2. Adapting to NC's Changing Climate

Description

This lesson is designed to provide an overview of how North Carolina's climate is changing and the impacts that are being experienced in the state or are projected to happen in the future. Additional focus will include how state and local entities are adapting to current and anticipated changes.

Objectives

- List key ways that North Carolina's climate is changing.
- Describe impacts (observed or projected) that are a result of North Carolina's changing climate (to plants, animals, people, ecosystems, etc.).
- Explain why adaptation is important in the context of climate change.

Learners

Extension Master Gardener Volunteers and other adults interested in climate change in North Carolina.

Lesson Materials

Slide Deck (see https://climate.ncsu.edu/learn/climate-change-lessons/)

Instructor notes (subsequent pages)

Summative Assessment (questions at end of instructor notes)

Lesson Outline

1. Engage

Describe adaptation in the context of climate change and how this supports resilience.

2. Present Content

Presentation on climate changes in North Carolina (observed and projected) and adaptation activities.

3. Support Practice

Small group brainstorming activity on adaptation actions with groups reporting back.

4. Assess Learning

Quiz (questions at end of instructor notes).

5. Reflection

Reflection activity for learners.

Note: Slide deck was developed with Extension Master Gardener Volunteers in mind, but could be readily adapted to other groups.

Adapting to North Carolina's Changing Climate

Instructor Materials and Notes

Title Slide: Adapting to North Carolina's Changing Climate

The aim of this presentation is to examine observed and projected changes to North Carolina's climate and discuss examples of climate adaptations to adjust to our new future.

Adaptation

- The focus of this lesson is on North Carolina's changing climate and steps we will need to take to adapt to current and projected changes. We begin by defining adaptation:
  - *Adaptation refers to actions taken at the individual, local, regional, and national levels to reduce risks from changed climate conditions and to prepare for impacts from additional changes projected for the future.*
- Importantly, adaptation is considered on two timescales:
  - the first is adapting to current climate variability and risks, and knowing that these may already be different than their historical record
  - the second is preparing for the future by anticipating future changes and risks and how we will need to adapt to these.
- A key aspect of adaptation is resilience, which refers to the ability of a system to recover from or adjust to change.

Resilience

U.S. Climate Resilience Toolkit

https://toolkit.climate.gov/

- Adaptation is important because it can increase our resilience to current and future climate-related hazards.
- Watch the video on resilience from the US Climate Resilience Toolkit, embedded on the slide.
- While this video is geared towards those involved in planning and decision making, such as local government, it is also relevant for individuals seeking to learn more about achieving resilience for themselves and/or their communities.
- In this lesson, we'll be loosely moving through the five steps to resilience, starting with a discussion of climate changes and impacts (the first step), brainstorming vulnerabilities and risks (the second step) as well as possible options to adapt to current and projected changes to increase our resilience (step 3). Optional homework at the end of this lesson encourages further exploration of implementable actions (steps 4 and 5).

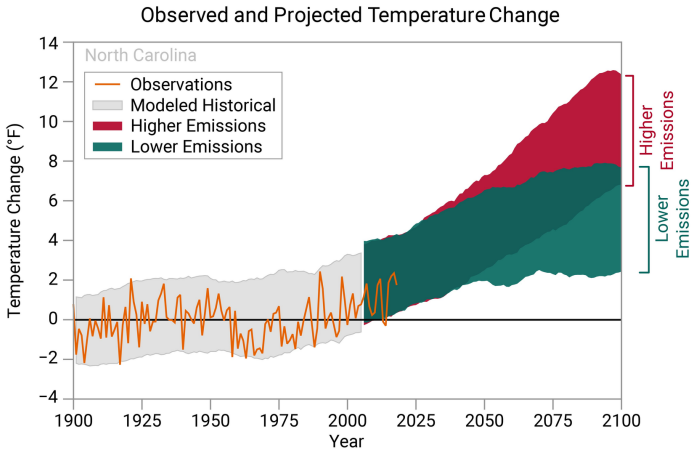
Key Climate Changes in North Carolina

Several key changes have already been observed to North Carolina's climate that we'll explore next:

- Our temperatures have been warming and are projected to warm more over this century. That warming isn't uniform though -- more of it is occurring at night.
- We are also experiencing more intense precipitation. More of our rainfall is falling as heavy events, and this is a pattern that is projected to continue in the future.
- We've also observed sea level rise. While we may not think of sea level as a climate variable, this is a consequence of the global climate change we're experiencing and it does compound other climate-based hazards, such as storm surge from hurricanes.

