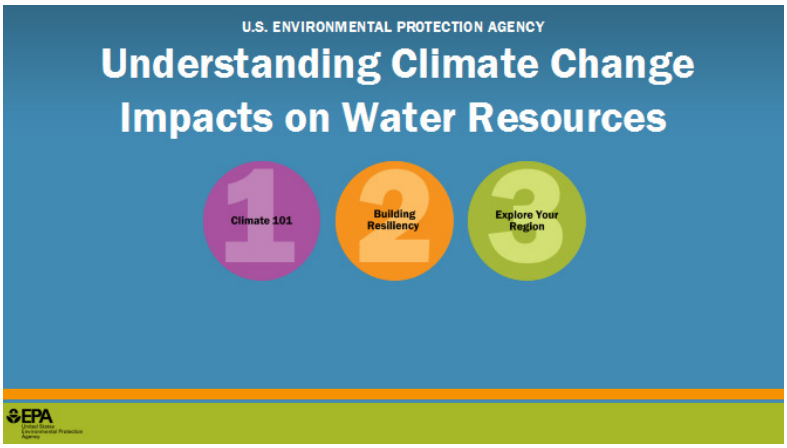
Transcript for Understanding Climate Change Impacts on Water Resources

Below is the transcript for the Understanding Climate Change Impacts on Water Resources course.

Introduction

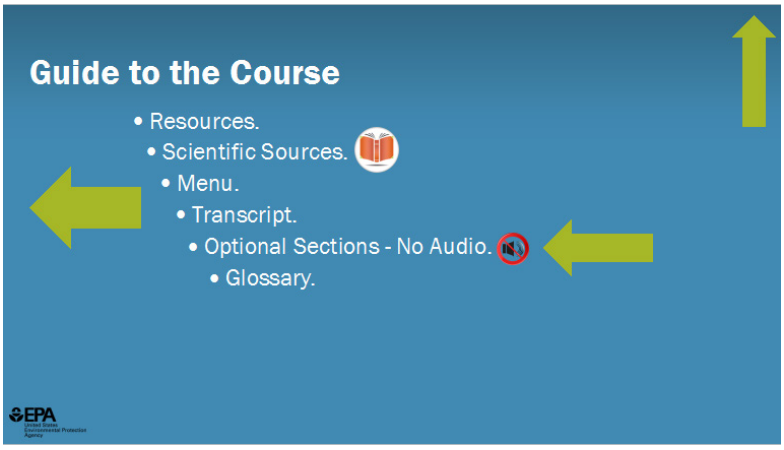


Notes:

Welcome to the U.S. Environmental Protection Agency's training on Understanding Climate Change Impacts on Water Resources in the United States.

This training module is intended to increase your understanding of the causes of climate change, its potential impacts on water resources, and the challenges water resource managers are facing. You also will learn about how water resource managers are working to make the United States more resilient to the impacts of climate change. This training focuses on the clean water and drinking water programs that EPA implements in cooperation with state, tribal, and local governments.

Guide to the Course



Notes:

Before we get started, let me explain how to navigate this course.

The course contains three parts which will take about 45 minutes to complete. Optional supplementary information on climate change impacts in the United States is included at the end of the course if you are interested in more details. You will also be asked to complete three short quizzes during the course.

I refer to a number of references and sources throughout the course. You can always pause the course and access these references by clicking on the Resources Tab on the upper-right side of the course player.

Because there is quite a bit of data presented in this course, we have provided a source book icon on many slides. You can click on the icon using your cursor to open the source information for that slide. To make the source information disappear, you just need to click the cursor outside of the source information box.

I'd also like to point out that, while this course is intended to be completed from start to finish, we hope that you will use it as a reference after you become more familiar with the material. If you need a refresher on one or more parts of the course, click on the topic you'd like to view from the Menu.

A copy of the transcript for this course can be found under the Transcript Tab.

All required portions of the course will have audio however, there are optional portions of the course that will not have audio. You will need to open the Transcript Tab for these sections and read the material. These slides are noted with a volume icon.

In addition, a copy of the glossary can be found under the Glossary Tab. The glossary contains terms that are used in this training.

Finally, you can enlarge many of the images and maps throughout this course by clicking on the text under each image.

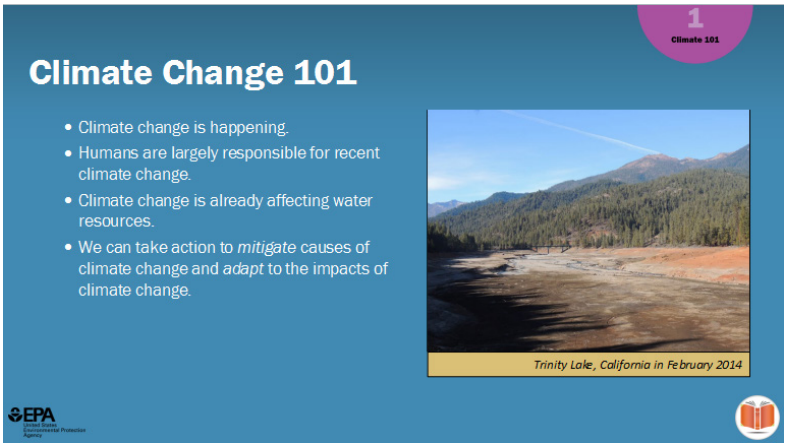
Please click the 'Next' button on the bottom of the course window to advance to the next slide.

Climate Change 101

Notes:

Let's get started with Part 1, Climate Change 101.

Climate Change 101



Notes:

According to the U.S. National Climate Assessment, our Earth is warming. Earth's average temperature has risen by 1.5 degrees Fahrenheit over the past century and is projected to rise another 2-11.5 °F over the next 100 years. Even small changes in the average temperature of the planet can translate into large and potentially dangerous shifts in climate and weather.

Changes to the climate and weather have already presented challenges for water resource managers, and those changes are expected to become more pronounced in the coming decades.

Before we go any further, let's pause to clarify two key terms used in this module.

- *Mitigation,* in the context of climate change, refers to actions taken to reduce emissions of greenhouse gases to the atmosphere.
- *Adaptation* refers to actions taken to build resilience and to adjust to the impacts of climate change on society and the environment.

Scientific Source:
http://nca2014.globalchange.gov/highlights/report-findings/our-changing-climate

Graphic:
Trinity Lake, California in February 2014 - U.S. Geological Survey,
http://ca.water.usgs.gov/data/drought/images/carousel/Trinity-Lake-drought-04Feb2014.jpg

Climate Change 101

Notes:

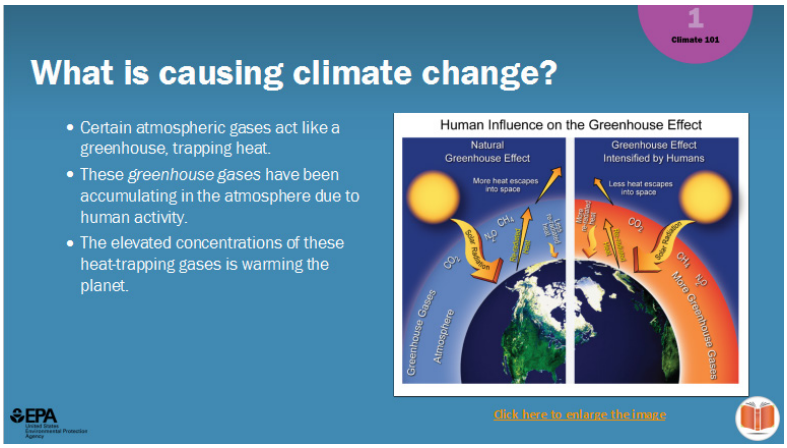
Most people are familiar with the term "global warming" which is defined as "the increase in average temperature near the Earth's surface." In common use, it often refers to the warming that has occurred as a result of increased emissions of greenhouse gases from human activities.

Climate change-which can result from either natural factors or human activities-refers to any significant change in weather patterns lasting for an extended period of time, typically 30 years or longer. Climate change encompasses both increases and decreases in temperature, as well as shifts in precipitation patterns and changes in the level of risk of severe weather events. This includes changes in average conditions as well as extreme conditions.

You might be wondering what the difference is between weather and climate. Weather is the day-to-day conditions of a particular place. Climate, on the other hand, refers to the observed patterns, range of extremes, and frequency of events over time in that place.

Scientific Sources:
http://nca2014.globalchange.gov/highlights/report-findings/our-changing-climate
http://www.globalchange.gov/climate-change/glossary

What is causing climate change?



Notes:

Let's talk about the cause of climate change. When sunlight reaches the Earth's surface, it can either be reflected back into space or absorbed by the Earth. The planet then releases some of the absorbed energy back into the atmosphere as heat. Certain gases are known as "greenhouse gases" because they trap the solar radiation in the Earth's atmosphere, acting much like a greenhouse.

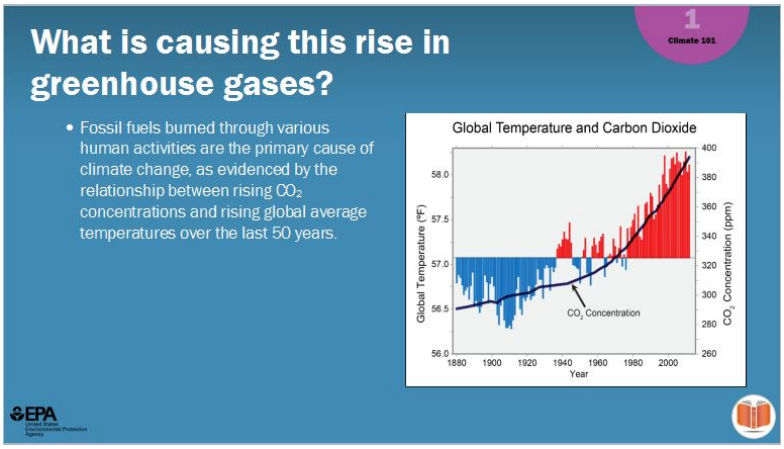
Greenhouse gases are vital to making Earth a habitable planet, but the amounts of the gases in the atmosphere-gases such as carbon dioxide, methane, and nitrous oxide-have been accumulating.

This accumulation of greenhouse gases is causing global average temperatures to rise.

Scientific Source:
http://nca2014.globalchange.gov/highlights/report-findings/our-changing-climate

Graphic:
U.S. Global Change Research Program, Climate Change Impacts in the United States: The Third National Climate Assessment,
http://www.globalchange.gov/browse/multimedia/human-influence-greenhouse-effect

What is causing this rise in greenhouse gases?



Notes:

So what is causing the rise in greenhouse gases?

In the past, climate change was driven exclusively by natural factors such as volcanic eruptions that inject reflective particles into the atmosphere, natural cycles that transfer heat between the ocean and the atmosphere, and natural variations in heat-trapping gases in the atmosphere.

But since the beginning of the Industrial Revolution the burning of coal, oil, and natural gas has increased the concentration of carbon dioxide in the atmosphere by more than 40 percent. Agriculture and other human activities have also added methane and nitrous oxide to the atmosphere.

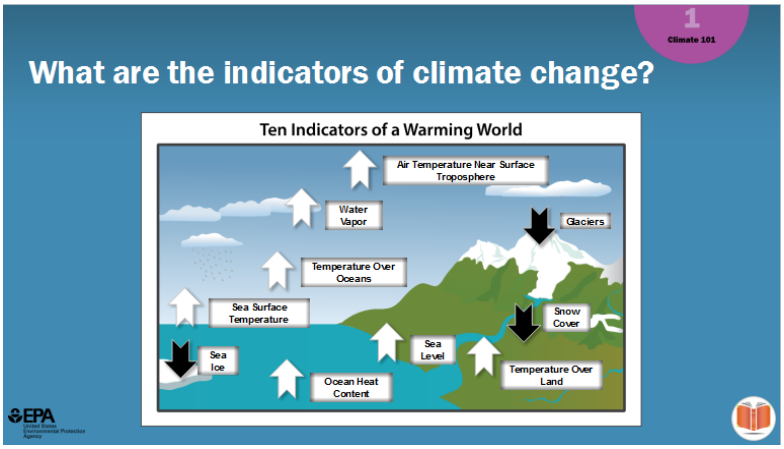
As you can see on this graph, there is a strong relationship between the increase in greenhouse gases and rising temperatures.

Observations of continued warming, and multiple lines of independent evidence, have strengthened confidence in the conclusions that the warming trend is clear and primarily the result of human activities.

Scientific Source:
http://nca2014.globalchange.gov/highlights/report-findings/our-changing-climate

Graphic:
National Climate Assessment; Our Changing Climate -
http://nca2014.globalchange.gov/highlights/report-findings/our-changing-climate#tab2-images

What are the indicators of climate change?



Notes:

Climate change is apparent worldwide and across the United States in a wide range of observations. This graphic illustrates just some of the many indicators that have been measured globally over many decades and show that Earth's climate is changing. White arrows indicate increasing trends, black arrows indicate decreasing trends.

For example:

- Temperatures at Earth's surface, in the troposphere, and in the oceans have all increased over recent decades.
- Snow and ice cover have decreased in most areas.
- Atmospheric water vapor is increasing in the lower atmosphere.
- Sea level is rising.

EPA tracks a set of 30 indicators describing trends related to the causes and effects of climate change. You can view these indicators by clicking on the scientific sources icon on this slide.

Scientific Sources:
http://nca2014.globalchange.gov/highlights/report-findings/our-changing-climate
http://www.epa.gov/climatechange/science/indicators/

Graphic:
National Oceanic and Atmospheric Administration, National Climatic Data Center,
http://www.globalchange.gov/browse/multimedia/ten-indicators-warming-world

What are the observed and projected changes in the U.S.?

Notes:

The U.S. Global Change Research Program has been studying climate change since the organization was formed by Congress in 1990. This cooperative program among federal agencies published the third National Climate Assessment in 2014.

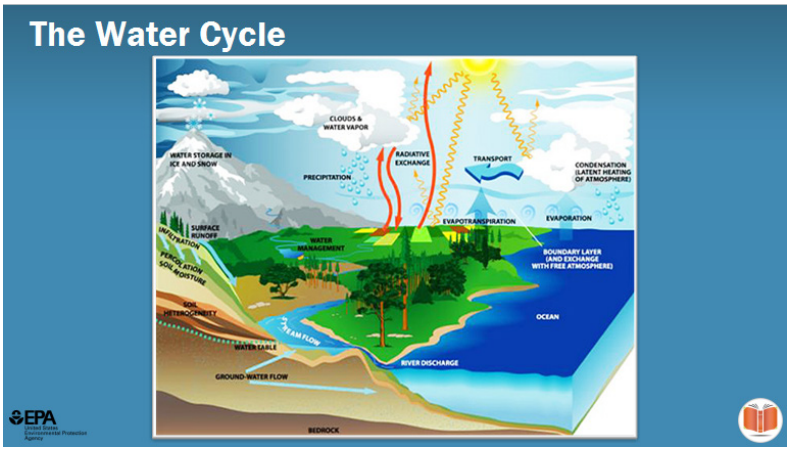
Key conclusions of the assessments are that air and water temperatures are increasing, precipitation patterns are changing, there are increasing incidents of extreme weather, sea level is rising and there are changes in the ocean environment. Furthermore, these changes are projected to continue into the future.

