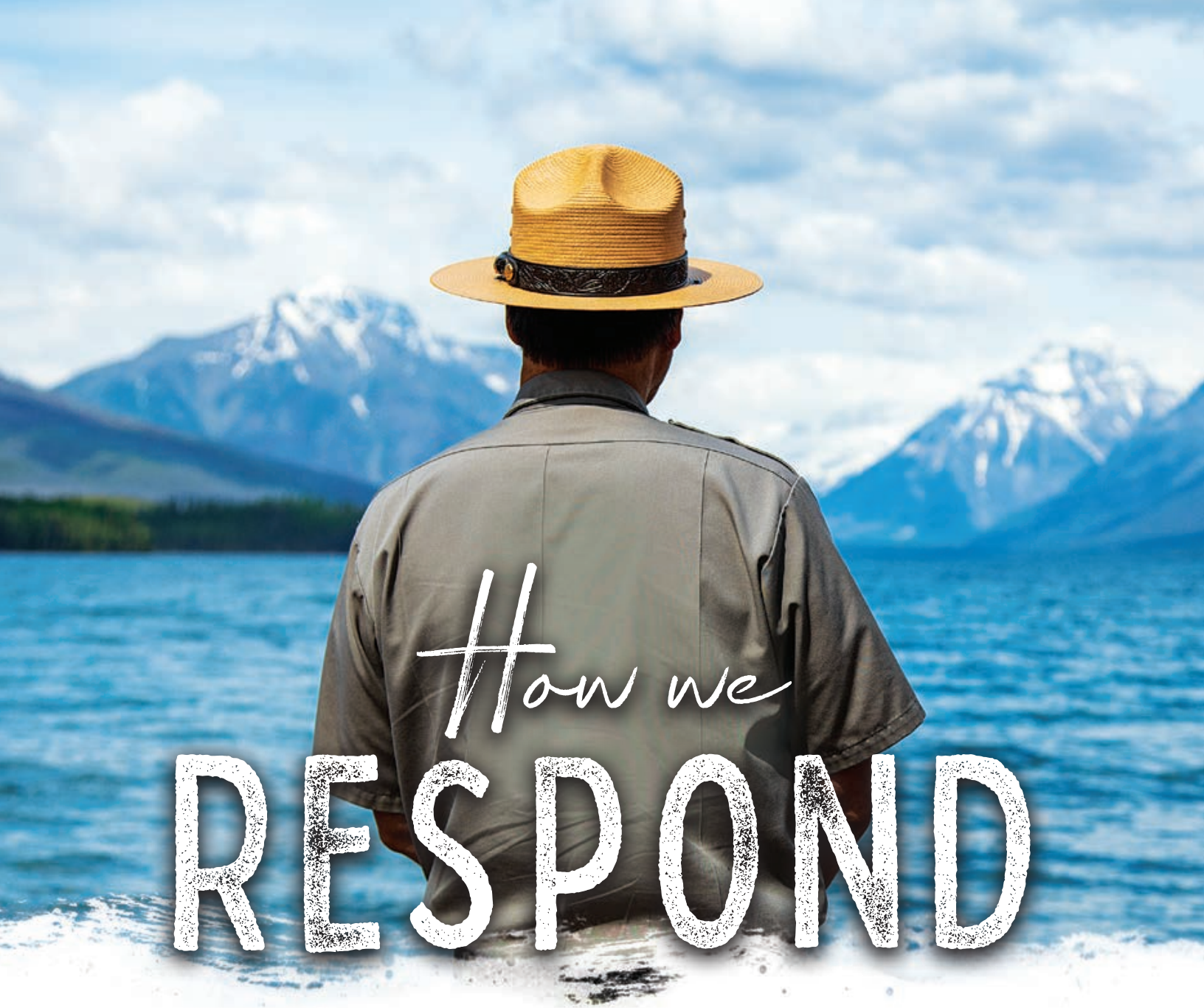

COMMUNITY RESPONSES TO CLIMATE CHANGE

AAAS

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

Windmills on the horizon near Colby, Kansas.

Credit: Impact Media Lab / AAAS

How We Respond: Community Responses to Climate Change

Report and community spotlights available online: https://howwerespond.aaas.org

IMAGE CREDITS

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Community Spotlights

Find community stories and short films online: https://howwerespond.aaas.org/communities

Scientists, governments, nonprofits, businesses and community members are using their knowledge and ingenuity to take action on climate change and find solutions that work for their communities. Some of these spotlights include new initiatives, while others account for climate change in existing projects focused on other important issues. *How We Respond* tells the stories of these communities — how they formed collaborations with scientists, acquired funding, collected data and implemented plans. While the impacts of climate change vary, and how communities respond depends on their needs, values and resources, these stories demonstrate what is possible and offer solutions and approaches for communities to consider.

Community Spotlights

Dane County, WI	Dane County Turns Waste Into Profit and Reduces Greenhouse Gas Emissions
Herring River Estuary, MA	Herring River Illustrates the Value of Wetlands in Reducing Greenhouse Gas Emissions
Homer and Napakiak, AK	Alaskan Communities Adapt to Dramatic Climate Change
Laramie, WY	Using Biochar in the High Plains to Reduce Carbon Emissions
Marquette, MI	As the Great Lakes Warm, Marquette Plans for a Healthier Future
Netarts Bay, OR	A Crippled Oregon Shellfish Hatchery Spawns Better Ocean Monitoring Systems
New Orleans, LA	New Orleans Residents Respond to Flooding With Citizen Science
Savannah, GA	Residents of Savanah Rise to the Occasion as Higher Seas Encroach
Sheridan County, KS	Kansas Farmers Minimize Water Use as the Southern Great Plains Become More Arid
Whitefish, MT	From Conversations to Action: Whitefish Tackles Climate Change Impacts on Wilderness and Tourism
Yurok Territory, CA	Restoring Yurok Forests and Rivers Using Traditional Knowledge

Brief Community Spotlights

Austin, TX	Churches Put Faith in Sustainability and Renewable Energy
California and New Jersey	Regional Alliances Forge Ahead in California and New Jersey, Expanding in Scope and Impact
Cambridge, MA	Starting Small and Scaling Up: Cambridge Sets Its Climate Adaptation Plan in Motion
Davenport, IA	Thinking Outside the Box: How Davenport Uses Marshes to Combat Floods and Climate Change
Fort Hood, TX	Fort Hood Embraces Renewable Energy; Other Military Posts Follow Suit
Phoenix, AZ	The Heat Is On: Phoenix Continues Its Search for a Sustainable and Healthy Future
Washington, D.C.	Washington, D.C., Transportation Policies Cut Pollution and Greenhouse Gases

INTRODUCTION

A lighthouse at sunset on Tybee Island, Georgia. The island is located in Chatham County, where the Smart Sea Level Sensors program is being implemented.
Credit: Impact Media Lab / AAAS

Our nation, our states, our cities and our towns face an urgent problem: climate change. Americans are already feeling its effects and will continue to do so in the coming decades. Rising temperatures will impact farmers in their fields and transit riders in cities. Across the country, extreme weather events such as hurricanes, floods, wildfires and drought are occurring with greater frequency and intensity. While these problems pose numerous risks to society and the planet, undoubtedly the biggest risk would be to do nothing. Science tells us that the sooner we respond to climate change, the lower the risks and the costs will be in the future.

Scientists, governments, nonprofits and concerned citizens are using their knowledge, ingenuity and resourcefulness to take action and find solutions that work for their communities. Some of these are new initiatives, while others are accounting for climate change in existing projects, such as those focused on transportation, energy, and clean air and water. *How We Respond* tells the stories of these communities — how they formed collaborations with scientists, acquired funding, collected data and implemented plans. The impacts of climate change vary across the United States, and how communities respond depends on those communities' needs, values and resources. The actions a large city can take are very different from those of a small town. While efforts to address climate change need to be tailored to the local scale, these stories demonstrate what is possible and offer some solutions and approaches for communities to consider.

