North Carolina

Climate Change Interagency Council

Executive Order No. 80: NC's Commitment to Address Climate Change and Transition to a Clean Energy Economy

3rd Meeting

April 26, 2019

Raleigh, NC

Agenda

1. Welcome and Updates (10 mins) **9:00-9:10**

a. Opening remarks (Sheila Holman, DEQ)
b. Overview of meeting (Sushma Masemore, DEQ)
c. Update on EO80 Activities (Jeremy Tarr, Governor's Office and Colin Mellor, DOT)

2. EO80 Section 9 – Climate Science, Impacts, Risks, Adaptation, and Resiliency (25 mins) **9:10-9:35**

a. Goals, strategy, and timeline (Sushma Masemore, DEQ)
b. Supporting agencies (program office staff)
c. Assistance from academic and science experts (Jenny Dissen, NC Institute for Climate Studies for Jessica Whitehead, NC Sea Grant)

3. Development of NC Climate Science Assessment Report (1.25 hrs) **9:35-10:50**

a. What is climate science telling us? (Adam Terando, USGS and Chris Weaver, U.S. Global Change Research Program)
b. Plans for NC Climate Science Assessment (Ken Kunkel, Jenny Dissen, and Otis Brown, NC Institute for Climate Studies)

Agenda

Break (10 minutes)

4. Natural and Working Lands **11:00-12:00**

a. Role of nature based solutions to build resiliency and sequestering carbon (Lydia Olander, Duke University)
b. NC carbon inventory (Paula Hemmer, DAQ)
c. Benefits of pocosins restoration (Sarah Ward, US Fish and Wildlife)
d. Investing in nature-based solutions for resilient communities and landowners (William McDow, Environmental Defense Fund)

3. Public engagement (30 mins) **12:00-12:30**

Oral presentations will be limited to 2 minutes.

Update on Executive Order No. 80 Activities

EO80 Section 9- Climate Science, Impacts, Risks, Adaptation, and Resiliency

Directives

Department of Environmental Quality & Cabinet Agencies

- **N.C. Climate Risk Assessment and Resiliency Plan -** provide a scientific assessment of current and projected climate impacts on North Carolina and prioritize effective resiliency strategies. Due Mar. 1, 2020.

All Cabinet Agencies - **Assess and Address Climate Change**

- Evaluate the impacts of climate change on agency programs and operations
- Integrate climate change mitigation and adaptation practices into agency programs and operations
- Support communities and sectors vulnerable to climate change impacts

Goals

Goal 1: Develop an updated Climate Science Assessment for NC

Goal 2: Assess vulnerability to climate change

Goal 3: Develop a NC Climate Risk Assessment and Resiliency Plan

Goal 4: Assist interested local communities develop resiliency strategies

Approach

Assess Climate Related Threats	Goal 1	Prioritize climate variables of interest	Framing (time & space)	Variability, change, and projections	Threats and stressors
Assess Vulnerability and Risk	Goal 2	Climate scenarios	Exposure/Impacts	Vulnerabilities	Risks
Plan and Take Action	Goal 3	Evaluate Options	Prioritize feasible actions	Plan	
Community Assistance	Goal 4	Workshops and training	Resources & Planning		

Partners and Stakeholders

- **Academia and scientific community**
- **Local and state agencies**
- **Environmental groups**
- **Businesses and community organizations**
- **Financing and funding entities**
- **Others**

EO80 Website

deq.nc.gov/climate-council

NORTH CAROLINA *Environmental Quality*

Search...

NC.GOV AGENCIES JOBS SERVICES

Home » Energy & Climate » Climate Change » NC Climate Change Interagency Council » Climate Change & Clean Energy: Plans & Progress

Climate Change & Clean Energy: Plans & Progress

Clean Energy Plan
Department of Environmental Quality

North Carolina ZEV Plan
Department of Transportation

Motor Fleet ZEV Plan
Department of Administration

Clean Energy and Clean Transportation Workforce Assessments
Department of Commerce

Climate Risk Assessment & Resiliency Plan
Department of Environmental Quality

Comprehensive Energy, Water & Utility Use Conservation Program
Department of Environmental Quality

Greenhouse Gas Inventory
Department of Environmental Quality

Climate Change Interagency Council
Learn More

Participating Agencies

- Department of Health and Human Services
- Department of Information Technology
- Department of Military and Veterans Affairs
- Department of Natural and Cultural Resources
- Department of Revenue
- Department of Public Safety
- Department of Transportation

NC Executive Order 80 - Section 9

Bringing Academic and Scientific Assessment to Decisions

April 26, 2019

Jessica Whitehead[1] and Jenny Dissen[2]

[1]*NC Sea Grant, North Carolina State University*
[2]*North Carolina Institute for Climate Studies, North Carolina State University, NOAA Cooperative Institute for Climate and Satellites*

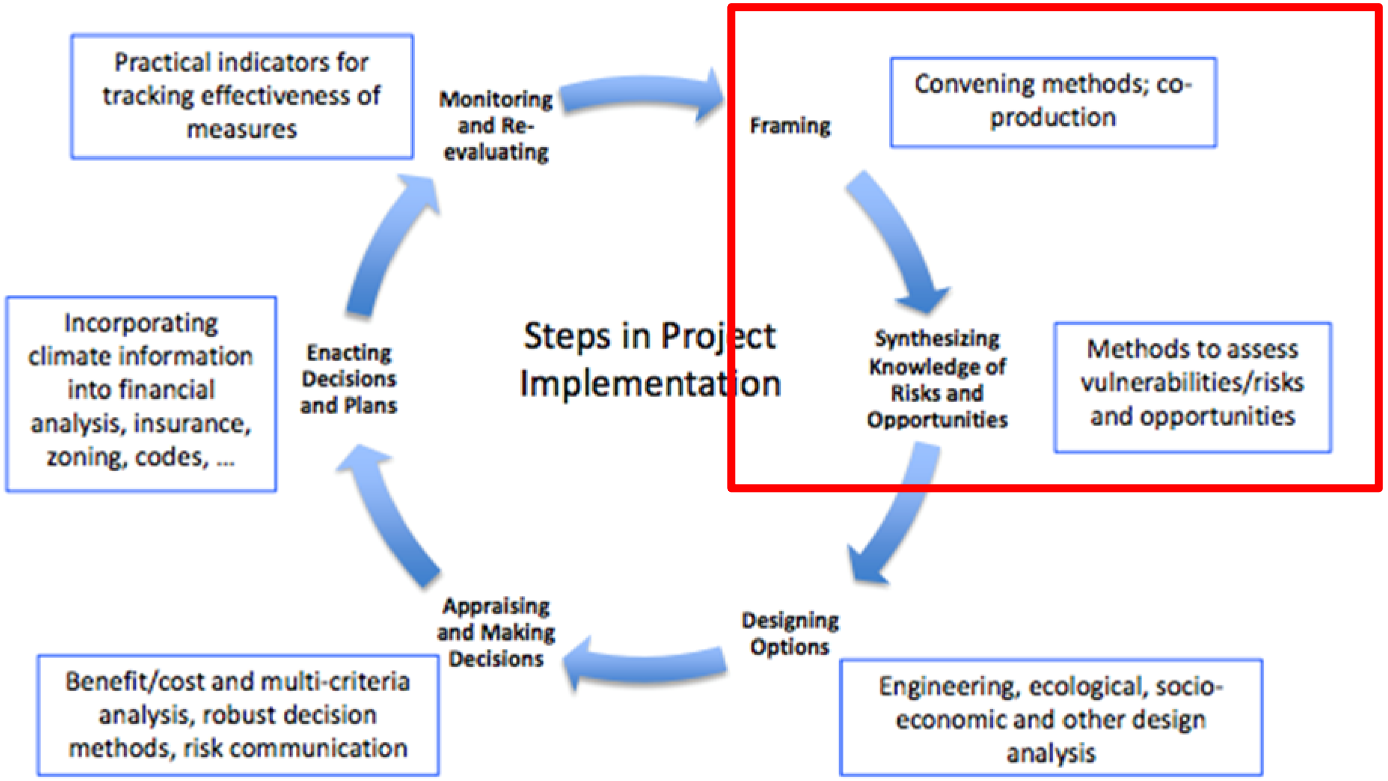
AGENDA

- How climate assessment fits with risk and resilience planning
  - Where are other municipalities and states?
  - How does climate information get used in planning?
- Academic / Expert engagement strategy
  - Proposed framework
  - Academic expertise
  - State agency experts

National Progress toward Resilience

(NCA 2018)

Implementing Resilience Planning



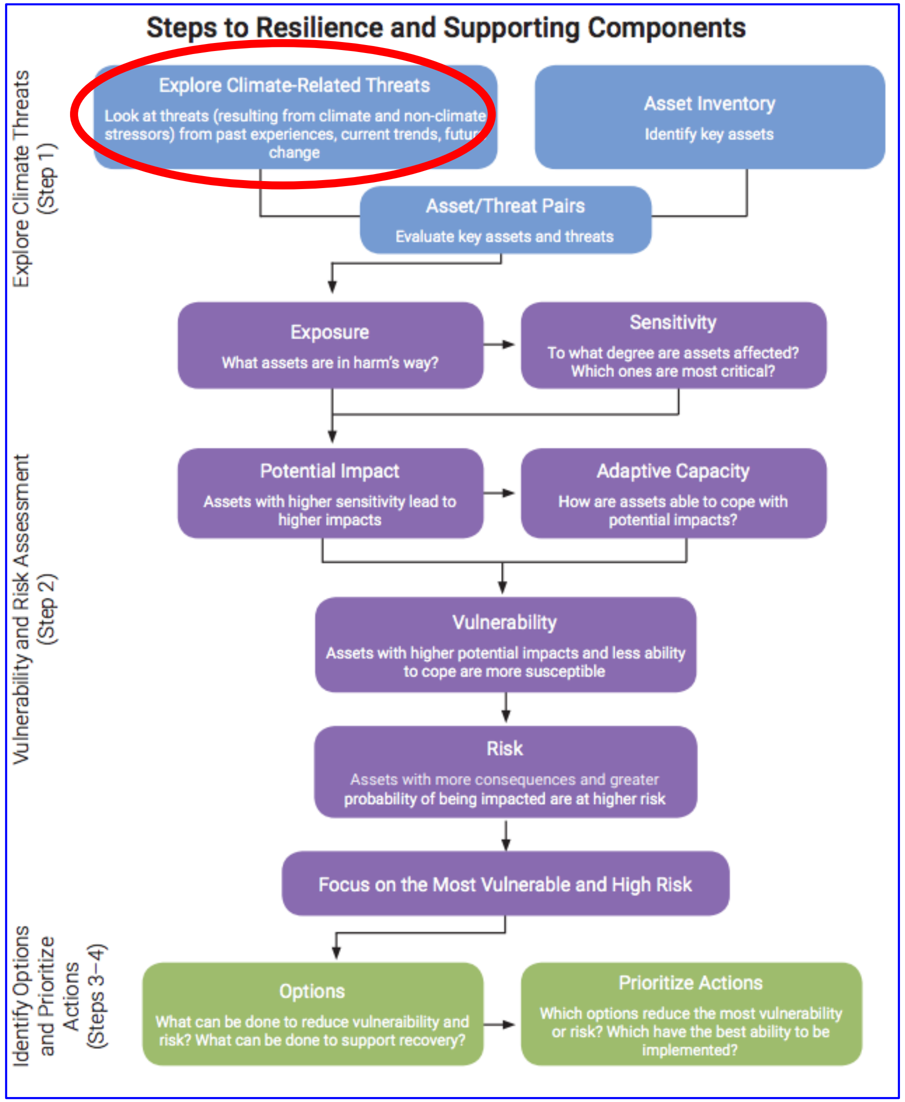
Moss et al. 2019: Evaluating Knowledge to Support Climate Action: A Framework for Sustained Assessment; Report of an Independent Advisory Committee on Applied Climate Assessment (https://journals.ametsoc.org/doi/pdf/10.1175/WCAS-D-18-0134.1)

Principles of Effective Resilience Plans

Principle	Definition	Components of Principle
Goals	Future desired conditions	Plan purpose, vision, goals, and objectives
Fact Base	Empirical foundation that identifies and prioritizes issues to ensure that strategies are well informed	Data sources; analysis of current conditions; climate change exposure; vulnerability and risk assessment
Strategies	Guide to decision making to assure plan goals are achieved	Capacity building, land use, green infrastructure etc.; cost and co-benefits of strategy options; prioritization of strategies
Public Participation	Recognition of actors engaged in preparing the plan	Description of planning process and techniques to engage stakeholders; Identify individuals involved in preparation of the plan
Coordination	Recognition of the interdependent actions of multiple organizations and the need for coordination	Engagement of local universities, state agencies, businesses, neighboring jurisdictions, etc. in the planning process
Implementation and Monitoring	Guidance to translate plan strategies into action and track progress towards goals	Organizational responsibilities, timelines, and funds for implementation and monitoring
Uncertainty	Plans recognition of and approaches to overcome uncertainty in future climate projections	Recognize sources of uncertainty; consider multiple future scenarios; flexible, robust, or no-regret strategies

(S. Woodruff, 2019, National Adaptation Forum)

Initial Framing and Assessment

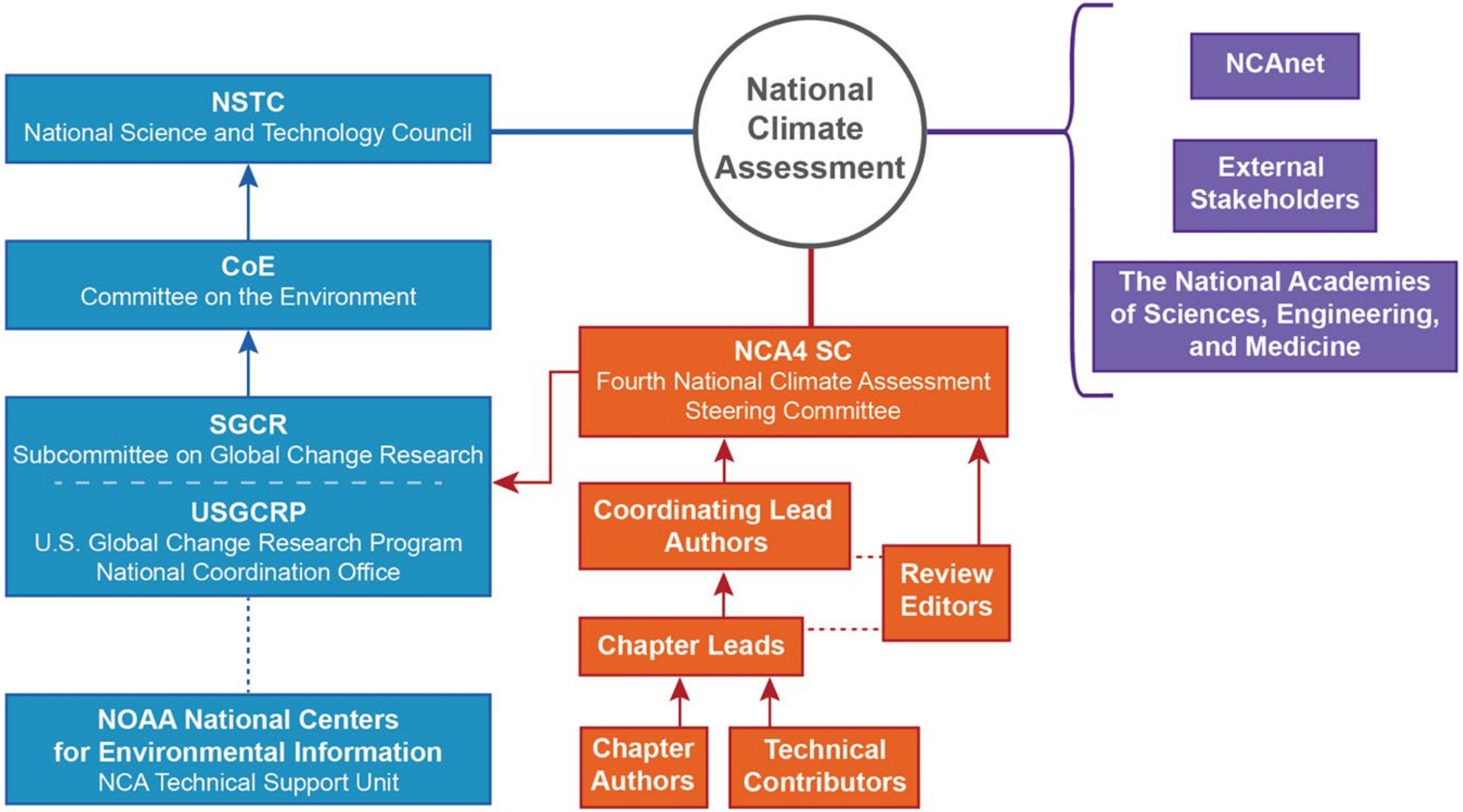


Source: NEMAC

NC Stressors Noted To Date:

- Temperature Information
  - Heatwaves (Days over/under xx degrees)
  - Frost Free Days
- Seasonal Climate Changes
- Precipitation (seasonal totals, intensity)
  - Landslides / Mudslides
- Drought / Water Shortage
- Flooding (storm, non-storm)
  - Nuisance Flooding
  - Runoff
  - Erosion
- Sea Level Rise / Tides
- Storms
  - Wind
- Wildfire
- Tornadoes

NCA Stakeholder Engagement Process



NC EO80 - Section 9: Process to Date

Identify Key Science Experts → **Determine Advisory vs. Review** → **Determine Gaps and Engage**

Identify Key Science Experts

- Master list of key players across the state
- Identify by domain and expertise area
- Climate science / physical science
- Impact / hazard expertise
- Adaptation and resilience experts

Determine Advisory vs. Review

- Identify core members of the advisory team
- Noted 11 key expert advisors from across the state
- Various institutions and organizations

Determine Gaps and Engage

- Identify gaps in the list
- Initiate engagement process to seek input, and identify others who should be involved
- Identify engagement mechanism to facilitate information sharing.

