevent contamination. At the other end of the water system, heavy rains can overwhelm stormwater and wastewater systems, resulting in the discharge of sewage and other pollutants into rivers, bays, and the ocean. These discharges can cause health risks from swimming or consuming contaminated seafood. When beaches, fisheries, and shellfish beds are closed, even temporarily, there are real economic consequences for the local fishing and tourism industries. For example, emergency shellfish harvesting closures in Machias Bay between 2001 and 2009 resulted in the loss of 1.3 million pounds of clams and over \$2 million in revenue for fisherman and local fishing economies.

As described below in the section on infrastructure, Maine also has several wastewater treatment systems that are vulnerable to failure due to sea level rise as well as significant storm events.

To safeguard public health against water-related climate hazards, Maine should protect drinking water sources and downstream water bodies by:

- implementing land use controls to regulate activities that could release nutrients or chemical contaminants into vulnerable watersheds that supply drinking water, such as source water protection ordinances, prohibitions of some high-risk land uses;
- adopting best management practices with respect to agriculture, chemical use, and construction practices in vulnerable watersheds, and low impact development strategies in municipal development plans;
- in municipalities with combined sewer overflow (CSO) discharge points, separate storm and sewer collection systems to prevent future sewage discharges into bays, estuaries, and rivers where contact with humans or shellfish is likely;
- in municipalities with public water systems located near floodplains, evaluate flood zone predictions to identify public water systems in danger of flood inundation due to climate change;
- developing programs to educate and assist private well owners to assess vulnerability of private drinking water wells.

In addition to safeguarding public health and preventing higher future costs, there are many potential co-benefits to protecting source water and downstream water bodies. The most cost-effective source water protection is protection of the forests that filter rainwater before it enters a surface or ground water source. This land protection provides habitat for wildlife and recreational opportunities that can drive tourism and outdoor sports industries. Clean downstream waters are also vital to commercial and recreational fisheries, beach and water recreation, and tourism.

Cost-Benefit Analysis

Continued combined sewer overflow abatement will help protect water sources from pollutants and bacteria during weather events and will cost approximately \$232 million over the next five years. These efforts will result in health and economic benefits for humans and marine life. They will also allow communities to avoid costs related to overflow damages such as losses in shellfish harvesting revenue, \$10,000 to \$10 million annually in harmful algal bloom treatments, and \$10,000 to \$1 million or more per watershed in chemical pollution cleanup.

Public Input Survey

Reducing health impacts from high intensity weather events was deemed either a “great fit” (64 percent) or “good fit” (24 percent) for their community by approximately 88 percent of respondents to the Community Resilience Planning, Public Health and Emergency Management Working Group survey.

For more information on this action, see the [Public Health Subgroup’s Strategy #3](#).

E. Invest in Climate-Ready Infrastructure

Objective: *Improve the climate readiness and resilience of infrastructure in Maine so that it serves Maine better under day-to-day conditions and functions reliably during emergencies.*

Infrastructure is the backbone of our state and our communities. Functioning infrastructure is a basic requirement for public safety and health, thriving state and local economies, and the flow of people, goods, and information.

From flooding to temperature extremes, climate change is already having a negative impact on our roadways and bridges, working waterfronts, water treatment facilities, and utilities. Infrastructure assets and networks typically have long lifetimes, often measured in decades, and much of Maine's infrastructure was constructed well before climate change was understood as a threat. The risk from climate change is now well understood and frequently on display as storms, erosion, inundation, freeze-thaw cycles, and high heat undermine the vital services that infrastructure provides across the state.

Maine's many historic downtowns and village centers (coastal and riverine) have specific vulnerabilities and concentrated economic losses result when that civic, economic, and historic infrastructure is damaged or lost by climate impacts.

Our aging infrastructure is both a burden on the state and communities as well as an opportunity. Investing in climate-ready infrastructure can increase day-to-day functional capacity and, during an emergency, can improve performance and survivability of the asset or network. Furthermore, new and upgraded infrastructure must be designed and built to withstand the conditions expected over its entire decades-long lifetime, not just the conditions experienced today. Otherwise, any modest cost savings today are purchased at the expense of much higher repair and replacement costs in the future, not to mention the public safety, health, and economic losses incurred when infrastructure fails.

For twenty-five years the National Institute of Building Sciences has reported on the results of disaster rebuilding dollars avoided through pre-disaster mitigation investments across three federal grant programs. The results continue to show that every \$1 invested in disaster mitigation results in \$6 of avoided disaster damages. With increasingly devastating and expensive disasters, the current disaster-rebuild cycle is increasingly unsustainable. A new model for investing in resilient infrastructure is needed.