Addressing the impacts of a changing climate can be challenging. *How We Respond* explores questions such as:

- How do communities understand the risks they face now and in the future?
- What resources are available to help deal with changes that are already happening (adaptation), and to reduce or eliminate the greenhouse gas emissions that are causing climate change (mitigation)?
- What are the opportunities to become more resilient?
- Who is responsible for developing and implementing plans to achieve these goals?

This report and the accompanying community spotlights provide an overview of climate change science, reasons why action is needed, how science supports decision-making and planning, ways to adapt to climate change and limit the severity of its effects, and how such efforts can help build resiliency.

One of the most powerful tools we have at our disposal is scientific research, which can help us better understand climate change and potential responses. This report illustrates the ways in which science can help individuals, communities, businesses and government agencies make informed decisions. By working together to identify solutions and bring about positive change, we can reduce the risks faced by current and future generations.

WE FACE AN URGENT PROBLEM: CLIMATE CHANGE

In the summer of 2018, firefighters battled a record number of wildfires in California, Oregon and neighboring states. In 2017, residents along and near the Atlantic coast experienced several record-breaking storms, including hurricanes Harvey and Maria, which exhibited more severe features (e.g., rapid intensification, more intense rainfall), which are to be expected in a warmer world. But it doesn't take a sudden crisis to illustrate the effects of climate change — many people can name ways that changing weather and climate patterns are affecting their family, business or community.

While more than half of Americans accept the fact that humans are causing climate change,[1] there is overwhelming consensus within the scientific community about the reality of climate change: global climate change is happening now, it is caused by humans and it poses significant risks to society. This realization is based on extensive evidence that has grown stronger over the past 50 years. In 2014, AAAS published *What We Know*,[2] summarizing the scientific community's consensus on climate change and opportunities to respond. Since then, additional research and comprehensive reports, including the 2018 Fourth National Climate Assessment[3] and several special reports from the Intergovernmental Panel on Climate Change,[4] have presented additional evidence of human-caused climate change and projections of how climate will continue to change over this century and beyond.

For more than 150 years, scientists have understood the fundamental physics of how greenhouse gases, including carbon dioxide, water vapor and methane, affect the Earth's climate, and they have been studying the effects of increased fossil fuel use on greenhouse gas emissions and the climate since the late 1800s. The first official warning from scientists to a U.S. president about the dangers of climate change came in 1965. Since then, the scientific evidence has grown, and the warnings have become more dire.

Greenhouse gases occur naturally and trap heat in the Earth's atmosphere, warming our planet's surface about 60°F above what it would otherwise be and making life on Earth possible. The concentrations of greenhouse gases in the atmosphere tend to fluctuate slowly over time — unless an event upsets this natural cycle. Between 1870 and 2017, such an event occurred when humans released an estimated 425 billion metric tons of carbon into the atmosphere by burning fossil fuels; we have contributed an additional 190 billion metric tons of carbon to the atmosphere by altering the landscape (e.g., by cutting down trees that would otherwise absorb carbon dioxide).[5] Collectively, these actions mean that humans have increased the overall amount of carbon dioxide in the atmosphere by more than 45% since the beginning of the Industrial Revolution.

This additional carbon dioxide and other greenhouse gases humans have released into the atmosphere have caused the average global temperature to increase by about 1.8°F since 1900. While this may not sound like a large increase, it is meaningful. An increase of just a few degrees can be detrimental to our planet's health and to the organisms our planet supports — especially because temperatures are rising at an alarming rate. While the Earth naturally cycles between glacial and warmer periods, the rate of temperature increase over the past 50 years is about eight times faster[6] than during past, typical cycles of warming. This rapid warming is resulting in numerous adverse climatic events, such as more frequent heat waves, more intense rainfall events and rapid melting of the Earth's ice sheets (fueling sea level rise).

Unfortunately, while climate change has the potential to affect nearly everyone, often the most severe impacts fall on those who are least able to cope with them. For instance, elderly people are particularly susceptible to health impacts of rising temperature, and low-income neighborhoods may have fewer resources to upgrade failing infrastructure. For these reasons, Cambridge, Massachusetts, decided to implement the first stage of its climate action plan in its most vulnerable neighborhood, Alewife, and then expand the plan to include other regions of the city.

Another important thing to consider is that certain climate events can combine to have greater consequences than if they occur separately. For instance, coastal towns can experience worse flooding if they are experiencing sea level rise in combination with more intense rainfall events than if just one of those factors is increasing. Similarly, hot and dry spells together increase the likelihood of wildfires. Combinations of extreme events such as these increase the risks of damage to infrastructure and human health. Similarly, more frequent extreme weather events have the potential to stress disaster relief and recovery systems.

Continuing to emit greenhouse gases will make climate change more severe, and the primary way to stabilize the climate is to reduce greenhouse gas emissions. To minimize the impacts of climate change, countries around the world adopted the 2015 Paris climate agreement, committing to collectively work together to limit warming to well below 3.6°F (or 2°C) above preindustrial levels. To achieve this target, net global human-caused greenhouse gas emissions must be reduced to about 75% below 2010 levels by 2050 and to zero by about 2070.[7] This would require aggressive measures to reduce emissions of carbon dioxide and other greenhouse gases. There are many opportunities to both adapt to climate change and reduce emissions (mitigate the amount of change that occurs).

THE FOURTH NATIONAL CLIMATE ASSESSMENT

In 2017 and 2018, the U.S. Global Change Research Program published two reports comprising the Fourth National Climate Assessment, analyzing the scientific evidence[8] for observed and future climate change and the effects of climate change[9] on human welfare, society and the environment.

According to the overview of the second volume *(Impacts, Risks, and Adaptation in the United States)*:

> ***"Earth's climate is now changing faster than at any point in the history of modern civilization, primarily as a result of human activities. The impacts of global climate change are already being felt in the United States and are projected to intensify in the future—but the sevexrity of future impacts will depend largely on actions taken to reduce greenhouse gas emissions and to adapt to the changes that will occur. Americans increasingly recognize the risks climate change poses to their everyday lives and livelihoods and are beginning to respond."***[10]

Below are the summary findings from that report.[11]

Communities: Climate change creates new risks and exacerbates existing vulnerabilities in communities across the United States, presenting growing challenges to human health and safety, quality of life, and the rate of economic growth.

Economy: Without substantial and sustained global mitigation and regional adaptation efforts, climate

change is expected to cause growing losses to American infrastructure and property and to impede the rate of economic growth over this century.

Interconnected Impacts: Climate change affects the natural, built and social systems we rely on individually and through their connections to one another. These interconnected systems are increasingly vulnerable to cascading impacts that are often difficult to predict, threatening essential services within and beyond the Nation's borders.

Actions to Reduce Risks: Communities, governments, and businesses are working to reduce risks from and costs associated with climate change by taking action to lower greenhouse gas emissions and implement adaptation strategies. While mitigation and adaptation efforts have expanded substantially in the last four years, they do not yet approach the scale considered necessary to avoid substantial damages to the economy, environment, and human health over the coming decades.

Water: The quality and quantity of water available for use by people and ecosystems across the country are being affected by climate change, increasing risks and costs to agriculture, energy production, industry, recreation, and the environment.

Health: Impacts from climate change on extreme weather and climate-related events, air quality, and the transmission of disease through insects and pests, food, and water increasingly threaten the health and well-being of the American people, particularly populations that are already vulnerable.

Indigenous Peoples: Climate change increasingly threatens Indigenous communities' livelihoods, economies, health, and cultural identities by disrupting interconnected social, physical, and ecological systems.

Ecosystems and Ecosystem Services: Ecosystems and the benefits they provide to society are being altered by climate change, and these impacts are projected to continue. Without substantial and sustained reductions in global greenhouse gas emissions, transformative impacts on some ecosystems will occur; some coral reef and sea ice ecosystems are already experiencing such transformational changes.