To learn more about these impacts, you can view the supplemental slides at the end of the module titled "Observed and Projected Impacts of Climate Change in the U.S."

Scientific Source:
http://nca2014.globalchange.gov

Graphic:
http://www.globalchange.gov/browse/reports/climate-change-impacts-united-states-third-national-climate-assessment-0

The Water Cycle



Notes:

While temperature is the most widely cited measure of climate change, other aspects of the climate are affected by temperature and are relevant to both society and the natural environment.

For example, when atmospheric temperatures rise, rate of evaporation increases, as does the capacity of the atmosphere to hold water. The result is dryer soils and water loss from reservoirs and waterways, resulting in reduced surface water flows and reduced groundwater recharge.

When it does rain, the increased atmospheric moisture content causes rain to fall in more intense events. This combination results in longer periods of drought punctuated by more intense rain storms.

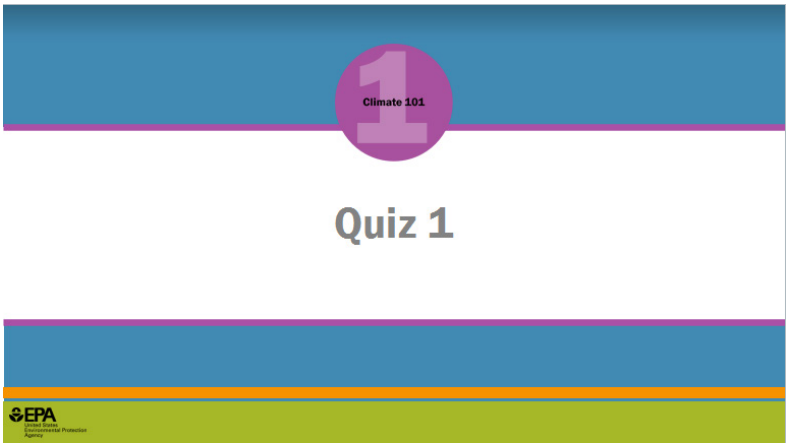
And warmer air temperatures cause water bodies to warm as well. In other words, as the atmosphere warms, the water cycle is intensified resulting in more intense precipitation events, droughts, and other impacts.

These changes from historic norms have implications for water supplies, water quality, public health and safety, and ecological functioning.

Scientific Sources:
http://nca2014.globalchange.gov/report/sectors/water#intro-section-2
http://nca2014.globalchange.gov/report/sectors/water
http://water.usgs.gov/edu/watercycle.html

Graphics:
Our Changing Planet: The Fiscal Year 2003 U.S. Global Change Research Program,
http://data.globalchange.gov/file/d7b7addb-6458-4587-87b4-d82661811e8b

Quiz 1

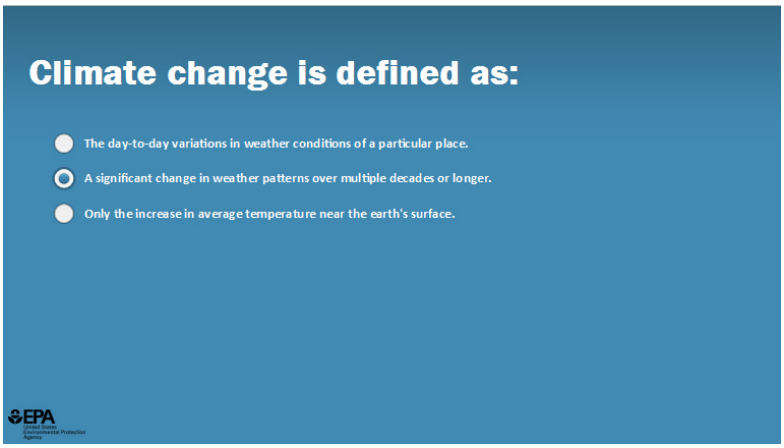


Notes:

Let's stop here and see what you've learned so far.

Quiz 1.1

(Multiple Choice, 0 points, unlimited attempts permitted)



Correct	Choice
	The day-to-day variations in weather conditions of a particular place.
X	A significant change in weather patterns over multiple decades or longer.
	Only the increase in average temperature near the earth's surface.

Feedback when correct:

Weather is the day-to-day variation. Global warming is the increase in temperature near the earth's surface. Climate change is the significant change in weather patterns over multiple decades, typically 30 years or longer.

Feedback when incorrect:

Weather is the day-to-day variation. Global warming is the increase in temperature near the earth's surface. Climate change is the significant change in weather patterns over multiple decades, typically 30 years or longer.

Quiz 1.2

(Multiple Choice, 0 points, unlimited attempts permitted)

Correct	Choice
	They have no effect on climate change.
X	Human activity has been increasing the amounts of these gases in the atmosphere.
	They did not exist in the atmosphere until humans started burning fossil fuels.
	Their concentrations in the atmosphere have not been changed by human activity.

Feedback when correct:

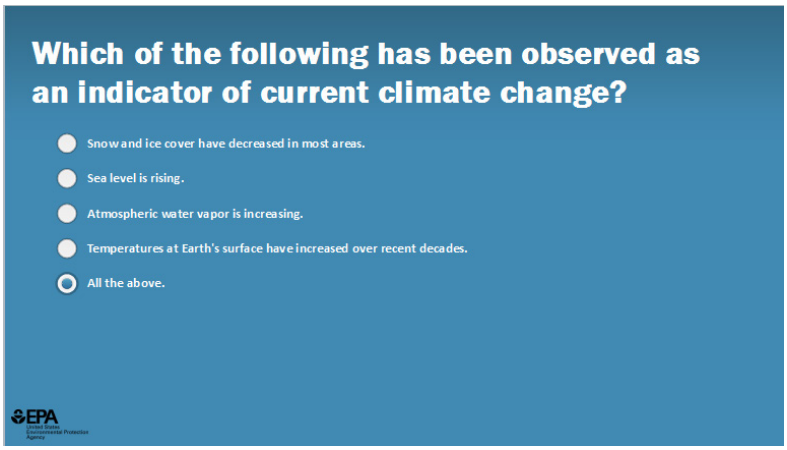
While greenhouse gases are vital to making earth a habitable planet, human activity has been increasing the amounts of these gases in the atmosphere — gases such as CO2, methane, and nitrous oxide — through the burning of fossil fuels and other activities. This accumulation of greenhouse gases is causing global average temperatures to rise.

Feedback when incorrect:

While greenhouse gases are vital to making earth a habitable planet, human activity has been increasing the amounts of these gases in the atmosphere — gases such as CO2, methane, and nitrous oxide — through the burning of fossil fuels and other activities. This accumulation of greenhouse gases is causing global average temperatures to rise.

Quiz 1.3

(Multiple Choice, 0 points, unlimited attempts permitted)



Correct	Choice
	Snow and ice cover have decreased in most areas.
	Sea level is rising.
	Atmospheric water vapor is increasing.
	Temperatures at Earth's surface have increased over recent decades.
X	All the above.

Feedback when correct:

All of these have been observed as indicators of current climate change.

Feedback when incorrect:

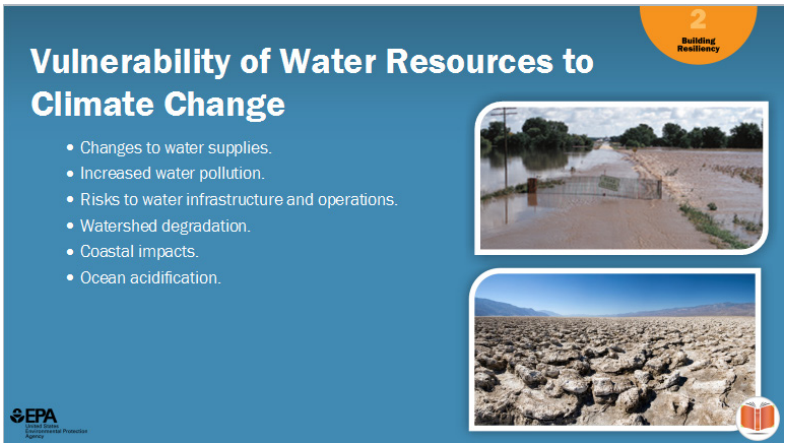
All of these have been observed as indicators of current climate change.

Building Resiliency of Water Resources to Climate Change

Notes:

Now we are ready to start Part 2, Building Resilience of Water Resources to Climate Change.

Vulnerability of Water Resources to Climate Change



Notes:

The vulnerabilities of water resources include: changes to water supplies, increased amounts of water pollution, risks to water and wastewater infrastructure and operations, degradation of watersheds, multiple impacts in coastal areas, and ocean acidification.

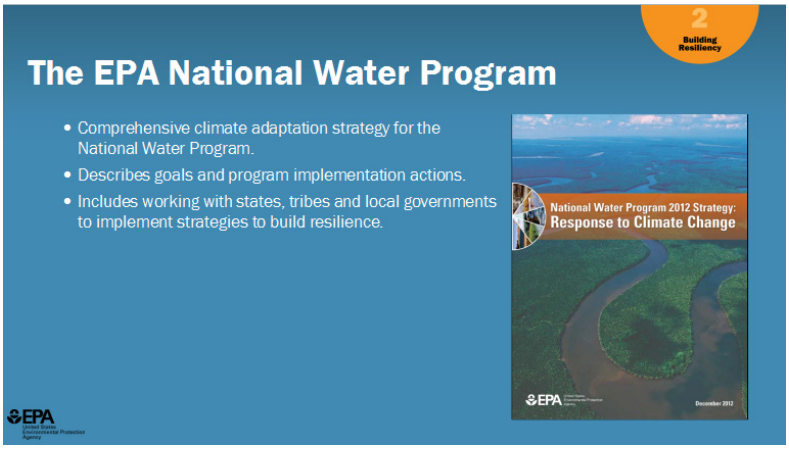
As we discuss the various aspects of vulnerability, keep in mind that climate change will affect different places in different ways, just as weather varies across the country.

Over the next several slides we'll cover the different ways in which water resources can be affected by climate change.

Scientific Source:
http://nca2014.globalchange.gov/report/sectors/water#intro-section-2

Graphics:
Upper: Flooded cropland in southwest Iowa by Keith McCall, USDA NRCS, http://photogallery.nrcs.usda.gov/netpub/server.np?find&catalog=catalog&template=detail.np&field=itemid&op=matches&value=3033&site=PhotoGallery
Lower: Devil's Golf Course in Death Valley, CA, http://www.istockphoto.com/photo/devils-golf-course-in-death-valley-np-11945953?st=5f50600

The EPA National Water Program



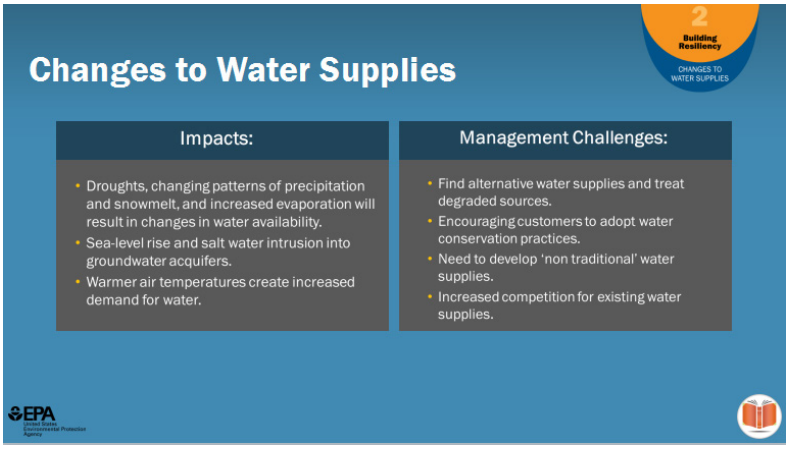
Notes:

As we discuss climate impacts, we will share information on what EPA has been doing to understand and address the risks to water resources posed by climate change. We also will provide specific examples of local adaptation strategies.

The actions described in the following slides are part of a larger, comprehensive strategy adopted by the National Water Program in 2012. We are working to mainstream the science of climate change into everything we do, understanding that the hydrological background upon which our programs function has changed and will continue to change in the future. And to do this, we are working closely with states, tribes and local governments.

This response to climate change by the National Water Program is part of a larger effort by EPA, including development of climate adaptation plans by other EPA national programs and EPA's ten Regional Offices. EPA's climate adaptation work is part of an effort by all Federal agencies to make Federal programs and investments more resilient to climate change risks.

Changes to Water Supplies



Notes:

Many areas of the United States, especially the West, already face water supply issues-due to growing populations, longer droughts, and declining snowpack.

Water supplies in coastal areas are also being affected by sea-level rise and storm surges that foul water sources with saltwater.

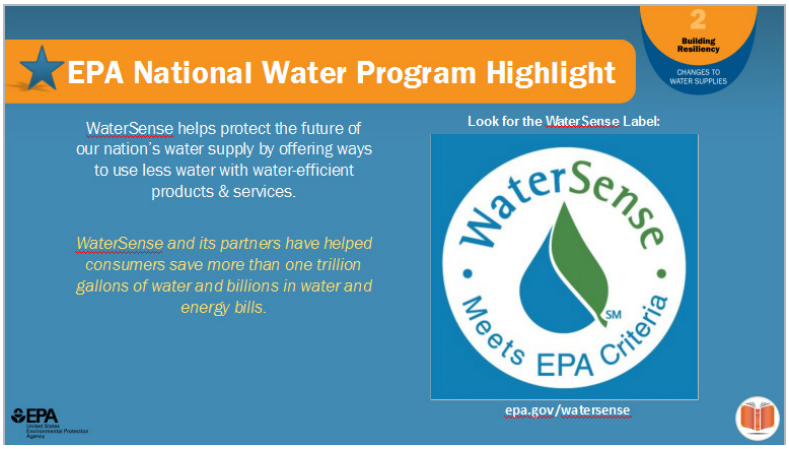
In addition, warmer air temperatures often result in increased demand for water.

Examples of some of the challenges that water managers are facing include:

- Costs to find alternative water supplies or to pay for treating degraded sources;
- Encouraging customers to support water conservation;
- The need to develop, and ensure safe use of, 'non traditional' water supplies such as using water from showers and dishwashers for irrigation or toilet flushing; and
- Increased competition for stressed water supplies between urban demand, agriculture, energy production, and ecological needs.