To improve the climate readiness and resilience of infrastructure in Maine, three key actions are needed:

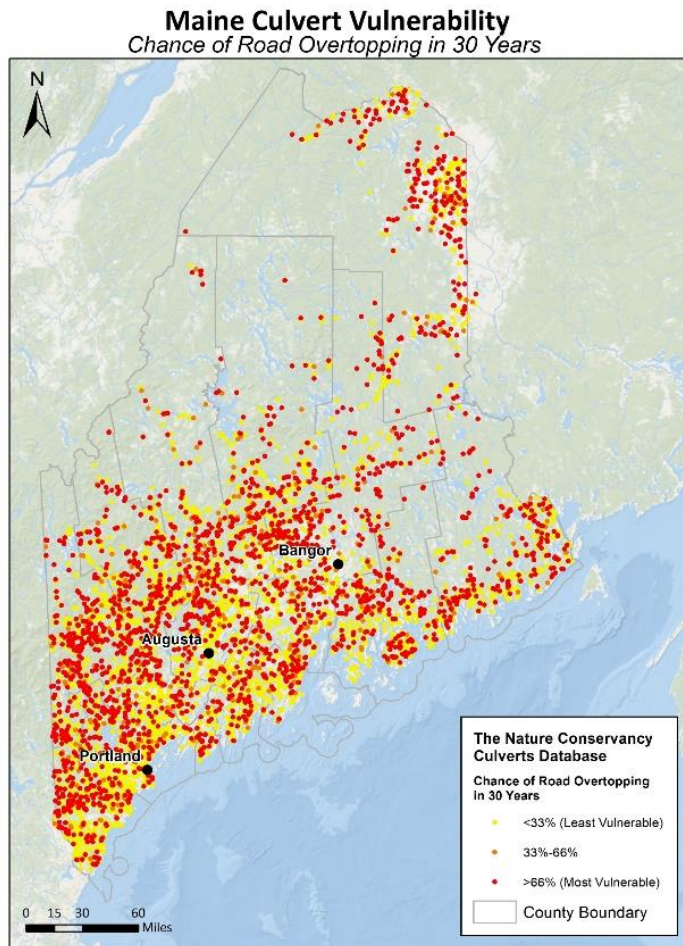
- 1) Assess the vulnerability of Maine's infrastructure to climate hazards;
- 2) Develop a state infrastructure adaptation fund to make it climate-ready;
- 3) Including specifically Maine's working waterfronts.

Action 1: Assess the Vulnerability of Maine’s Infrastructure to Climate Hazards

Maine’s state agencies, municipalities, and industries need a clear understanding of the risks to infrastructure assets posed by climate change. Not only is this a requirement for responsible planning and investment of taxpayer dollars, the major credit rating agencies are beginning to consider how well states and municipalities are anticipating climate risks when assigning credit ratings. Failure to understand and incorporate climate risk can increase the borrowing costs for the state and towns, making infrastructure projects even more expensive over time.

This work is well underway in many places and that this would be a new assessment as well as a knitting together of work that is already complete.

Statewide vulnerability assessments should be conducted for: transportation infrastructure (including roads, bridges, culverts, airports, railroads, ferries, ports and wharfs, maintenance facilities, and public transit systems), water infrastructure (including drinking water systems, wastewater treatment facilities, and dams and stormwater management assets), energy infrastructure (including electricity generation, storage, and transmission; and fuel supply infrastructure), communications infrastructure (including landline, mobile, and broadband), and other infrastructure classes (health systems, public housing, state and municipal buildings, food systems, solid waste systems, etc.).



Transportation infrastructure offers an example. The Vulnerability Mapping described above found that in the next 30 years, 26 miles of roadway and 7 miles of railway are at risk of permanent inundation if they are not elevated or rerouted. Some of those obstructions will affect the only access or evacuation routes available to these communities. Other potential obstructions are to major transportation arteries like Route 1 or the Amtrak Downeaster line, which will have impacts on the daily movement of emergency services, people, and goods. Years before any of these roads or

railways become permanently impassable, they will be subjected to repeat flooding, degrading safety and reliability and requiring expensive maintenance.

Below Maine's roadways are tens of thousands of culverts that are intended to prevent stormwater from washing out the roads. Approximately 2,300 of these culverts are undersized and have a two-out-of-three chance of overtopping in the next 30 years. When roadways are overtopped, they become dangerous for vehicles to pass and experience erosion that can degrade or destroy the roadway. One estimate of the cumulative replacement cost for all of these culverts is \$76.6 million dollars.

Vulnerability assessments should provide an understanding of:

- the climate hazards to which infrastructure assets are exposed, the likelihood of that hazard occurring, and how the intensity and likelihood of those hazards may change over time;
- the asset's susceptibility to damage or failure given its location, design, age, condition, and state of repair;
- the consequences that impairment or failure of the asset will have on public safety and health, state and local economies, and the environment and natural resources. The assessments should identify "critical infrastructure" assets that are important for public safety and health.

The vulnerability assessments should be used to inform state and local adaptation strategies and capital investment plans that prioritize, implement, and track improvements to each asset class. A maintenance database should track improvements to each asset as well as record every instance in which an asset is affected by a climate hazard. Resilient design guidance or standards for different infrastructure types should be developed to ensure the success of the vulnerability assessment and the subsequent plan to upgrade the infrastructure. Agencies and other supporting organizations and the private sector should continue research into construction materials that will increase durability and resilience to climate hazards.



Figure 1: Route 129 during a 500-year storm event in July 2020

Cost-Benefit Analysis

A cost-benefit analysis was not conducted for this strategy. The Cost of Doing Nothing Analysis (described above) identified significant vulnerability to climate change impacts among Maine’s buildings, transportation, transportation infrastructure, and wastewater treatments plants.

Public Input Survey

Adapting critical transportation infrastructure for climate change impacts was deemed either a “great fit” (56 percent) or “good fit” (26 percent) for their community e by 82 percent of respondents to the Transportation Working Group’s survey.

For more information on this action, see the [Transportation Work Group’s Strategy #4](#).