Agriculture: Rising temperatures, extreme heat, drought, wildfire on rangelands, and heavy downpours are expected to increasingly disrupt agricultural productivity in the United States. Expected increases in challenges to livestock health, declines in crop yields and quality, and changes in extreme events in the United States and abroad threaten rural livelihoods, sustainable food security, and price stability.

Infrastructure: Our Nation's aging and deteriorating infrastructure is further stressed by increases in heavy precipitation events, coastal flooding, heat, wildfires, and other extreme events, as well as changes to average precipitation and temperature. Without adaptation, climate change will continue to degrade infrastructure performance over the rest of the century, with the potential for cascading impacts that threaten our economy, national security, essential services, and health and well-being.

Oceans & Coasts: Coastal communities and the ecosystems that support them are increasingly threatened by the impacts of climate change. Without significant reductions in global greenhouse gas emissions and regional adaptation measures, many coastal regions will be transformed by the latter part of this century, with impacts affecting other regions and sectors. Even in a future with lower greenhouse gas emissions, many communities are expected to suffer financial impacts as chronic high-tide flooding leads to higher costs and lower property values.

Tourism & Recreation: Outdoor recreation, tourist economies, and quality of life are reliant on benefits provided by our natural environment that will be degraded by the impacts of climate change in many ways.

These are just some examples of the impacts of climate change. The National Climate Assessment provides data and information about current and future climate-related risks for each region across the U.S., including the Northeast,[12] Southeast,[13] U.S. Caribbean,[14] Midwest,[15] Northern Great Plains,[16] Southern Great Plains,[17] Northwest,[18] Southwest,[19] Alaska,[20] and Hawaii and the U.S.-affiliated Pacific Islands.[21]

REASONS TO ACT

Herring River Estuary in Wellfleet, Massachusetts.

Credit: Impact Media Lab / AAAS

Infrastructure, the economy, health, food and water, biodiversity — virtually all aspects of our lives and environments will be affected by a changing climate. While each community faces different climate challenges, the need to respond is universal.

Many communities are already experiencing changes, prompting local individuals and groups to take action. For example, scientist Russell Clark lives in a small community of 20 homes about eight miles inland from the coast of Georgia. His home has stood for nearly 50 years without being affected by the nearby ocean — but that changed when high winds from Hurricane Irma pushed water right up to his doorstep in 2017. Motivated to better protect his neighborhood and others along the Georgia coast, he started a project to make the community more resilient to sea level rise and storm surges. Clark partnered with scientists and local groups to create a low-cost sea level sensor, which alerts residents to dangerous water levels and informs adaptation planning.

Extreme weather events provide clear reasons to act because we can directly observe these phenomena. But there are many other ways that climate change is affecting our lives and livelihoods, such as through economic productivity and the quality of people's health. Here are some examples.

Air Quality Issues

- Burning fossil fuels creates pollutants that directly reduce our air quality. These pollutants are associated with many health problems, including diminished lung function, increased hospital admissions and emergency department visits for asthma, and increases in premature deaths;[22] a study from 2013 estimated that 200,000 people in the U.S. die prematurely each year due to emissions from industrial smokestacks, vehicle tailpipes, marine and rail operations, and commercial and residential heating.[23] In contrast, renewable energy sources such as solar and wind are associated with little air pollution, meaning that using these resources could reduce the incidence of illness and premature death related to poor air quality.[24] A warmer climate can also negatively impact air quality by creating longer pollen seasons and increasing the amount of smoke we breathe in from wildfires, for example.

Limiting greenhouse gas emissions will provide us with cleaner air to breathe.

Illness and Death

- Increasingly extreme temperature will also result in higher rates of death and illness. The Fourth National Climate Assessment estimates that the number of heat-related premature deaths in the Southwest could rise by 850 deaths each year by 2050 if no efforts to reduce greenhouse gas emissions are taken; notably, this number could be halved if we take more aggressive measures to lower those emissions.[25] The city of Phoenix is taking steps to inform the public about the health risks associated with the extreme heat caused by climate change.

Other impacts of climate change on health include warmer water temperatures, which will increase the risk of waterborne diseases, and the prevalence of mosquitoes, which carry life-threatening diseases such as Zika.

Efforts to limit climate change can limit the number of deaths and illnesses that occur.

Energy Costs

- A remarkable amount of the energy that goes into heating, cooling and lighting our buildings is wasted, for example when buildings are not insulated properly or when we leave lights on in empty rooms. This creates unnecessary pollution and greenhouse gas emissions from generating that wasted energy — as well as unnecessarily high utility bills for individuals, families and businesses. A national program called the Better Buildings Challenge,[26] hosted by the Department of Energy, illustrates how far standards for energy efficiency can go; in just its first three years, the program helped 38,000 private and public buildings collectively save $3.1 billion in energy costs.

Becoming more energy-efficient saves money and reduces emissions of greenhouse gases.

Energy Security and Opportunities

- By installing more solar panels and wind farms locally, Americans would depend less on fossil fuels — the price and availability of which can fluctuate. Fort Hood, a military base in Texas, decided to adopt a renewable energy plan, in part because it gains energy independence by using locally sourced power rather than relying on fossil fuels; the plan is also expected to save the U.S. Department of Defense millions of dollars.

Renewable energy helps reduce greenhouse gas emissions and provides a more secure energy supply to meet the country's continuing needs. It also can create jobs and save money.

Economic Costs of Climate Change

- Extreme weather events come with a hefty price tag. Between 1980 and 2018, the U.S. experienced 241 extreme weather-related events that each cost more than $1 billion — collectively, the cost of these events is more than $1.6 trillion.[27] Repairing damaged infrastructure is expensive — but analyses show that communities that build infrastructure to better withstand these events in the first place save substantial amounts of money in the long run. Every $1 invested in infrastructure that can withstand the effects of climate hazards such as flooding can save $6, according to the National Institute of Building Sciences.[28] There are also more subtle ways in which a changing climate can impact the economy, beyond the direct costs of rebuilding damaged infrastructure. Increases in illness and deaths will mean greater health care costs, and extreme heat waves will limit the number of paid hours that outdoor laborers, such as farmers and construction workers, will be able to work. Some industries, such as tourism and fisheries, will suffer losses as biodiversity dwindles and ecosystems are altered, and agriculture is increasingly threatened by wildfires, drought and other harmful weather events that will increase in frequency and intensity with climate change. In contrast, some initiatives that address climate change involve stimulating the economy and creating jobs, for example in wind farm construction and solar panel installation.

In the long run, doing nothing to limit climate change and adapt to its effects will be more costly than taking action now.

These are just some examples of how climate change can impact society. Although responding to climate change may not be the top priority for a community, climate change likely affects something that is a priority, such as health, economics or social well-being. This means that direct measures to address climate change do not need to be developed independently but rather can be incorporated into existing projects, plans and discussions that address these issues.

For instance, city planners in regions prone to flooding who are working on new development can incorporate features that will make buildings and streets more resilient to future flooding, and design them to be more energy-efficient (which can reduce greenhouse gas emissions). Volunteers planting a community garden in a flood-prone area can consider plant species that are especially tolerant of excess water, while larger greenspaces can help absorb runoff before it gets to already swollen waterways. For example, Davenport, Iowa is using riverfront parks and a large urban wetland as flood protection.

In many cases, taking an action that addresses climate change — directly or indirectly — has additional benefits. Reducing reliance on fossil fuels in turn improves air quality, limits the number of people who become sick and reduces the number of labor hours lost due to illness and death. Creating more energy-efficient buildings saves money on utility bills and reduces emissions from wasted energy. These intertwined factors are called co-benefits.

One example of a community that has reaped many co-benefits through its climate change efforts is Dane County, Wisconsin. After assessing ways to manage the county's largest landfill, the sustainability team chose to harvest the site's methane, converting it into compressed renewable gas and selling it into a pipeline for profit. Their approach saves taxpayers money, secures a local energy supply, reduces greenhouse gas emissions and fosters economic relationships with local utility companies.