Scientific Source:
http://nca2014.globalchange.gov/report/sectors/water

EPA National Water Program Highlight



Notes:

EPA is working in a number of ways to ensure that people have access to safe water, including conserving water, helping utilities adopt new technologies for water use, and other practices.

For example, EPA's WaterSense program partners with manufacturers, retailers, distributors, and utilities to bring WaterSense-labeled products to the marketplace and make it easy for consumers to purchase high-performing, water-efficient products.

WaterSense also partners with professional certifying organizations to promote landscape irrigation professionals who are trained for water efficiency.

WaterSense and its partners have helped consumers save more than one trillion gallons of water and billions in water and energy bills.

WaterSense resources include:

- Specifications for WaterSense-labeled products for residential indoor, outdoor, and commercial uses.
- Specifications for WaterSense-labeled homes.
- Best management practices for commercial and institutional water efficiency and outdoor water use and,
- Consumer campaigns to engage the public.

Scientific Source:
http://www.epa.gov/watersense/

Colorado Springs, CO Case Study

Notes:

The following case study provides an example of how one utility is rising to the challenge of increasing demand for water and a less predictable pattern of precipitation. Colorado Springs Utilities helped home and business owners significantly reduce their water use through an education campaign that advocated the use of WaterSense-labeled products. The utility provided thousands of WaterSense-labeled product rebates and retrofits to consumers eager to save water and energy.

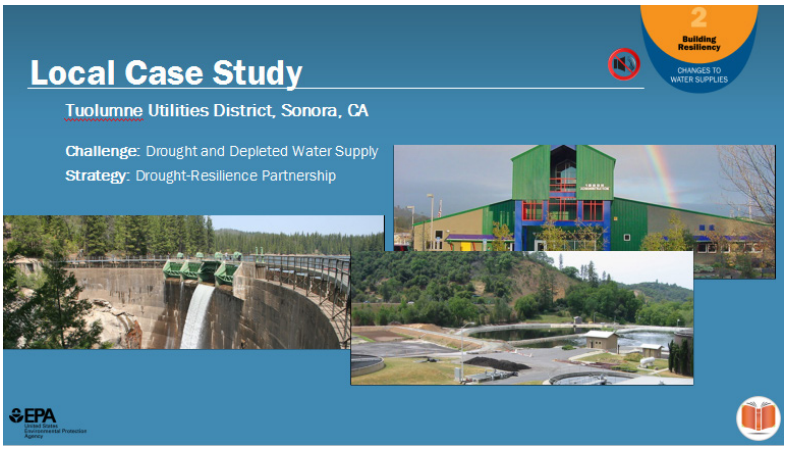
Colorado Springs Utilities hosts a Conservation and Environmental Center that houses a WaterSense showcase and serves as a centerpiece for its outreach efforts, hosting more than 20,000 visitors per year. The showcase displays fully functioning WaterSense-labeled products; a 1-gallon water jug savings comparison between labeled products and less efficient fixtures; and facts about the water, energy, and cost savings achieved with WaterSense-labeled products.

By coupling educational programs with efficient technologies, Colorado Springs Utilities has implemented a successful campaign that will continue to reduce water and energy use for years to come.

The resulting water savings was an estimated 80 million gallons of water in 2013 alone.

Graphics:
Left: Juhan Sonin, www.flickr.com, Creative Commons, https://www.flickr.com/photos/juhansonin/463545370/in/photolist-GXMTy-2xPpBs-aBebK5-c4zmSs-4esZNa-3KudVa-58egJW-ob62Jx-5Kwc2y-sF6uA-qKvLV-4pMnbv-7KY69Y-sF625-8brCnH-dgr9ks-69SQMC-36Birs-te8Jz-sWaUZ-tf2kj-sWbfY-9hKSAQ-dq97m6-74gjvB-nCjZoK-bkjWL-nCjZpM-9kN9Qo-nQJpX5-9hKSrG-duZpUH-9hKSCm-9hKSKf-mQqJY-sWbqu-sQLUC-kposY-76GfY5-4gnE7q-38u7JB-nTwpnd-9eFTod-9tvC4f-nStQgt-nSLboL-ojbctR-nq91G-nCiZvc-sm1H
Middle and Right: Mary, Monterey Bay Aquarium, www.flickr.com, Creative Commons, https://www.flickr.com/photos/42614915@N00/456172287/in/photolist-GXMTy-5HujBx-7b5GBM-Gj18r

Sonora, CA Case Study



Notes:

Here is an example of how a utility in California is dealing with its water shortages.

The Tuolumne Utilities District (TUD) is a water and wastewater district headquartered in Sonora, California. TUD's combined reservoir storage of 24,000 acre-feet typically is significantly depleted each year and then refills as a result of snowmelt and precipitation between the months of November and April. Concern arose in 2013 during the second year of intense drought because precipitation was at 25 percent of the average annual rainfall, coupled with a severely declining snowpack.

By January 2014, based on existing storage, snowpack, and long-range forecasts, TUD began implementing drought response measures.

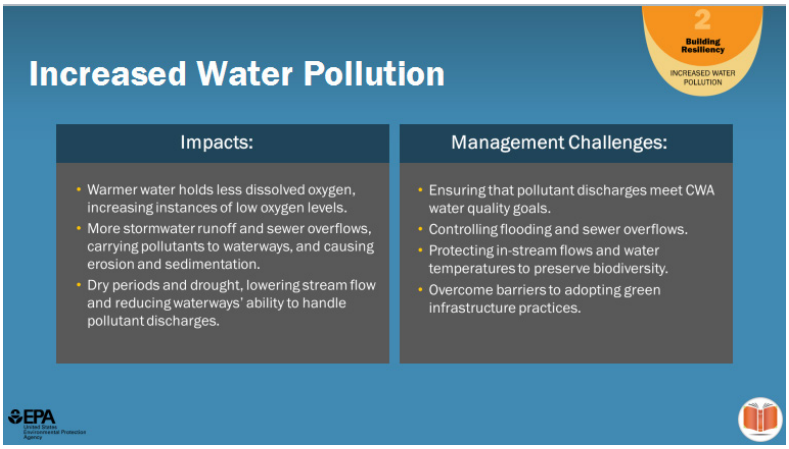
They adopted an overall 50 percent water reduction goal, and prohibited outdoor landscape watering. Public outreach was a critical piece of their success, including contacting individual high water users to ensure that they were aware of restrictions, and a telephone and website hotline to report leaks and excessive use. WaterSense-certified low-flow showerheads and other water efficient fixtures were distributed, and rebates were provided for the purchase of low-flow toilets. The water district also conserves water supplies by recycling 100 percent of its treated wastewater for agricultural irrigation.

By the end of the summer, they had reduced their average summer time water use by 41 percent as compared to 2013 and reduced their total average calendar year water use by 32 percent. TUD has partnered with EPA to create a drought-resilience checklist to help others facing similar issues.

Scientific Source:
http://www.tudwater.com/tud-teams-epa-drought-resilience-project/

Graphics:
Left: Lyons Reservoir, Courtesy of TUD, www.tudwater.com
Middle: Regional Wastewater Treatment Plant in Sonora, Courtesy of TUD, www.tudwater.com
Right: TUD Main Office, Courtesy of TUD, www.tudwater.com

Increased Water Pollution



Notes:

EPA works with states, tribes, and municipalities to implement the Clean Water Act "to restore and maintain the chemical, physical, and biological integrity of the Nation's waters."

But, as we described earlier, climate change is affecting hydrological patterns that are likely to make protecting water quality more difficult. Examples of the water quality impacts include:

- The reduced ability of warm water to hold dissolved oxygen, making instances of low oxygen levels or "hypoxia" more likely. The combination of warm waters, hypoxia, and nutrient pollution can lead to harmful algal blooms.
- More intense precipitation, potentially increasing stormwater runoff and causing sewer overflows.
- Intense rainfall events increasing velocity of stream flow, causing more erosion and sedimentation and,
- Dry periods and drought lowering stream flow and reducing dilution of pollutant discharges.

Water resource managers will need to adopt new strategies to:

- Ensure that Clean Water Act standards and permits can meet water quality protection goals.
- Control stormwater and sewer overflow and,
- Work to preserve biodiversity of species that rely on certain seasonal stream flows or water temperatures.

Scientific Sources:
http://nca2014.globalchange.gov/report/sectors/water
http://nca2014.globalchange.gov/report/sectors/ecosystems

EPA National Water Program Highlight

Notes:

One strategy that many communities are adopting to address the pollution challenges of a changing climate is using green infrastructure to manage stormwater.

Green infrastructure uses vegetation, soils, and natural hydrologic processes to manage stormwater and create healthier urban environments.

Green infrastructure can help build resilience to climate change as different parts of the country become drier, wetter, or hotter. For example:

- Rain gardens, bioswales, and other green infrastructure tools can help reduce localized flooding.
- Green streets, including permeable pavements, let water soak into the ground, watering plants and recharging groundwater supplies.
- Rainwater captured in cisterns and rain barrels reduce use of potable municipal water.
- Trees and green roofs can lower building energy demands and reduce the urban heat island effect.
- Living shorelines act as buffers to reduce the impact of storm surges.

EPA's website has a wide variety of resources, shown here, to help communities adopt these practices.

These resources include:

- Cost-Benefit Resources that demonstrate the triple bottom line benefits of green infrastructure: environmental, social, and financial.
- Funding opportunities for project sponsors to tap a variety of federal funding sources.
- Policy Guides to help select policy and planning strategies.
- Design and Implementation Resources to tailor, install and maintain the design.
- Modeling Tools to assess the performance, costs, and benefits.
- EPA Regulatory Programs that include green infrastructure in stormwater permits and Combined Sewer Overflow enforcement agreements.

Scientific Source:
Green Infrastructure website, http://water.epa.gov/infrastructure/greeninfrastructure/climate_res.cfm

Kansas City, MO Case Study

Notes:

Many communities have sewers that combine both sewage and urban stormwater. With the advent of more intense downpours, controlling overflows of the combined sewers has become a critical issue.

Green infrastructure can help slow down and reduce the amount of stormwater running into sewers.

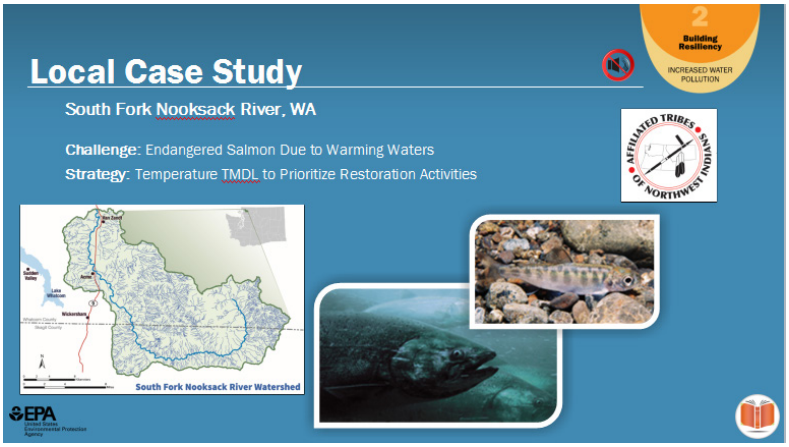
Controlling combined sewer overflows is a priority in Kansas City, Missouri, and they understand that increasingly intense storm events are exacerbating their wet-weather water pollution problem.

Kansas City's Overflow Control Plan incorporates green infrastructure as part of its strategy to capture 88 percent of stormwater and reduce overflow events. In the first pilot project under the plan, a variety of green infrastructure practices were installed in a 100-acre portion of the city. The use of rain gardens, bioretention cells, pervious pavement, and infiltration infrastructure was shown to be a more cost-effective solution than grey infrastructure alternatives. The 25-year implementation plan now includes extensive use of green infrastructure across their service area, involving seven basins covering 58 square miles.

Scientific Sources:
Stormwater Management Model-Climate Adjustment Tool;
http://www.epa.gov/water-research/storm-water-management-model-swmm
National Stormwater Calculator-Climate Assessment Tool;
http://www.epa.gov/water-research/national-stormwater-calculator

Graphics:
Kansas City Water Services
www.kcwaterservices.org

South Fork Nooksack River, WA Case Study



Notes:

The Nooksack Indian Tribe in northwest Washington State relies on salmon for subsistence, commercial, cultural, and ceremonial purposes. Salmon also are a protected species under the Endangered Species Act. Yet, in 2013, a mere 200 adult Chinook salmon out of an estimated population of more than 10,000 returned to the South Fork Nooksack River for the spring spawning season. A significant factor contributing to the serious decline was warming waters in the river, driven in part by climate change.

EPA scientists have partnered with the Nooksack Indian Tribe, Lummi Nation, Washington State Department of Ecology, and other Federal agencies to explore ways in which to better understand the dynamics of the warming waters and help offer solutions to restore the threatened salmon runs.

The researchers are developing a way to account for the impacts of climate change on hydrology and its effects on salmon, and are evaluating the effectiveness of stream restoration actions that can be taken to reduce risks to salmon populations.

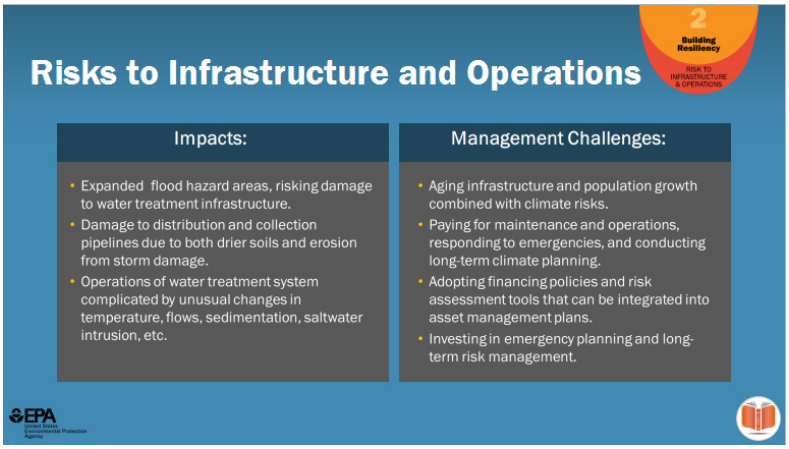
This will lead to a prioritized list of actions that resource managers can incorporate into plans to protect and restore wild salmon populations being affected by climate change. Partnering with tribal communities ensures that they are incorporating traditional ecological knowledge into their findings.