Action 2: Develop a State Infrastructure Adaptation Fund

Maine currently has a backlog of 1,798 infrastructure adaptation projects listed across all sixteen counties at a proposed cost of \$325 million. Maine’s municipalities and state agencies all struggle to fund infrastructure projects with limited tax bases, budgets, and revenues. While there are currently significant potential federal resources available, federal grant programs often require cost-share or “matching” funds from state or local governments. For multimillion-dollar infrastructure projects, the cost-share requirements can amount to significant costs that municipal budgets are not able to take on. Essential upgrades and new projects go undone because of the cost-share requirement, making the existing infrastructure and the communities that rely on that infrastructure more vulnerable.

A new “State Infrastructure Adaptation Fund” could help municipalities and state agencies meet these cost-share requirements, unlocking new federal funds for infrastructure projects. Because the cost-share requirements are frequently 10 to 25 percent of the total project cost, a relatively modest investment of state funds would result in four to ten times match from federal grants.

As an example, Maine has six wastewater treatment facilities that are especially vulnerable to sea level rise flooding in the next 30 years (Kennebunk, Machias, Wiscasset, Ogunquit, Saco, and South Berwick). A conservative estimate of the cumulative replacement cost for all six is \$30 million. Proactive upgrades will be much less expensive to communities and will avoid the public health consequences and discharge penalties if the facilities were to fail or become impaired.

A State Infrastructure Adaptation Fund directly addresses the greatest infrastructure funding obstacle for Maine’s municipalities, empowering them to reduce risk associated with changing climate conditions. Creation of this fund in conjunction with the vulnerability assessment described above, emphasizes the “whole-community” approach of financial and technical support across local, state, and federal levels.

While the state has appropriated limited funds to meet some of these match requirements, there is no ongoing funding source currently available to capitalize this fund. The State Adaptation Fund could be funded through an ongoing revenue source, state bond proceeds, or another special revenue fund, to be identified.

In addition to the funding, state agencies and other entities such as regional planning agencies, county emergency management professionals, academia, non-profits, and a robust private sector could provide much needed “predevelopment assistance” to municipalities that supports local infrastructure projects with resilient design and engineering, grant writing and grant management, and even matchmaking with investors in public-private partnerships.

Cost-Benefit Analysis

FEMA (Federal Emergency Management Agency) funds and other significant federal grants are available for hazard-mitigation projects, and the National Institute of Building Sciences finds that investment in *these projects return an average benefit-cost ratio of 6 to 1*.

Maine has an estimated \$325 million in backlogged county hazard-mitigation projects. As federal hazard mitigation grants often require 25 percent cost share by municipalities, \$325 million accessed through a state climate adaptation fund over time can open an additional \$975 million in federal dollars (about \$1.3 billion total). For a project with a 6 to 1 benefit-cost ratio overall, this could be about a \$7.8 billion benefit and approximately a 24 to 1 benefit-cost ratio based on the state and local contributions.

Public Input Survey

Assisting communities with responses to climate change through funding for infrastructure was deemed either a “great fit” or a “good fit” for their community by approximately 88 percent of respondents to the Community Resilience Planning, Public Health and Emergency Management Working Group survey.

For more information on this action, see the [Emergency Management Subgroup’s Strategy #1](#).

Action 3: Support Working Waterfronts in Becoming Climate-Ready

Maine’s coastal and marine economy, and the cultural and economic identity of its coastal communities, depends on the marine infrastructure that supports thriving ports and working waterfronts. Waterfront infrastructure is among the most vulnerable to climate impacts.

Working waterfronts provide access and support services for commercial fishing fleets and aquaculture businesses, recreational fishing and boaters, marinas and boatyards, boatbuilders, maritime security, marine transportation of seafood and goods and services, transportation for Maine’s islands residents and tourists, and support for other maritime heritage industries. The lobster fishery, the largest fishery in Maine, generated \$485 million in landings in 2019 (Maine Department of Marine Resources, 2020).

Working waterfronts and maritime infrastructure are threatened by storm surge flooding, nuisance flooding, and permanent inundation from sea level rise as well as accelerated shoreline erosion and sedimentation that requires dredging.

Technical assistance and funding are needed to support municipalities and business owners in planning and investing in working waterfront improvements that prepare for rising sea levels, increased flooding, and large storm events. The Coastal & Marine Working Group estimated that a \$1 million working waterfront infrastructure trust fund or revolving loan fund could finance resilience improvements for a few small to medium-sized working waterfronts.

Technical assistance should guide municipalities and business owners in:

- 1) conducting vulnerability assessments for waterfront infrastructure;
- 2) the design and construction of resilient facilities; and
- 3) identifying funding sources. Assistance can take form of direct assistance, incentives, guidance on best practices, recognition of outstanding projects, and case studies.

Cost-Benefit Analysis

Further financial planning is needed to determine how far \$1 million in revolving funds can go toward meeting the infrastructure needs of all of the state's working waterfronts. There are more than a thousand commercial working waterfront access points in Maine. The need for waterfront adaptation funding may go significantly beyond this \$1 million fund.

Public Input Survey

Protecting Maine's working waterfront infrastructure from climate change impacts was deemed either a "great fit" (62 percent) or a "good fit" (21 percent) for their community by 83 percent of respondents to the Coastal and Marine Working Group survey.

For more information on this action, see the [Coastal & Marine Work Group's Strategy #6](#).