A tractor moves piles of trash at the Dane County Landfill. Because of the new RNG facility, the county can harvest methane produced by decomposing trash in the landfill and convert it into renewable transportation fuel.

Credit: Impact Media Lab / AAAS

In Northern California, efforts by the Yurok Tribe to restore their land will also yield co-benefits. Decades of deforestation have caused sediments to accumulate in the once-clear streams and rivers. This is hurting the salmon population, which is central to Yurok culture and subsistence. By participating in a cap-and-trade program, the tribe is funding efforts to plant and maintain trees that offset the carbon emissions of credit buyers and buying back more land from a local logging company. As they regain more of their ancestral land, tribe members plant more trees — which will reduce sediment runoff into the rivers, help the local salmon population and absorb more carbon dioxide from the atmosphere.

By responding sooner rather than later to climate change, we can limit the amount of change that occurs, the severity of impacts and thus the overall costs. Studies of the costs of delaying action have found that postponing climate mitigation goals by just 10 years could increase the costs of mitigation by 40% [29] to 50%.[30] Delaying action even further may make the goal unachievable.

There are also benefits of implementing adaptation projects sooner rather than later. Estimates of adaptation costs for the U.S. range from tens to hundreds of billions of dollars per year, but this is expected to save several times that over the long run.[31]

For both adaptation and mitigation efforts, science can inform the development of action plans, which are discussed in the next section.

HOW SCIENCE CAN SUPPORT DECISION-MAKING AND PLANNING

A field of crops used for research purposes at the Kansas State University Northwest Research-Extension Center.

Credit: Impact Media Lab / AAAS

In our day-to-day lives, we are constantly assessing our situation and planning ahead, while hardly noticing these efforts. Is it likely to rain, so should I bring an umbrella? How far is the next gas station, and should I fill up now? What groceries will I need to pick up at the store this week?

When it comes to climate change, similar planning is required — but on a larger scale. To come up with an effective plan of action, communities need a good understanding of the problems they face and the options available. Science can help provide that information.

When and How Can Science Be Used?

Science can be used to inform decision-making and action throughout the entire process of responding to climate change. It can be used in the early stages, when communities are trying to understand their risks; the exploratory stage, when analyzing possible options; as action plans are implemented, to help achieve the desired goals and targets; and later, when monitoring progress, to determine how successful the approach has been and when adjustments or different approaches may be needed.

Examples of how to incorporate science include:

- Vulnerability assessments — to understand climate risks.
- Cost-benefit analyses — to understand the overall costs of a climate change plan.
- Comparative studies — to understand which options are available and best suited to your needs.
- New technologies — to successfully adapt to changes and reduce the severity of climate change.
- Data monitoring — to inform climate plans and adjust accordingly.

There are many overlapping factors involved in climate change. Burning fossil fuels can reduce air quality, exacerbate climate change and involve hidden costs, for example by negatively impacting the economy over time. The best analyses will account for all these factors, which is why communities often work with a team of scientists. For example, physical scientists can provide information about the current and future climate and analyze potential impacts on ecosystems or water supply; social scientists can help assess impacts on human health or the economy; and risk scientists can analyze how to quantify and manage risks associated with climate change.

Understanding Local Climate Risks and Opportunities

The impacts of climate change vary greatly depending on geographic location and socioeconomic factors. To understand local risks and opportunities, communities often begin by using tools such as the National Oceanic and Atmospheric Administration's (NOAA) Climate Explorer[32] or existing assessments that have been created for larger geographic regions, such as their state.

State and regional climate change reports provide a general overview of changes already occurring in the area and changes that are projected in the coming years. Cities and towns may decide to undertake a more specific assessment that accounts for their unique features, resources, risks and opportunities. Across the country, many community leaders are collaborating with climate scientists and other local experts to conduct vulnerability assessments. Such an assessment can help a community understand:

- What climate hazards (e.g., heat waves, sea level rise, wildfires) it might be exposed to now and in the future.
- How those climate hazards may affect important aspects of the community (e.g., infrastructure, transportation, local industry, drinking water supply, people's health).
- How sensitive it may be to these impacts (e.g., whether structures already built to withstand a certain amount of sea level rise and how the community can protect vulnerable populations like the elderly during a heat wave).
- What ability the community has to adapt to the changes (e.g., what resources it has available to reinforce infrastructure that protects from storm surges).
- What opportunities there are to reduce greenhouse gas emissions at the local, state or regional levels.

A vulnerability assessment accounts for the direct effects of a changing climate, such as the increasing intensity of storms, which could lead to more flooding. These factors are called *climatic stressors*. Vulnerability assessments also account for *non-climatic stressors* — factors that aren't directly linked to the climate but will make the impacts of climate change worse. This could include expected population or demographic changes or the physical characteristics of an area — for example, pavement can exacerbate the effects of flooding in an area because it doesn't allow water to be absorbed by the ground, and can make an area much hotter because it reflects heat back into the air. The asphalt is not directly linked to climate change, but has the potential to make the effects of climate change worse. To truly understand risks, it's important to consider both types of stressors.

Assessments should also account for uncertainties, especially when it comes to carbon emissions in the near future and how different climate factors will interact with one another. For these reasons, climate risks and projections are often presented as a range rather than as a precise number.

The biggest uncertainty surrounding climate change is the amount of greenhouse gases that will be emitted globally over the next few decades. Cities and countries may become more active in reducing their emissions — or they may continue emitting greenhouse gases at the same or even higher rates. For each of these greenhouse gas scenarios, scientists have created a variety of projections for how the climate might change. Some communities are choosing to create plans that account for the most severe projections. Others are creating plans that address the impacts deemed more likely — but they risk being underprepared if more severe impacts occur.

There is also uncertainty about how different climatic factors will interact with one another. In terms of sea level rise, for example, it is currently difficult to know precisely how stable ice sheets will be over the course of this century and thus the rate of melting that will occur. Because of the uncertainty surrounding these complex, related factors and around the magnitude of future

carbon emissions, scientists estimate that the average sea level rise over the year 2000 sea level will be 0.3 to 0.6 feet by 2030, 0.5 to 1.2 feet by 2050 and 1.0 to 4.3 feet by 2100.[33]

What Resources Are Available?

Funding and Resources

At a national level, federal government agencies have funded climate change responses over the past decade or more. These agencies collectively provide hundreds of millions of dollars to initiatives across the country every year. Many of these funds are allocated to regional or local initiatives via grants, and in some cases, the funding is in response to needs such as disaster recovery rather than climate change planning. More information about these programs is available from sources including the U.S. Climate Resilience Toolkit[34] and the State and Local Climate Change Resource Center.[35]

Mountain view in Glacier National Park, Montana.

Credit: Impact Media Lab / AAAS

In some cases, very few new resources are needed to achieve climate goals and resiliency. Rather, existing departments, funds and other resources can be used. For example, to help manage increasing temperatures in Phoenix, Arizona, city officials and local stakeholders are outlining new criteria in proposals for transportation development. By requiring developers to incorporate measures that help reduce residents' exposure to heat while in transit, the city is able to promote infrastructure changes that benefit the community as a part of regular infrastructure development and replacement, often at no extra cost. Similarly, many standards for building efficiency (e.g., Leadership in Energy and Environmental Design, or LEED) have been developed that can be incorporated into infrastructure projects at low cost, and aim to reduce energy expenditures and greenhouse gas emissions associated with operating buildings.

Experts

There are many networks of climate scientists that work with communities to help them apply climate science to their contexts and develop local action plans. One example is the Resilience Dialogues, coordinated by the American Society of Adaptation Professionals and the U.S. Global Change Research Program with support from several other public and private entities. The Resilience Dialogues connect communities, including Whitefish, Montana, with climate experts.