The research is putting climate change adaptation into a real-world problem-solving context. It is not a story that is unique to this one location or this particular salmon run; so what we learn in this watershed can be scaled and repeated to help other watersheds faced with similar challenges.

Scientific Sources:
http://cfpub.epa.gov/si/si_public_record_report.cfm?dirEntryId=307432
http://cfpub.epa.gov/si/si_public_record_report.cfm?dirEntryId=288533

Graphics:
Small Fish: Juvenile Chinook by Roger Tabor, U.S. Fish and Wildlife Service
Large Fish: Josh Larios, https://commons.wikimedia.org/wiki/File:Chinook_salmon1.jpg

Risks to Infrastructure and Operations



Notes:

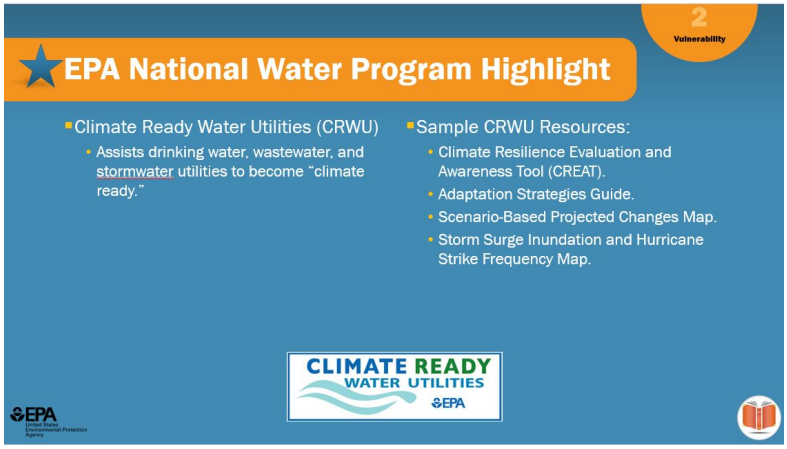
If water is the lifeblood of a community, water infrastructure is the circulatory system. Water infrastructure is the conduit that delivers fresh supplies and carries away and treats wastes.

Unfortunately, we have already witnessed some of the effects of climate change on water infrastructure-from sudden impacts of storms and flooding of treatment facilities, to the slower moving impacts of long-term drought that affect availability of water supplies.

To manage climate impacts, water managers will need to adopt policies and practices that integrate planning for climate change into their overall management plans and invest in emergency response planning.

Scientific Sources:
http://nca2014.globalchange.gov/report/sectors/water
http://nca2014.globalchange.gov/report/regions/coasts
http://www.epa.gov/climatechange/adaptation/index.html
http://www.epa.gov/climate-change-water-sector/planning-and-management-programmatic-response-climate-change-and-water

EPA National Water Program Highlight



Notes:

The EPA Climate Ready Water Utilities (CRWU)-the acronym is pronounced “crew”-assists drinking water, wastewater, and stormwater utilities in becoming “climate ready.”

CRWU has been working with water utilities and climate experts to develop several tools to help water utility mangers in communities of all sizes. One of our most notable tools is the Climate Resilience Evaluation and Awareness Tool (or CREAT).

EPA also has a variety of resources to help increase the sustainability of infrastructure, including improving energy efficiency.

A few of these resources are listed here.

Sample CRWU Resources:

- Adaptation Strategies Guide.
- Scenario-Based Projected Changes Map.
- Storm Surge Inundation and Hurricane Strike Frequency Map.
- Sustainable Infrastructure-including energy efficiency at water utilities.

Scientific Sources:
http://www.epa.gov/crwu
http://www.epa.gov/sites/production/files/2015-04/documents/sustainable_practices_utilities_roadmap_crwu.pdf

South Monmouth, NJ Case Study

Notes:

How is it that, when Superstorm Sandy hit New Jersey in October 2012, the South Monmouth Regional Sewerage Authority sustained no appreciable damage to their Sea Girt Pump Station? Other sewage plants and pump stations along the coast were inundated by flood waters and without power for as long as three days, resulting in the discharge of about 2 billion gallons of untreated and partially treated sewage into New Jersey waterways.

In 2006, the Authority used EPA’s Climate Resilience Evaluation and Awareness Tool to determine that there was the risk of repeated flooding. Without substantial funding to build a new facility, they devised

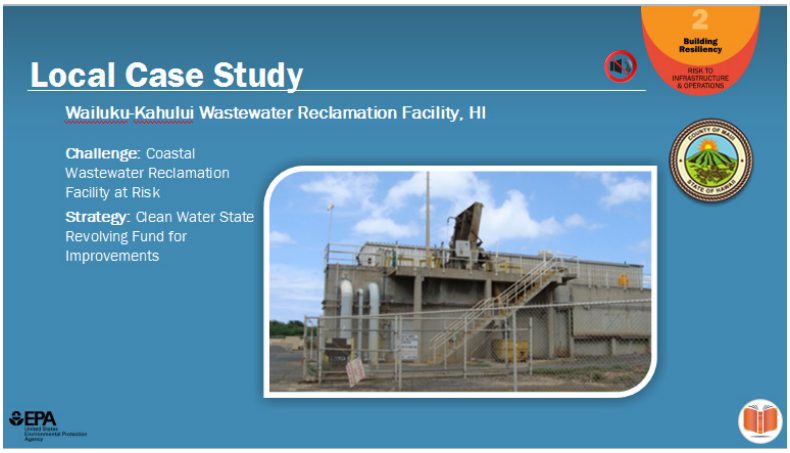
an innovative solution: to house their most sensitive equipment in a mobile trailer. Subsequently, as Superstorm Sandy approached, the trailer was moved and replaced with an expendable generator that enabled the facility to remain operational until the generator was damaged or destroyed. When the storm subsided, the trailer was moved back into place and the generator was put back online, allowing for cost savings and minimal downtime.

The result was that the sewerage authority saved $1.5 million in potential damage, and had no loss of sewer service to residents and no sewer service overflows.

Scientific Sources:
http://www.onewaterohio.org/docs/1300._EPAs_Climate_Resilience_Evaluation_and_Awareness.pdf
Video: https://www.fema.gov/media-library/assets/videos/86134
https://www.fema.gov/news-release/2013/11/21/sewerage-authority-mitigation-plan-reduces-risk-environmental-disaster

Graphics:
http://www.smrsa.org/
https://www.fema.gov/sites/default/files/images/femaphotosrosannaarias-9926_medium_9.jpg

Wailuki-Kahului, HI Case Study



Notes:

In many ways, Pacific Islands face the brunt of climate change impacts. Tropical cyclones, unpredictable precipitation patterns, and sea-level rise are just a few of the climate challenges they face.

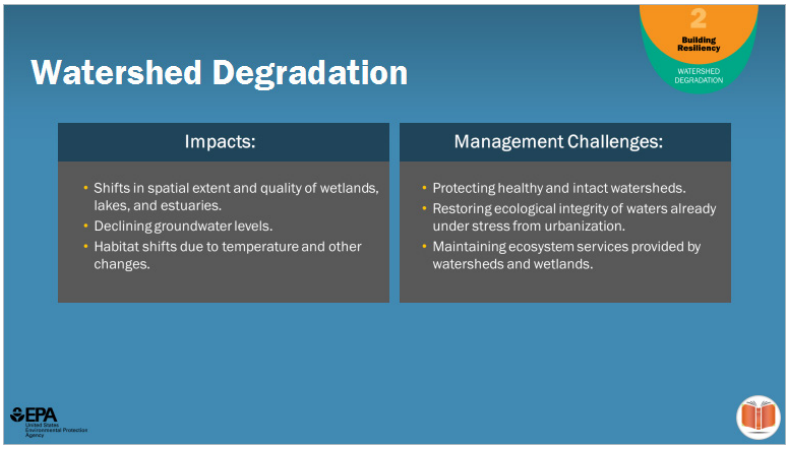
Located close to the ocean, the Wailuku-Kahului Wastewater Reclamation Facility in Hawaii is an example of an important coastal facility at risk. Recognizing these risks, Maui County, the operator of the facility, studied its vulnerabilities and determined that structural modifications, repairs, and reinforcement of the facility were needed. The county used the Clean Water State Revolving Loan Fund to help finance facility improvements to adapt to the long-term effects of climate change. This included constructing a new second floor room and moving all electrical components to that level. An extended foundation for the facility also was built. The county also constructed a revetment designed to absorb the energy of tidal flows and guard against erosion.

These measures ensure the continued operation of the facility during extreme weather, and ensure that the facility can remain functional for many years under various sea-level rise scenarios.

Scientific Source:
Wailuku-Kahului; http://files.hawaii.gov/dlnr/meeting/submittals/140411/K-2.pdf

Graphic:
Kahului Wailuku Wastewater Treatment Plant, Juan Rivera, County of Maui, Wastewater Reclamation Division
http://mauinow.com/2012/09/20/shoreline-protection-proposed-at-kahului-wastewater-facility/

Watershed Degradation



Notes:

Watersheds provide benefits to humans known as "ecosystem services," which include buffering shorelines, absorbing flood waters, and providing clean drinking water. Watersheds are stressed by urbanization and pollution, making them less resilient to climate change.

These stressors, combined with changes in climate, affect watersheds in a number of ways:

- Changes in precipitation and increased evaporation are likely to change flows to lakes and streams, affecting the extent and quality of wetlands, lakes, and estuaries.
- Declining groundwater levels due to withdrawals and reduced recharge are likely to reduce stream flows.
- Temperature and other changes will affect habitat for certain species, such as cold-water fish.

Water managers are working to protect and restore natural systems including buffering the impacts of climate change so we can continue to reap the benefits of these services.

Scientific Sources:
http://nca2014.globalchange.gov/report/sectors/water
http://nca2014.globalchange.gov/report/sectors/ecosystems

EPA National Water Program Highlight

Notes:

EPA created the Healthy Watersheds Program to provide a holistic protection approach to addressing threats to watershed health, including loss and fragmentation of aquatic habitat, hydrologic alteration, invasive species, and climate change.

In addition, Recovery Potential Screening is a systematic desktop tool that can be used to identify differences and set priorities among watersheds that might influence their relative likelihood to be successfully restored or protected.

The Watershed Index Online is an EPA website and database that hosts a library of hundreds of watershed indicators that include ecological condition metrics, stressor metrics, and social metrics to help when using other tools like the Healthy Watersheds Program and Recovery Potential Screening.

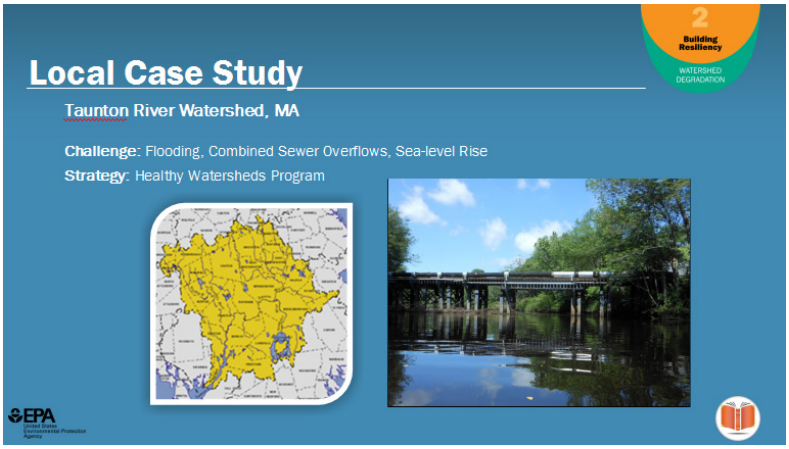
All these watershed tools can be used to offset the potential impacts of climate change by:

- Remediating water quality impairments.
- Maintaining baseflow during periods of drought.
- Reducing Flooding.
- Maximizing surface water and groundwater recharge.
- Abating water temperature extremes.
- Preserving habitat corridors for species migration, and
- Restoring and protecting native vegetation and soils.

Scientific Sources:
http://water.epa.gov/polwaste/nps/watershed/
http://www.epa.gov/rps/
http://gispub.epa.gov/wsio/

Graphic:
Photo by Tetra Tech, Inc., Fairfax County, VA

Taunton River, MA Case Study



Notes:

As the longest undammed river in the region, the Taunton River in Southeastern Massachusetts forms a unique ecosystem and is designated a National Wild & Scenic River. Climate change is already affecting the Taunton River watershed in a variety of ways, threatening the attributes that make the river and its watershed special to residents and visitors.

In the past 50 years, heavy precipitation events have increased 67 percent, increasing flooding and threatening water quality. Over the past 100 years, sea level has risen ¾ of a foot in the Narragansett Bay and is projected to increase more, further impacting the Taunton River watershed.

To ensure the long-term health of this watershed in the face of climate change, EPA's Healthy Watersheds Program, worked with partners to develop a comprehensive climate adaptation plan.

The plan calls for a network of watershed-scale green infrastructure, including a network of working lands, urban forests, bioswales, riparian buffers, and urban stormwater management. Protecting and restoring blocks of habitat and the corridors that connect them improves watershed resilience while reducing flooding and combined sewer overflows that impact water quality.

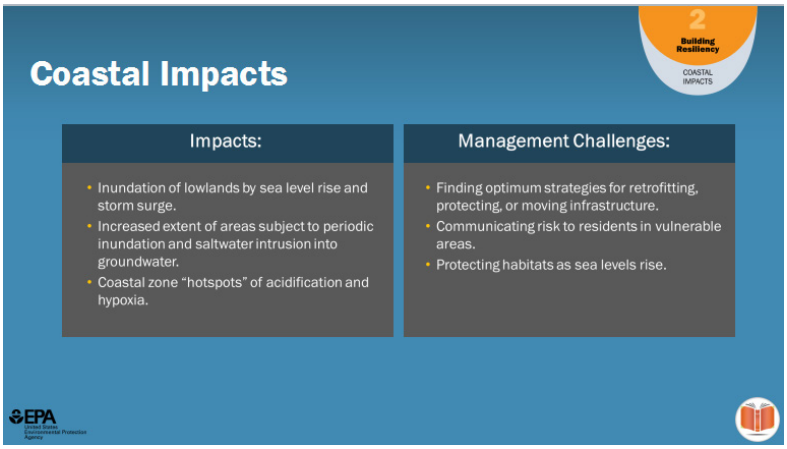
Over the long term, the adaptation plan calls for the protection of prime agricultural soils to foster new agricultural opportunities while preventing an increase in impervious surfaces.

The Taunton River watershed exemplifies how to use a variety of approaches to design a robust, yet adaptable, response to climate change.