SME List - Working Draft

Advisory	Source:	Name	Organization	Details/Topic	Email	Website	NOTES	REGION	TOPIC	AVAILABILITY?
	Climate Information Specialists in North Carolina									
	DRAFT - In Development by NCICS, Jen Weiss, Jessica Whitehead									
	NCICS	Adam Terando	SE CASC	U.S. Geological Survey, Southe	ajterand@ncsu.edu					
	NCICS	Aranzazu Lascurain	NCSU/SE CASC	assistant university director of th	alascur@ncsu.edu					
x	NCICS	**Chip Konrad**	UNC CH	SE Regional Climate Center	konrad@unc.edu	http://www.sercc.				
	NCICS	Christine Voss	UNC CMAST	Morehead City ecologist involve						
x	NCICS	**Doug Miller**	UNCA		dmiller@unca.edu	http://www.atms.		MOUNTAIN		
	NCICS	Gary Lackmann	NCSU		gary@ncsu.edu	https://meas.scie		STATE		
	NCICS	Gregg Marland	App State	Gregg Marland, Appalachian Sta	marlandg@appstate.edu	https://earth.apps		STATE		
	NCICS	James S. Clark	Duke	James S. Clark, Duke University				TBD	Land use, cross sector	
x	NCICS	**Jessica Whitehead**	NCSU Sea Grant	North Carolina Sea Grant	j_whitehead@ncsu.edu			COAST		
	NCICS	Jim Fox / Karin Rogers	UNC Asheville	NEMAC	jfox@unca.edu			STATE	adaptation, resilience, engagement	
x	NCICS	**Ken Kunkel and TSU Tear**	NCSU NCICS	TSU Lead	kekunkel@ncsu.edu, jen	ncics.org		STATE		
	NCICS	Orrin Pilkey	Duke	retired Duke University coastal g			check with Jer			
	NCICS	Rob S. Young	W[illegible]	a coastal geology profess[illegible]	[illegible]	[illegible]		COAST; SLR		
x	NCICS	**Ryan Boyles**	SE CASC	DOI	rboyles@usgs.gov	https://www.usgs.		STATE		
	NCICS	Sankar Arumugam	NCSU ENE	professor in NC State's Departm	sarumug@ncsu.edu			STATE		
	NCICS	Susan Cohen	UNC CH IE	UNC Institute for the Environme	susanac@email.unc.edu	https://ie.unc.edu		COAST; SLR	military and ecological impacts	
	NCICS	Jane Hoppin / Rob Smart	NCSU	Center for Human, Health and E						
	NCICS	Thomas Allen	ODU	Professor, Political Science and	tallen@odu.edu	https://www.odu.		COAST; SLR	still has active work in APNEP regio	
x	NCICS	**Walt Robinson**	NCSCO	Professor / Interim Director, Nor Telephone: 919-513-2101	warobin3@ncsu.edu			STATE	loop in until incoming SCO begins 7.	
	NI	Elizabeth Shay	App State	Geography and Planning	shayed@appstate.edu					
x	NCICS	**Dr. Marjorie Overton**	NCSU	CCCE		https://www.ncle		SLR		
	NCSG	Casey Dietrich	NCSU	Storm surge modeling with wind	jcdietri@ncsu.edu	https://www.ccee		COAST; SLR		
x	NCSG	**Reide Corbett**	ECU CSI	SLR and coastal geology; marsh	corbettd@ecu.edu	https://www.coas				
	NCSG	Greg Carbone	CISA/USC	precipitation downscaling for CIS	greg.carbone@sc.edu	https://www.cisa.		STATE	drought, water supply	
	NCSG	Doug Gamble	UNC-W	applied climatology and coastal	gambled@uncw.edu	http://people.unc				
	NCSG	Joanne Halls	UNC-W	Spatial Analysis Lab - watershe	hallsj@uncw.edu	https://uncw.edu/				
x	NCSG	**Devon Eulie**	UNC-W	Impacts of extreme events on co	eulied@uncw.edu	https://sites.goog				
x	NCSG	**Ryan Emanuel**	NCSU	SLR, precipitation, and salt wate	reemanue@ncsu.edu	https://cnr.ncsu.e			tribues, specific tailored analysis	
	NCSG	Jared Bowden	NCSU	downscaled climate scenarios fo	jhbowden@ncsu.edu	https://globalchai				
	NCSG	Alex Manda	ECU	climate impacts on groundwater	mandaa@ecu.edu	http://blog.ecu.ec				
x	NCSG	**Kirstin Dow**	CISA/USC	NCA4 SE co-author, adaptation	DOWK@mailbox.sc.edu					
	NCSG	Jason West	UNC	climate change and air quality in	jjwest@email.unc.edu					
	NCSG	Ashley Ward	Duke	Extremes and health					someone on forest health impacts?	
	NCICS	John F. Bruno	UNC CH	University of North Carolina at C	jbruno@unc.edu	https://bio.unc.ec			oceans and corals?	
	NCICS	Andy Keeler	UNC CH	Coastal Studies Institute; Program Head, Public Policy an	agkeeler@csi.northcaroli	https://www.coas		COAST	economics and policy - especially re	

Executives and Workgroup Leads

	Executive Designee			Section 9 Workgroup Leads - Climate Science Assessment & Risk Assessment/Resiliency Plan		
Agency	***Name***	***Title***	***Email***	***Name***	***Title***	***Email***
Governor's Office	Jeremy Tarr	Policy Advisor	Jeremy.Tarr@NC.Gov			
DEQ	Sushma Masemore	Deputy Assistant Secretary for the Environment	sushma.masemore@ncdenr.gov	Tancred Miller	Coastal & Ocean Policy Manager	tancred.miller@ncdenr.gov
				Toby Vinson, P.E.	Section Chief, Division of Energy, Mineral, and Land Resources	toby.vinson@ncdenr.gov
				Klaus Albertin		klaus.albertin@ncdenr.gov
DOT	Bobby Lewis	Chief Operating Officer	Rwlewis1@ncdot.gov	Colin Mellor, LG	Environmental Policy Unit	cmellor@ncdot.gov
				Matthew (Matt) Lauffer, PE, CPM	Assistant State Hydraulics Engineer – Divisions 7, 9-14	mslauffer@ncdot.gov
	Chris Werner	Technical Services Administrator	cmwerner@ncdot.gov			
DOC	George Sherrill	Chief of Staff	gsherrill@nccommerce.com	Grace Lawrence	Community Economic Development Planner	grace.lawrence@nccommerce.com
DHHS	Iris Cooper	Assistant Secretary, Office of Procurement, Contracts and Grants	Iris.Cooper@dhhs.nc.gov	Lauren Thie, MSPH	Environmental Program Consultant	lauren.thie@dhhs.nc.gov
DNCR	Reid Wilson	Chief Deputy Secretary	reid.wilson@ncdcr.gov	Misty Buchanan	Director of the Natural Heritage Program	misty.buchanan@ncdcr.gov
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				Baden, Joe		joe.baden@doa.nc.gov
				JAMES McDANIEL		jim.mcdaniel@doa.nc.gov

DEQ Section 9 Members

DEQ Section 9 Workgroup members		
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Matthew Porter	Air Quality	Matthew.porter@ncdenr.gov
Bill Crowell	APNEP	bill.crowell@apnep.org
Stacey Feken	APNEP	stacey.feken@ncdenr.gov
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Rebecca Ellin	Coastal Management	Rebecca.Ellin@ncdenr.gov
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Jeff Manning	Water Resources	jeff.manning@ncdenr.gov
Linwood Peele	Water Resources	linwood.peele@ncdenr.gov

Some Next Steps

Survey / Questions	
1	Send out a short engagement email / questionnaire to authors
2	Assess interest and self selection
3	Recommend additional names / experts
4	What additional information are we looking for from the survey?
5	Determine other topics for the assessment, if any
6	Identify experts in downscaling for coasts vs. mountain
7	Determine experts in extremes and future extreme projections
	Storms
	Wind
	Haze
	Soil moisture
	Wildfires
	Landslides

Development of NC Climate Science Assessment Report

U.S. Global Change Research Program

- USGCRP began as a Presidential initiative in 1989
- Mandated by Congress in the U.S. Global Change Research Act (GCRA) of 1990 “to assist the Nation and the world to understand, assess, predict, and respond to human-induced and natural processes of global change”
- Overseen by Principals representing the 13 member agencies of the Subcommittee on Global Change Research (SGCR)

National Climate Assessment (NCA) in the GCRA

GCRA (1990), Section 106:

Not less frequently than every 4 years [USGCRP] shall prepare and submit to the President and Congress an assessment which:

- Integrates, evaluates, and interprets the findings of [USGCRP] and discusses the scientific uncertainties associated with such findings
- Analyzes the effects of global change on the natural environment, agriculture, energy production and use, land and water resources, transportation, human health and welfare, human social systems, and biological diversity
- Analyzes current trends in global change, both human- induced and natural, and projects major trends for the subsequent 25 to 100 years.

NCA4: a two-volume effort

Congressional Mandate	Fourth National Climate Assessment (NCA4)	
	Vol I: Climate Science Special Report	Vol II: Impacts, Risks, and Adaptation in the U.S.
Integrates, evaluates, and interprets the findings of the Program (USGCRP) and discusses the scientific uncertainties associated with such findings	✔☐	✔☐
Analyzes the effects of global change on the natural environment, agriculture, energy production and use, land and water resources, transportation, human health and welfare, human social systems, and biological diversity	✔☐	✔☐
Analyzes current trends in global change, both human- induced and natural, and projects major trends for the subsequent 25 to 100 years.	✔☐	✔☐

NCA4 Vol I:
Climate Science Special Report

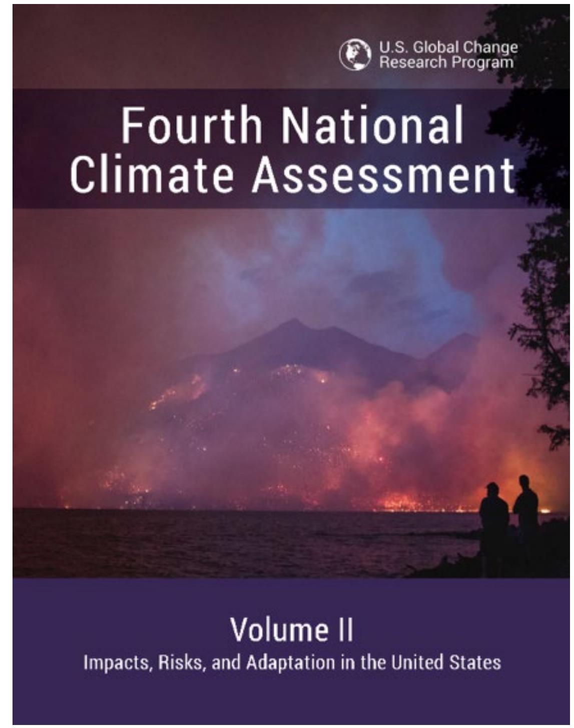
- Released Nov 3, 2017
- Key advances:
  - Detection and attribution
  - Extreme events (tropical cyclones, tornadoes, atmospheric rivers)
  - Downscaled information (including sea level rise)
  - Potential surprises
  - Climate model weighting

– Summarized in Our Changing Climate chapter of NCA4 Vol II

Read and download the report at
science2017.globalchange.gov

NCA4 Vol II: *Impacts, Risks, and Adaptation in the U.S.*

- Policy relevant, but not policy prescriptive
- Places a strong emphasis on regional information
- Assesses a range of potential impacts, helping decision makers better identify risks that could be avoided or reduced
- Uses case studies to provide additional context and opportunities to showcase community success stories



NCA4 Vol II will be available at
nca2018.globalchange.gov

Development timeline

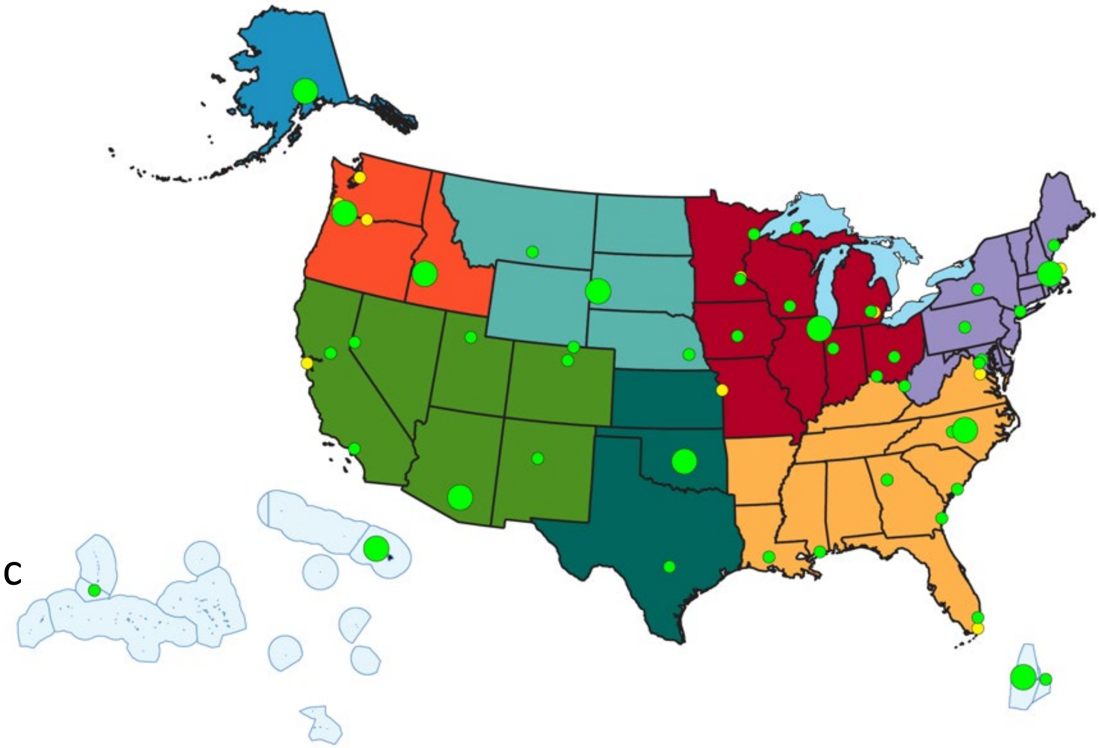
Early 2016	Federal Steering Committee and process guidance established
Summer 2016	Public comment on draft prospectus
Fall 2016	Public call for authors and technical inputs
Dec 2016	**REVIEW:** Steering Committee review of early chapter outlines
Jan 2017	**REVIEW:** SGCR (Interagency) review of annotated outlines
Spring 2017	Stakeholder engagement; First Order Draft developed
Summer 2017	**REVIEW:** SGCR (Interagency) review
Winter 2017	**REVIEW:** Public comment and National Academies of Sciences, Engineering, and Medicine review periods
Spring 2018	**REVIEW:** Final Federal review and clearance
Q3+Q4 2018	Final revisions; production and layout
Nov 2018	***Release***

Process guidance: overview

- Draw on a wide range of scientific and technical inputs
- Provide multiple opportunities for stakeholder engagement
- Operate on clear science communication principles
- Ensure transparency of process and information
- Employ an extensive review process

Public participation

- Public feedback on the draft prospectus
- Public call for author nominations
- Public call for technical inputs
- A series of Regional Engagement Workshops (REWs) and sector-specific webinars
- Public call for Review Editors
- A 90-day public review & comment period



Large green dots illustrate the hub locations for the 11 REWs in early 2017. Small green dots indicate satellite locations for those workshops. Small yellow dots show locations of some additional engagement activities, such as presentations or listening sessions at professional society meetings.

Table of Contents

Chapter structure

National Topics and Responses

6-10 pages each

- Executive Summary
- Background/state of the sector
- Regional roll-up
- 2-3 Key Messages
- Traceable Accounts
- References

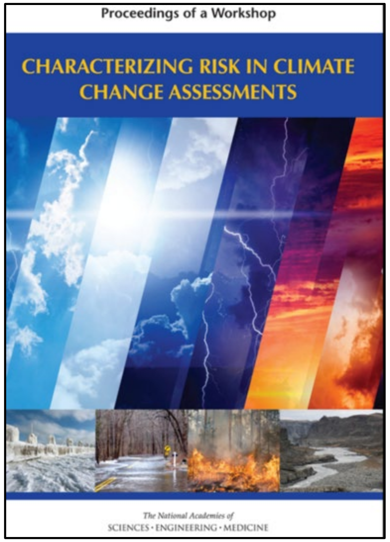
Regions

Approximately 20 pages each

- Executive Summary
- Background
- 4-6 region-specific Key Messages
- Traceable Accounts
- References

Risk Framing in Key Messages

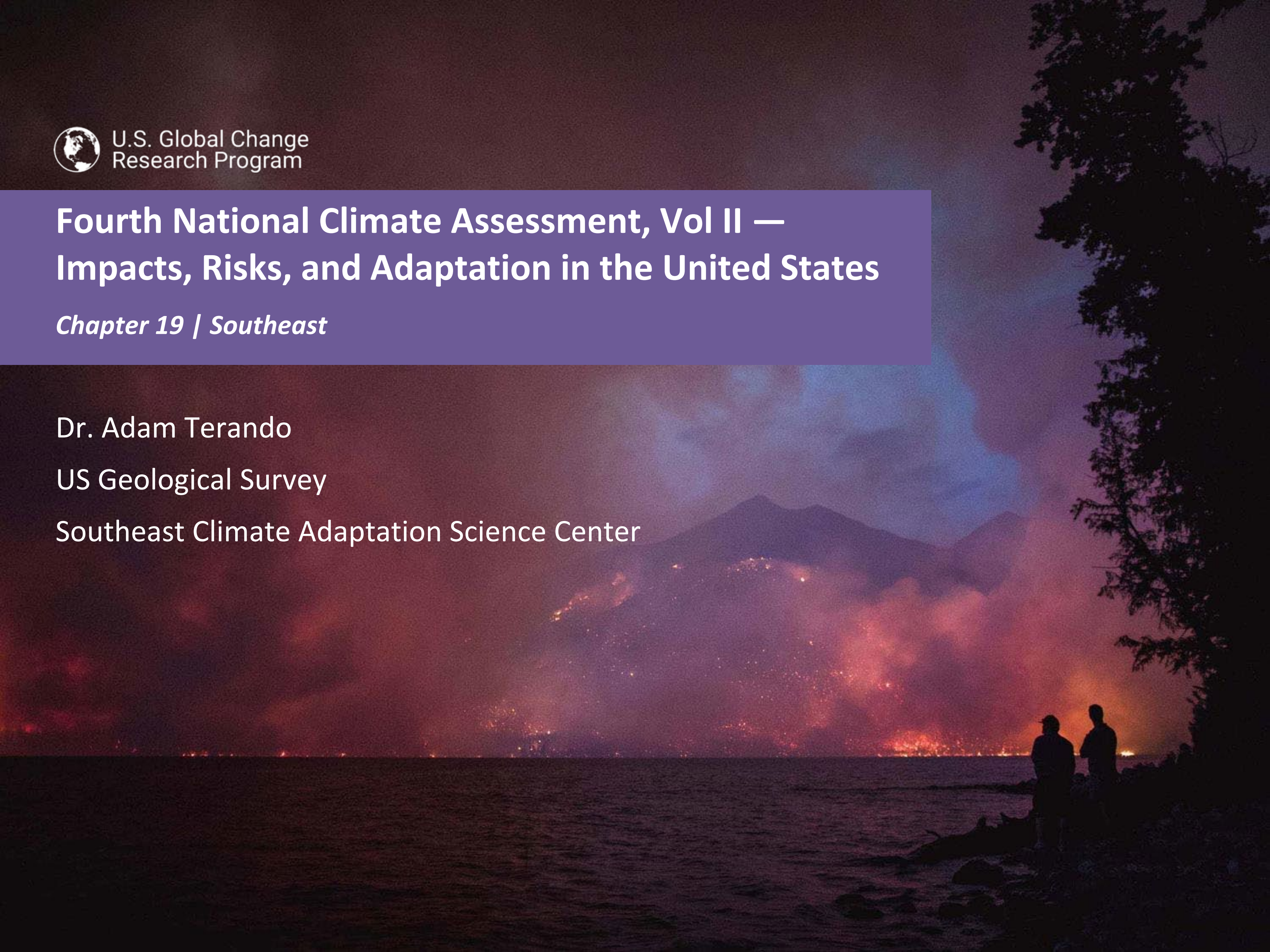
- A **“risk-based framing”** is used to ensure NCA4 focuses on issues of high importance to decision-making and to help with communicating assessment outcomes
- In response to audience needs and with guidance from a workshop of the National Academies, NCA4 Key Messages addressed:
  - ✓ What do stakeholders value/what is at risk in a given sector or region?
  - ✓ What outcomes do we wish to avoid with respect to these valued things?
  - ✓ What do we expect to happen in the absence of adaptive action and/or mitigation?
  - ✓ How bad could things plausibly get/are there important thresholds or tipping points in the unique context of a given region, sector, etc.?