Other examples of programs and networks designed to connect local scientists with community members include:

- The American Geophysical Union's Thriving Earth Exchange program connects experts with communities and groups interested in addressing climate change.[36]
- The Regional Integrated Sciences and Assessments program, hosted by NOAA, funds research teams that help communities understand their risks and support action plans and policy initiatives.[37]

- U.S. Department of Agriculture Climate Hubs support agricultural and natural resource managers by providing science-based, region-specific information and technologies.[38]
- U.S. Geological Survey Climate Adaptation Science Centers produce science to help fish, wildlife and ecosystem managers understand and adapt to a changing climate.[39]
- Regional Economies and Renewable Energy Policy Dialogue, a partnership between the University of Minnesota's Institute on the Environment and Germany's Federal Ministry for Economic Affairs and Energy, has led to policies and actions in the electricity sector for greenhouse gas reduction and resiliency through public-private partnerships.[40]

In other cases, scientists and community members have formed collaborations outside established networks. Regardless of how the collaboration arose, successful response efforts require contributions from the perspectives of local leaders, tribal members, resource managers, consulting firms and others who have lived and worked in the community for years. Their knowledge about local history, management practices and other issues is essential to creating response strategies that are likely to be successful.

Data

Communities can find a variety of data sets that can help them understand past, current and future climate issues. Some examples include:

- The Climate Explorer is a tool that offers county-specific projections for different emissions scenarios.[41]
- Storm Events Database records significant or unusual weather phenomena.[42]
- Climate at a Glance is an interactive map showing climate anomalies.[43]
- USGCRP Indicators contains data of key climate change trends, including air temperature and greenhouse gas levels.[44]

Founder of ISeeChange, Julia Kumari Drapkin, shows children a map of historic New Orleans. Drapkin highlights the parts of the city that used to be swamp.

Credit: Impact Media Lab / AAAS

- National Drought Portal shows a livestreamed view of which areas are experiencing drought.[45]
- National Land Cover Database is a collection of satellite data showing land use (e.g., road, urban areas, tree canopy).[46]
- State Climate Summaries contains state-level data indicating current and future climate trends.[47]
- Sea Level Rise Viewer is a map visualizing community-level impacts from coastal flooding or sea level rise.[48]
- The Climate Central Surging Seas Risk Finder is a tool showing sea level rise and flooding at the neighborhood scale as well as projections of risk.[49]
- Partnership for Resilience and Preparedness is a collection of databases to inform resiliency planning.[50]

These data sets capture climate impacts at different scales, so some communities may want to collect more detailed, local data to inform their decision-making and action. While this could involve partnering with local experts and professionals, in some cases the community itself can participate in data collection and contribute to the overall project. Starting in 2017, after one of the worst flooding seasons since Hurricane Katrina, residents

of a neighborhood in New Orleans wanted to help build resilience to future flooding. As part of an initiative led by the nonprofit organization ISeeChange, residents began monitoring rainfall and flooding, and the data they collected is now being used to inform city planning efforts.

Partnerships

Planning and implementing responses to climate change involve many individuals and organizations. Scientists, universities, local governments, nonprofits, businesses, volunteers and other stakeholders bring different strengths and limitations to collaborations and partnerships that address climate change. Partners may provide funding, offer expertise or dedicate time to implement projects. The most successful climate change initiatives occurring across the country tend to involve a high degree of collaboration between groups. For instance, the Yurok Tribe in California receives grant money from the federal government to support its environmental program, which is implemented by tribe members and a handful of employees of the Yurok Tribe Environmental Program. The tribe has also partnered with state and federal scientists to monitor fish health. Through this collective action, the partners are striving to restore the area's dwindling salmon population, which is threatened by climate change.

RESPONDING TO CLIMATE CHANGE

Human activity is causing the climate to change rapidly. How we respond to this problem will directly affect our survival and well-being as well as that of other living organisms.

There are two primary ways we can respond to climate change: by increasing our capacity to cope with the changes that are underway (adaptation) and by limiting the extent of changes that occur by reducing our greenhouse gas emissions (mitigation). Using both approaches is essential to reduce the risks that climate change poses to human health, infrastructure, the economy and other aspects of our lives. This section of the report highlights ways in which Americans are adapting to and mitigating climate change and how these two techniques can be used together to maximize outcomes. Indeed, the best way to become resilient to climate change is to adopt both approaches.

Adapting to Climate Change

When people hear about a big storm approaching, they mobilize to make their homes more resilient — by ensuring windows are locked, clearing loose or dead branches that could cause damage, and maybe even surrounding their home with sandbags to protect it from flooding. Similar measures for preparedness and resilience are needed to adapt to climate change — just on a larger scale and in a longer time frame.

Taking measures to reinforce a home before a storm hits tends to be cheaper than rebuilding a damaged home after a storm. The same is true when planning for climate change. Proactive adaptation initiatives often yield benefits that exceed the costs in the near term as well as over the long term. While estimates of adaptation costs range from tens to hundreds of billions of dollars per year, those investments are expected to save several times that over the long run.[51]

Recognizing the need to be prepared, many federal and state agencies are funding initiatives to help Americans become more resilient to the changing climate. The U.S. Environmental Protection Agency hosts a number of programs[52] that offer financial and technical assistance to help communities and groups become more resilient. For example, its Smart Growth Technical Assistance Programs[53] cover a range of specialties, including rural, coastal, health, local food and technical initiatives. The U.S. Centers for Disease Control and Prevention offers support to cities and states looking to prepare for the human health impacts of climate change. This is how Marquette, Michigan found funding to develop and implement a health adaptation plan.

In some cases, previous disasters have provided an opportunity for communities to become more resilient moving forward. For example, the five states affected by Hurricane Sandy in 2012 received $10.5 billion from the U.S. Department of Housing and Urban Development to help with rebuilding efforts — but grant recipients were required to incorporate a risk assessment in their planning efforts in order to ensure long-term resilience.

Through these national programs as well as many locally based initiatives across the country, Americans have made some progress in adapting to climate change. Between the publication of the Third National Climate Assessment in 2014 and the fourth report in 2018, there was a noticeable increase in the efforts of public, private and nonprofit groups across the country to become more resilient to the changing climate.[54] This is due in part to growing awareness of the risks, recognition of the economic and social benefits of taking action, and increasing damage from extreme events. Unfortunately, the Fourth National Climate Assessment also found that while more Americans are building capacity to better cope with climate change, the scale of these efforts does not match the projected scale of climate threats. In some cases, adaptation efforts are accounting only for changes that a community is currently facing — and not accounting for changes that will happen in the coming decades. This means communities still have much work to do as they consider how to become more resilient.

One such example of a community facing immediate threats is an oyster hatchery situated along the coast of Oregon. In 2009, hatchery managers realized that millions of oyster larvae were unable to build shells because of ocean acidification caused by climate change. As the Whiskey Creek Shellfish Hatchery saw its profits plummet, it partnered with scientists to develop new technology to save its industry. In Kansas, as another example, farmers who rely on irrigation and already face a water shortage saw no choice but to change their farming practices and dramatically lower the amount of water they used, a collective action that has yielded substantial results.

Alan Barton, manager of Whiskey Creek Shellfish Hatchery, holds bags of adult oysters as he stands in front of Netarts Bay. The oysters must be raised under the controlled conditions of the nearby hatchery, since the ocean water in the bay is too acidic for oyster larvae during their early stages of development.

Credit: Impact Media Lab / AAAS

Notably, in some cases, the option to adapt simply does not exist, and managed retreat is the only option. In Alaska, thawing permafrost and increased flooding are causing some communities, such as the village of Napakiak, to relocate buildings and other infrastructure. This is a last resort, but one that communities are increasingly facing.