Scientific Sources:
https://www.manomet.org/sites/default/files/publications_and_tools/Taunton_Watershed%205-13.pdf
http://kresge.org/sites/default/files/Uploaded%20Docs/Manomet%20CCS.pdf

Graphics:
Left: Taunton River Watershed, USGS,
https://en.wikipedia.org/wiki/Taunton_River_Watershed#/media/File:Taunton_River_Watershed.gif
Right: Railroad Bridge over Taunton River near Dean Street, Taunton, Massachusetts, by Marbela,
https://en.wikipedia.org/wiki/List_of_crossings_of_the_Taunton_River#/media/File:Taunton_River_third_RR_bridge.JPG

Coastal Impacts



Notes:

Coastal resources, ranging from water infrastructure to fisheries, are increasingly vulnerable to sea-level rise, storm surge, erosion, flooding, and related hazards.

Examples of coastal impacts include:

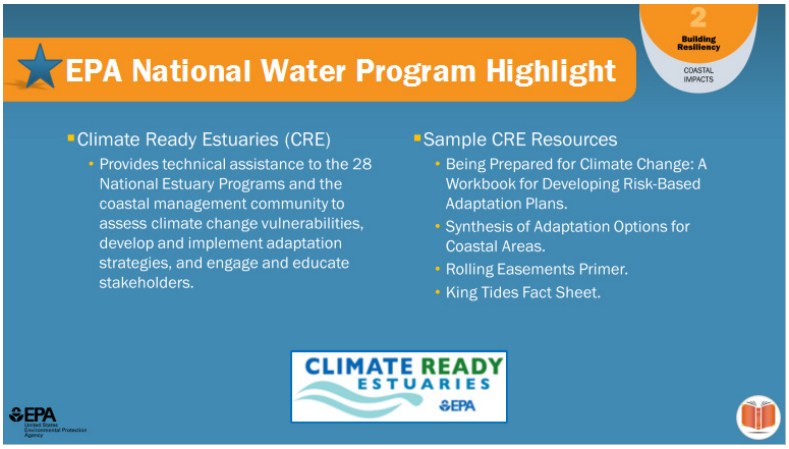
- Rising sea levels moving shorelines by inundating lowlands, displacing wetlands, and altering tidal ranges.
- Storm surges, combined with sea-level rise, increasing the areas subject to periodic inundation and saltwater intrusion into groundwater and,
- Water pollution and increased absorption of carbon dioxide creating coastal zone "hotspots" of acidification and hypoxia.

Managers are being challenged to find optimum strategies for retrofitting, protecting, or moving infrastructure.

They must also find ways to better communicate risk to residents in vulnerable areas and protect habitat as sea levels rise.

Scientific Source:
http://nca2014.globalchange.gov/report/regions/coasts

EPA National Water Program Highlight



Notes:

The Climate Ready Estuaries program provides technical assistance to coastal program managers around the country to help them assess climate change vulnerabilities, develop and implement adaptation strategies, and engage and educate stakeholders.

Since its inception in 2007, CRE has conducted many pilot projects that have informed the development of several tools and guidance, including the ones listed on this slide.

The Climate Ready Estuaries program focuses on the 28 estuaries in EPA's National Estuary Program. Each of these local programs addresses climate challenges in its Comprehensive Conservation and Management Plan (CCMP).

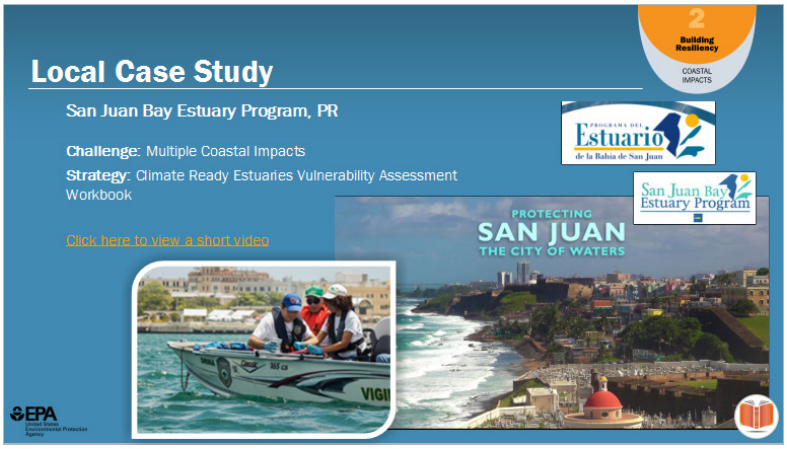
Links to those resources are included under the Resources Tab.

Sample CRE Resources:

- Being Prepared for Climate Change: A Workbook for Developing Risk-Based Adaptation Plans.
- Synthesis of Adaptation Options for Coastal Areas.
- Rolling Easements Primer.
- King Tides Fact Sheet.

Scientific Source:
http://www.epa.gov/cre

San Juan, PR Case Study



Notes:

Residents along the highly valued San Juan Bay in Puerto Rico have become aware of multiple climate change impacts that are affecting both the health of the estuary and their quality of life.

Local leaders decided to use the Climate Ready Estuaries guide, titled: *Being Prepared for Climate Change: A Workbook for Developing Risk-Based Adaptation Plans*. They have supported broad public engagement-which has resulted in identifying 27 high risks to address-and have subsequently instituted projects to increase the resilience of the ecosystem.

At every step, they have involved the community to ensure that local residents are educated and invested in the long-term success of the project. Actions underway include:

- Eliminating sewage discharge and reducing runoff to prevent nutrient and pathogen loading.
- Planting red mangroves and restoring seagrass beds to protect shorelines and to sequester carbon.
- Removing invasive species to facilitate succession of native species and,
- Using “citizen science” to monitor water quality and sea-level rise.

Scientific Sources:
http://water.epa.gov/type/oceb/nep/programs_sjb.cfm
http://www.estuario.org/
http://www.epa.gov/national-aquatic-resource-surveys/national-coastal-condition-assessment

Graphics:
http://water.epa.gov/type/oceb/nep/programs_sjb.cfm
http://sanjuanbayestuary.blogspot.com/

Ocean Acidification: The Other CO2 Problem

Notes:

Ocean acidification is often referred to as "the other carbon dioxide problem." It is not caused by climate change-rather, it is another effect of the increase of CO_2 in the atmosphere.

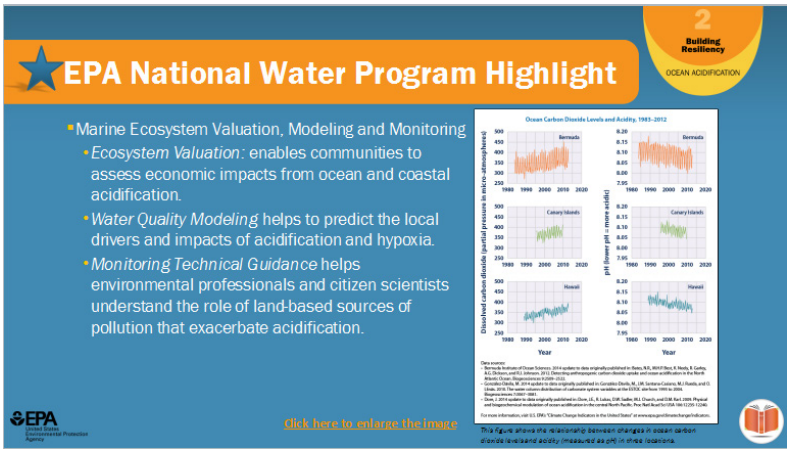
As human-induced emissions of carbon dioxide build up in the atmosphere, excess CO_2 is dissolving into the oceans. The carbon dioxide reacts with seawater to form carbonic acid, lowering ocean pH levels, which is known as "ocean acidification." Other factors such as nutrient pollution from stormwater runoff exacerbate acidification.

Ocean acidification poses several threats to marine ecosystems. Shellfish and corals are sensitive to rising acidity, which makes it difficult for them to create and maintain the skeletal structures they need for support and protection. Scientists are finding as much as 75 percent of the world's coral reefs are threatened by the compounding effects of ocean acidification, overfishing, nutrient pollution, warming waters, and disease.

The bottom line is that ocean acidification is anticipated to bring about significant impacts to our oceans in the coming years.

Scientific Source:
http://nca2014.globalchange.gov/report/our-changing-climate/ocean-acidification

EPA National Water Program Highlight



Notes:

EPA is working with partners to develop tools to monitor and protect marine waters from impacts of acidification.

For example:

- EPA is providing models for valuing marine ecosystem services and assessing economic impacts of acidification. Initial efforts are focusing on impacts in the Gulf of Maine and the Salish Sea.
- EPA is also providing water quality models to assess and predict the local drivers and impacts of acidification and, in some cases, its co-occurrence and interaction with hypoxia.
- In addition, EPA is providing technical guidance for measuring and monitoring acidification in estuarine waters.

This work will help us understand the role of land-based sources (e.g., nutrients) in exacerbating acidification.

Scientific Source:
http://nca2014.globalchange.gov/report/our-changing-climate/ocean-acidification

Graphic:
http://www3.epa.gov/climatechange/images/indicator_downloads/acidity-download1-2014.png

Casco Bay Estuary, ME Case Study

Notes:

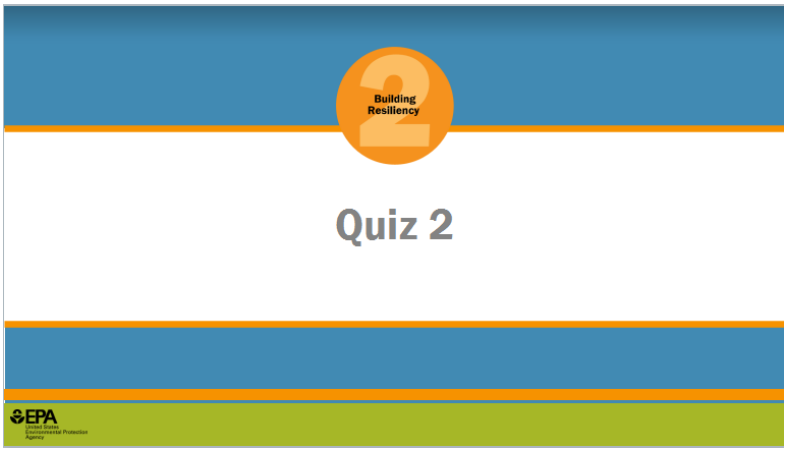
Residents of Portland, Maine, and neighboring communities have been concerned about the declining productivity of clam flats.

In an effort to understand the causes of this decline, the Casco Bay Estuary Partnership is monitoring pH and CO_2 in near-shore waters. This work is being coupled with ongoing studies of nutrient concentrations to better understand how nutrients can exacerbate acidification.

The outcome of this effort will help communities identify cost effective response options.

Graphics:
Left: Sea Snail, Nina Bednarsek, National Oceanic and Atmospheric Administration Pacific Marine Environmental Laboratory,
http://nca2014.globalchange.gov/report/regions/oceans#tab2-images
Middle and Bottom Right: Landscape photo/little boy photo,
http://www.cascobayestuary.org/about-us/
Upper Right: People moving pH monitor, Brian Rappoli, USEPA

Quiz 2

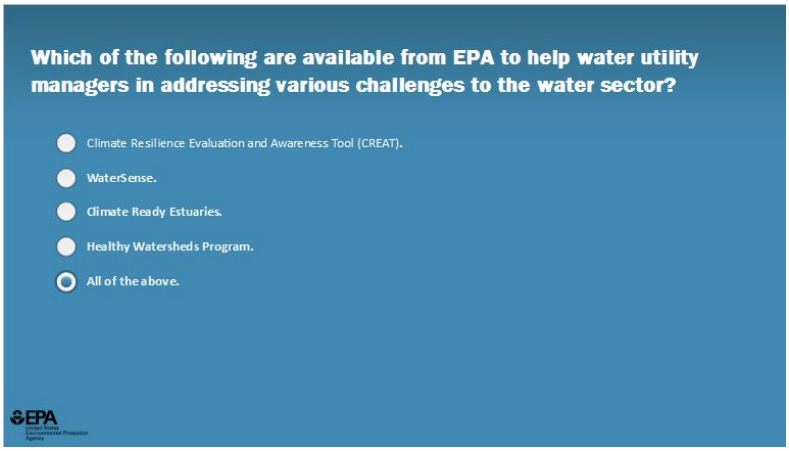


Notes:

We've completed part 2 of the course. Let's take a moment to test your knowledge.

Quiz 2.1

(Multiple Choice, 0 points, unlimited attempts permitted)



Correct	Choice
	Climate Resilience and Awareness Tool (CREAT).
	WaterSense.
	Climate Ready Estuaries.
	Healthy Watersheds Program.
X	All of the above.

Feedback when correct:

The Climate Resilience and Awareness Tool (CREAT) is available to help water utilities evaluate risk. The WaterSense program works with manufacturers, retailers and distributors, and utilities, to bring WaterSense-labeled, water-efficient products to the marketplace. Climate Ready Estuaries (CRE) works with estuaries and coastal programs. The Healthy Watersheds Program assists states to maintain healthy watersheds and habitat corridors.

Feedback when incorrect:

The Climate Resilience and Awareness Tool (CREAT) is available to help water utilities evaluate risk. The WaterSense program works with manufacturers, retailers and distributors, and utilities, to bring WaterSense-labeled, water-efficient products to the marketplace. Climate Ready Estuaries (CRE) works with estuaries and coastal programs. The Healthy Watersheds Program assists states to maintain healthy watersheds and habitat corridors.

Quiz 2.2

(Multiple Choice, 0 points, unlimited attempts permitted)

Correct	Choice
	Trees and green roofs can help lower building energy use, reducing the need to turn up the AC.
	Rain gardens and permeable pavement can help reduce nuisance flooding.
	Rainwater captured in cisterns and rain barrels reduce use of potable municipal water (which also reduces energy used to treat the water).
	Living shorelines act as buffers to reduce impact of storm surges.
	None of the above.
X	All of the above.

Feedback when correct:

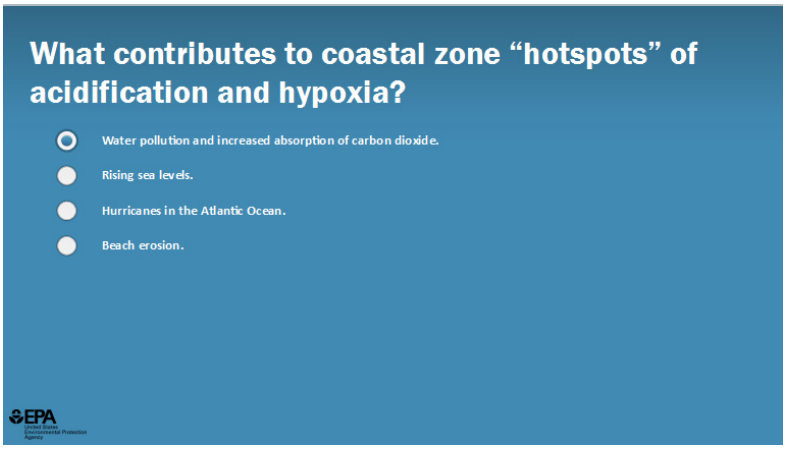
All of the above are climate change related benefits of using green infrastructure.