Traceable Accounts

- Describe and document the process and rationale used for reaching conclusions
- Include calibrated confidence level and, where appropriate, likelihood
- Identify areas with limited and/or emerging data or scientific uncertainty
- Provide an opportunity for a more technical discussion than chapter narrative

National Climate Assessment Impacts, Risks, Adaptation Southeast United States



U.S. Global Change Research Program

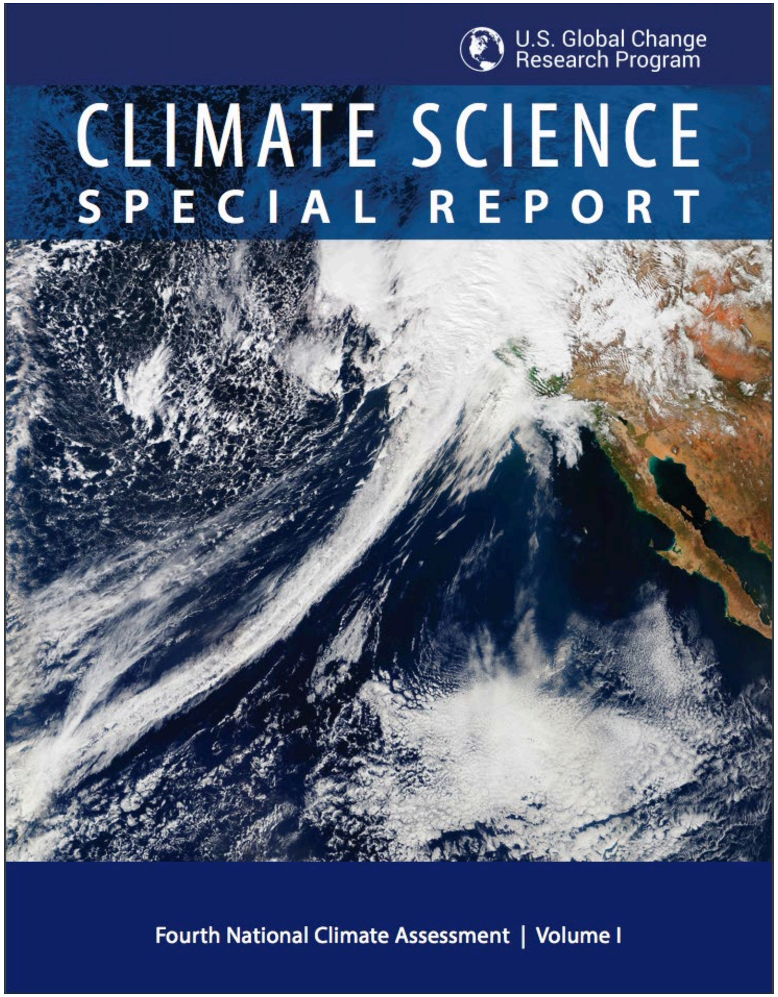
Fourth National Climate Assessment, Vol II — Impacts, Risks, and Adaptation in the United States

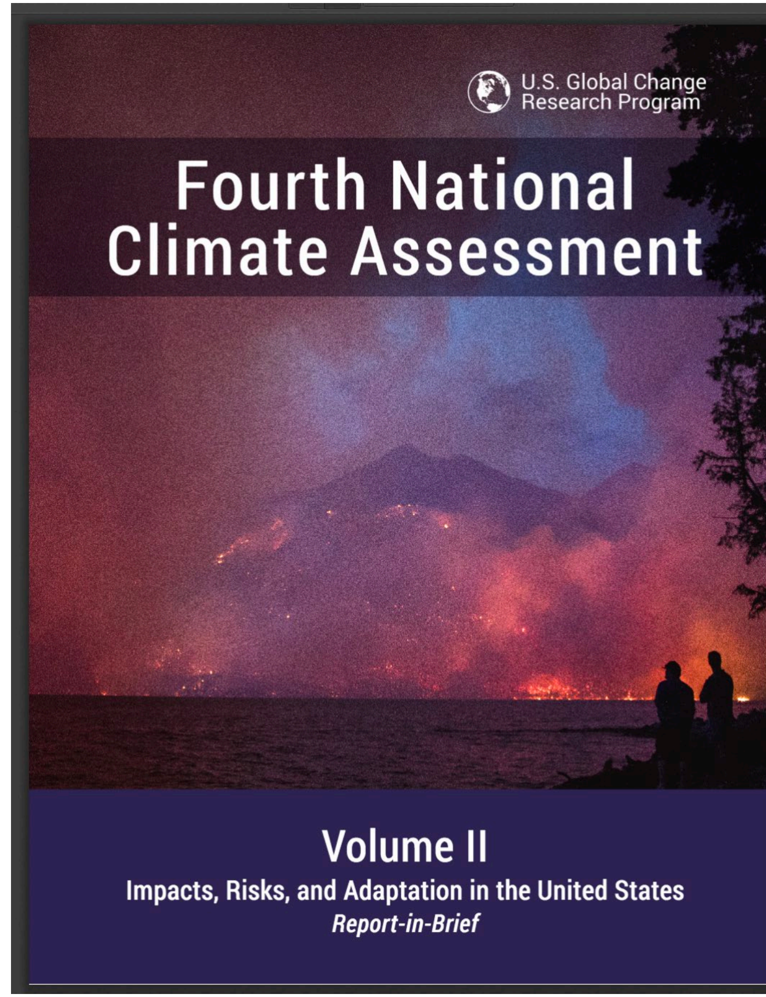
Chapter 19 | Southeast

Dr. Adam Terando

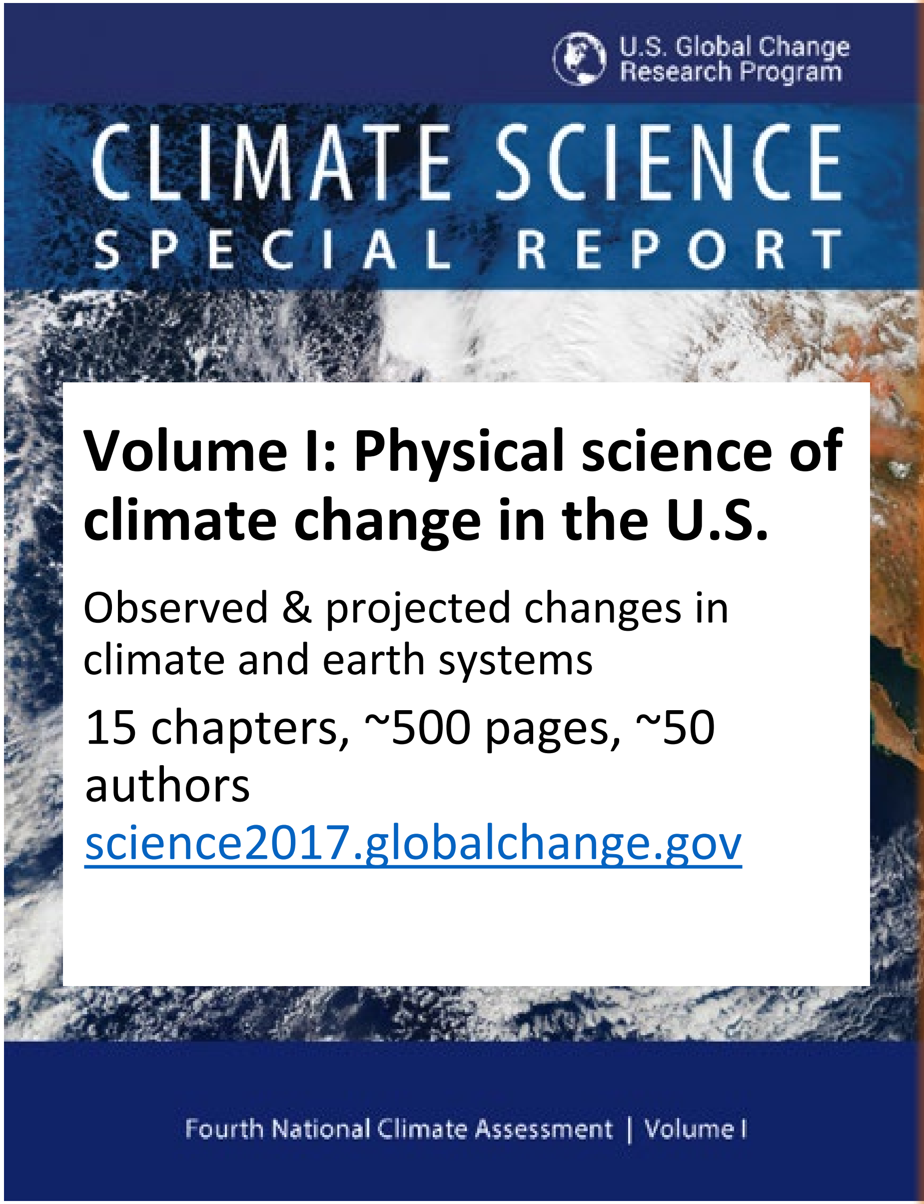
US Geological Survey

Southeast Climate Adaptation Science Center





science2017.globalchange.gov **nca2018.globalchange.gov**

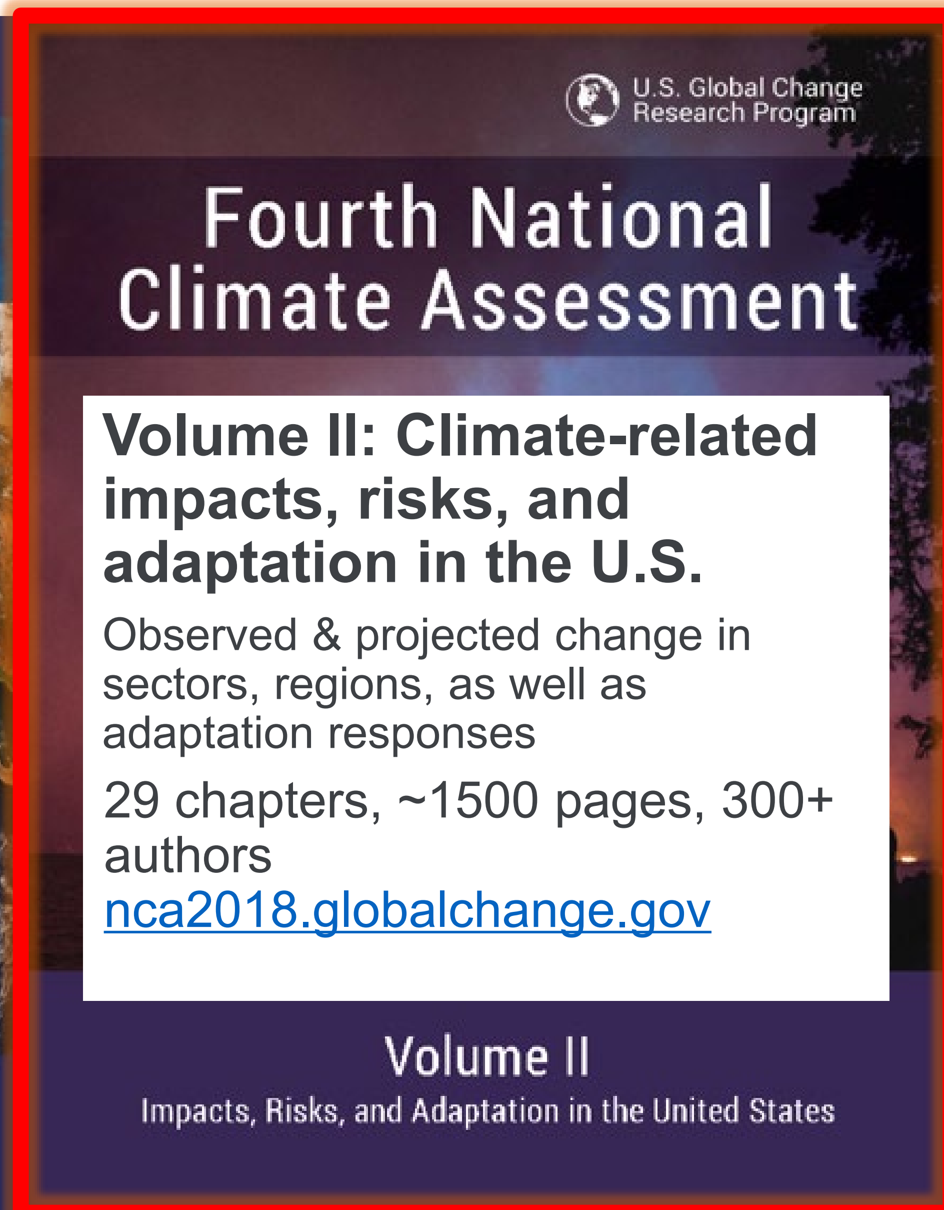


Volume I: Physical science of climate change in the U.S.

Observed & projected changes in climate and earth systems

15 chapters, ~500 pages, ~50 authors

science2017.globalchange.gov



Volume II: Climate-related impacts, risks, and adaptation in the U.S.

Observed & projected change in sectors, regions, as well as adaptation responses

29 chapters, ~1500 pages, 300+ authors

nca2018.globalchange.gov

NCA4 Volumes I + II

PA31D-1168

Assessing Climate Risks and Adaptation Opportunities in the Southeast U.S. As Part of the Fourth National Climate Assessment

Adam Terando[1,2], Lynne Carter[3], Kirstin Dow[4], Kevin Hiers[5], Kenneth E. Kunkel[2], Aranzazu Lascurain[2], Doug Marcy[6], Michael Osland[1], Paul Schramm[7], Allyza Lustig[8]

Learn more

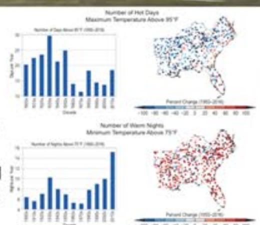
nca2018.globalchange.gov/chapter/19

Adam Terando: aterando@usgs.gov

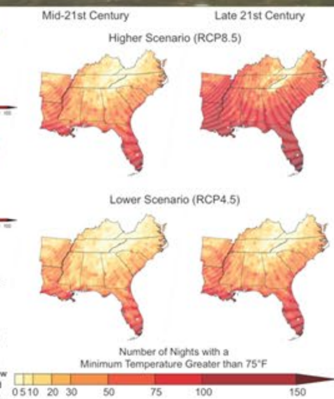
U.S. Global Change Research Program

Key Message 1: Urban Infrastructure and Health Risks

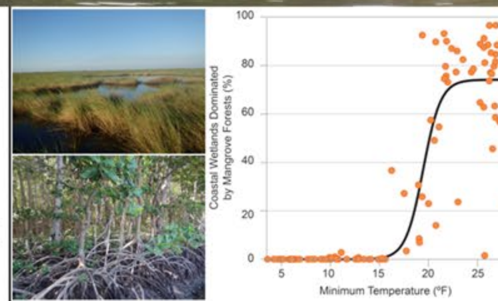
Many southeastern cities are particularly vulnerable to climate change compared to cities in other regions, with expected impacts to infrastructure and human health. The vibrancy and viability of these metropolitan areas, including the people and critical regional resources located in them, are increasingly at risk due to heat, flooding, and vector-borne disease brought about by a changing climate. Many of these urban areas are rapidly growing and offer opportunities to adopt effective adaptation efforts to prevent future negative impacts of climate change.



Hotter Nights for Growing Cities
Variability and change in (top) the annual number of hot days and (bottom) warm nights. The bar charts show averages over the region by decade for 1900–2016, while the maps show the trends for 1950–2016 for individual weather stations. Sources: NOAA NCEI and CICS-NC.



(right) Projected number of warm nights per year in the Southeast for the mid-21st century (left; 2036–2065) and the late 21st century (right; 2070–2099) under a higher scenario (RCP8.5; top row) and a lower scenario (RCP4.5; bottom row). These warm nights currently occur only a few times per year across most of the region but are expected to become common events across much of the Southeast under a higher scenario. Sources: NOAA NCEI and CICS-NC.



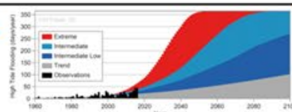
Salt Marshes Transitions to Mangroves
In Louisiana and parts of northern Florida, coastal wetlands (top left) are expected to look and function more like the mangrove-dominated systems (bottom left) currently present in South Florida and the Caribbean. Mangrove forests are sensitive to freezing temperatures (right) but with warmer winter temperatures these are expected to expand northward at the expense of salt marshes. This shift has implications for wildlife dependent on these two habitats, but also could societal benefits in the form of coastal protection against wind and waves. Figure adapted from Osland et al. 2013.

Key Message 3: Natural Ecosystems Will be Transformed

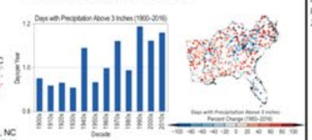
The Southeast's diverse natural systems, which provide many benefits to society, will be transformed by climate change. Changing winter temperature extremes, wildfire patterns, sea levels, hurricanes, floods, droughts, and warming ocean temperatures are expected to redistribute species and greatly modify ecosystems. As a result, the ecological resources that people depend on for livelihood, protection, and well-being are increasingly at risk, and future generations can expect to experience and interact with natural systems that are much different than those that we see today.

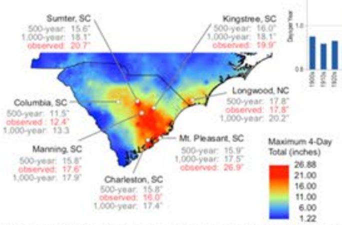
Key Message 2: Increasing Flood Risks in Coastal and Low-Lying Regions

The Southeast's coastal plain and inland low-lying regions support a rapidly growing population, a tourism economy, critical industries, and important cultural resources that are highly vulnerable to climate change impacts. The combined effects of changing extreme rainfall events and sea level rise are already increasing flood frequencies, which impacts property values and infrastructure viability, particularly in coastal cities. Without significant adaptation measures, these regions are projected to experience daily high tide flooding by the end of the century.



Flood Risk from Sea Level Rise and Extreme Precipitation
Observed sea level rates in many parts of the Southeast are higher than the global average. This is already causing frequent high-tide flood events in many coastal cities (such as the Savannah, Georgia region, black bars in left figure) and is projected to become a daily occurrence under some scenarios of sea level rise. In addition, extreme precipitation events are becoming more frequent (below) and are projected to further increase, increasing the risk of flooding in coastal and low-lying regions. Sources: Sweet et al. (2017), Sweet and Park (2014), NOAA NCEI, and CICS-NC.



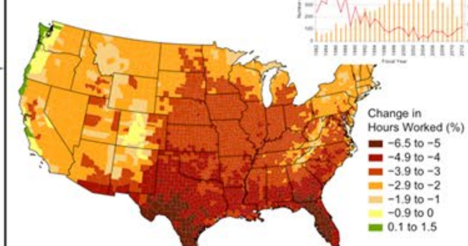


Case Study: Coastal and Inland Impacts of Extreme Rainfall in South Carolina
In October 2015, an extreme rainfall event impacted both inland and coastal South Carolina, leading to the largest flood-related disaster in the state since Hurricane Hugo struck in 1989. This is one of a series of devastating precipitation events that have occurred across the Southeast in recent years. Deep tropical moisture combined with a slow-moving upper-level low pressure system to pump moisture into South Carolina's coastal and interior regions. Much of the affected region received between 10 and 26 inches (254 to 660 mm) of rain over the 4-day event, breaking many records. Some of these totals exceeded the 500-year and 1,000-year return period amounts (i.e. expected to have only a 0.2% or 0.1% chance of annual occurrence). The rainfall sparked inland flooding that led to three dam breaches and the destruction of countless roads and homes. At the coast, a combination of high tide and heavy rain caused significant flooding in downtown Charleston with a recorded high tide of 2.38 feet (0.73 m) above Mean Higher High Water. Under future climate scenarios, the combination of extreme precipitation and sea level rise will likely cause more frequent events of this intensity and magnitude. Source: CISA 2016

Affiliations and Roles

References

Adaptation Strategy Case Study - Wildfire
Wildfire is projected to increase in the Southeast. Prescribed fire could be an effective adaptive response to this increased risk and is already a commonly used tool across the region's rural lands. For example, Department of Defense (DoD) activities on its large regional footprint are a frequent source of wildfires, but increases in prescribed fire acres (such as the example from Ft. Benning, Georgia; bottom right) show a corresponding decrease in wildfire ignitions. Climate resilience by DoD is further achieved through restoration of native longleaf pine forests that occupy a wide range of site types, including wetland and well-drained soils—the latter leading many to characterize this forest as being drought resistant. Photo credit: Kevin Hiers, Tall Timbers; Eglin Air Force Base Wildfire, 2012. Figure source: adapted from Addington et al. 2015.



Heat-related Health Threats to Outdoor Rural Workers Estimated percent change in hours worked in 2090 under a higher scenario (RCP8.5). Projections indicate an annual average of 570 million labor hours lost per year in the Southeast by 2090 (with models ranging from 340 million to 820 million labor hours). Estimates represent a change in hours worked as compared to a 2003–2007 average baseline for high-risk industries only. These industries are defined as agriculture, forestry, and fishing; hunting, mining, and construction; manufacturing, transportation, and utilities. Source: adapted from EPA 2017.