F. Protect Maine’s Environment and Natural Resource Economies and Promote Natural Climate Solutions

Maine people value our state’s iconic environments and the species that live within them: our vast forests with moose and deer; our rocky coastline and puffins, groundfish, and lobster; glacial soils and blueberry barrens; and inland lakes and streams that host salmon and loons. These natural resources provide our state with clean water and food, recreation opportunities, and support significant economic activity and jobs. Many of Maine’s plant and animal species rely on the state’s unique habitats to thrive, and as a result more than two-thirds of Maine’s species are particularly vulnerable to the effects of climate change.

Climate change is already affecting our environments and communities: warming winter temperatures and changing seasons, more intense downpours, coastal flooding and erosion from sea level rise, and growing pests, among many other changes, are impacting all areas of our state and many of our iconic species. The effects of climate change are predicted to increase – and become more severe – in the coming decades, and Maine’s environments and the communities, and industries that rely on them will have a difficult time adapting without action to reduce their risks and prepare.

Increasing temperatures and changes in rainfall and snowfall will affect the makeup of Maine’s forests and the habitat and biodiversity of plant and animal species, many of which are at the southernmost parts of their ranges in Maine. New pests, diseases, and invasive species threaten overall forest health and many types of agriculture crops. With warming temperatures and drought, presently infrequent wildfires are more likely, turning forests into carbon emitters. Increasing extreme storms cause damage, erosion, soil loss, and water quality issues.

The Gulf of Maine sea surface temperature is warming faster than 99 percent of the world’s oceans. As it warms and loses its subarctic characteristics, some species such as lobster are moving northward, while temperate species from the south invade. As described above, continued ocean warming would likely cause lobster populations to move further northward, reducing a key Maine fishing stock.

Climate change also worsens ocean acidity, which has increased 30 percent worldwide and will continue rising with growing greenhouse gas levels. Ocean acidification is already impacting some aquaculture operations in Maine and will increasingly have negative effects on marine organisms that use calcium carbonate to build shells, such as oysters, scallops, clams, mussels, and sea urchins. For Maine seafood harvesters, climate change is expected to reduce their regional catches and associated revenue. This will have a ripple effect on the Maine economy, especially in coastal communities.

Natural climate solutions offer both mitigation and adaptation opportunities. Maine’s extensive natural and working lands and waters, including coastal and marine areas, play an essential role in capturing atmospheric carbon. Current estimates indicate that Maine farms and forests and their soils are sequestering an amount of carbon equivalent to over 75% of our greenhouse gas

emissions. The state’s natural and working lands and waters hold a tremendous potential - with greater focus and investment - to sequester even more carbon, making them a major driver towards achieving Maine’s goal of carbon neutrality by 2045. Healthy and connected natural environments and working areas also provide protection against the increasing effects of climate change such as flooding, severe coastal storms, sea level rise, ocean acidification, declining biodiversity, and many more co-benefits.

As Maine is increasingly affected by climate change, gaps in information about impacts and opportunities limit the ability of Maine’s communities and resource users and managers to plan for future changes and improve their resilience to the public health, environmental, and economic impacts of climate change. Collecting data in critical gap areas and providing better access to data and technical advice will allow Maine’s municipalities, public health organizations, marine-based businesses, fishermen, farmers, foresters, and land owners and managers better prepare for and respond to changing environmental conditions.

The cost of not taking action will be much larger than the cost of taking action early to enhance our greenhouse gas sequestration and improve the resilience of our natural and working lands and waters to climate change impacts (see ERG’s [Summary Report, Assessing the Impacts Climate Change May Have on the State’s Economy, Revenues, and Investment Decisions](#)).

Natural climate solutions like well-managed forests, healthy soils and “living shorelines” can be very cost-effective to reduce carbon dioxide in the atmosphere and provide important co-benefits such as flood-control, water quality improvements, providing wildlife habitat, and mitigating coastal erosion.

Living shorelines use natural elements to stabilize estuarine coasts, bays and tributaries. They can be a cost-effective nature-based solution to coastal erosion compared to harder infrastructure like sea walls, while also providing ecosystem services such as improved water quality and wildlife habitats.

To improve the climate readiness and resilience of Maine’s natural and working lands and waters, prepare our natural resource economies for climate impacts, and improve our ability to sequester carbon, four key actions are needed:

- 1) Protect Maine’s natural and working lands and waters;
- 2) Support Maine’s natural resource economies;
- 3) Increase carbon sequestration from natural and working lands and waters;
- 4) Improve monitoring of natural and working lands and waters to understand and manage the response to climate change.

Action 1: Protect Maine’s Natural and Working Lands and Waters

Maine’s natural and working lands and waters, including forests, farms, and wetlands as well as coastal and marine areas, provide essential ecosystem services. They store carbon, offer flood

protection, and provide clean drinking water. They provide important wildlife habitat and recreation opportunities. They also support Maine's vital fishing, farming, forestry, recreation, and tourism industries.

Loss of Maine's natural land and working lands to development (currently estimated at approximately 10,000 acres lost per year) reduces the potential for carbon storage and the many additional benefits those areas provide. Maine's coastal and marine areas are threatened by sea level rise and other climate impacts.

Biodiversity areas of statewide significance host species and habitats most vulnerable to climate change and are most likely to serve as refuge for biodiversity in a changing climate. The best way to maintain biodiversity is to ensure a network of biologically and geographically diverse lands that are well connected so that plants and animals can move across the landscape to find the places they need for breeding, feeding, resting, and raising their young.