Feedback when incorrect:

All of the above are climate change related benefits of using green infrastructure.

Quiz 2.3

(Multiple Choice, 0 points, unlimited attempts permitted)



Correct	Choice
X	Water pollution and increased absorption of carbon dioxide.
	Rising sea levels.
	Hurricanes in the Atlantic Ocean.
	Beach erosion.

Feedback when correct:

Correct: Water pollution and increased absorption of carbon dioxide from both the atmosphere and polluted runoff in certain areas can lower the pH of sea water making it more acidic. Polluted runoff containing excess nutrients can create algal blooms that deplete oxygen levels and create hypoxic conditions.

Feedback when incorrect:

Incorrect: Water pollution and increased absorption of carbon dioxide from both the atmosphere and polluted runoff in certain areas can lower the pH of sea water making it more acidic. Polluted runoff containing excess nutrients can create algal blooms that deplete oxygen levels and create hypoxic conditions.

Explore Your Region

Notes:

Climate change impacts vary by geographic region. For this reason, adaptation measures need to address local issues, depending on vulnerabilities and local conditions. In Part 3, you can explore the specific changes to water resources expected in your region as a result of a changing climate.

Explore Your Climate Region

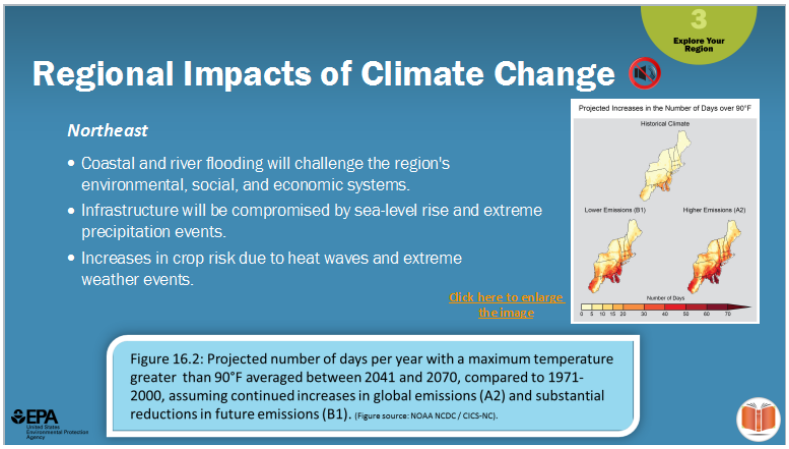
Notes:

To see some of the projected impacts on water resources specific to your part of the country, click on the different regions of the map. You will need to click on the Transcript Tab to read about each region. There is no audio for these optional regional slides. Because they are optional, clicking "Next" below the map slide on this screen skips over the regional slides to take you directly to the Final Test for the course.

This material is provided for your information and is not included in the Final Test.

Graphic:
http://scenarios.globalchange.gov/regions

Regional Impacts of Climate Change: Northeast

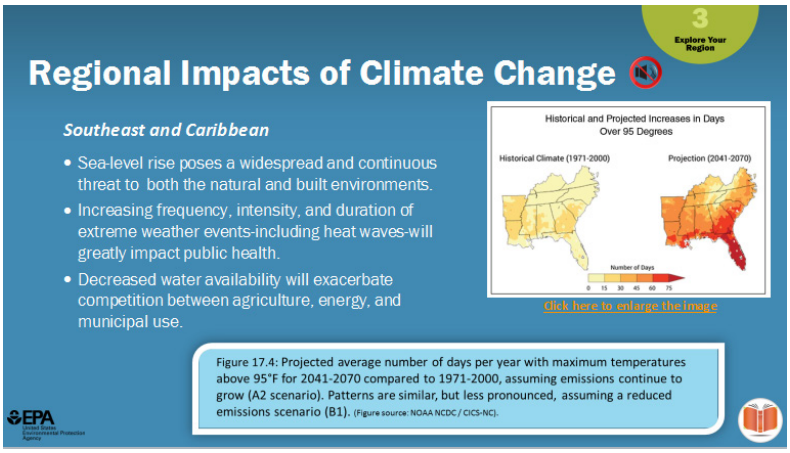


Notes:

In the northeastern United States, climate change will lead to increased coastal flooding due to sea-level rise and extreme precipitation events. Extreme precipitation will increase the frequency and severity of flooding-especially in rivers-which will challenge the region's environmental, social, and economic systems. Infrastructure-especially drinking and wastewater systems-will become increasingly compromised by these climate-related hazards. A longer growing season could result in different crop options; however, crop risk will increase due to more erratic weather conditions.

Scientific Source:
http://www.globalchange.gov/sites/globalchange/files/Regional_NE_V4.pdf

Regional Impacts of Climate Change: Southeast and Caribbean



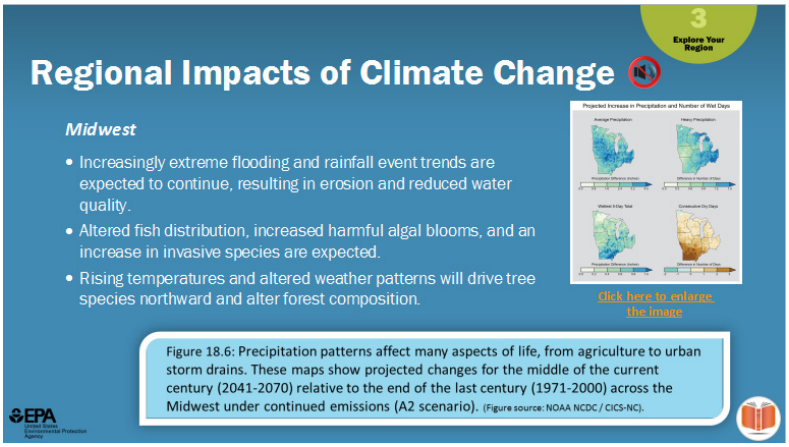
Notes:

Sea-level rise will pose widespread and continuing threats to both the natural and built environments. Impacts of sea-level rise will also have a great effect on the regional economy. Rising temperatures coupled with increasing frequency, intensity, and duration of heat-related events will affect public health, agriculture, forestry, and energy demand, production, and distribution.

Water availability will decline and be worsened by population growth and land-use changes, impacting human and environmental health. Drinking water needs as well as energy, agriculture, forestry, and unique ecosystem needs will be in direct competition over a shrinking supply.

Scientific Source:
http://www.globalchange.gov/sites/globalchange/files/Regional_SE_V2.pdf

Regional Impacts of Climate Change: Midwest



Notes:

Climate change impacts in the Midwest include increased occurrences of extreme weather events-such as droughts, floods, and heat waves-resulting in combined stresses that are expected to decrease agricultural productivity. Longer growing seasons and rising carbon dioxide levels could increase yields of some crops; however, those benefits will be increasingly offset by other climate impacts over time.

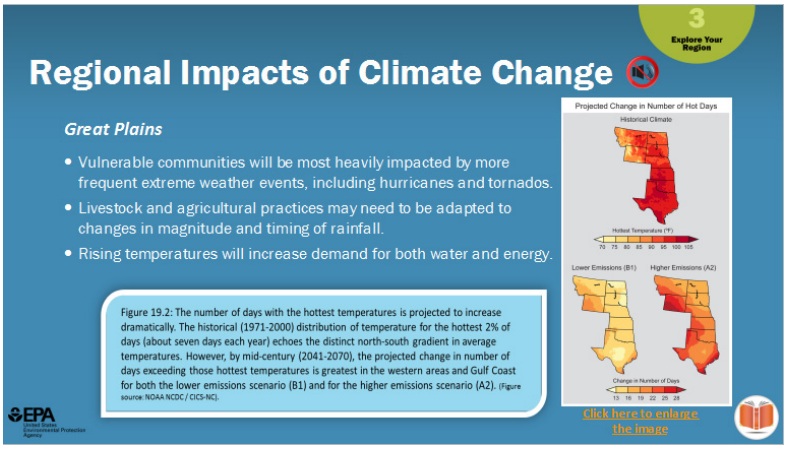
As the climate of the Midwest changes, rising temperatures will drive many species northward, altering the composition of the region's forests. Although the region is a net absorber of carbon, a species migration northward could disrupt ecosystems and the carbon cycling associated with them.

Water and air quality will be negatively impacted by the effects of extreme weather patterns, including drought and heat waves.

- Increased flooding will hasten erosion, impacting wildlife as well as agricultural land.
- In the Great Lakes the range and distribution of fish species are likely to change and invasive species are expected to spread.
- The various impacts are likely to result in declining beach health and harmful algal blooms, which pose a threat to human health.

Scientific Source:
http://www.globalchange.gov/sites/globalchange/files/Regional_MW_V2.pdf

Regional Impacts of Climate Change: Great Plains



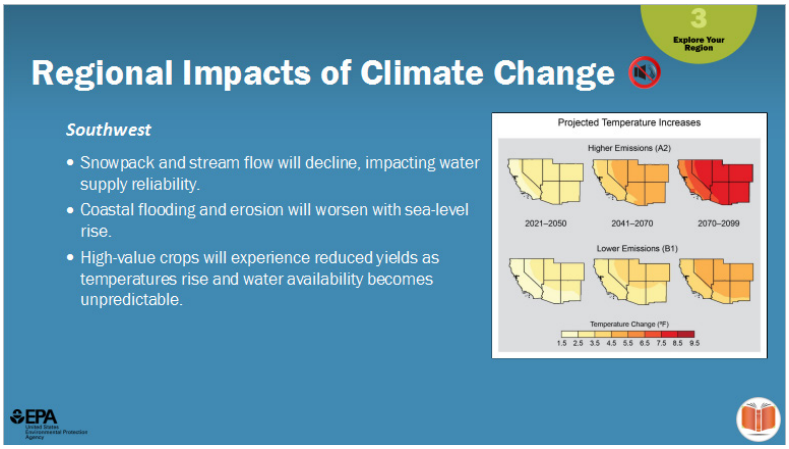
Notes:

Rising temperatures will lead to increased demand for water and energy resources. This will constrain development, increase competition over the limited resources, and impact communities that are already vulnerable to weather and climate extremes. Agricultural systems will change due to warming winters, changes in timing, and magnitude of rainfall, and may require new management practices for both livestock and crop growth.

Energy development in this region coupled with a changing climate will lead to increased landscape fragmentation, which will hinder the adaptation and migration of species when climate change alters habitat and timing of plant development cycles.

Scientific Source:
http://www.globalchange.gov/sites/globalchange/files/Regional_GP_V6.pdf

Regional Impacts of Climate Change: Southwest



Notes:

Declining snowpack and stream flow amounts will decrease water supply for cities, agriculture, and ecosystems. More than half of the nation's high-value specialty crops are currently produced in this region, where they rely on irrigation and are vulnerable to extreme weather conditions, and as a result

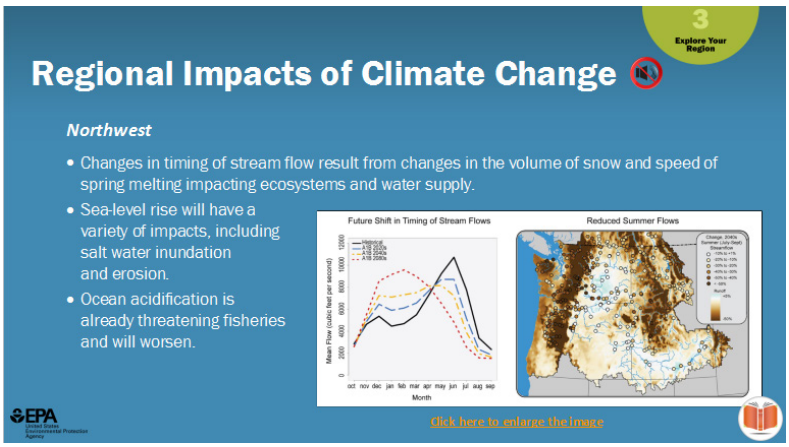
are threatened by climate change. Increased warming and drought will lead to increased wildfires impacting both people and fragile ecosystems.

In coastal areas, flooding and erosion are already damaging some areas of the California coast. As storms and extreme high tides become more common and are coupled with sea-level rise, these effects will impact infrastructure and communities even more.

More than 90 percent of the region's population inhabits cities where temperature increases-coupled with the amplification of heat that occurs in cities-will result in serious impacts to human health and stress on water and energy supplies.

Scientific Source:
http://www.globalchange.gov/sites/globalchange/files/Regional_SW_V2.pdf

Regional Impacts of Climate Change: Northwest



Notes:

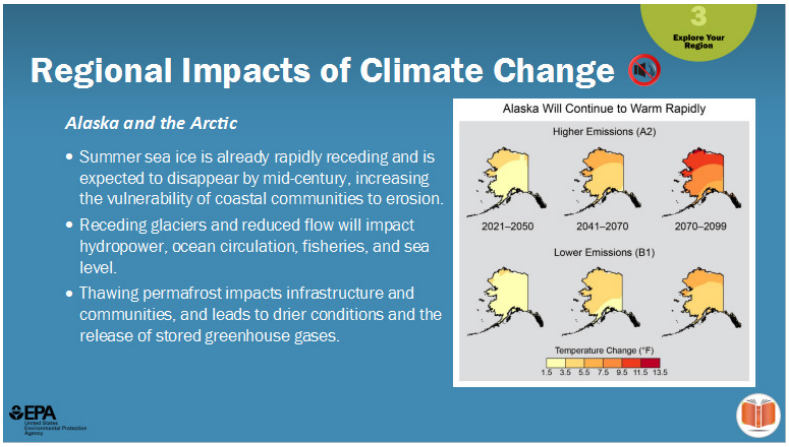
Changes to stream flow, due to the earlier melting, and overall reduction of snowpack will alter the timing and volume of available freshwater. A reduced water supply and increasing water demand will result in ecological and socioeconomic issues.

In coastal areas, sea-level rise will worsen erosion and inundation, threatening infrastructure as well as habitat. Ocean acidification is already impacting marine ecosystems and fisheries and will worsen in the years to come.

With warmer temperatures, insect outbreaks and disease will pose a greater risk to forests. Combined with increased wildfires, forests of the region will change dramatically, including the loss of subalpine forests before the end of the century.