Key Message 4: Economic and Health Risks for Rural Communities

Rural communities are integral to the Southeast's cultural heritage and to the strong agricultural and forest products industries across the region. More frequent extreme heat episodes and changing seasonal climates are projected to increase exposure-linked health impacts and economic vulnerabilities in the agricultural, timber, and manufacturing sectors. By the end of the century, over one-half billion labor hours could be lost from extreme heat-related impacts. Such changes would negatively impact the region's labor-intensive agricultural industry and compound existing social stresses in rural areas related to limited local community capabilities and associated with rural demography, occupations, earnings, literacy, and poverty incidence. Reduction of existing stresses can increase resilience.

19 Key Message #1

Urban Infrastructure and Health Risks

Many ***southeastern cities*** are particularly vulnerable to climate change compared to cities in other regions, with expected impacts to infrastructure and human health. The ***vibrancy and viability*** of these metropolitan areas, including the ***people and critical regional resources*** located in them, are ***increasingly at risk due to heat, flooding, and vector-borne disease brought about by a changing climate***. Many of these urban areas are rapidly growing and offer ***opportunities*** to adopt effective ***adaptation*** efforts to prevent future negative impacts of climate change.

19 Key Message #2

Increasing Flood Risks in Coastal and Low-Lying Regions

The Southeast's coastal plain and inland low-lying regions support a rapidly growing population, a tourism economy, critical industries, and important cultural resources that are highly vulnerable to climate change impacts. The combined effects of changing extreme rainfall events and sea level rise are already increasing flood frequencies, which impacts property values and infrastructure viability, particularly in coastal cities. Without significant adaptation measures, these regions are projected to experience daily high tide flooding by the end of the century.

19 Key Message #3

Natural Ecosystems Will Be Transformed

The Southeast's diverse natural systems, which provide many benefits to society, will be transformed by climate change. Changing winter temperature extremes, wildfire patterns, sea levels, hurricanes, floods, droughts, and warming ocean temperatures are expected to redistribute species and greatly modify ecosystems. As a result, the ecological resources that people depend on for livelihood, protection, and well-being are increasingly at risk, and future generations can expect to experience and interact with natural systems that are much different than those that we see today.

19 Key Message #4

Economic and Health Risks for Rural Communities

Rural communities are integral to the Southeast's cultural heritage and to the strong agricultural and forest products industries across the region. More frequent extreme heat episodes and changing seasonal climates are projected to increase exposure-linked health impacts and economic vulnerabilities in the agricultural, timber, and manufacturing sectors. By the end of the century, over one-half billion labor hours could be lost from extreme heat-related impacts. Such changes would negatively impact the region's labor-intensive agricultural industry and compound existing social stresses in rural areas related to limited local community capabilities and associated with rural demography, occupations, earnings, literacy, and poverty incidence. Reduction of existing stresses can increase resilience.

Fig. 19.1: Historical Changes in Hot Days and Warm Nights

Sixty-one percent of major Southeast cities are exhibiting some aspects of worsening heat waves, which is a higher percentage than any other region of the country.[12] Hot days and warm nights together impact human comfort and health and result in the need for increased cooling efforts. Agriculture is also impacted by a lack of nighttime cooling. Variability and change in (top) the annual number of hot days and (bottom) warm nights are shown. The bar charts show averages over the region by decade for 1900–2016, while the maps show the trends for 1950–2016 for individual weather stations. Average summer temperatures during the most recent 10 years have been the warmest on record, with very large increases in nighttime temperatures and more modest increases in daytime temperatures, as indicated by contrasting changes in hot days and warm nights. (top left) The annual number of hot days (maximum temperature above 95°F) has been lower since 1960 than the average during the first half of the 20th century; (top right) trends in hot days since 1950 are generally downward except along the south Atlantic coast and in Florida due to high numbers during the 1950s but have been slightly upward since 1960, following a gradual increase in average daytime maximum temperatures during that time. (bottom left) Conversely, the number of warm nights (minimum temperature above 75°F) has doubled on average compared to the first half of the 20th century and (bottom right) locally has increased at most stations. *Sources: NOAA NCEI and CICS-NC.*

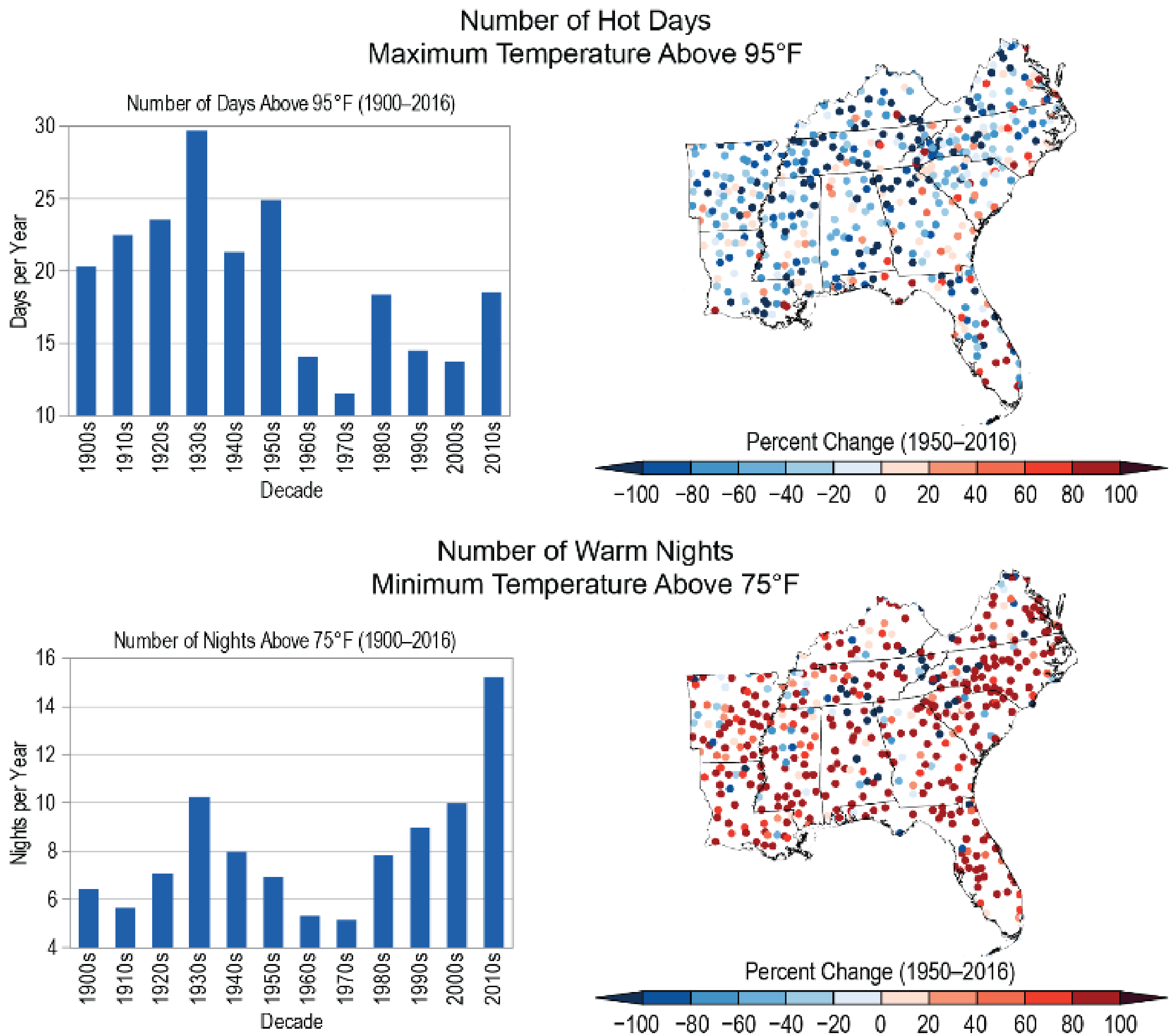


Fig. 19.4: Historical Number of Warm Nights

The map shows the historical number of warm nights (days with minimum temperatures above 75°F) per year in the Southeast, based on model simulations averaged over the period 1976–2005. *Sources: NOAA NCEI and CICS-NC.*

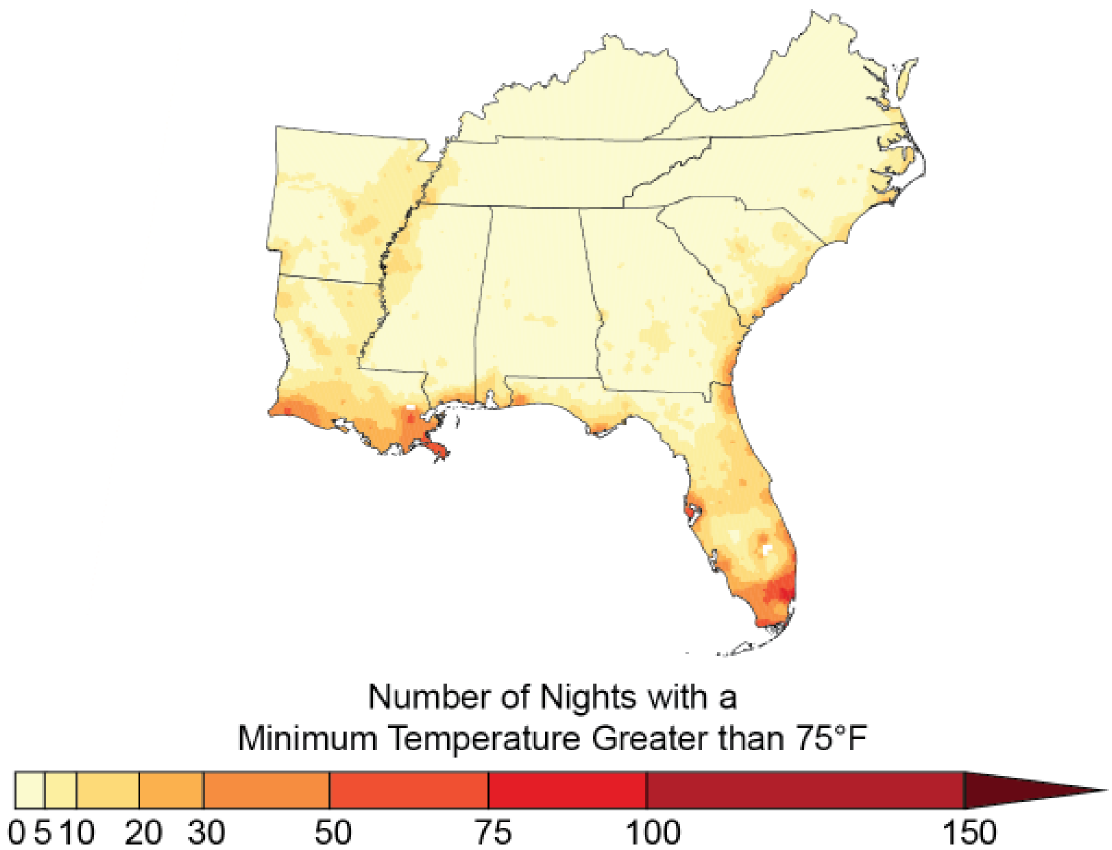


Fig. 19.5: Projected Number of Warm Nights

The maps show the projected number of warm nights (days with minimum temperatures above 75°F) per year in the Southeast for the mid-21st century (left; 2036–2065) and the late 21st century (right; 2070–2099) under a higher scenario (RCP8.5; top row) and a lower scenario (RCP4.5; bottom row). These warm nights currently occur only a few times per year across most of the region (Figure 19.4) but are expected to become common events across much of the Southeast under a higher scenario. Increases in the number of warm nights adversely affect agriculture and reduce the ability of some people to recover from high daytime temperatures. With more heat waves expected, there will likely be a higher risk for more heat-related illness and deaths. *Sources: NOAA NCEI and CICS-NC.*

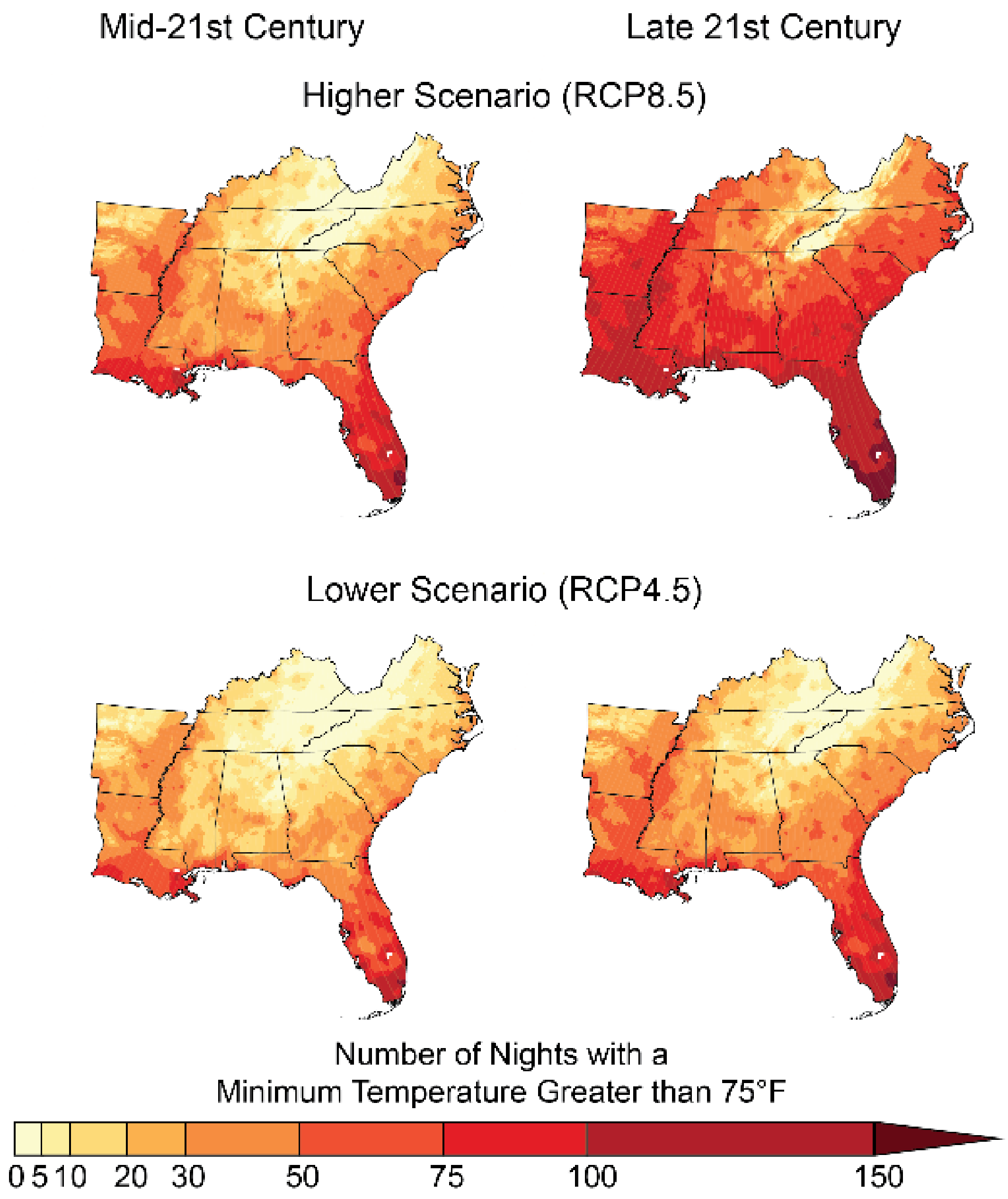
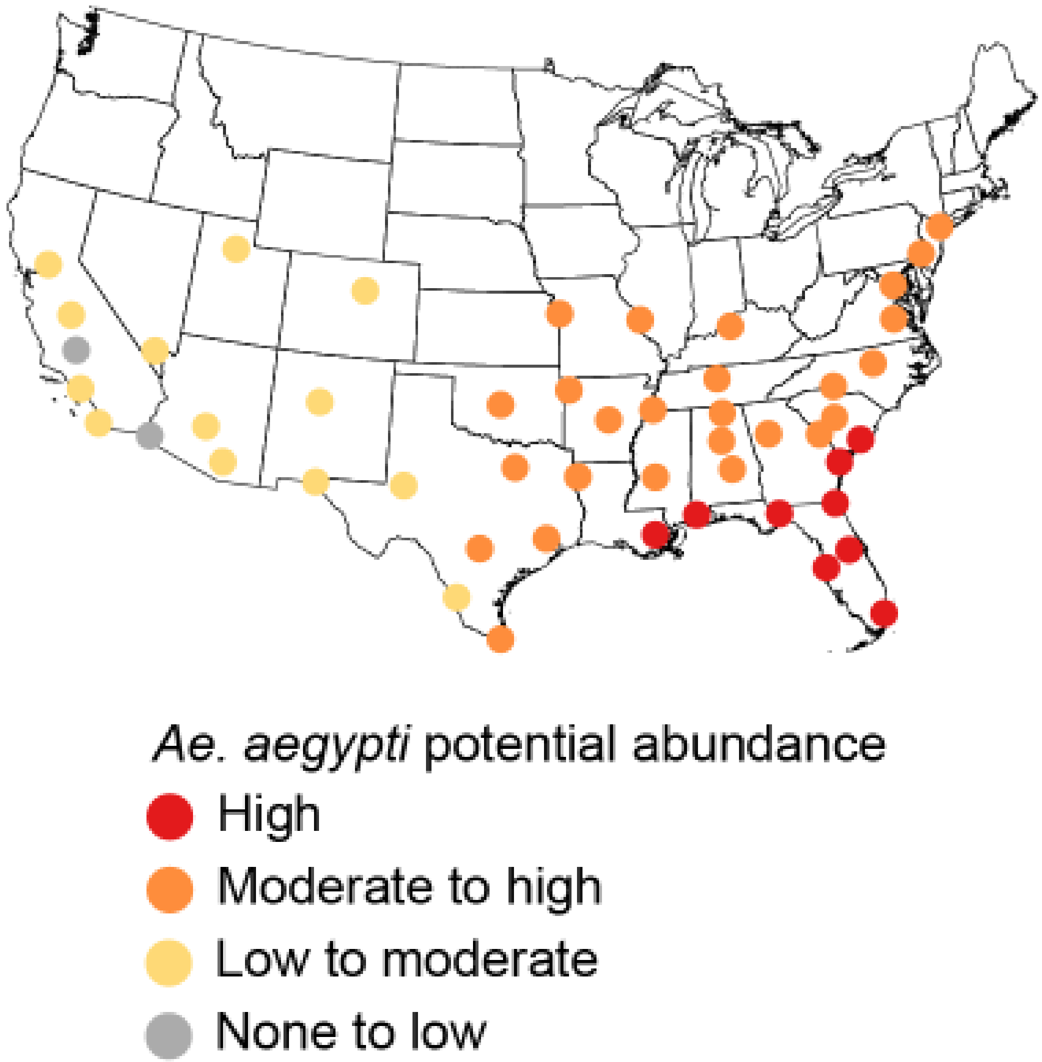


Fig. 19.6: Potential Abundance of Disease-Carrying Mosquito

The map shows current suitability for the *Aedes aegypti* mosquito in July in 50 different cities. *Aedes aegypti* mosquitoes can spread several important diseases, including dengue fever, chikungunya, and Zika fever. The Southeast is the region of the country with the greatest potential mosquito activity. Warming temperatures have the potential to expand mosquito habitat and disease risk. *Source: adapted from Monaghan et al. 2016.*[30]