We'll next step through these, discuss the observed changes and projections, what impacts we're observing or projecting, and things to think about in terms of adaptation.

Warming Temperatures



- North Carolina's average annual temperatures have risen by approximately 1°F over the past 120 years (since 1900).
- Looking at our historical record, shown as the orange line on the graph, we experience quite a bit of year-to-year variability in our temperatures, but the warming we've observed -- especially since the middle of the 20th century, if clear looking at the time series..
- Scientists expect that North Carolina will continue to experience warming over the 21st century in all seasons.
- The amount of warming that we experience depends on future global emissions of greenhouse gases.
- Shown here are projected ranges of warming that the state could experience through the year 2100 under two different emissions scenarios:
  - a higher emissions scenario, shown in the red shaded area, in which emissions of greenhouse gases continue with limited climate change mitigation
  - and a lower emissions scenario, shown in the green shaded area, in which emissions of greenhouse gases decrease over time.
- Over the next few decades, through to about 2050, the amount of warming we experience in North Carolina is fairly equal no matter our emissions pathway, and this is because the warming we experience over the near-term really depends on the emissions we've already put into the atmosphere.
- Beyond this point, the amount of warming we experience under different emissions scenarios varies considerably.

Hotter Days and Warmer Nights (1)

- While average temperatures are one way that we can measure and project changes, in terms of how we are and will *feel* our changing temperatures are better represented by the two metrics shown on this slide: very hot days and very warm nights.
- Very hot days, defined as days where the maximum temperature reaches 95 F or higher, are projected to increase in the future, which is consistent with the overall warming trend we've observed in the state.
- The number of very warm nights, defined as nights where the minimum temperature does not fall below 75 F, are also projected to increase in the future.
- Scientists have greater confidence in future projections for very warm nights because there has also been an increasing trend in the number of very warm nights in our historic record. While there is not a trend in the number of very hot days in our historic record, consistent with our overall warming trend, it is likely that the number of very hot days will increase in the future.
- Both of these changes have impacts to health and agriculture.
  - Very hot days in North Carolina are generally also very humid, and can present public health risks, especially to vulnerable people, such as those with preexisting medical conditions.
  - Very warm nights can also be a health risk because people -- as well as plants and animals -- need to cool down at night. Those who lack access to sources of cooling, such as air conditioners, will be most vulnerable.

Hotter Days and Warmer Nights (2)

How much of a change is projected in these two variables?

- Included on this slide are maps that came from the North Carolina Climate Science Report, which was released in 2020 and is the latest climate assessment for the state, representing the most up-to-date climate science for the state of North Carolina.
- These maps show projected changes to the number of very hot days and very warm nights per year for two different future periods: 2021-2040 in the top maps, and for 2041-2060 in the bottom maps.
- Further, the bottom maps show projected changes under two different future global emissions scenarios: on the left of each side is a lower emissions scenario and on the right is a higher emissions scenario. Having these two scenarios present offers perspective on the range of future changes we may experience.

- The key takeaways from these maps of future climate projections are that the number of very hot days and very warm nights are projected to increase across North Carolina, especially in the Piedmont and Coastal Plain regions.
- Additionally, there is a marked difference between the two emissions scenarios, with a much greater increase in the number of very hot days and very warm nights projected by the middle of this century under a higher emissions scenario.

Adapting to Changing Temperatures: The Home Garden

How can we adapt to the changes we've already experienced while also thinking about ways to adapt to increase our resilience to current and future warming?

For this lesson, we're focusing on the home garden scale. As in the past, the climate, the season, and potential pests all affect the selection of what, when, and where to plant. Considering these factors when making gardening decisions is something that won't change with the future, but those climate-based factors are changing.