Scientific Source:
http://www.globalchange.gov/sites/globalchange/files/Regional_NW_V2.pdf

Regional Impacts of Climate Change: Alaska and the Artic



Notes:

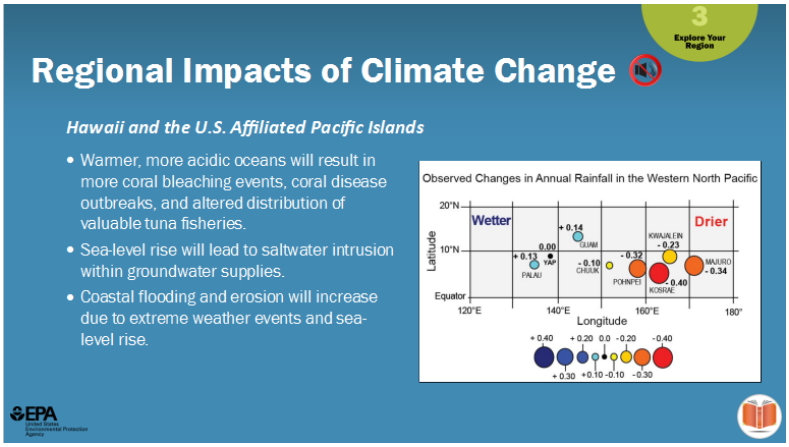
Summer sea ice has been rapidly receding in recent years and is projected to disappear by mid-century. The melting of sea ice greatly impacts marine ecosystems as well as species that rely on the ice for habitat and food. Reduced sea ice will lead to greater ship access and open the possibility of offshore development, which could result in increased environmental degradation. Coastal communities will also be more vulnerable to coastal erosion.

As glaciers shrink, stream flow is altered, impacting hydropower production, ocean circulation patterns, fisheries, and sea level. Melting permafrost impacts infrastructure and can lead to drier landscapes, increased occurrences of wildfires, and the release of formerly trapped greenhouse gases.

The cumulative effects of climate change will strongly affect native communities, which are highly vulnerable due to their close ties to the natural world.

Scientific Source:
http://www.globalchange.gov/sites/globalchange/files/Regional_AK_V2.pdf

Regional Impacts of Climate Change: Hawaii and the U.S. Affiliated Pacific Islands



Notes:

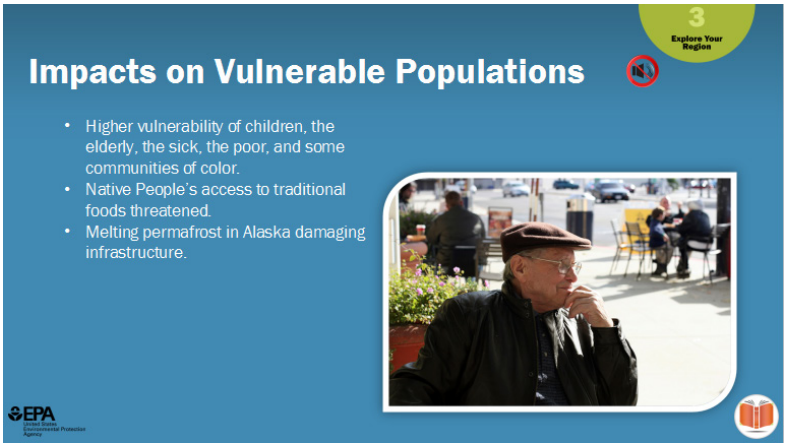
Hawaii and the Pacific Islands are threatened by a host of climate change impacts. Marine ecosystems will be greatly altered and degraded. Rising ocean temperatures are leading to a rise in coral bleaching events as well as outbreaks of disease in coral reefs, degrading and destroying those bio-diverse ecosystems. These changes will affect the distribution of commercially important species such as tuna. In addition, increasing ocean acidification will suppress the growth of coralline algae, corals, and shelled marine species.

Already constrained freshwater supplies will be more limited as aquifers and surface catchments decline in response to drier conditions, unpredictable rainfall, and saltwater intrusion associated with sea-level rise. Reduced supply will have impacts on human health and also on native wildlife, especially in high-elevation ecosystems. The added stress will increase exposure to invasive species and disease and likely result in additional extinctions of rare and endemic species.

Severe weather, including cyclones and tropical storms, will pose a threat to food and water security as well as infrastructure, health, and safety.

Scientific Source:
http://www.globalchange.gov/sites/globalchange/files/Regional_HI_V2.pdf

Impacts on Vulnerable Populations



Notes:

"Social vulnerability" describes populations that are sensitive to climate change impacts and that have limited capacity to prepare for, respond to, and recover from climate change related hazards and disasters. Socioeconomic status, age, special needs, race, and ethnicity as well as geographic location influence adaptive capacity.

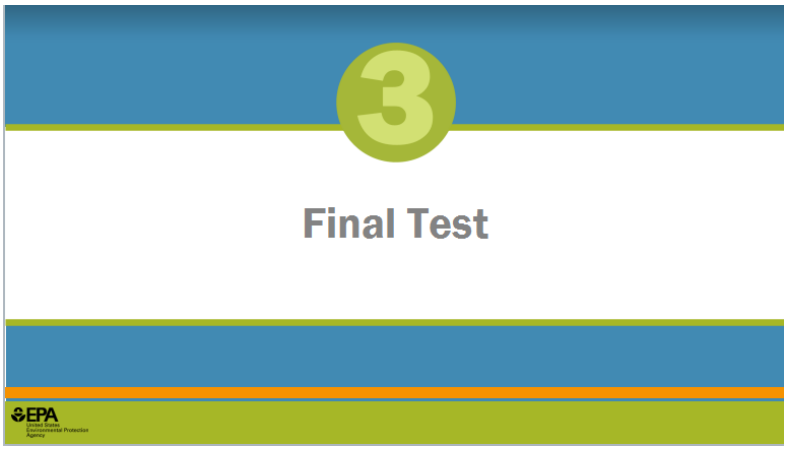
The urban elderly are particularly sensitive as they are often physically frail, have limited financial resources, or live in relative isolation.

Some Native American populations also have higher vulnerability to climate change impacts due to changes in distribution of traditional species that they rely on for a subsistence lifestyle. Native people in places like Alaska are also faced with melting permafrost, declining sea ice, and extreme weather that impact community infrastructure and cultural practices.

Scientific Sources:
http://nca2014.globalchange.gov/report/sectors/urban#narrative-page-10245
http://nca2014.globalchange.gov/highlights/report-findings/human-health

Graphic:
Istockphoto.com

Final Test

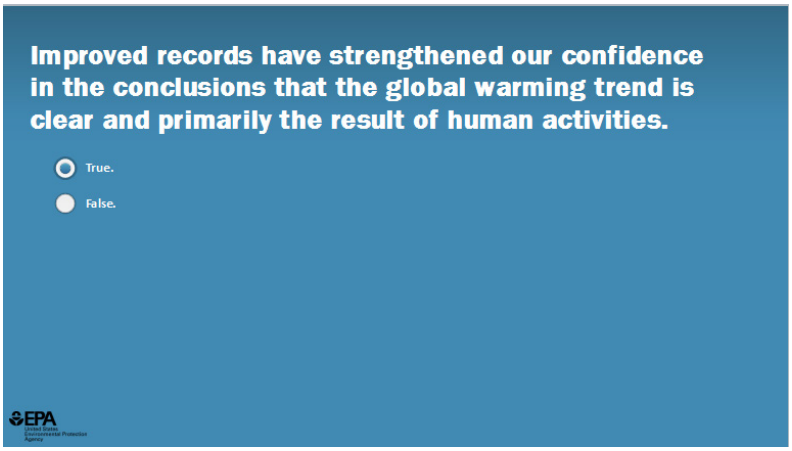


Notes:

Now that you've completed the three parts of the course, let's test your knowledge.

Final Test 1

(True/False, 25 points, 1 attempt permitted)



Correct	Choice
X	True.
	False.

Feedback when correct:

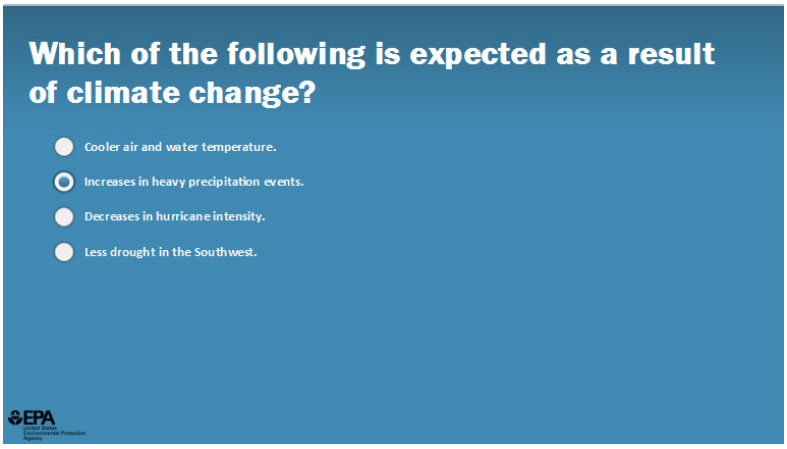
Observations of continued warming and multiple other sources of evidence, have strengthened our confidence in the conclusions that the warming trend is clear and primarily the result of human activities. In fact, multiple lines of independent evidence confirm that human activities are the primary cause of the global warming of the past 50 years.

Feedback when incorrect:

Observations of continued warming and multiple other sources of evidence, have strengthened our confidence in the conclusions that the warming trend is clear and primarily the result of human activities. In fact, multiple lines of independent evidence confirm that human activities are the primary cause of the global warming of the past 50 years.

Final Test 2

(Multiple Choice, 25 points, 1 attempt permitted)



Correct	Choice
	Cooler air and water temperature.
X	Increases in heavy precipitation events.
	Decreases in hurricane intensity.
	Less drought in the Southwest.

Feedback when correct:

More frequent and intense heat waves have been observed in some areas, but cold waves have been less frequent and intense. The intensity of the strongest hurricanes will continue to increase as the oceans continue to warm. Droughts in the Southwest and heat waves everywhere will become more intense.

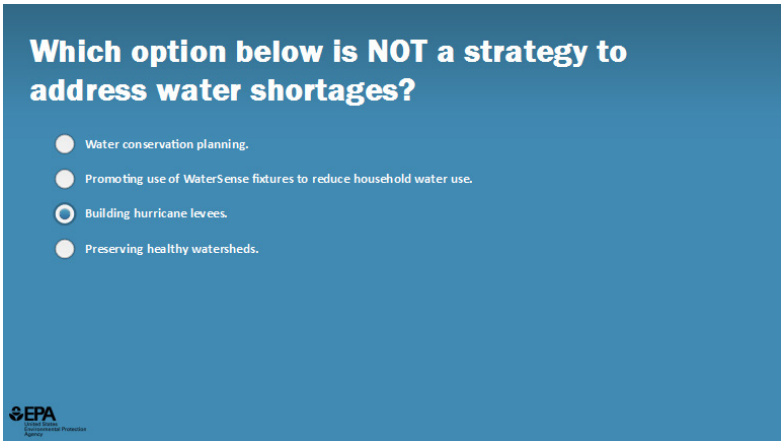
Feedback when incorrect:

More frequent and intense heat waves have been observed in some areas, but cold waves have been less frequent and intense. The intensity of the strongest hurricanes will continue to increase as the

oceans continue to warm. Droughts in the Southwest and heat waves everywhere will become more intense.

Final Test 3

(Multiple Choice, 25 points, 1 attempt permitted)



Correct	Choice
	Water conservation planning.
	Promoting use of WaterSense fixtures to reduce household water use.
X	Building hurricane levees.
	Preserving healthy watersheds.

Feedback when correct:

While hurricane levees can prevent some flooding, they do not address water shortages. Water conservation planning can help identify ways to reduce water use and adjust to shortages. WaterSense fixtures can also reduce water use. Preserving healthy watersheds helps keep drinking water supplies clean.

Feedback when incorrect:

While hurricane levees can prevent some flooding, they do not address water shortages. Water conservation planning can help identify ways to reduce water use and adjust to shortages. WaterSense fixtures can also reduce water use. Preserving healthy watersheds helps keep drinking water supplies clean.

Final Test 4

(Multiple Choice, 25 points, 1 attempt permitted)

Correct	Choice
	Help retain water in the watershed to maintain baseflows.
	Help reduce air and water temperature.
	Protect riparian and stream habitat and provide corridors for species migration.
X	Provide technical assistance to the 28 National Estuary Programs.

Feedback when correct:

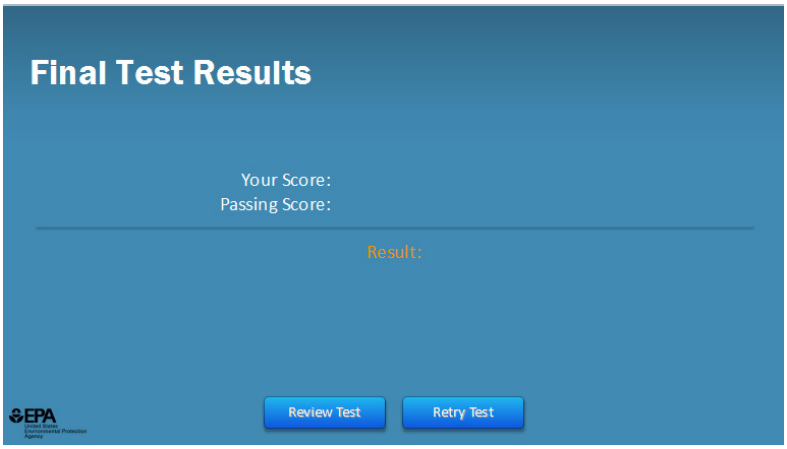
Climate Ready Estuaries is the program that provides technical assistance to coastal managers, focusing on the 28 National Estuary Programs. The Healthy Watersheds Program helps to offset the potential impacts of climate change in a variety of ways, including: maintenance of baseflow during periods of drought, flood mitigation through natural stormwater infiltration and floodplain connectivity, natural surface and groundwater hydraulic storage, air and water temperature regulation, riparian and stream habitat corridors for species migration as well as carbon sequestration in native flora and soils.

Feedback when incorrect:

Climate Ready Estuaries is the program that provides technical assistance to coastal managers, focusing on the 28 National Estuary Programs. The Healthy Watersheds Program helps to offset the potential impacts of climate change in a variety of ways, including: maintenance of baseflow during periods of drought, flood mitigation through natural stormwater infiltration and floodplain connectivity, natural surface and groundwater hydraulic storage, air and water temperature regulation, riparian and stream habitat corridors for species migration as well as carbon sequestration in native flora and soils.