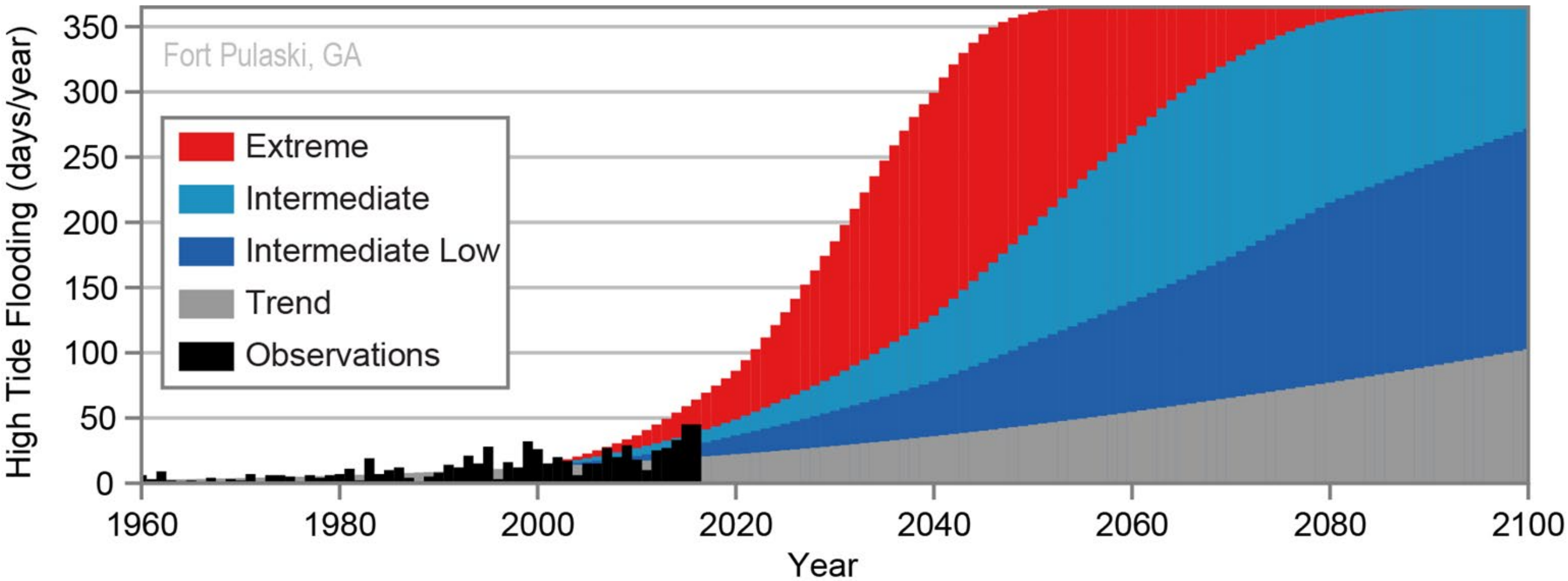


Fig. 19.7: Annual Number of High Tide Flooding Days

The figure shows the annual number of days experiencing high tide floods based on observations for 1960–2016 for Fort Pulaski, near Savannah, Georgia (black), and projected increases in the number of annual flood events based on four future scenarios: a continuation of the current relative sea level trend (gray) and the Intermediate-Low (dark blue), Intermediate (light blue), and Extreme (red) sea level rise scenarios. See Sweet et al. (2017)[51] and Appendix 3: Data & Scenarios for additional information on projection and trend data. *Source: adapted from Sweet and Park 2014.*[63]

Fig. 19.9: Storm Water in Charleston, South Carolina

(left) U.S. Highway 17 (Septima Clark Parkway—crosstown) in Charleston, South Carolina, during a flood event. Floodwaters can get deep enough to stall vehicles. (right) Market Street drainage tunnel being constructed in Charleston, South Carolina, as part of a drainage improvement project to prevent current and future flooding. This tunnel crosses a portion of downtown Charleston 140 feet underground and is designed to rapidly convey storm water to the nearby Ashley River. *Photo credit: City of Charleston 2015.*[45]

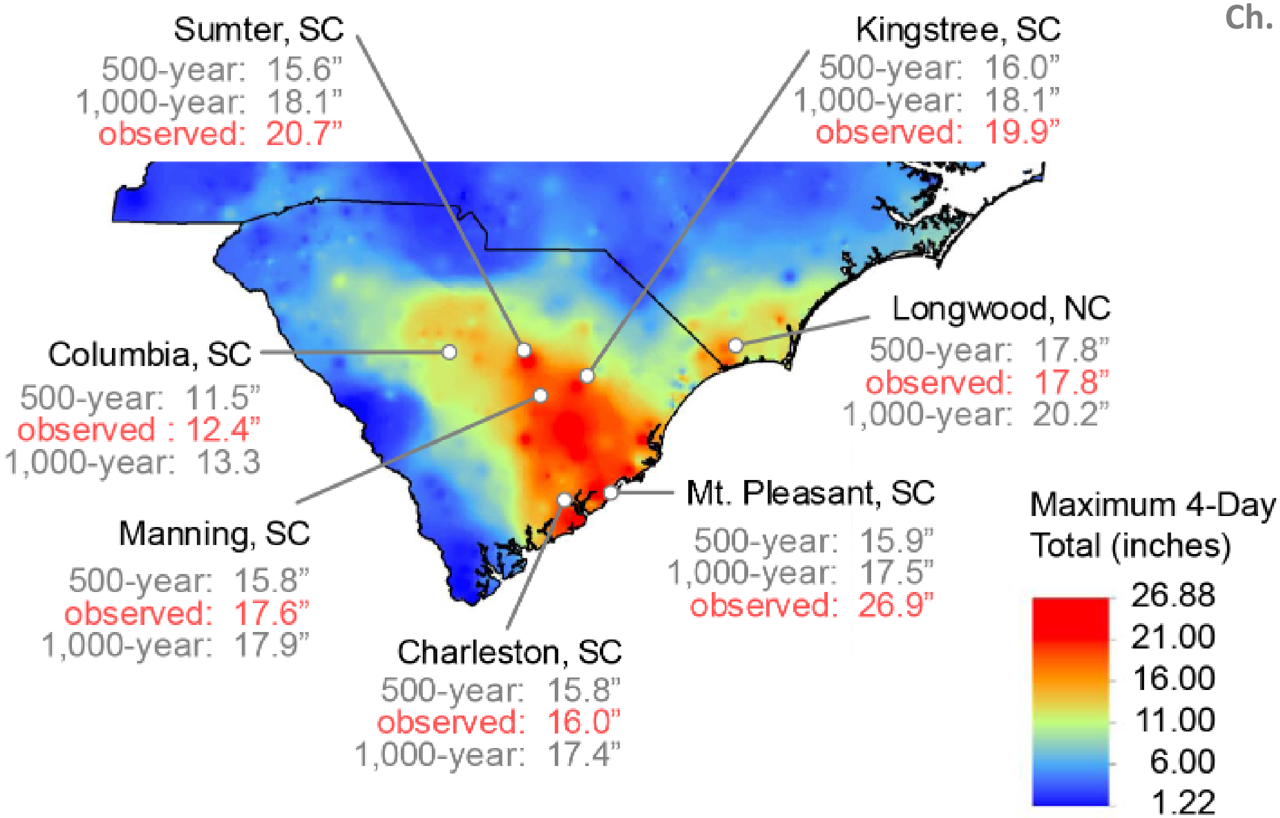


Fig. 19.12: October 2015 Extreme Rainfall Event

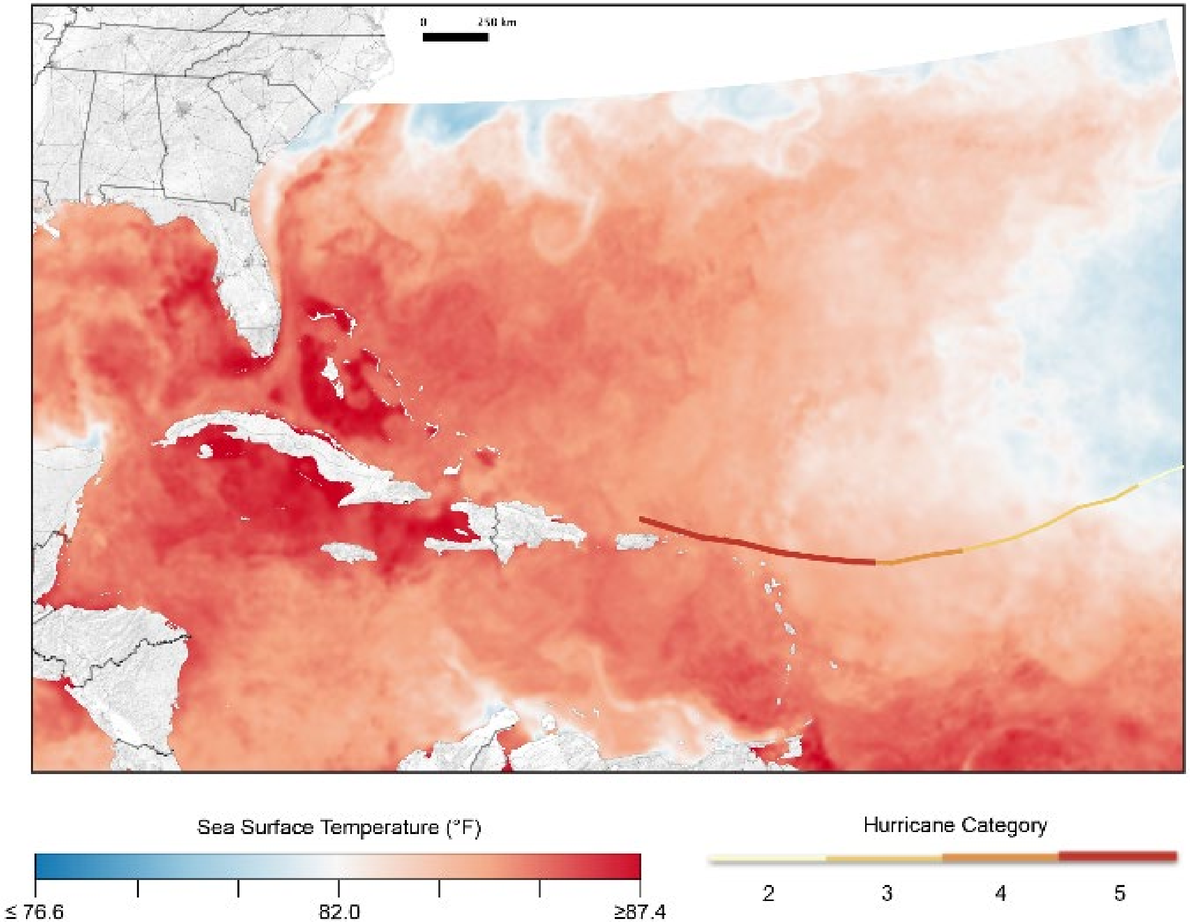
The map shows rainfall totals from the October 2015 South Carolina flood event. Red colors in the map indicate areas that received excessive rainfall totals that broke all-time records. Some of these totals exceeded the 500-year and 1,000-year return period amounts (rainfall amounts that would be expected to have only a 0.2% or 0.1% chance of occurring in a given year). Extreme precipitation events will likely increase in frequency in the Southeast. *Source: CISA 2015.*[98]

Fig. 19.13: October 2015 Charleston Flood

Many roads became impassable in the inland areas of South Carolina as a result of the October 2015 extreme rainfall event. This photo shows a neighborhood in North Charleston after the event with knee-deep flooding. *Photo credit: Ryan Johnson (CC BY-SA 2.0).*

Fig. 19.14: Warm Waters Contribute to the Formation of Hurricane Irma

Two factors supported Hurricane Irma's strength as it reached the Southeast region: the very warm waters it passed over, depicted in this figure, and the light winds Irma encountered in the upper atmosphere.[101] High-intensity hurricanes such as Irma are expected to become more common in the future due to climate change.[103] *Source: NASA 2017.*[102]



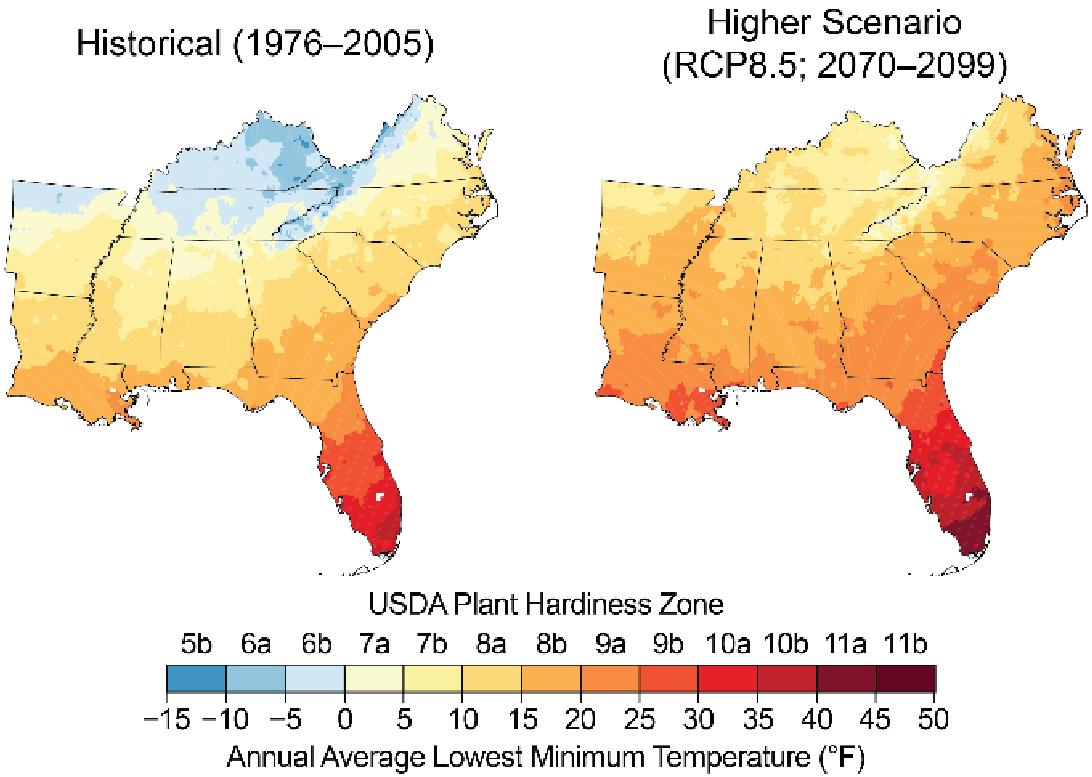


Fig. 19.15: Projected Changes in Plant Hardiness Zones

Increasing winter temperatures are expected to result in a northward shift of the zones conducive to growing various types of plants, known as plant hardiness zones. These maps show the mean projected changes in the plant hardiness zones, as defined by the U.S. Department of Agriculture (USDA), by the late 21st century (2070–2099) under a higher scenario (RCP8.5). The USDA plant hardiness zones are based on the average lowest minimum temperature for the year, divided into increments of 5°F. Based on these projected changes, freeze-sensitive plants, like oranges, papayas, and mangoes, would be able to survive in new areas.[142] Note that large changes are projected across the region, but especially in Kentucky, Tennessee, and northern Arkansas. *Sources: NOAA NCEI and CICS-NC.*

Fig. 19.17: Transitioning Coastal Ecosystems

In Louisiana and parts of northern Florida, future coastal wetlands are expected to look and function more like the mangrove-dominated systems currently present in South Florida and the Caribbean. Like salt marshes (left), mangrove forests (right) provide coastal protection against wind and waves (Ch. 20: U.S. Caribbean, KM 2). *Photo credit: Michael Osland.*

Fig. 19.18: Warm Winters Favor Invasive Species

Burmese pythons are apex predators (not preyed upon by other animals) that are sensitive to cold temperatures and are expected to be favored by warming winters. This photo is from Everglades National Park, where unintentionally introduced pythons have expanded and reduced native mammal populations. *Photo credit: U.S. Geological Survey.*

Fig. 19.19: Wildlife and Prescribed Fire

(top) A helicopter drops water on a 1,500-hectare wildfire on Hurlburt Field (Eglin Air Force Base) in Florida in June of 2012. (bottom) The increased use of prescribed fire at Ft. Benning, Georgia, led to a decrease in wildfire occurrence from 1982 to 2012. *Photo credit: Kevin Hiers, Tall Timbers. Figure source: adapted from Addington et al. 2015.*[4] *Reprinted by permission of CSIRO Australia, ©CSIRO.*

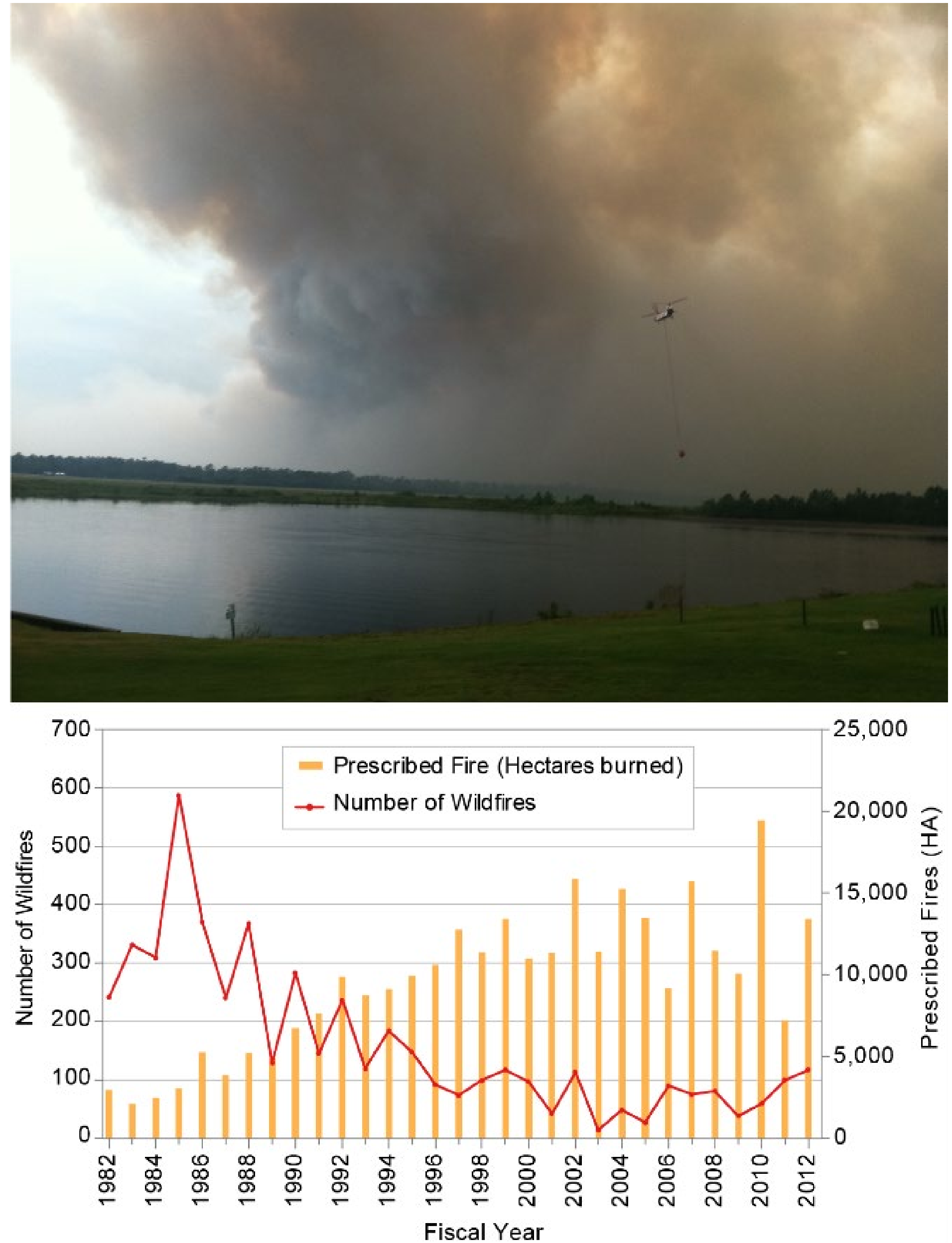


Fig. 19.20: Mountain Ramps

This up-close image of a ramp (*Allium tricoccum*), harvested from the wild, shows leaves and the bulb/corm of the plant. *Photo credit: Gary Kaufman, USDA Forest Service Southern Research Station.*