One thing to consider is how long you intend for something to remain a part of the landscape.

- The climate information you consider for something that's only expected to live for the current growing season will be different from the information you examine for something that you would like to live for fifty or more years.
- For the former, current and recent climate information will best suit your needs and ensure that what you plant can survive and thrive this growing season.
- For the latter, considering future climate changes are more important. For instance, if you're deciding between several different tree species to plant, your decision may include which species is best adapted to not just the climate of today, but the projected climate of 20 or 30 or 40 years from now

We will revisit these thought points at later times during this lesson to think more about how we can adapt to our state's changing climate and foster climate resilience..

Annual and Extreme Rainfall

Annual precipitation is projected to increase in North Carolina.

- The map on this slide comes from the North Carolina Institute for Climate Studies, which is located in Asheville, NC, and is part of a state climate summaries series in response to the 4th National Climate Assessment.
- This map shows projected changes in total annual precipitation, as a percentage, for the middle of this century compared to the late 20th century under a higher emissions pathway.
- North Carolina is on the southern end of a large area of projected increases in annual precipitation over the northeastern United States. Hatching on this map represents areas where the majority of climate models indicate a statistically significant change in annual precipitation.

How our precipitation is falling is also changing, and is perhaps more relevant to how we consider future climate risks and adaptation.

- More of our precipitation is falling in the heaviest events, and heavy precipitation is becoming more common.
- This is a consequence of a warming atmosphere.

Heavy Precipitation

- According to the laws of thermodynamics, for every degree Fahrenheit that Earth's atmospheric temperature rises, the amount of water vapor in the atmosphere can increase by about 7%.
- Specifically, this happens because water vapor does not condense and precipitate out of the atmosphere as easily at higher temperatures.
- Data from satellites, weather balloons, and ground measurements confirm the amount of atmospheric water vapor is increasing as the climate warms.
- Increases in atmospheric water vapor amplify the global water cycle. They contribute to making wet regions wetter and dry regions drier.
- The more water vapor that air contains, the more energy it holds. This energy fuels intense storms, particularly over land. This results in more extreme weather events.
- When we think about recent extreme precipitation events, one of the ones that likely comes to mind is Hurricane Florence, which caused record precipitation and flooding when it made landfall in 2018 and impacted almost all parts of the state.
- The extreme precipitation experienced during Hurricane Florence was in part fueled by climate change. While we cannot say with certainty how every future hurricane will look or the impacts it will cause in our state, Hurricane Florence is exemplary of the types of extreme precipitation we can expect from future storms.

Sources: NASA Global Climate Change

Hurricanes

- Hurricanes are projected to become stronger overall under a warming climate. This is largely due to warming ocean temperatures and increasing atmospheric water vapor content, which fuel these storms.
- As discussed on the previous slide, hurricanes in a warmer world are also projected to be wetter.
- There is limited evidence to suggest how future hurricane tracks will change, or what this might mean for future landfalling hurricanes in North Carolina or elsewhere, but it is likely that hurricanes will continue to be a part of North Carolina's climate.

Droughts and Wildfires

It is likely that future severe droughts in North Carolina will be more intense.

- Rising temperatures and the resulting increase in evaporation will accelerate the rate at which soils dry out. Thus, naturally occurring droughts in North Carolina will be more severe.
- Additionally, it is likely that future severe droughts in their multiple forms in North Carolina will be more frequent and intense due to higher temperatures leading to increased evaporation.

Wildfires are a part of North Carolina's historic climate and occur whether or not a drought is present. However, the presence of a drought often increases the severity of a wildfire. As a result, it is likely that the frequency of climate conditions conducive to wildfires in North Carolina will increase.

- Additionally, one of the key ways that forests in North Carolina are managed is through prescribed burns. Prescribed burns can only be conducted when conditions are right, such as having low wind speeds and available fuels (e.g., leaves, dead plants) in the landscape that will burn, but not so many that a fire will spread beyond containment.