Coastal and marine species face the multiple risks of sea level rise, warming waters and ocean acidification. As sea level rises, the dry beach area will decrease. If Maine's marshes, sand dunes, and beaches cannot keep up with rates of sea level rise or do not have room to move inland, these environments run a significant risk of being submerged or being reduced in size, impacting both wildlife habitat and tourism (See the [Scientific and Technical Subcommittee Report](#), Scientific Assessment of Climate Change in Maine: Sea Level Rise and Storm Surge chapter).

Maine must protect and conserve our working and natural lands and waters to protect against the impacts of climate change, and to maximize the opportunity to sequester carbon.

First, we can protect our natural and working lands through a dedicated, sustained funding source. This includes increasing permanent protection of forest land and farmland through conservation easements (especially prime agricultural soils and soils of statewide significance, which are a finite resource).

Maine must also conserve areas of high biodiversity value and areas that support land and water connectivity and ecosystem health through the conservation of natural areas and ecological reserves.

This action also includes:

- revising scoring criteria for state and federal land conservation funding sources to incorporate climate mitigation and resiliency goals into grant criteria and project selection;
- supporting land trusts, land managers, and landowners with increased technical assistance to conserve native species and land and water resources vulnerable to climate change and to address climate-related threats such as invasive species; and
- ensuring smart development, shoreland protection, and appropriate renewable energy project placement by assessing and improving state, regional and local land use

planning efforts, policies, and regulations and supporting comprehensive and timely environmental review of land and water resources and permitting of projects.

To protect and conserve our coastal and marine ecosystems from the impacts of climate change, Maine should promote nature-based solutions. Nature-based solutions (also known as natural infrastructure or green infrastructure) provide effective and lower-cost protection for climate change related challenges while restoring coastal and marine habitats. Healthy seagrasses and tidal marshes act as natural barriers to waves. Restoring floodplains, wetlands, and streams and updating the design guidance for culverts and bridges provides effective stormwater management, flood control, and habitat connectivity. “Living Shorelines” projects, constructed with plants, oyster shells, and other natural materials, protect against coastal erosion.

This action also includes:

- Protecting and restoring beaches and sand dunes in order to help coastal marshes, beaches and dunes migrate inland with sea level rise.
- Updating relevant state regulations, programs, and design guidance and standards to improve coastal bridge and culvert resilience to sea level rise and support habitat and hydrological connectivity. Improve aquatic connectivity at private and publicly owned barriers (including dams and road-crossing infrastructure) using Stream Smart practices for freshwater bridges and culverts, Coast Wise practices for tidal crossings, and a temporary steel bridge cost share program for forestry operations (administered by the Maine Forest Service).
- Characterizing and mapping marine and coastal habitats to inform climate adaptive management, planning, and conservation and restoration priorities.
- Supporting use of the latest monitoring and assessment information related to climate change and resiliency for land use planning in coastal areas
- Strengthening stormwater management tools to reduce nitrogen and pollutant inputs which harm marine life, lead to coastal acidification, and negatively impact shellfish harvesting and aquaculture.
- Recalibrate and strengthen protections of inland natural resources to detain storm flows and recharge groundwater, decrease nitrogen pollution of nearshore waters, reduce flood risks, protect aquifers, and maintain habitat connectivity and climate refugia.
- Improving other regulatory approaches to protect coastal areas from development that will impede marsh migration, impact water quality, and directly or indirectly affect the function and viability of coastal habitats.

Cost-Benefit Analysis

Conserving forests is one of the more cost-effective strategies to help reach carbon neutrality with various scenarios ranging from about \$4 to \$20 per metric ton of carbon dioxide sequestered between 2020 and 2100. Working forest conservation easements are cost-effective, ensure timber harvesting and keep forests as forests.

Emissions changes are harder to establish for agricultural lands because they serve as a source of emissions as well as a sequestration method. Farms are presently a net source of emissions in Maine, but increasing crop cover, reducing tillage, and increasing nutrient management practices can reduce those emissions.

Marsh and eelgrass restoration do not prove highly cost-effective in terms of carbon sequestration alone but they provide a range of other ecosystem services. Thus, blue carbon projects should be implemented based on where they can maximize ecosystem service values. Cost-effectiveness of marsh and eelgrass restoration improves over the decades.

Significant federal grants are available for nature-based solution projects, including several programs from EPA as well as FEMA and HUD. The National Institute of Building Sciences finds that investment in these projects return an average benefit-cost ratio of 6 to 1. Similarly, living shorelines appear to be a cost-effective nature-based solution to coastal erosion compared to harder infrastructure like sea walls, while also providing ecosystem services such as improved water quality and wildlife habitats.

Beach nourishment projects, costing an average \$5 to \$32 per cubic yard of sand, may also help avoid economic losses related to beach area decline from to sea level rise across Maine. Projects to successfully protect beaches across the state would prevent up to \$39 million loss in economic value across Maine, based on diminished tourist visits.

Public Input

- Protecting and conserving working forests, farms and natural lands was deemed either a “great fit” (76 percent) or “good fit” (18 percent) for their community by 94 percent of respondents to the Natural and Working Lands Working Group survey.
- Investments to increase wildlife crossings and aquatic organism passage was deemed either a “great fit” or “good fit” for their community by 89 percent of respondents to the Natural and Working Lands Working Group strategy.
- Promoting nature-based solutions to protect coastal communities from climate change impacts was deemed either a “great fit” or “good fit” for their community by 89 percent of respondents to the Coastal and Marine Working Group survey.