Building Resiliency

In general, there are three key ways to build resiliency to climate change. These are reducing people's exposure to climate hazards (e.g., constructing new buildings away from coastlines where sea level rise is anticipated); reducing people's vulnerability to climate impacts (e.g., using building standards that limit the impacts of flooding); and increasing people's ability to adjust to, respond to and recover from climate impacts (e.g., dedicating more funds for emergency escape routes, recovery efforts, new infrastructure, etc.). Assessments outlined in the previous section can help communities understand what options are available to achieve these types of resiliency and help them develop an appropriate and effective climate action plan.

Planning for Action

When developing adaptation strategies, communities also need to consider a number of other factors.

- **Short-term and long-term strategies are required.** Adaptation means addressing the problems that communities are currently facing as well as the ones they expect to encounter down the road. For instance, New York City and the Federal Emergency Management Agency have agreed to develop two sets of flood maps, one showing current risk, used for setting insurance rates, and the other showing projections of future flooding, used for setting building codes and land-use planning. This provides tools to understand flooding in the short term and to become more resilient in the long term.
- **Adaptation and resilience goals can be integrated into existing programs and plans.** It may not be necessary to create a whole project from scratch that addresses only climate change. Instead, climate adaptation strategies can be integrated into existing organizational and sectoral investments, policies and practices such as health plans, urban development planning and farming practices. This approach may even make adaptation planning easier, since it relies on familiar processes rather than requiring extensive new approaches.
- **The unique features of communities should be incorporated into plans.** Factors such as access to resources, culture, governance and available information can affect not only the risk faced by different populations but also the best ways to reduce their risks. What strengths does each community have, and how can those be used to build resilience? Who in a community will feel the effects the most, and what can be done to support them?
- **Adaptation plans can be integrated with mitigation.** Many efforts can include elements of both mitigation and adaptation: Washington, D.C., is doing a lot to reduce pollution and make public transportation more accessible (mitigation), while also making its infrastructure more resilient to increased flooding and higher temperature (adaptation).

Allowing for Flexibility

Climate is a combination of many factors, and climate change will affect the natural and human systems we rely on in ways that are sometimes difficult to predict or that may surprise us. Communities can build flexibility into their adaptation plans by including regular evaluation of the effectiveness of individual projects and making adjustments when needed, especially since the future will be variable and uncertain. One example is the city of Boston,[55] which every three years re-evaluates strategies within its existing plan and develops new strategies to fill any potential shortfalls.

Limiting Future Climate Change

Global temperatures and the prevalence of extreme weather events — such as hurricanes, wildfires and drought — are on the rise. Scientific evidence shows that human behavior, especially our reliance on fossil fuels, is the key underlying cause of these changes. The speed and magnitude at which we can change our society will directly influence the amount of climate change that occurs over the course of this century and beyond. Climate scientists have created numerous models of climate change impacts under different emissions scenarios — reflecting whether the U.S. and other countries keep emitting greenhouse gas at the same rate, take some steps to limit emissions by midcentury or take aggressive measures to limit emissions now. The evidence consistently suggests that the sooner we act to limit our emissions, the greater the savings will be in both money and lives.

According to the Fourth National Climate Assessment, aggressive action to reduce greenhouse gas emissions by the middle of the century rather than no action would prevent thousands to tens of thousands of deaths each year that otherwise would be caused by extreme temperatures and poor air quality, for example. In terms of lost labor hours, taking aggressive action to combat climate change, compared with taking the "business as usual" approach of continuing to emit greenhouse

gases at the current rate, could save tens to hundreds of billions of dollars (see Figure 29.2 in the NCA4).[56]

Many Americans understand the need to cut back on greenhouse gas emissions, and are responding. After President Trump announced in 2017 that he planned to remove the United States from the Paris climate agreement, more than 3,500 mayors, governors and business leaders pledged to continue to meet the agreement's goals of limiting greenhouse gas emissions as part of the We Are Still In[57] campaign. The number of cities committed to acquiring 100% of their energy from renewable sources now exceeds 100.

In the absence of federal action, some states have formed mandatory cap-and-trade programs, setting limits on greenhouse gases; businesses that exceed those limits must pay fees or offset those emissions. The two mandatory programs in the U.S. are California's Cap and Trade Program, which was launched in 2013, and the Regional Greenhouse Gas Initiative, a cooperative effort launched in 2009 that includes Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New York, Rhode Island and Vermont.

Some businesses are also stepping up to the plate. The Carbon Disclosure Project[58] is one example of a voluntary program that allows companies to register pledges to reduce greenhouse gas emissions and/or to manage their climate risks. In addition, corporate purchases of and commitments to purchase renewable energy have increased over the past decade.[59]

In 2017, the U.S. emitted about 6.5 billion metric tons of carbon dioxide, representing a 0.5%[60] decrease in emissions over the previous year. Unfortunately, this trend was reversed in 2018; preliminary estimates range between increases of 2.5%[61] and 3.4%.[62] Limiting the effects of climate change will require reductions in carbon emissions at every level — from individuals, businesses, communities and nations. There are many ways to do this, each of which may also yield additional co-benefits.

Reducing Greenhouse Gas Emissions

In the U.S., the sectors that emit the most greenhouse gases are transportation (29%), electricity generation (28%) and industry (22%).[63] In addition, land use changes,[64] such as cutting down forests and replacing them with agricultural fields or subdivisions, reduce the amount of carbon dioxide that land and vegetation absorb from the atmosphere; these activities indirectly add even more carbon dioxide to the air.

Some groups across the U.S. are exploring ways to restore certain ecosystems in order to mitigate carbon emissions. Coastal wetlands are particularly effective at absorbing carbon from the atmosphere and trapping it within soil, which is why a collaboration of nonprofits has been working to have these ecosystems included in voluntary and mandatory carbon markets. By collecting data at the Herring River Estuary in Massachusetts, the collaboration is paving the way for greater recognition and restoration of coastal wetlands, which also serve as natural buffers against storm surges.

The Chequessett Neck Road dike at Herring River. Dikes, including this one, can block tidal flow between the ocean on one side and a marsh on the other. As part of the Herring River Restoration Project, conservation organizations and local stakeholders are working to remove the dike to restore tidal flow and stem the release of methane back into the atmosphere.

Credit: Impact Media Lab / AAAS

Because there are many different ways that we emit greenhouse gases, there are many opportunities available for reducing emissions. Examples are given below.

- **Using low-carbon electricity sources, like wind, solar and nuclear:** Electricity generation in the U.S. is currently the second-largest source of our greenhouse gas emissions. Transitioning away from carbon-intensive energy sources (e.g., coal) and using more low-carbon energy sources for electricity generation can reduce emissions from the energy sector.
- **Electrifying vehicles:** Traditional cars that rely on gasoline emit greenhouse gases directly into the atmosphere. While electric cars do not directly emit greenhouse gases, using these vehicles may still involve greenhouse gas emissions, depending on how batteries for the vehicles are manufactured and on how the electricity the cars use is produced. Nonetheless, in much of the U.S., electric cars are already emitting less than are high-efficiency gasoline cars. As more countries adopt renewable energy, carbon emissions associated with electric cars will continue to decrease.[65]
- **Increasing the efficiency of our buildings and appliances:** Reducing the amount of energy used by buildings and appliances reduces the amount of energy we need to produce, and thus reduces greenhouse gas emissions from energy production. Increased efficiency can be accomplished by installing high-performing or ENERGY STAR appliances, windows and lights and by installing better insulation and making buildings more airtight.
- **Restoring forests and wetlands:** People substantially contribute to climate change by altering the land itself, for example by clearing trees and other plants that remove carbon dioxide from the atmosphere. By restoring forests, wetlands and other ecosystems, we can substantially lower atmospheric carbon dioxide concentration.
- **Adopting sustainable agricultural practices:** In the U.S., agriculture accounts for about 9% of greenhouse gas emissions,[66] for example through the use and production of fertilizers; the tilling of soil, which releases carbon into the atmosphere; and the raising of livestock such as cows and sheep, which have digestive systems that produce high amounts of greenhouse gases. Modifying the amount of fertilizer used, soil practices and how livestock are raised, among other sustainable agricultural practices, can help reduce greenhouse gas emissions.[67]

Many of these steps to reduce carbon emissions bring additional benefits. Increasing the energy efficiency of buildings and appliances can save homeowners and businesses money by lowering utility bills. This is what inspired Colby May to start a nonprofit organization that conducts energy assessments for churches in the hopes this will free up more money for missionary efforts. Electrifying vehicles could improve air quality and public health, while restoring forests and wetlands could benefit local economies and ecosystems by boosting recreation and tourism. In many cases, there are multiple incentives for reducing our carbon footprint.