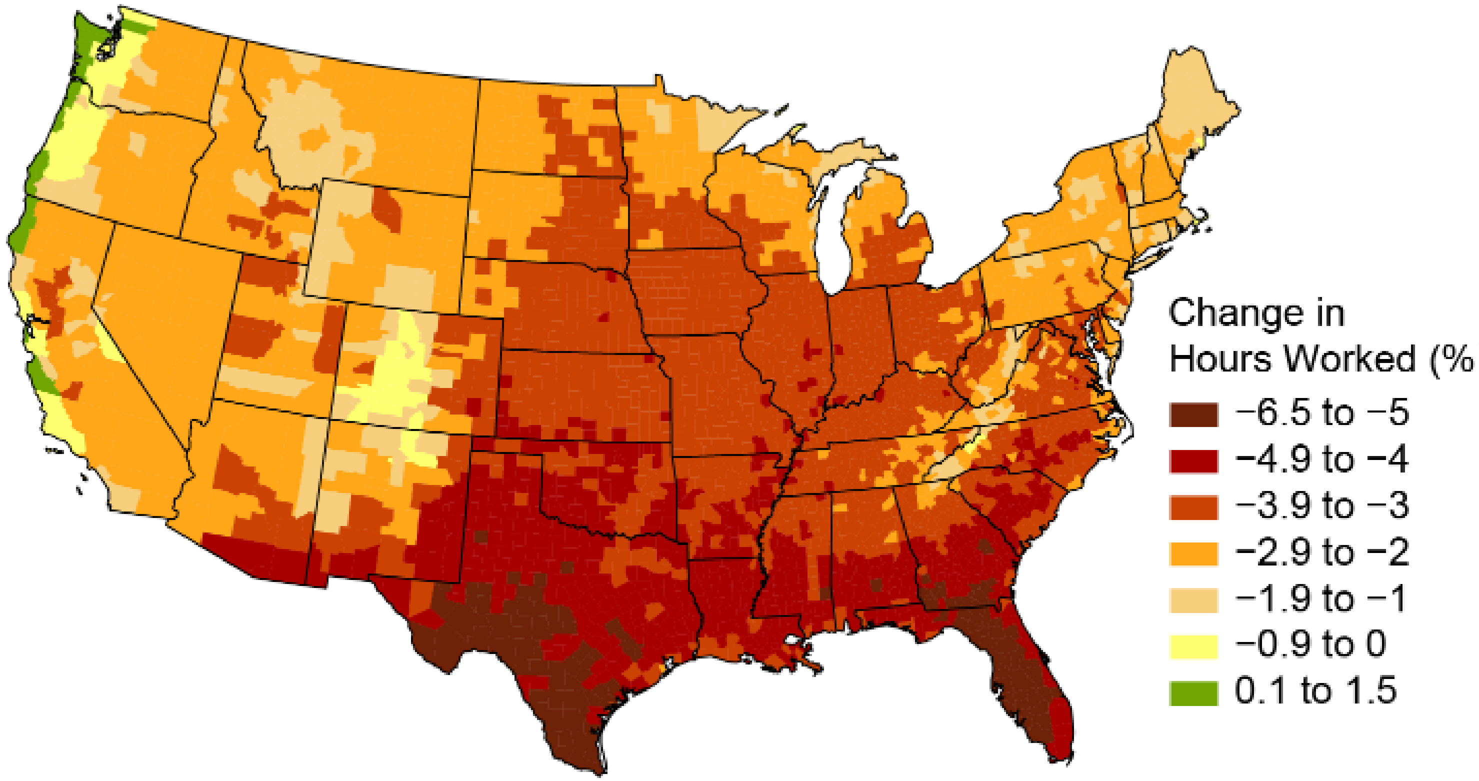


Fig. 19.21: Projected Changes in Hours Worked

This map shows the estimated percent change in hours worked in 2090 under a higher scenario (RCP8.5). Projections indicate an annual average of 570 million labor hours lost per year in the Southeast by 2090 (with models ranging from 340 million to 820 million labor hours).[35] Estimates represent a change in hours worked as compared to a 2003–2007 average baseline for high-risk industries only. These industries are defined as agriculture, forestry, and fishing; hunting, mining, and construction; manufacturing, transportation, and utilities. *Source: adapted from EPA 2017.*[35]

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NC Executive Order 80 - Section 9

Climate Information for North Carolina

April 26, 2019

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AGENDA

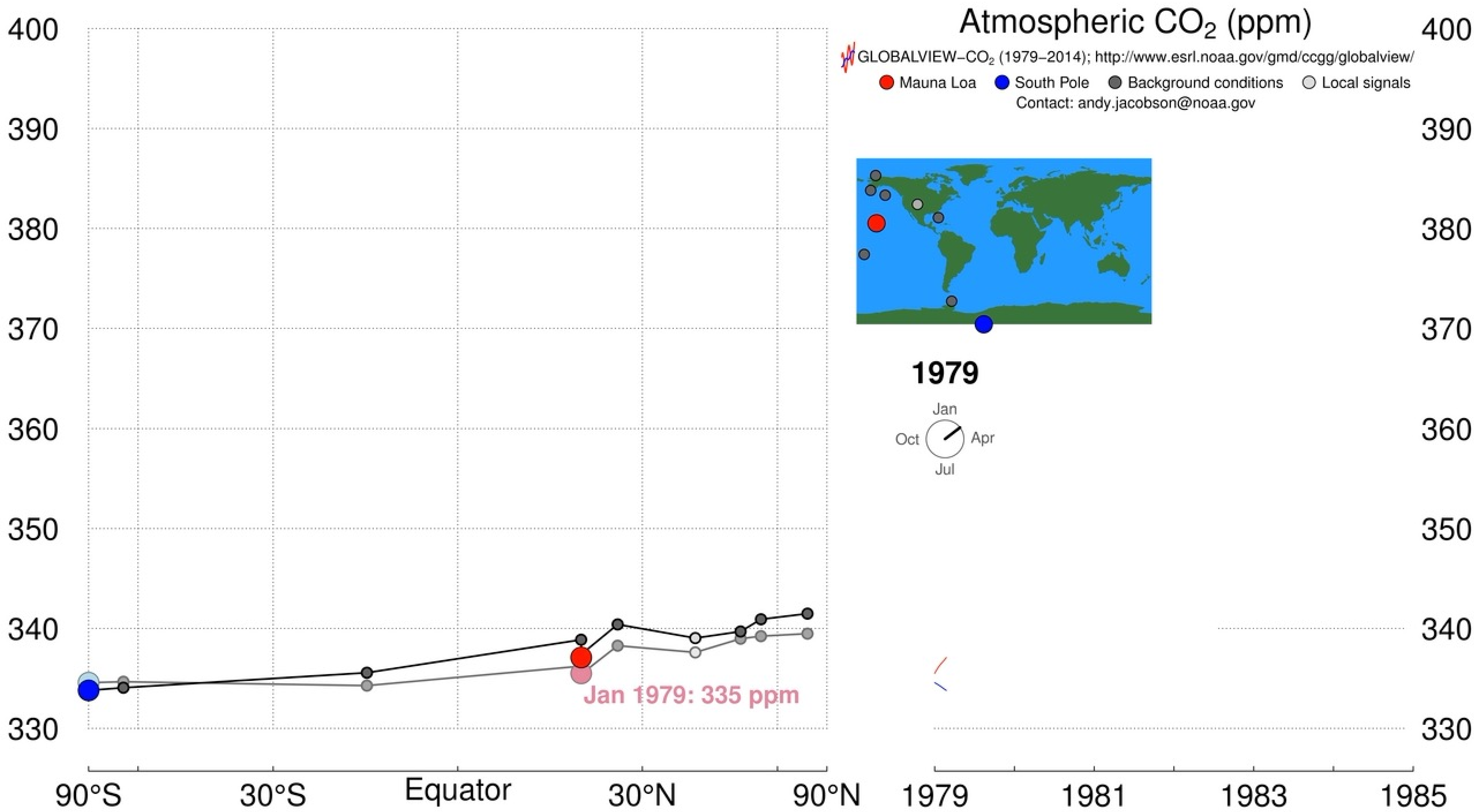
Today's Topics

- **NCICS**
- **Review of Current Climate Science Information**
  - **US results from Volume I of National Climate Assessment**
  - ***Initial* updated North Carolina analysis**

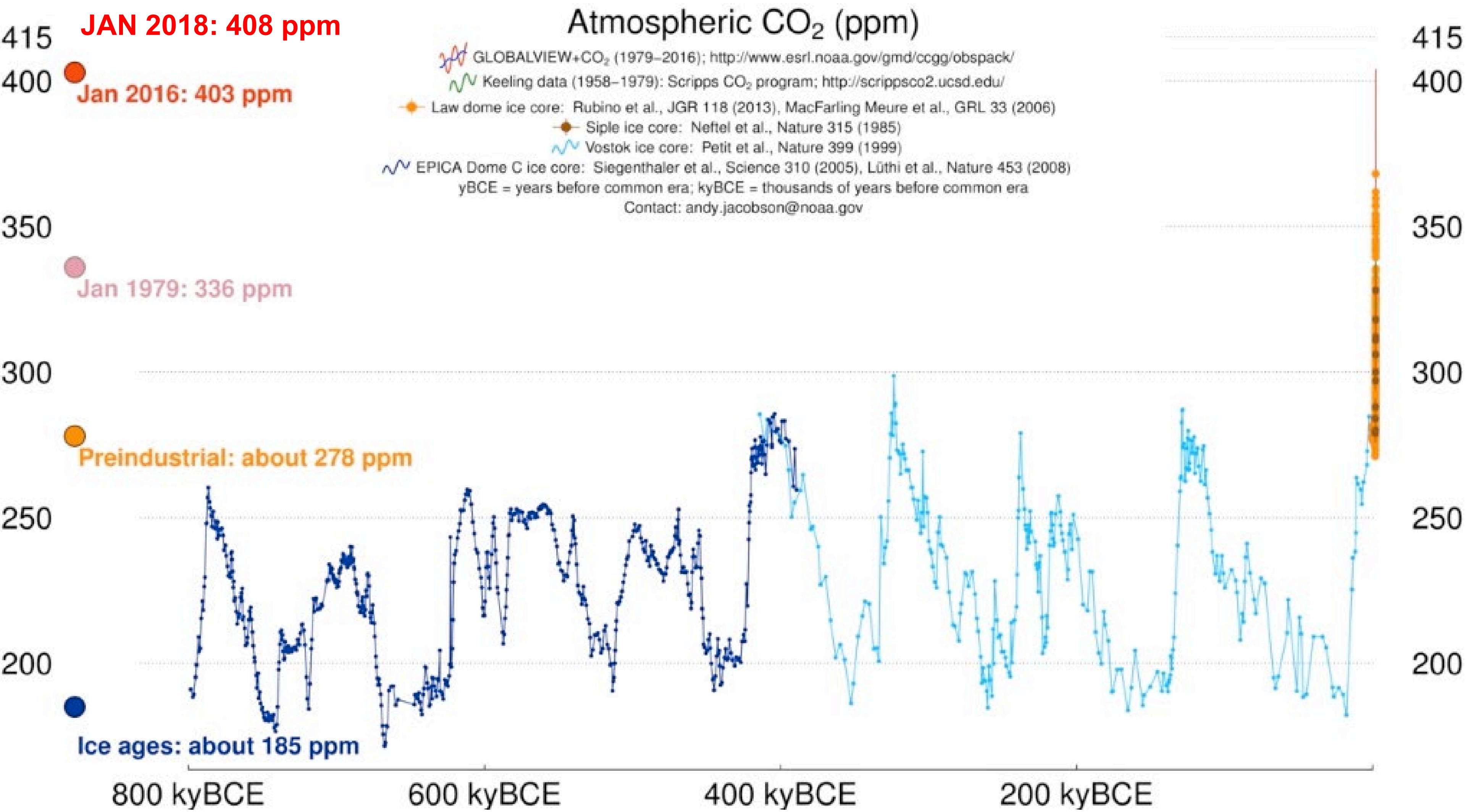
North Carolina Institute for Climate Studies
Cooperative Institute for Climate and Satellites–North Carolina

ncics.org/cics-nc

- NCICS' primary activity is CICS-NC—a NOAA/NC State Cooperative Institute
- Co-located with NOAA's National Centers for Environmental Information (NCEI) in Asheville, North Carolina.
- CICS-NC is a multidisciplinary team of experts collaborating in climate and satellite research to support NCEI's "research to operations" strategy.
    - Including the USGCRP TSU Team involved in the National Climate Assessment



Atmospheric CO_2 (ppm)
GLOBALVIEW-CO_2 (1979–2014); http://www.esrl.noaa.gov/gmd/ccgg/globalview/
Mauna Loa
South Pole
Background conditions
Local signals
Contact: andy.jacobson@noaa.gov
1979
Jan
Apr
Jul
Oct
Jan 1979: 335 ppm
400
390
380
370
360
350
340
330
90°S
30°S
Equator
30°N
90°N
1979
1981
1983
1985



CO_2 in atmosphere now higher than any point in last ***800,000 years***.

THREE BIG CHANGES….

Source: electricspacekoolaid.tumblr.com

IT GETS WARMER

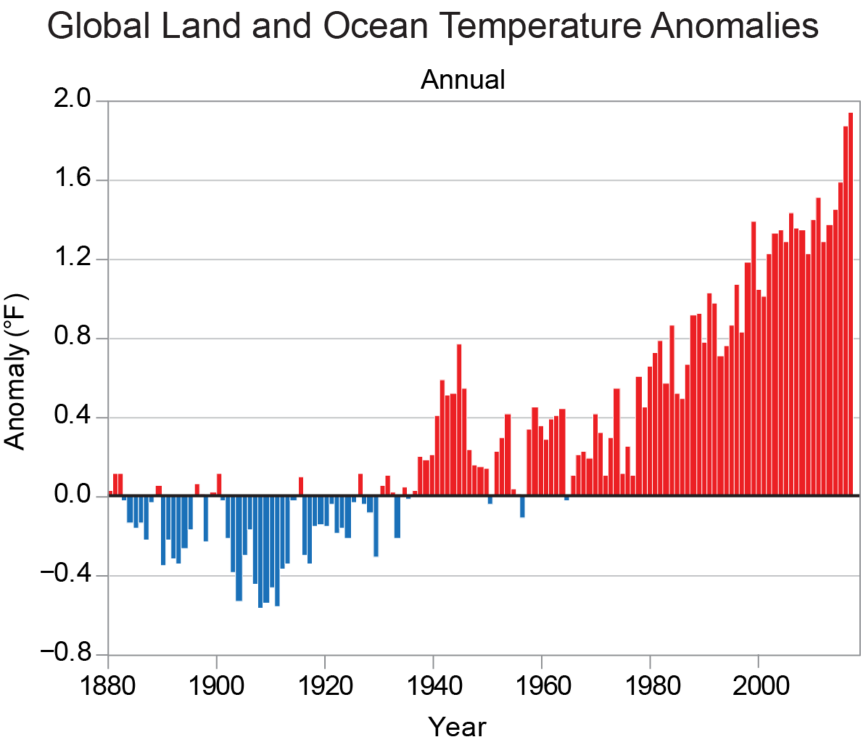
Source: electricspacekoolaid.tumblr.com

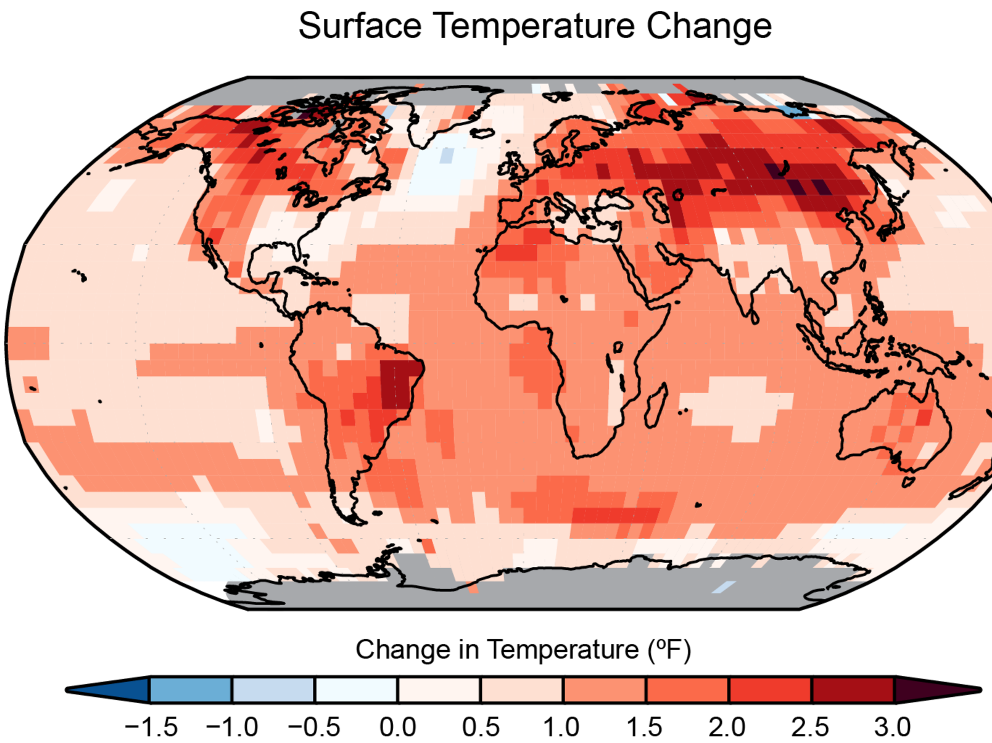

KANGAROO
Unleaded
272 9
Money Orders
GO GAMECOCKS
S40 454
STOP
WHALEY
IT RAINS HARDER