Final Test Results

(Results Slide, 0 points, 1 attempt permitted)

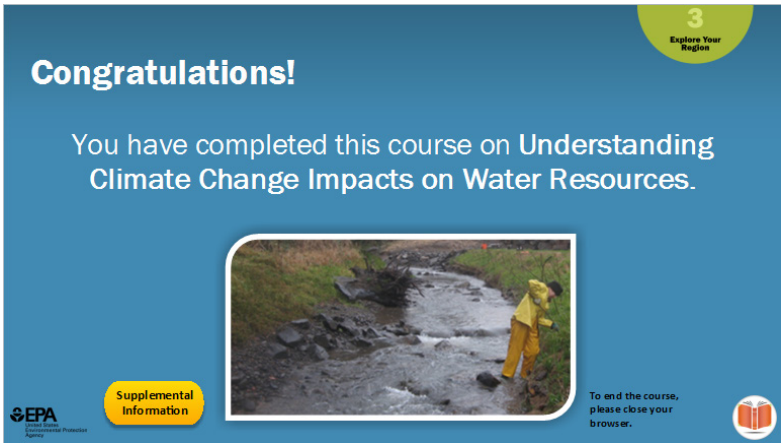


Results for
1.46 Final Test 1
1.47 Final Test 2
1.48 Final Test 3
1.49 Final Test 4

Result slide properties

Passing Score 70%

You Have Completed This Course!



Notes:

That concludes this training module on understanding climate change impacts on water resources. We hope you have gained some insight into this important issue, including what you can do to build resilience in your community. Be sure to check out the additional resources listed in the Resources Tab. The list of additional resources in the Resources Tab includes a link to an additional training entitled: Local Government Climate Adaptation Training. The remainder of the course contains supplemental

information on observed and projected impacts of climate change in the United States. This portion of the course is encouraged but optional.

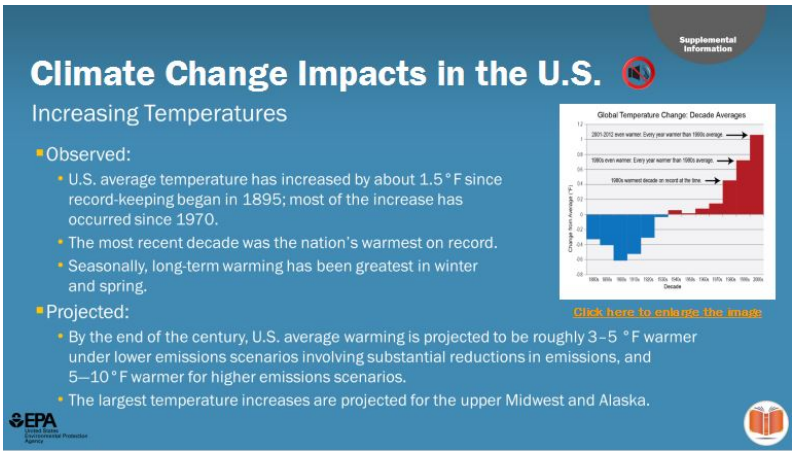
Graphic:
Streambank willow planting in the Johnson Creek Watershed in Portland, OR.
Photo by Tetra Tech.

Supplemental Information

Notes:

This optional section of the course discusses temperature, precipitation, extreme weather, sea level rise and ocean environments specific to the United States.

Climate Change Impacts in the U.S. - Temperature



Notes:

Temperature is one of the most well-understood aspects of climate projections. The U.S. annual average temperature has increased by 1.3-1.9 °F since 1895. The most recent decade was the nation's warmest on record.

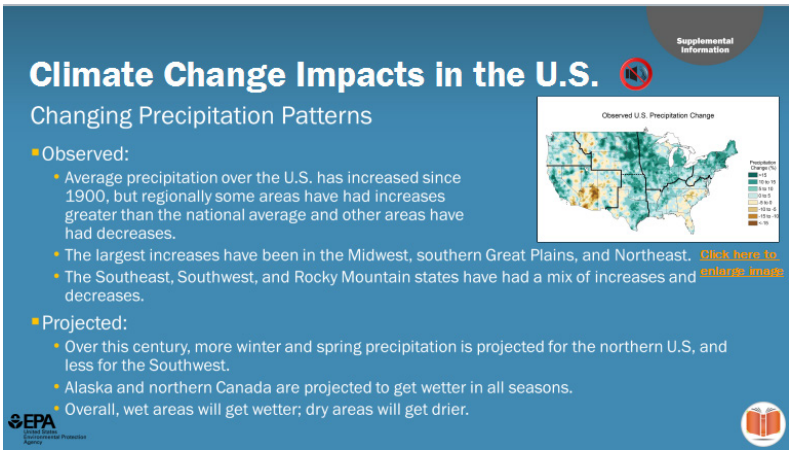
For the rest of this century, warming is ultimately projected for all parts of the nation. In the next few decades, this warming will be roughly 2-4 °F in most areas.

By the end of the century, however, we can expect to experience roughly 3-5 °F warmer under lower emissions scenarios and as much as 5-11 °F warmer for higher emissions scenarios that assume continued increases in emissions.

Scientific Sources:
http://nca2014.globalchange.gov/report/our-changing-climate/recent-us-temperature-trends
http://nca2014.globalchange.gov/highlights/report-findings/our-changing-climate

Graphic:
http://www.globalchange.gov/browse/multimedia/global-temperature-change-decade-averages

Climate Change Impacts in the U.S. - Changing Precipitation



Notes:

As we just discussed, warming temperatures cause other effects on the climate system. One effect they cause is changes in precipitation in general. Since 1900, records indicate that, while there are regional differences, the average annual precipitation over the United States has increased by roughly 5 percent- a direct effect of more evaporation.

It is important to note that, while scientists have detected and can project significant trends in precipitation across the United States, it is much more difficult to quantify projected changes at regional and local scales.

If emissions of heat-trapping gases continue their upward trend, however, certain global patterns of precipitation change are indeed projected to emerge that will affect northern and southwestern areas of the United States due to both a warmer atmosphere (which can hold more moisture than a colder one) and associated changes in large-scale weather patterns (which affect where precipitation occurs).

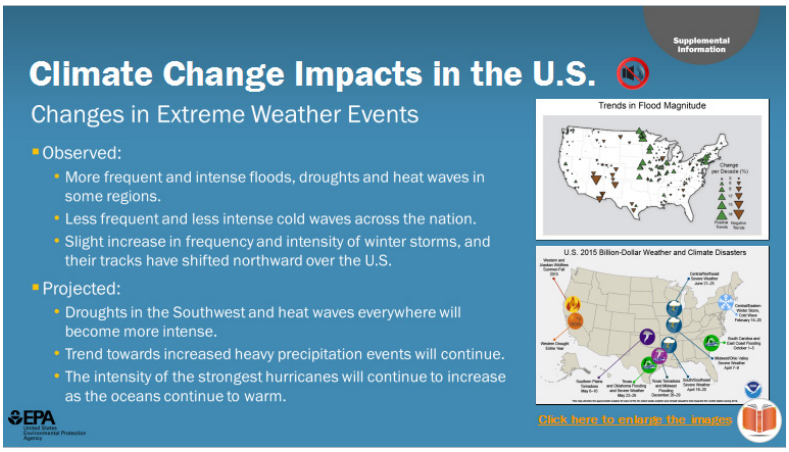
Specifically, the northern United States is projected to experience more precipitation in the winter and spring while the Southwest is projected to experience less.

Further, the contrast between wet and dry areas will increase both in the United States and globally-in other words, the wet areas will get wetter and the dry areas will get drier.

Scientific Source:
http://nca2014.globalchange.gov/report/our-changing-climate/precipitation-change#narrative-page-16568

Graphic:
http://www.globalchange.gov/browse/multimedia/observed-us-precipitation-change

Climate Change Impacts in the U.S. - Extreme Weather



Notes:

There have been changes in some types of extreme weather events over the last several decades, for example:

Heavy downpours have been increasing nationally-especially over the last 30-50 years-and the amount of rain falling on the heaviest rain days also has increased.

There has been an increase in flooding events in the Midwest and Northeast. Heat waves have become more frequent and intense, especially in the West. Cold waves have become less frequent and intense across the nation.

In the future, we can expect the number of extremely hot days to continue to increase over much of the United States, especially by late century:

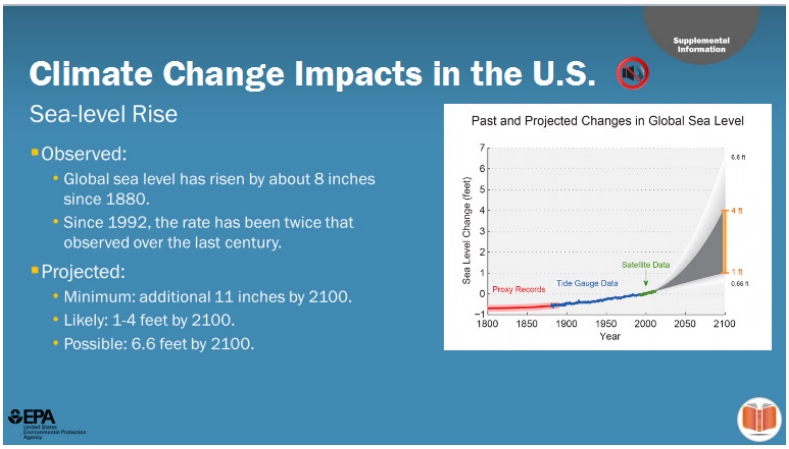
The recent trend towards increased heavy precipitation events will also continue-even in regions where total precipitation is projected to decrease, such as the Southwest.

The intensity of the strongest hurricanes is projected to continue to increase as the oceans continue to warm.

Scientific Source:
http://www.globalchange.gov/explore/extreme-events

Graphics:
http://nca2014.globalchange.gov/sites/report/files/images/web-large/Figure-2.21hi.jpg
http://www.ncdc.noaa.gov/billions/

Climate Change Impacts in the U.S. - Sea-level Rise



Notes:

Sea-level rise is caused by a combination of factors including "thermal expansion," and melting glaciers and ice sheets, as well as local geological factors such as coastal subsidence or uplift.

Since the late 1800s, tide gauges throughout the world have shown that global sea level has risen by about 8 inches.

And, since 1992, the rate of global sea-level rise measured by satellites has been roughly twice the rate observed over the last century.

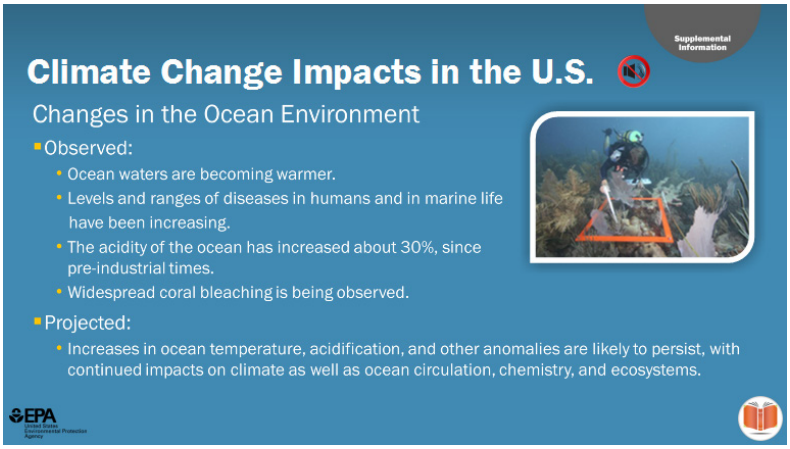
Projecting future rates of sea-level rise is challenging. Nonetheless:

- Recent projections show that, for even the lowest emissions scenarios, thermal expansion of ocean waters and the melting of small mountain glaciers will result in 11 inches of sea-level rise by 2100, even without any contribution from melting ice sheets in Greenland and Antarctica.
- This suggests that about 1 foot of global sea-level rise by 2100 is probably a realistic low end. On the high end, recent work suggests that 4 feet is plausible, and could be as high as 6.6 feet.
- Although scientists cannot yet assign likelihood to any particular scenario, in general, higher emissions scenarios that lead to more warming would be expected to lead to higher amounts of sea-level rise.

Scientific Sources:
http://nca2014.globalchange.gov/report/our-changing-climate/sea-level-rise
http://nca2014.globalchange.gov/report/our-changing-climate/ocean-acidification

Graphics:
http://www.globalchange.gov/browse/multimedia/past-and-projected-changes-global-sea-level-risse

Climate Change Impacts in the U.S. - Changes in the Ocean Environment



Notes:

The ocean is a critical reservoir for heat within Earth's climate system, and because of seawater's large heat-storing capacity, small changes in ocean temperature reflect large changes in ocean heat storage.

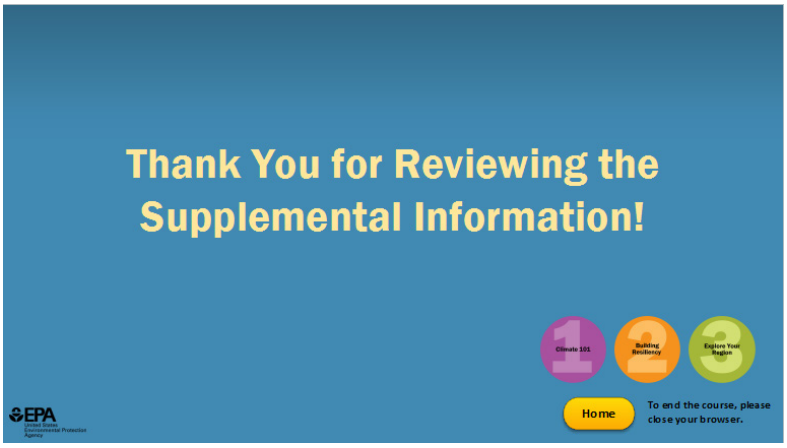
- Direct measurements of ocean temperatures show warming beginning in about 1970.
- Rising sea surface temperatures and thermal anomalies have been linked with increasing levels and ranges of diseases in humans and in marine life.
- In addition, the ocean absorbs about a quarter of human-caused emissions of carbon dioxide annually, thereby changing seawater chemistry and decreasing pH (making seawater more acidic).
- As a result, the acidity of the ocean has increased about 30%, since pre-industrial times.
- Mass coral bleachings are being observed worldwide.

All of these trends are expected to continue, with implications for humans as well as marine life, such as corals, abalones, oysters, fishes, and marine mammals due to the potential disruption of marine food webs.

Scientific Source:
http://nca2014.globalchange.gov/report/regions/oceans

Graphic:
Coral reef survey off the coast of Puerto Rico - EPA Flickr,
https://www.flickr.com/photos/usepagov/7932040500/in/album-72157629017469667/

Thank You for Reviewing the Supplemental Information!



Notes:

You have completed your review of the supplemental information provided in this course. Thank you for taking the time to learn more about the impacts of climate change on water resources. See you next time!