With many opportunities, benefits and resources in place, it's possible to substantially reduce reliance on fossil fuels and reduce the amount of greenhouse gasses that enter the atmosphere.

Removing Greenhouse Gases From the Atmosphere

To reduce our carbon footprint more quickly, some scientists and policymakers are increasingly exploring ways to *remove* greenhouse gases from the atmosphere, a process sometimes called geoengineering or climate intervention.

As previously mentioned, proposed methods of removing carbon dioxide from the atmosphere include changing the way we manage land in order to increase the amount of carbon stored in living plants and sediments, for example by reforestation and restoration

of wetlands. Another option, called bioenergy with carbon capture and storage, involves extracting energy from biomass and capturing and storing the carbon. Such approaches involving plant matter require a substantial amount of land, which is finite and must also support biodiversity and our agricultural needs.[68]

Other methods, such as technologies that capture carbon dioxide from the air and store it below ground, are currently too costly, and our understanding of how to chemically trap carbon in rock is not yet sophisticated enough. As scientists and policymakers continue to explore feasible ways to remove greenhouse gases from the atmosphere, it is imperative that society work to reduce how much is emitted in the first place.[69]

Combining Adaptation and Mitigation Approaches

Aggressive action to reduce our greenhouse gas emissions and thus the extent of climate change will reduce the magnitude of adaptation needed to ensure the safety and well-being of our communities. Research consistently shows that adaptation will be more difficult, more costly and less likely to work unless mitigation efforts are taken as well. This relationship between mitigation and adaptation means that the best way to address climate change is to take an integrated approach. Although some communities may begin their climate response efforts by focusing on just one approach, or may make progress more quickly on projects in one area, pursuing a combined strategy will contribute to longer-term resilience.

Adaptation and mitigation approaches are often complementary. For instance, restoring wetlands or planting more trees helps absorb carbon dioxide from the atmosphere (mitigation) — but it can also limit the amount of flooding that residents experience or help keep people in heat-prone areas cooler (adaptation). One example of an agricultural practice that both sequesters carbon dioxide and allows soil to be more resilient to climate change is the application of biochar, a type of plant-based charcoal that can be added to soils to increase nutrient availability and water retention while reducing the amount of carbon released from the soil.

In some cases, adaptation and mitigation strategies can conflict. For example, air conditioners can be used more frequently to help people cope with warmer temperatures, but will result in greater energy usage, which could add more greenhouse gases to the atmosphere and further fuel climate change. Another example is deploying solar arrays, which can help reduce our greenhouse gas emissions but may also require the clearing of land to make space for the systems.

Despite the conflicts that sometimes occur, both adaptation and mitigation are necessary in our response to climate change. Communities should consider the interactions between the two approaches — and how they can build on each other — in their climate assessments and action plans.

Rowdy Yeatts and a colleague search for dung beetles under a cow patty. Dung beetles may help transport biochar deep into the ground, if the substance is fed to cows and then excreted.

Credit: Impact Media Lab / AAAS

ACTING TOGETHER, WE CAN MAKE A DIFFERENCE

ISeeChange ambassador Yasmin Davis gets some help from students to install a rain gauge at a community center in New Orleans, Louisiana.

Credit: Impact Media Lab / AAAS

The impacts of climate change pose a substantial threat to communities across the country. While individuals can make some lifestyle changes that might help them adapt to climate impacts or reduce their own emissions, no single effort will be as effective as collaborative ones. Indeed, at the heart of most solutions to climate change is cooperation and knowledge-sharing within and across communities.

For example, when shellfish hatchery owners on the Northwest Coast joined forces with local scientists from Oregon State University, they were able to work together to salvage a shellfish industry severely crippled by ocean acidification caused by climate change. In New Orleans, local residents experiencing flooding collected data around their homes to support city planners in developing a more resilient community. In Whitefish, Montana, the community has worked together to prepare for changes to its tourism economy and way of life. These stories are unique to each place, but they hold valuable insights and ideas that other communities across the country can learn from. What works in one place may not work as well elsewhere, but we can look to success stories for inspiration and innovation.

Nationwide, there is one tool that everyone can use to address climate change: science can help us both understand the risks that climate change poses to us now and in the future and find solutions. The people addressing climate change are business owners, government officials, nonprofit employees and concerned community members as well as scientists — and they all need knowledge and data to inform decisions and climate action plans. By relying on each other's expertise, skills and resources, we can make our communities stronger and more resilient to a changing climate.

BIBLIOGRAPHY

[1] Leiserowitz, A., et al. (2019). Climate change in the American mind: April 2019. Yale University and George Mason University. New Haven, CT: Yale Program on Climate Change Communication. https://climatecommunication.yale.edu/wp-content/uploads/2019/06/Climate_Change_American_Mind_April_2019c.pdf.

[2] American Association for the Advancement of Science (2014). *What We Know*. http://whatweknow.aaas.org/.

[3] U.S. Global Change Research Program (2018). *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II*. https://nca2018.globalchange.gov/.

[4] Intergovernmental Panel on Climate Change (n.d.). Reports. https://www.ipcc.ch/reports/.

[5] Le Quéré, C., et al. (2018). Global Carbon Budget 2018. *Earth System Science Data*, 10(4), 2141-2194. https://doi.org/10.5194/essd-10-2141-2018.

[6] Dzaugis, M.P., et al. (2018). Frequently Asked Questions. In *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II*. U.S. Global Change Research Program (2018). https://nca2018.globalchange.gov/chapter/appendix-5/#heading-1-2.

[7] Intergovernmental Panel on Climate Change (2019). *Mitigation Pathways Compatible with 1.5°C in the Context of Sustainable Development*. https://www.ipcc.ch/site/assets/uploads/sites/2/2019/05/SR15_Chapter2_Low_Res.pdf.

[8] U.S. Global Change Research Program (2017). *Climate Science Special Report: Fourth National Climate Assessment, Volume I*. https://science2017.globalchange.gov/.

[9] U.S. Global Change Research Program (2018). *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II*. https://nca2018.globalchange.gov/.

[10] Jay, A. et al. (2018). Overview. In *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II*. U.S. Global Change Research Program (2018). https://nca2018.globalchange.gov/chapter/1/.

[11] https://nca2018.globalchange.gov/#sf-1.

[12] https://nca2018.globalchange.gov/chapter/18/.

[13] https://nca2018.globalchange.gov/chapter/19/.

[14] https://nca2018.globalchange.gov/chapter/20/.

[15] https://nca2018.globalchange.gov/chapter/21/.

[16] https://nca2018.globalchange.gov/chapter/22/.

[17] https://nca2018.globalchange.gov/chapter/23/.

[18] https://nca2018.globalchange.gov/chapter/24/.

[19] https://nca2018.globalchange.gov/chapter/25/.

[20] https://nca2018.globalchange.gov/chapter/26/.

[21] https://nca2018.globalchange.gov/chapter/27/.

[22] Centers for Disease Control (n.d.). *Climate Change Decreases the Quality of the Air We Breathe*. Retrieved July 15, 2019, from https://www.cdc.gov/climateandhealth/pubs/AIR-QUALITY-Final_508.pdf.

[23] Caiazzo, F., et al. (2013). Air pollution and early deaths in the United States. Part I: Quantifying the impact of major sectors in 2005. *Atmospheric Environment*, 70, 198-208. https://doi.org/10.1016/j.atmosenv.2013.05.081.