For more information on this action, see the [Natural and Working Lands Working Group’s Strategy #1 and #2](#), [Coastal and Marine Working Group’s Strategy #4](#), and the [STS report’s Biodiversity chapter](#).

Action 2: Support Maine's Natural Resource Economies

Maine has several industries that are inextricably linked to the health of our natural resources, including fishing, farming, forestry, recreation, and tourism. These industries need information and technical support and tools to adapt to the rapidly intensifying impacts of climate change and take advantage of new opportunities.

In order to address the pressing need to sequester as much carbon as possible through natural and working lands and waters, and to build resilience within Maine's natural resource industries, this action recommends providing technical assistance to our land and water users, including forest landowners and managers, agricultural producers, fishermen, and aquaculture businesses.

Marine Sector

Maine's fishery and aquaculture industries are critical to our state's economy. Maine's commercial fish harvest was valued at about \$637 million in 2018. About two-thirds of that value is attributed to Maine's lobster fishery. Nearly 30,000 people are employed in the state's commercial fishing industry. Market analyses for the developing shellfish and seaweed aquaculture industries point to significant potential for market growth.

Maine should support Maine's coastal and marine stakeholders' ability to prepare and respond to changing environments by closely monitoring species and habitat changes and providing information about ocean temperature, salinity and acidity changes at the local level. Maine should also ensure that the fishing industry is able to access new market opportunities as species move in response to warming waters.

This action recommends providing technical assistance to coastal and marine stakeholders for climate adaptation and mitigation, while managing for resiliency of Maine's marine fisheries and aquaculture industries in the context of climate change. This includes:

- Providing clear information, forecasts, and tools about climate change impacts that is relevant to business planning, operations, and management of Maine's fisheries and aquaculture sectors.
- Creating a Coastal and Marine Information Exchange to provide accessible, relevant information and decision-making support to Maine's coastal communities and industries.
- Establishing a Maine Seafood Business Council to provide Maine's seafood harvesters, shoreside businesses, and working waterfronts with access to information and tools that can support operational decisions, capital investments, and long-range planning to implement climate adaptation and mitigation strategies.

Forestry

Forests currently cover nearly 89% of Maine's land area and sequester over half of the state's annual emissions. The forest products sector is statewide, multi-faceted, and provides around

\$8 billion in economic impacts to Maine, over 33,500 full- or part-time positions (4.13 percent of the employment in Maine). Due to climate change, forest productivity will likely be more variable with some portions of the state seeing greater growth due to a longer growing season and more favorable climate, while other areas will decline due to the increased occurrence of drought. The current spruce-fir forest type will likely decline as Maine's forest gains more hardwoods, with more of the landscape becoming a mixed forest type.

Harvest operations are likely to become more expensive due to less consistent winter conditions, thereby reducing stand accessibility. The forest response to climate change will be complex and difficult to predict given the range of conditions and species present in Maine's current forest as well as variation in future management.

Technical services provide the knowledge necessary for effective implementation of mitigation and adaptation practices. They support landowners and land managers to adopt carbon-friendly and resilient land management practices such as timber management and soil health. They also advance warning of emerging land management threats, such as pests, diseases and invasive species. Technical assistance helps farmers, woodland owners, and forest land managers modify their practices to prepare effectively for more frequent and extreme weather events and adapt to growing season changes brought on by climate change.

The strategy also urges increasing climate education related to forestry, agriculture and natural lands, through public school curricula, consumer awareness, and landowner information.

Farming

Maine has nearly 8,000 farms that generate more than \$1 billion per year in economic output. Farming and its related industries are a key component of Maine's economy, supporting over 24,000 jobs statewide. The plant hardiness zones used by farmers and gardeners have shifted north, allowing Mainers to grow crops, plants, and flowers previously available only in warmer climates. Warmer temperatures will give farmers and the horticulture industry continued access to new crops and livestock. Farmers and gardeners can expect a greater need for irrigation, particularly for high value crops, to offset increased soil moisture loss through evaporation and transpiration. However, for certain crops, such as hay production, irrigation is often impractical. Increasing temperatures will also negatively affect confined livestock in the state. New pests, invasive plants, and pathogens will increasingly encroach into Maine, threatening plants, animals, and humans, and making management more difficult.

Financial support should be provided in addition to technical assistance to strengthen Maine's food systems so that more food can be produced and processed locally, distributed efficiently, and priced affordably. With approximately 90% of the food we consume currently coming from outside the state, increasing our capacity to grow and process food in Maine will ensure that a greater portion of the food we do consume is produced using climate-smart practices.

Recreation and Tourism

Maine’s outdoor recreation economy, which depends on abundant native species and habitats and available natural and conserved lands, generates \$8.2 billion in spending and supports 76,000 jobs. Tourism is one of the largest industries in Maine, generating over \$6 billion in direct expenditures per year (Maine Office of Tourism 2019). Tourism in Maine relies heavily on outdoor and recreational activities, most of which are significantly influenced by temperature and precipitation (e.g., snow), which are both changing due to climate changes. Technical assistance to Maine’s outdoor recreation businesses can help them prepare for climate change impacts as well as new opportunities.

Cost-Benefit Analysis

A cost-benefit analysis was not conducted for these actions.