Adapting to Changing Precipitation

The changes to our state's precipitation patterns are and will continue to impact the landscape through things like flooding, increased runoff, and droughts. How we manage the landscape - such as backyard gardens - will increasingly need to consider these climatic changes. Some prompts for discussion or individual thought:

- Consider the water needs of landscape and garden plants. How will these handle more frequent drying (droughts) associated with warming temperatures?
- Examine low-lying areas and areas prone to (flash) flooding. Can existing vegetation handle (more) frequent inundation?
- What inputs do you currently need to grow _____?
  - fertilizer?
  - water?
  - frost/freeze protection?
  - pesticide application?
- How might these inputs grow or shrink under future climate change?

Suggestions for instructors:

- Ask attendees to work through these prompts individually for 5-10 minutes, depending on the size of the group and level of interest. At the end of the time, ask for volunteers to report out: what are key things they thought of? what questions or challenges did they encountered during their brainstorming session?
- This individual brainstorming time can be used to assist with later group discussion on adaptation measures.

Sea Level Rise (1)

The final climatic change that will be covered during today's lesson is sea level rise. Globally, sea levels are rising due to two mechanisms:

1. Thermal expansion: when water warms, it expands. The oceans are absorbing lots of additional heat that is being produced by global warming. This heat is leading to water molecules to expand, raising sea levels.
2. Melting land ice: Temperatures have been warming at more pronounced rates over places that are typically cold - such as Greenland - and causing glaciers and other land ice to melt. This melted water flows into the ocean, raising the water level.

For most of the 20th century, both water expansion and melting land ice contributed about equally to rising sea levels. However, in recent decades melting land ice has overtaken expansion, and is estimated to be contributing twice as much as thermal expansion to current rates of sea level rise.

In North Carolina, sea level rise has been observed along the entire coast, and is more pronounced along the northern coast.

- The table on this slide comes from the North Carolina Climate Science Report and shows the rate of sea level rise in inches per year that has been observed at five locations along North Carolina's coast.
- While the amounts in this table may appear small -- fractions of inches per year -- they accumulate over time, and exacerbate flooding that we experience during coastal storm events, such as Nor'easters or hurricanes, and have also been leading to more instances of flooding during high tide.

It is virtually certain that sea level along the North Carolina coast will continue to rise due to expansion of ocean water from warming and melting of ice on land.

- It is also virtually certain that rising sea level and increasing intensity of coastal storms will lead to an increase in storm surge flooding in coastal North Carolina.
- Many areas along NC's coast projected to be impacted by high tide flooding on a near daily basis by 2100.

Sea Level Rise (2)

In addition to flooding, rising sea levels are enabling saltier water to penetrate farther inland, known as saltwater intrusion.

- This happens gradually, as sea levels rise and the freshwater/saltwater interface moves farther inland through streams and canals, such as the canal that is pictured on this slide from northeastern NC, as well as through groundwater. Low lying areas are also losing land as the ocean levels rise.
- We can observe this gradual in the landscape through things like 'ghost forests', which are places where previously forests existed but now the water level has risen (because of sea level rise) and/or become saltier, killing trees that cannot withstand the more frequent inundation or salt.
- We can also experience more sudden shifts in saltwater intrusion during things like coastal storms, which often bring storm surge. Because the sea levels are higher, this is adding to the level of storm surge, enabling it to move farther inland. When water recede after a storm moves on, that salty residue is left in the soils.
- This creates challenges for farming in coastal North Carolina as well because most crops are not adapted to this salt, and land is become less arable.

Recap: Projected Climate Changes and Impacts in NC

Summarizing what's been covered so far, this slide highlights key projected changes and related impacts from climate change in North Carolina. These are:

- It is virtually certain that sea levels will continue to rise. With rising sea levels, we will experience more coastal flooding during storms as well as more frequent instances of flooding during high tide.
- As our temperatures warm, it is very likely that summer heat index values will increase. Heat stress, which already presents a health risk for North Carolinians will become more prominent in the future, and is likely to impact populations that are more vulnerable, such as because they work outside or lack access to cooling.
- Overall, North Carolina is projected to become wetter and it is likely that our annual total precipitation will increase.
- As our climate warms, the amount of water vapor in the atmosphere increases, which favors heavy precipitation events. Partly as a result of this, the intensity of future hurricanes is likely to increase, and future hurricanes are likely to be wetter.
- As we experience more and heavier precipitation, our risk of inland flooding, such as we've seen with recent tropical systems and frontal passages, is likely to increase.
- Lastly, future droughts are likely to be more intense than their historic counterparts because they will be occurring in a warmer climate, which will create additional evaporation and transpiration.