Photo Credit: Erica Henry

IT GETS WARMER

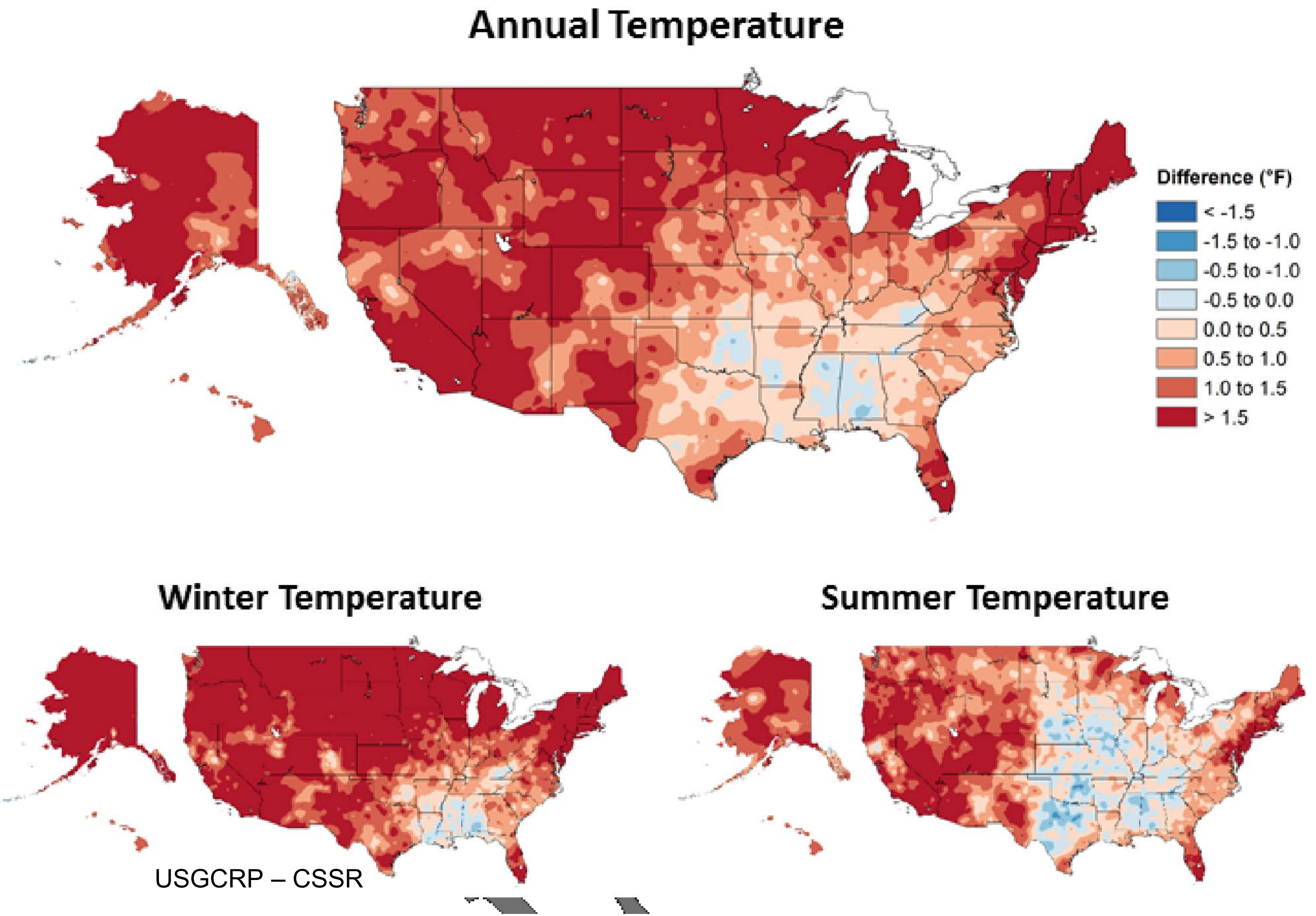
Source: electricspacekoolaid.tumblr.com



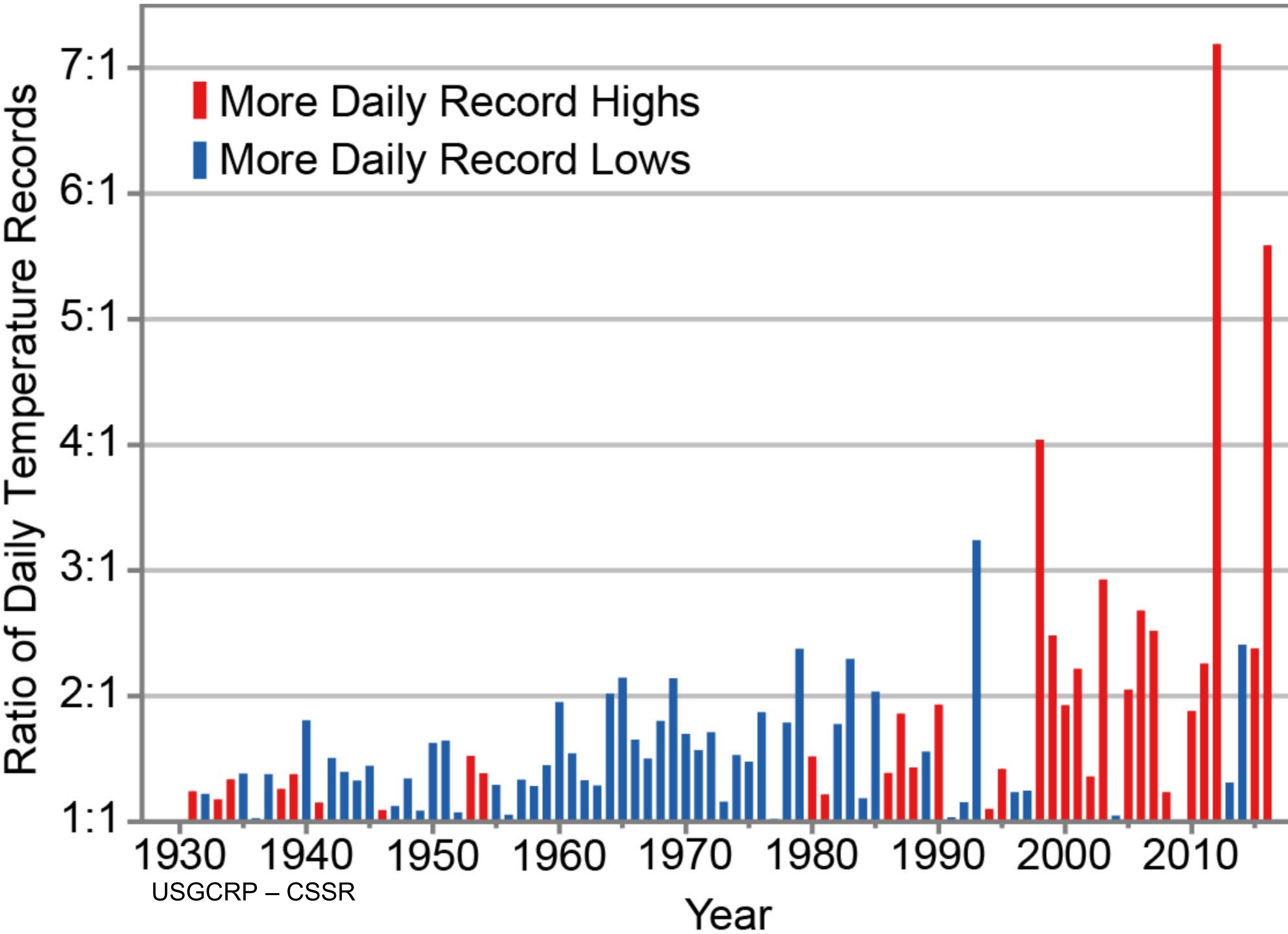


USGCRP – CSSR

USGCRP CSSR 2


Annual Temperature
Difference (°F)
< -1.5
-1.5 to -1.0
-0.5 to -1.0
-0.5 to 0.0
0.0 to 0.5
0.5 to 1.0
1.0 to 1.5
> 1.5
Winter Temperature
Summer Temperature

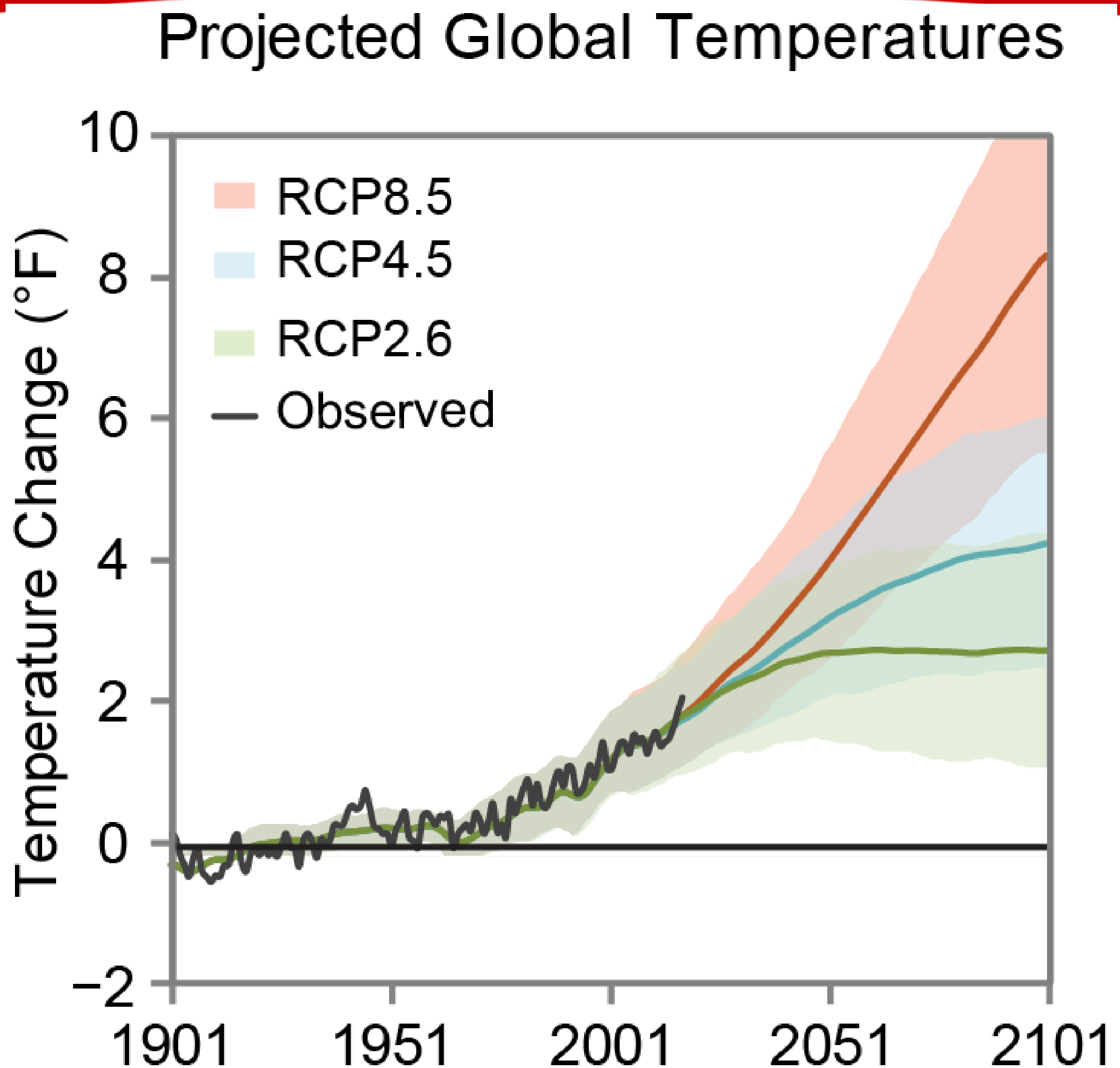
USGCRP – CSSR



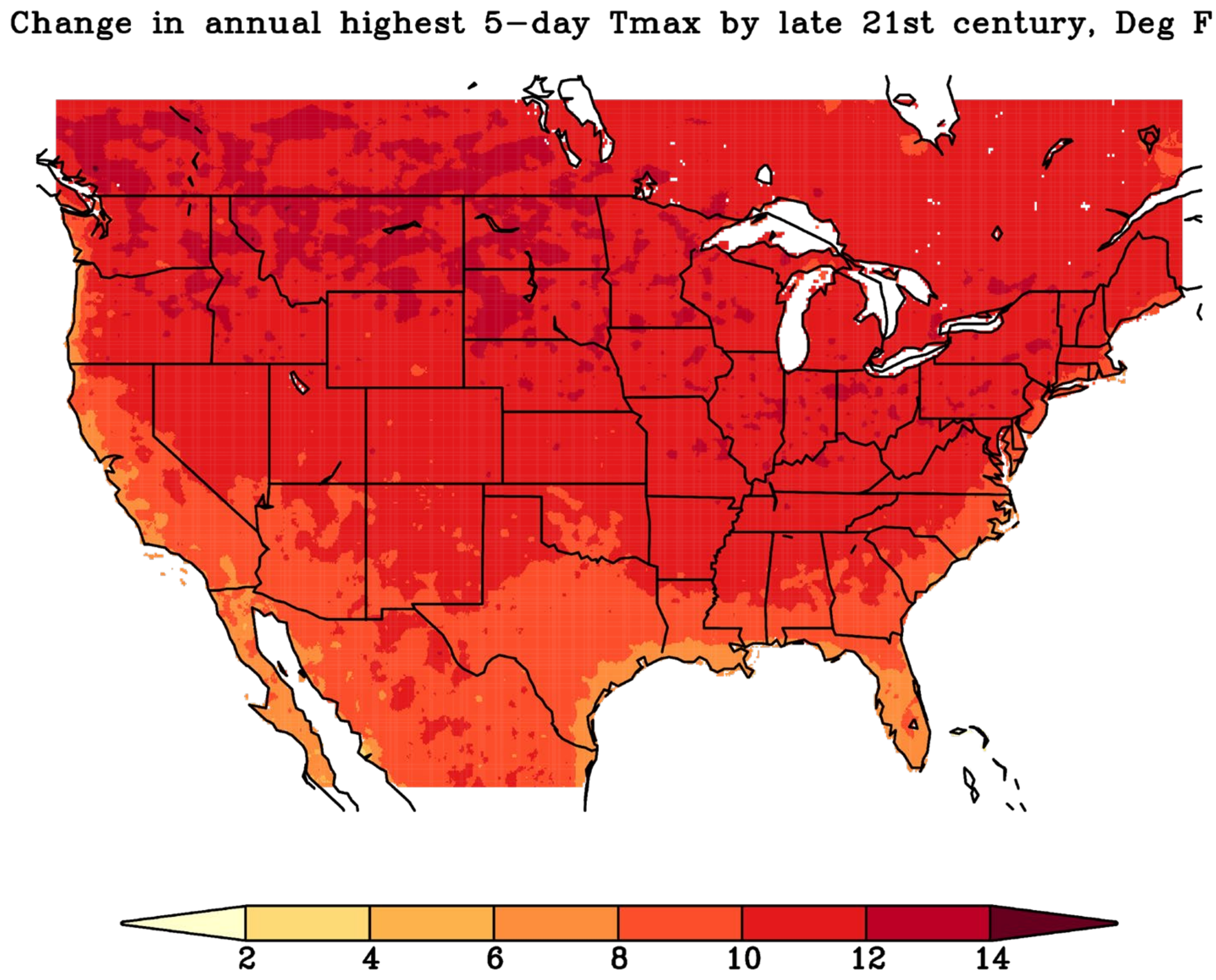
7:1
6:1
5:1
4:1
3:1
2:1
1:1
More Daily Record Highs
More Daily Record Lows
Ratio of Daily Temperature Records
1930
1940
1950
1960
1970
1980
1990
2000
2010
Year

USGCRP – CSSR

Global Mean Temperature Anomalies

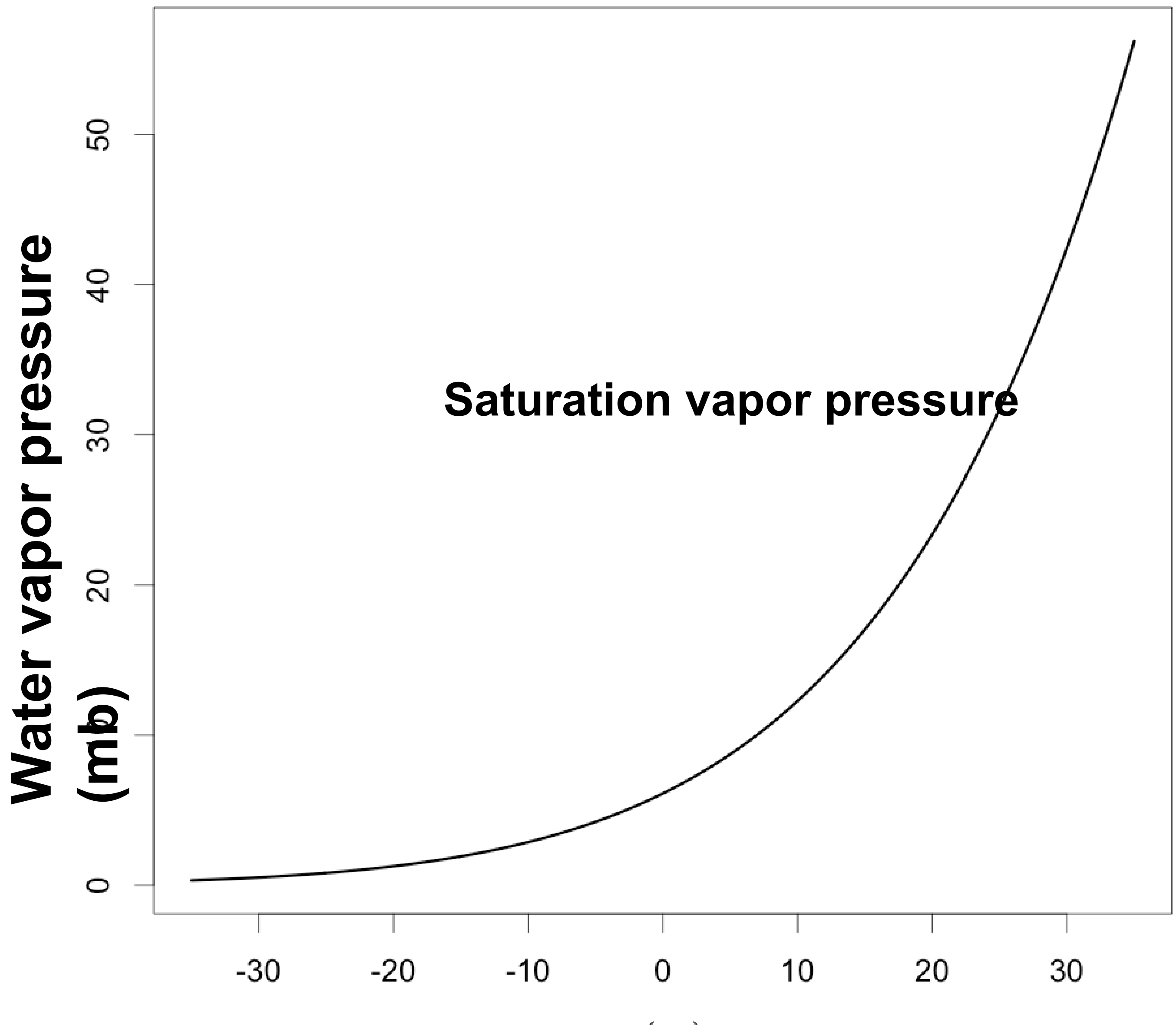


5-day Annual Tmax, high emissions



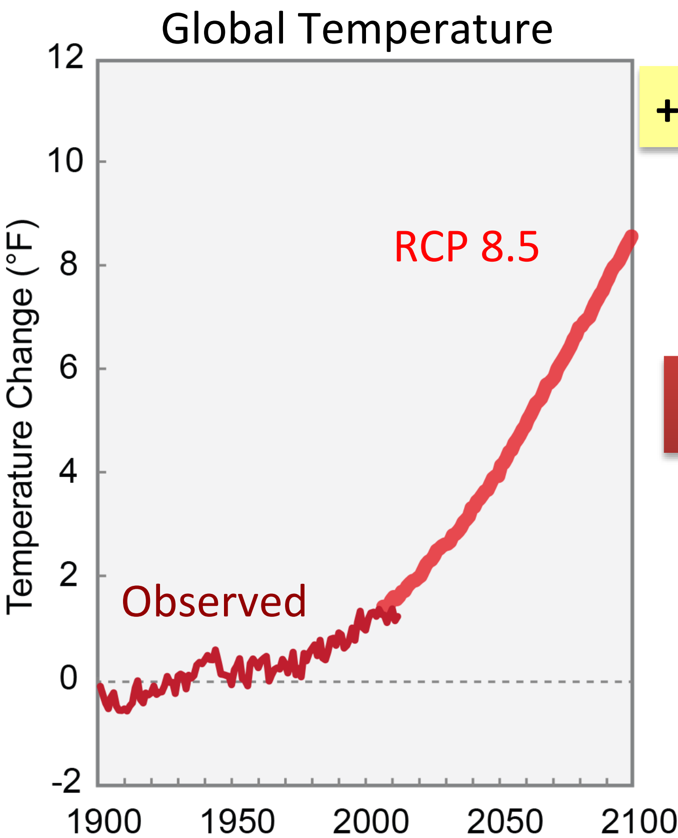

KANGAROO
Unleaded
272 9
GO GAMECOCKS
S40 454
STOP
WHALEY
IT RAINS HARDER


A warmer atmosphere will
have more water in it

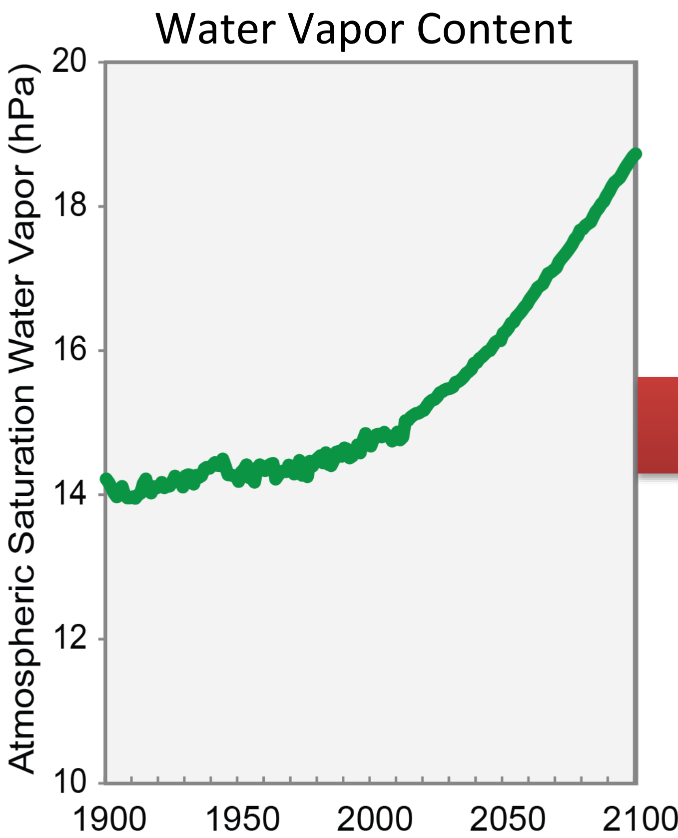


Clausius-Clapeyron Relation: Amount of water vapor in atmosphere increases as temperature increases