Public Input Survey

- Supporting Maine’s lobster and fishing businesses to prepare and respond to changing environments was deemed either a “great fit” (63 percent) or a “good fit” (22 percent) for their community by 85 percent of respondents to the Coastal and Marine Working Group survey.
- Expanding local marketing opportunities for Maine seafood was deemed either a “great fit” (60 percent) or a “good fit” (22 percent) for their community by 82 percent of respondents to the Coastal and Marine Working Group survey.
- Continuing to grow Maine’s diverse aquaculture sector was deemed either a “great fit” (45 percent) or a “good fit” (28 percent) for their community by 73 percent of respondents to the Coastal and Marine Working Group survey.
- Providing clear information and tools about climate change impacts was deemed either a “great fit” (76 percent) or a “good fit” (13 percent) for their community by 89 percent of respondents to the Coastal and Marine Working Group survey.
- Providing financial incentives and technical support to help farmers, loggers, and landowners prepare for climate change impacts was deemed either a “great fit” (66 percent) or a good fit (24 percent) by 90 percent of respondents to the Natural and Working Lands Working Group survey.
- Strengthening Maine’s food system was deemed either a “great fit” (80 percent) or a good fit (14 percent) by 94 percent of respondents to the Natural and Working Lands Working Group survey.

For more information on this strategy, see the [Coastal and Marine Working Group’s Strategies #2 and 5](#), and [Natural and Working Lands Working Group’s Strategy #3](#).

Action 3: Increase Carbon Sequestration in Maine’s Natural and Working Lands and Waters

Maine’s forests and forest soils are estimated to sequester at least 13 million metric tons of CO₂-equivalent per year, equal to about 75% of Maine’s gross emissions. There is potential to capture an even greater amount of carbon through active and effective natural and working land management approaches.

This initial estimate only covers forests and forest soils, as a full accounting of Maine’s carbon cycle, including agriculture and coastal and marine environments, has not yet been completed. Blue carbon ecosystems are an order of magnitude more efficient at burying carbon per unit area than forests, yet when they are degraded, flooded with freshwater, or drained, they can become sources of carbon dioxide and other greenhouse gases (GHGs), including methane. Land use change to development almost always reduces carbon stored on the landscape in forests, wetlands, and other ecosystems, adding to greenhouse gas emissions and negatively impacting ongoing carbon sequestration potential.

Improving carbon sequestration in Maine’s natural and working lands and waters is essential to enable the state to reach its goal of carbon neutrality by 2045.

The first part of this action recommends the creation of new financial incentives and support to reduce greenhouse gas emissions and support adaptation in forest, agricultural, and natural lands. Financial incentives would help private landowners implement more carbon-friendly land management practices. This could include a voluntary incentives program for small to medium-sized woodlots to capture more carbon. Property taxation policy for working lands and open space is also a critical incentive for climate-friendly land management. State and federal programs that currently provide incentives to local landowners should be refocused to ensure that financial assistance is targeted specifically to climate mitigation and adaptation measures. The state should also continue to update its own climate-friendly public land management practices and policies.

Developing and improving marketing programs for Maine forest products for climate-friendly, bio-based wood market innovations, such as Cross Laminated Timber (CLT) and wood fiber insulation, can help sequester more carbon in durable products. This was also a recommendation in the Modernizing Buildings Strategy B.

The second part of this action would enhance greenhouse gas mitigation by conserving and restoring coastal habitats that naturally store carbon (blue carbon optimization). Maine’s approximately 5,000 miles of total coastline provides a unique opportunity to store carbon long-term, while also providing benefits such as protecting ocean water quality, providing important wildlife habitat, protecting coastal properties from erosion and flooding, and providing recreational opportunities. Maine should determine where and how much “blue carbon” can be stored by conducting a comprehensive coastwide survey of coastal environments like salt marshes, seaweeds, and seagrass beds. Maine can also achieve blue carbon burial by managing, conserving and restoring tidal marsh, eelgrass, and seaweed habitats.

Cost-Benefit Analysis

Conserving forests is one of the more cost-effective strategies to help reach carbon neutrality with various scenarios ranging from about \$4 to \$20 per metric ton of carbon dioxide sequestered between 2020 and 2100. Working forest conservation easements are cost-effective, ensure timber harvesting and keeps forests as forests.

Emissions changes are harder to establish for agricultural lands because they serve as a source of emissions as well as a sequestration method. Farms are presently a net source of emissions, but increasing crop cover, reducing tillage, and increasing nutrient management practices can reduce those emissions.

While marsh and eelgrass restoration do not prove highly cost-effective in terms of carbon sequestration alone (ranging from \$1,673 to \$321,933 per metric ton of CO₂ sequestered), they include a range of other ecosystem services such as providing flood protection, enhancing fishing, and increasing nearby property value. Thus, blue carbon projects should be implemented based on where they can maximize ecosystem service values but not implemented strictly as a way to sequester carbon. Cost-effectiveness of marsh and eelgrass restoration improves over the decades and eelgrass proves more efficient than marsh because it sequesters more carbon.

Public Input Survey

- The Natural and Working Lands Working Group survey, 52 percent of respondents deemed promoting the use of Maine’s value-added forest products as a “great fit” for their community. This strategy also had the highest percentage of neutral responses in the survey, with 15 percent.
- Providing financial incentives and technical support to help farmers, loggers, and landowners prepare for climate change impacts was deemed either a “great fit” (66 percent) or a good fit (24 percent) by 90 percent of respondents to the Natural and Working Lands Working Group survey.
- Storing greenhouse gases by conserving and restoring salt marches and other coastal environments was deemed either a “great fit” (72 percent) or “good fit” (15 percent) for their community by 87 percent of respondents to the Coastal and Marine Working Group survey.