Group Brainstorming Activity

As described at the start of this lesson, the first step in planning for resilience is to identify the hazards. We have done this in a broad sense for the state of North Carolina. Now we will do a group activity in which we will more narrowly think about hazards and potential adaptation actions to be resilient to these now and in the future.

Instructors:

- Divide attendees into groups of 2-4, depending on the size of the audience. Each group will be brainstorming climate hazards, impacts, and potential adaptive actions.
- Once attendees are split into groups, instruct each group to introduce themselves (e.g., name, where you're from, area of expertise or interest, and what brought you here today).
- Next instruct each group to decide on a location (e.g., a garden, park, community center) and brainstorm the climate-related impacts it may face over the next few decades. One suggestion is for each group member to suggest a location during the introductions.
- Once groups have cataloged the climate-related impacts each location may experience over the upcoming decades, instruct them to brainstorm how that impact could be reduced or eliminated through adaptation. Some additional prompts:
  - What types of activities or actions could be implemented to reduce risks from the hazards your group identified?
  - When would action be taken, ideally, to reduce the risk from the climate hazard(s) your group identified?
  - How "easy" to implement are these? What resources (e.g., time, money, people) will be needed to make them happen?
- After groups have finished brainstorming, bring everyone together and ask for groups to volunteer to share the results from their discussion.

Explore More: Resilience Toolkits

Listed on this slide are three resources for learning more about resilience and adaptation actions to foster resilience. While most tools and resources, like the ones listed here, are aimed at local governments and city planners rather than individuals, they still contain useful information for further learning.

- The US Climate Resilience Toolkit is hosted by the National Oceanic and Atmospheric Administration (NOAA), and provides a space for users to learn about potential climate hazards and explore climate data, as well as learn more about building resilience and view case studies from across the nation. https://toolkit.climate.gov/
- The Georgetown Adaptation Clearinghouse is an online database and networking site that serves policymakers and others who are working to help communities adapt to climate change. https://www.adaptationclearinghouse.org/
- Finally, the Climate Adaptation Knowledge Exchange is where users can explore climate adaptation case studies and related resources. https://www.cakex.org/

End of Lesson Reflection Activity

An optional reflection assignment follows this lesson. In this, attendees are instructed to explore case studies in the US Climate Resilience Toolkit https://toolkit.climate.gov/case-studies) and to select on that is relevant or interesting to read. After reading the case study, attendees are asked to reflect on the following prompts:

- How did the five steps to resilience appear in this case study?
- What is one thing you learned?
- Can you apply anything from this case study to your area (e.g., your town/city? community?) What is it, and how would you apply it?

A short assessment follows on the next page.

Assessment

The following four questions can serve as a summative assessment for this lesson. Instructors can give these as a quiz at the end of the lesson (e.g., as handouts or a Zoom poll) to check for understanding.

1. Temperatures in North Carolina are projected to _____ through at least the end of the century.
a. increase
b. decrease
c. stay the same
e. not enough data to know

a. increase

2. A warmer atmosphere contains more _____, which favors extreme precipitation.
a. carbon dioxide
b. rain droplets
c. water vapor
d. all of the above

c. water vapor

3. List three impacts (either observed already or projected to occur) resulting from North Carolina's changing climate.

Answers may be a range of impacts, such as increased heat stress to humans or animals, more and more intense drought impacts to plants, flooding, etc.

4. Explain: why is climate adaptation important?

Answers may vary, but will likely center on the following: Adaptation is important because it can increase our resilience to both current and future climate-related hazards.