[24] Millstein, D,. et al. (2017). The climate and air-quality benefits of wind and solar power in the United States. *Nature Energy*, 2, 17134. https://doi.org/10.1038/nenergy.2017.134.

[25] https://nca2018.globalchange.gov/chapter/25/.

[26] U.S. Department of Energy (n.d.). *Better Buildings*. Retrieved July 24, 2019, from https://betterbuildingsinitiative.energy.gov/.

[27] NOAA National Centers for Environmental Information (2019). *Billion-Dollar Weather and Climate Disasters: Overview*. Retrieved July 15, 2019, from https://www.ncdc.noaa.gov/billions/.

[28] National Institutes of Building Science (2017). *Natural Hazard Mitigation Saves: 2017 Interim Report*. http://www.wbdg.org/files/pdfs/MS2_2017Interim%20Report.pdf.

[29] Knittel, Nina (2016). *The Costs of Mitigation: An Overview*. http://climatepolicyinfohub.eu/costs-mitigation-overview.

[30] Furman, J., et al (2015). Center for Economic Policy Research. *The cost of delaying action to stem climate change: A meta-analysis*. https://voxeu.org/article/cost-delaying-action-stem-climate-change-meta-analysis.

[31] https://nca2018.globalchange.gov/chapter/28/.

[32] U.S. Climate Resiliency Toolkit (2018). *Climate Explorer*. https://toolkit.climate.gov/tools/climate-explorer.

[33] Sweet, W.V., et al. (2017). Global and Regional Sea Level Rise Scenarios for the United States. NOAA Technical Report NOS CO-OPS 083. https://tidesandcurrents.noaa.gov/publications/techrpt83_Global_and_Regional_SLR_Scenarios_for_the_US_final.pdf.

[34] U.S. Global Change Research Program (2014). *Climate Resiliency Toolkit*. https://toolkit.climate.gov/.

[35] Columbia Law School's Sabin Center for Climate Change Law (2011). *State and Local Climate Change Resource Center*. Retrieved July 24, 2019, from http://columbiaclimatelaw.com/resources/archived-materials/state-and-local-climate-change-resource-center/.

[36] The American Geophysical Union (2019). *Thriving Earth Exchange*. Retrieved July 24, 2019, from https://thrivingearthexchange.org/.

[37] The National Oceanic and Atmospheric Administration (2019). *Regional Integrated Sciences and Assessments*. Retrieved July 24, 2019, from https://cpo.noaa.gov/Meet-the-Divisions/Climate-and-Societal-Interactions/RISA.

[38] U.S. Department of Agriculture (2019). *USDA Climate Hubs*. Retrieved July 24, 2019, from *https://www.climatehubs.oce.usda.gov/*.

[39] U.S. Geological Survey (n.d.). *Climate Adaptation Science Centers*. Retrieved July 24, 2019, from https://www.usgs.gov/land-resources/climate-adaptation-science-centers.

[40] University of Minnesota press release (2018). The Berlin Seminar: An innovative exchange to advance clean energy. Retrieved July 29, 2019, from http://environment.umn.edu/press-release/berlin-seminar-innovative-exchange-advance-clean-energy/.

[41] U.S. Climate Resiliency Toolkit (2018). *Climate Explorer*. https://toolkit.climate.gov/tools/climate-explorer.

[42] National Oceanic and Atmospheric Administration (n.d.). *Storm Events Database*. Retrieved July 24, 2019, from https://www.ncdc.noaa.gov/stormevents/.

[43] NOAA National Centers for Environmental Information (n.d.). *Climate at a Glance: Global Mapping*. Retrieved July 24, 2019, from https://www.ncdc.noaa.gov/cag/.

[44] U.S. Global Change Research Program (n.d.). *USGCRP Indicator Platform*. Retrieved July 24, 2019, from https://www.globalchange.gov/browse/indicators.

[45] The National Drought Resilience Partnership (n.d.). *U.S. National Drought Portal*. Retrieved July 24, 2019, from https://www.drought.gov/drought/.

[46] Multi-Resolution Land Characteristics Consortium (2016). *National Land Cover Database*. https://www.mrlc.gov/.

[47] The National Oceanic and Atmospheric Administration (2017). *State Climate Summaries*. https://statesummaries.ncics.org/.

[48] The National Oceanic and Atmospheric Administration (n.d.). *Sea Level Rise Viewer*. Retrieved July 24, 2019, from https://coast.noaa.gov/digitalcoast/tools/slr.html.

[49] Climate Central (n.d.). *Surging Seas*. Retrieved July 24, 2019, from http://sealevel.climatecentral.org/.

[50] Partnership for Resilience and Preparedness (n.d.). *Visualizing data to build climate resilience*. Retrieved July 24, 2019, from https://prepdata.org/.

[51] Lempert, R., et al. (2018). Reducing Risks through Adaptation Actions. In *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II*. https://nca2018.globalchange.gov/chapter/28/.

[52] The U.S. Environmental Protection Agency. *Federal Funding and Technical Assistance for Climate Adaptation*. Retrieved July 15, 2019, from https://www.epa.gov/arc-x/federal-funding-and-technical-assistance-climate-adaptation.

[53] The U.S. Environmental Protection Agency. *Smart Growth Technical Assistance Programs*. Retrieved July 15, 2019, from https://www.epa.gov/smartgrowth/smart-growth-technical-assistance-programs.

[54] https://nca2018.globalchange.gov/chapter/28/.

[55] A Better City (n.d.). *Updating the Boston Climate Action Plan*. Retrieved July 24, 2019, from https://www.abettercity.org/news-and-events/blog/updating-the-boston-climate-action-plan.

[56] Martinich, J., et al. (2018). Reducing Risks through Emissions Mitigation. In *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II*. https://nca2018.globalchange.gov/chapter/29/

[57] We Are Still In (2017). *We Are Still In*. Retrieved July 24, 2019, from https://www.wearestillin.com/

[58] https://www.cdp.net/en.

[59] Heeter, J., et al. (2017). Charting the Emergence of Corporate Procurement of Utility-Scale PV. NREL/TP-6A20-69080. National Renewable Energy Laboratory, Golden, CO, 43 pp. https://www.nrel.gov/docs/fy17osti/69080.pdf.

[60] The U.S. Environmental Protection Agency (2019). *Inventory of U.S. Greenhouse Gas Emissions and Sinks*. https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks.

[61] Harvey, C. (2019). CO_2 Emissions Reached an All-Time High in 2018. *Scientific American*. Retrieved July 24, 2019, from https://www.scientificamerican.com/article/co2-emissions-reached-an-all-time-high-in-2018/.

[62] Rhodium Group (2019). *Preliminary US Emissions Estimates*. https://rhg.com/research/preliminary-us-emissions-estimates-for-2018/.

[63] https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks.

[64] Intergovernmental Panel on Climate Change (2019). *Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems*. https://www.ipcc.ch/report/srccl/.

[65] Hausfather, Z. (2019). Factcheck: How electric vehicles help to tackle climate change. *Carbon Brief*. https://www.carbonbrief.org/factcheck-how-electric-vehicles-help-to-tackle-climate-change.

[66] https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks.

[67] Climate Focus (2014). *Strategies for Mitigation Climate Change in Agriculture*. https://climatefocus.com/publications/strategies-mitigating-climate-change-agriculture.

[68] The National Academies of Science (2019). Negative Emissions Technologies and Reliable Sequestration. *The National Academies Press*. https://doi.org/10.17226/25259.

[69] Ibid.

Report and community spotlights available online: https://howwerespond.aaas.org

Alan Barton, manager of Whiskey Creek Shellfish Hatchery, overlooking Netarts Bay. The pipes draw water from the bay into the hatchery for filling the tanks. In the past, the water was used directly from the bay. Today, the hatchery has to buffer all of the water for use.

Credit: Impact Media Lab / AAAS

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