For more information on this action, see the [Coastal and Marine Working Group’s Strategy #3](#) and the [Natural and Working Lands Working Group’s Strategies #2 and 4](#).

Action 4: Improve Monitoring of Natural and Working Lands and Waters to Understand and Manage the Response to Climate Change

Gaps in data and information about the effects of climate change in Maine persist. Filling these information gaps will provide critical, actionable information for the State of Maine and our communities and natural resource economies to prepare and adapt.

Why is this information needed? High quality information is essential to support science-informed decision-making and the most effective allocation of limited resources. This takes the form of filling gaps in data where we have little or none (e.g., ocean acidification, air-borne pollen, freshwater harmful algal blooms), increasing the density of data to improve our understanding of variability and uncertainty, improving the scale of available data to support local decision-making, or new data to encompass emerging conditions (e.g., invasive species, disease).

We need research to continuously advance our understanding of the data that supports the development of better solutions. Understanding the changing ecology of a warming Gulf of Maine, understanding carbon cycling in Maine as a framework for our greenhouse gas goals, and developing new technologies to improve adaptation and mitigation options will support improved responses to climate change.

There are certain themes for information needs to assure that our response to climate change is effective. These include:

- Continued benefit/cost analyses to assure that climate actions are successful investments in Maine's future;
- Life-cycle analyses to assure that our actions are effective and do not merely displace greenhouse gas sources to other places or result in unintended consequences;
- Social equity evaluations to assure Maine develops a climate response that minimizes social injustices and does not disadvantage communities that are most vulnerable to climate change.

Much remains poorly understood regarding how to maximize the capacity of trees, forest soils, agricultural soils, and coastal environments to sequester carbon. Many questions still exist about the most effective adaptive management strategies for the forestry, agricultural, and outdoor recreation sectors, and for species and habitats, in the face of climate change. There are also significant research needs associated with the development of new wood-based products and in establishing viable markets for these products. In addition, Maine needs continued development and planning efforts supporting the growth and stability of Maine food systems. We cannot make our forest, agriculture, and coastal and marine communities and industries resilient without understanding what is changing, how changes are likely to continue, and what measures work best to address the impacts of climate change.

Maine is well-positioned to undertake long-term research projects associated with forestry, agriculture and natural lands, both as a leader and as part of a national and international network of ongoing research efforts. We have major marine research institutions that can lead essential research in the coastal and marine sectors. But we will need to improve both funding and coordination of research in order to more effectively support our adaptation and mitigation goals.

Maine must create near-term and sustained sources of funding for research. Near-term funding would allow Maine to make better use of existing data and fill gaps where we lack essential information, while sustained funding to allows us to monitor and respond to changes in the future. A coordinated funding strategy that leverages federal, state, foundation, and private sources towards an integrated monitoring system is essential.

Substantial climate change data are already being gathered by federal and state agencies; municipalities; colleges and universities; non-profits; and the private sector. However, efforts are often poorly coordinated and chronically underfunded, and significant data gaps remain. Maine should develop a model for gathering this data and a system for disseminating it so public and private sector decision makers can respond constructively to climate change impacts.

Cost-Benefit Analysis

A cost-benefit analysis was not conducted for this strategy.

Public Input

- Collecting scientific data to understand the changes to Maine’s coastal and marine areas was deemed either a “great fit” (78 percent) or a “good fit” (14 percent) for their community by 92 percent of respondents to the Coastal and Marine Working Group survey.
- Strengthening research, development, and monitoring of natural and working land practices was deemed either a “great fit” (73.5 percent) or a “good fit” (18 percent) by 91 percent of respondents to the Natural and Working Lands Working Group survey.

For more information on this action, see the [Natural and Working Lands Working Group’s Strategies #5](#), [the Coastal and Marine Working Group’s Strategy #1](#), and the [STS Report’s Priority Information Needs section](#).

DEFINITIONS

Adaptation - an adjustment by nature or a community that reduces the hazardous effects of climate change.

Climate - the average weather condition at a given place over a period. For example, meteorologists often make comparisons against a 30-year period, called a climate normal.

Climate Change - a difference in the climate over multiple decades or longer. Long-term changes/shifts in climate can result from both natural and human factors.

Greenhouse Gases - gases that absorb/act as a blanket, trapping heat in the atmosphere, including but not limited to water vapor, carbon dioxide, methane, nitrous oxide, and ozone.

(Climate) Mitigation - a human intervention intended to reduce the rate of climate change by limiting the emission of greenhouse gases or by removing greenhouse gases from the atmosphere through natural or technological processes.

(Hazard) Mitigation - any sustained action taken intended to reduce or eliminate the long-term risk to human life and property from natural hazards.

Resilience - the ability of a community, business or the natural environment to prepare for, withstand, respond to and recover from a hazardous event.

Sequestration or Carbon Sequestration - the process of capturing carbon dioxide from the atmosphere or industrial processes and storing it for years to centuries; sometimes referred to as “negative emissions”. Carbon may be stored in biomass (such as trees, branches, wood products, foliage, and roots), soils, and rocks for varying periods of time, or reused in industrial applications; research and technological development into direct air capture of carbon dioxide for storage or reuse is ongoing but not yet developed at a large scale.

Weather - atmospheric conditions at any given time or place, measured from variables such as wind, temperature, humidity, air pressure, cloudiness, and precipitation. Weather can vary from hour-to-hour, day-to-day, and week-to-week.