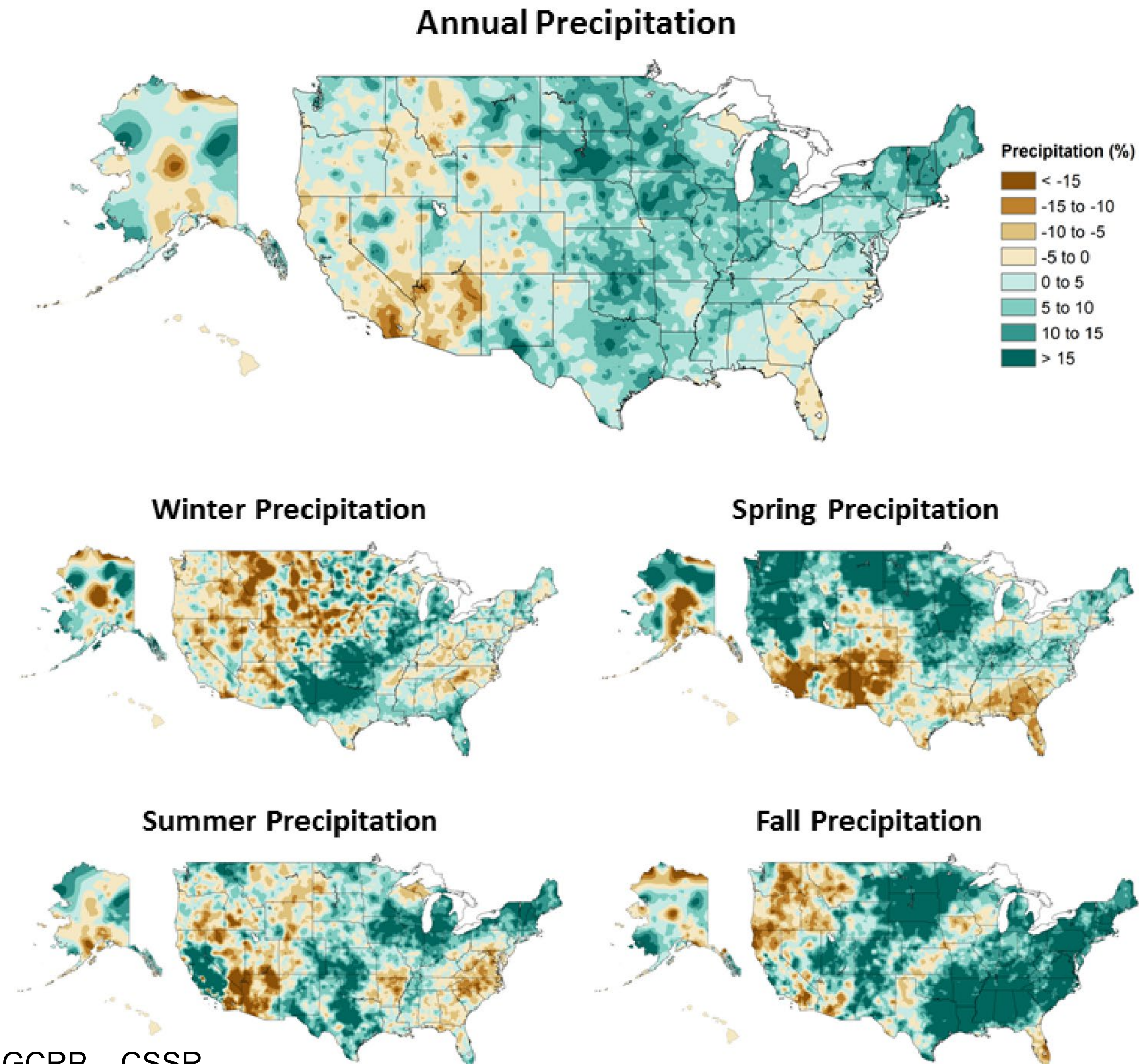
Global Warming->Saturation Water Vapor Increases



+7%/°C



Increases in Rainfall Rate (Capacity)


Annual Precipitation
Precipitation (%)
< -15
-15 to -10
-10 to -5
-5 to 0
0 to 5
5 to 10
10 to 15
> 15
Winter Precipitation
Spring Precipitation
Summer Precipitation
Fall Precipitation

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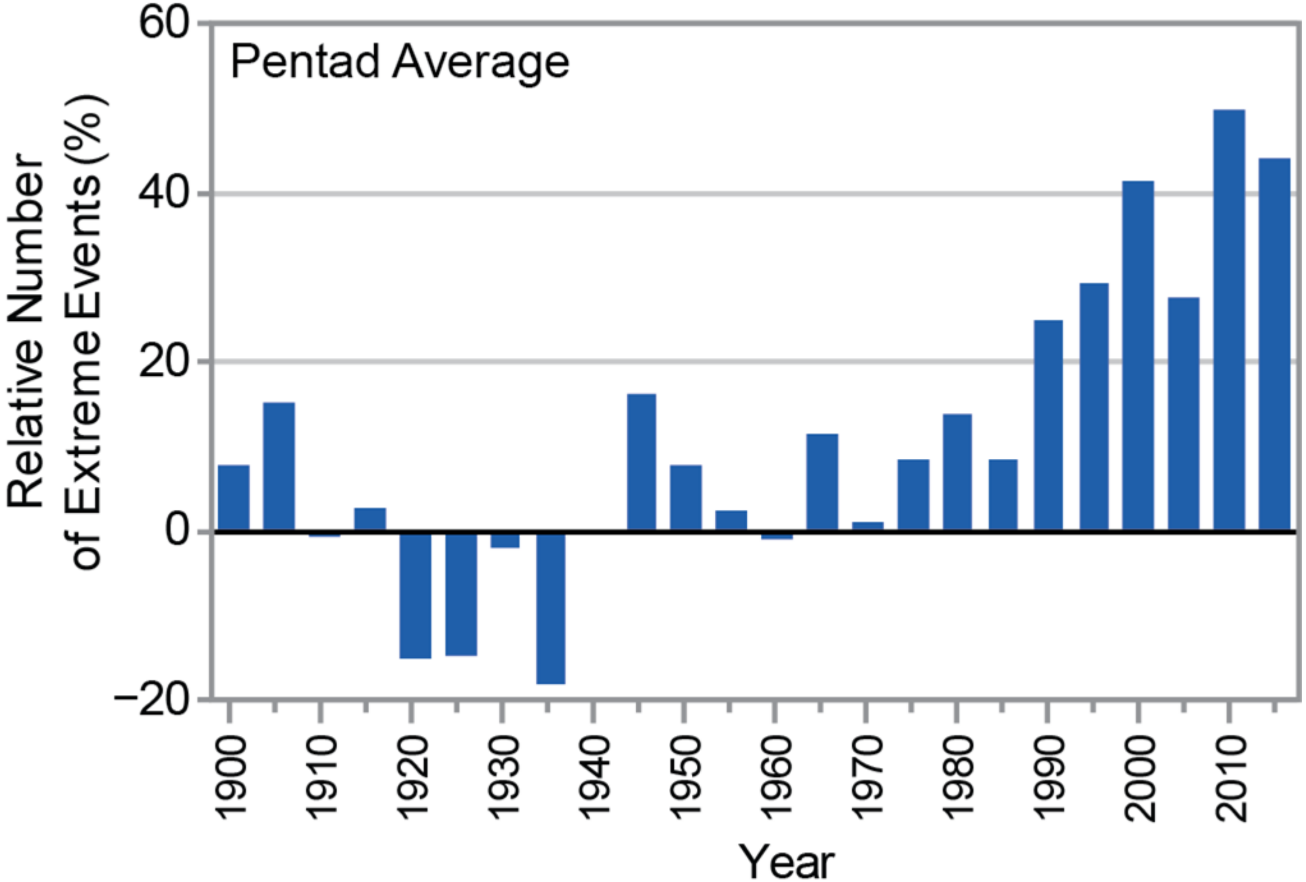
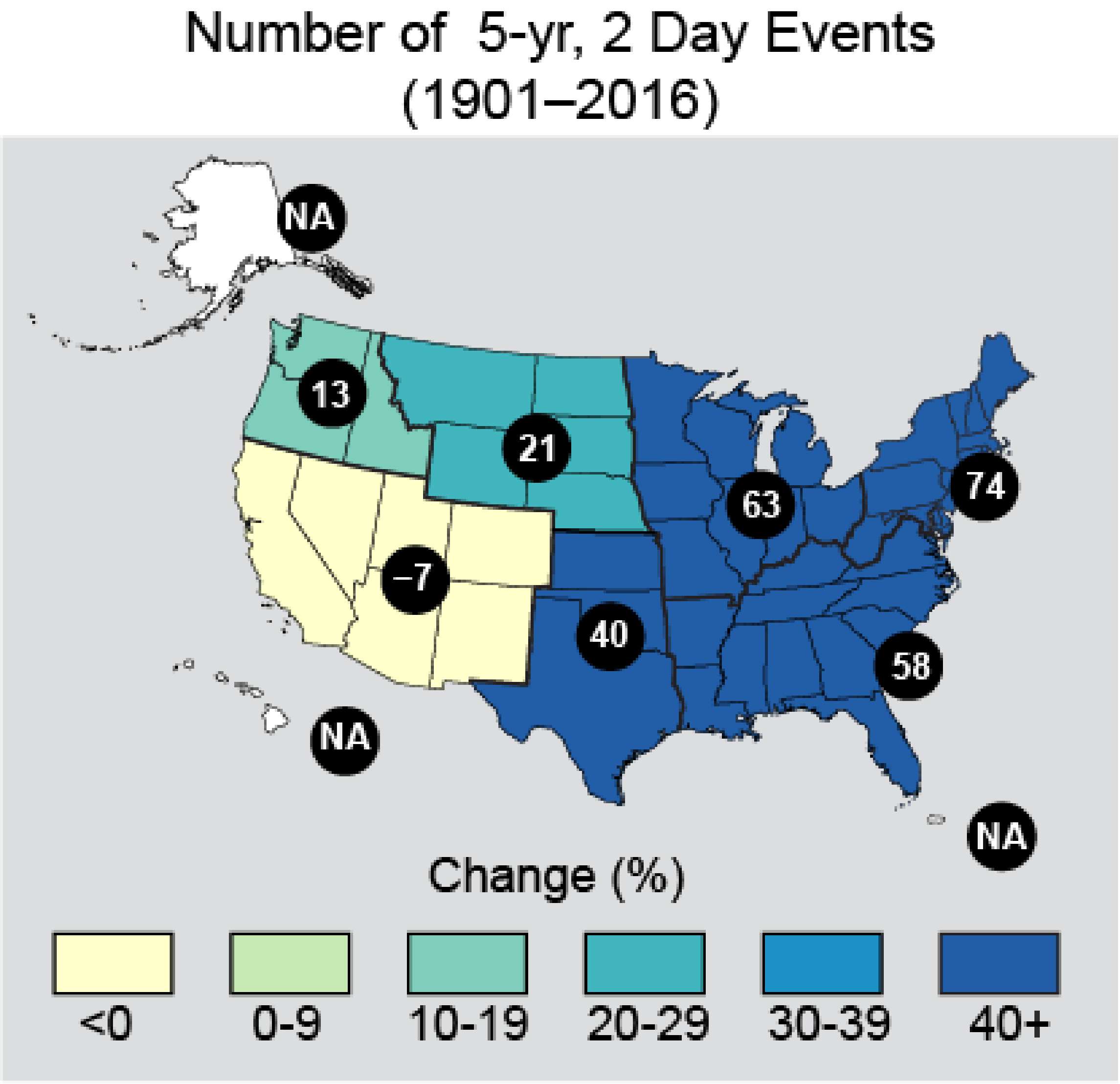
2-Day Precipitation Events Exceeding a 5-Year Recurrence Interval

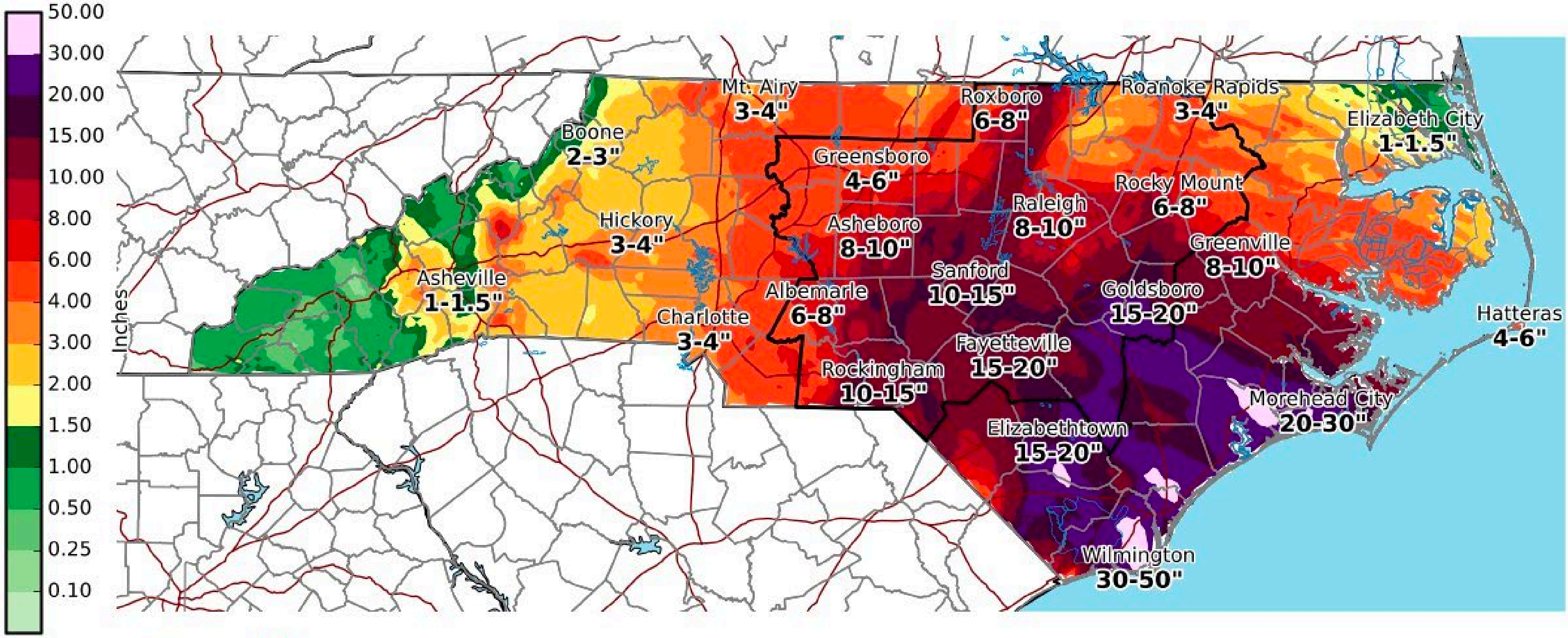


Observed U.S. Trends in Heavy Precipitation



62

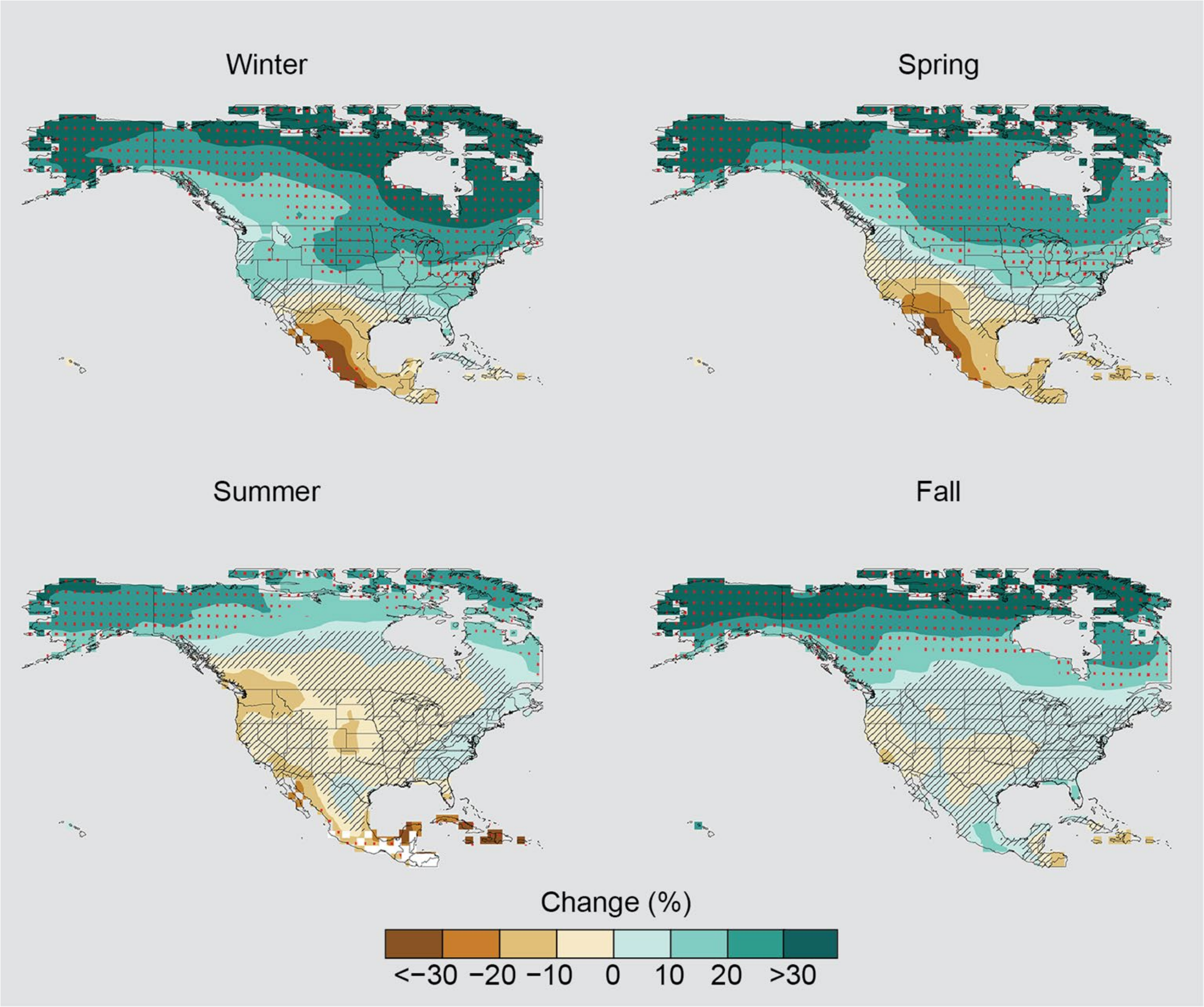
Radar-Estimated Florence Total Rainfall
Valid: 09/13/2018 08:00 AM - 09/17/2018 08:00 PM EDT



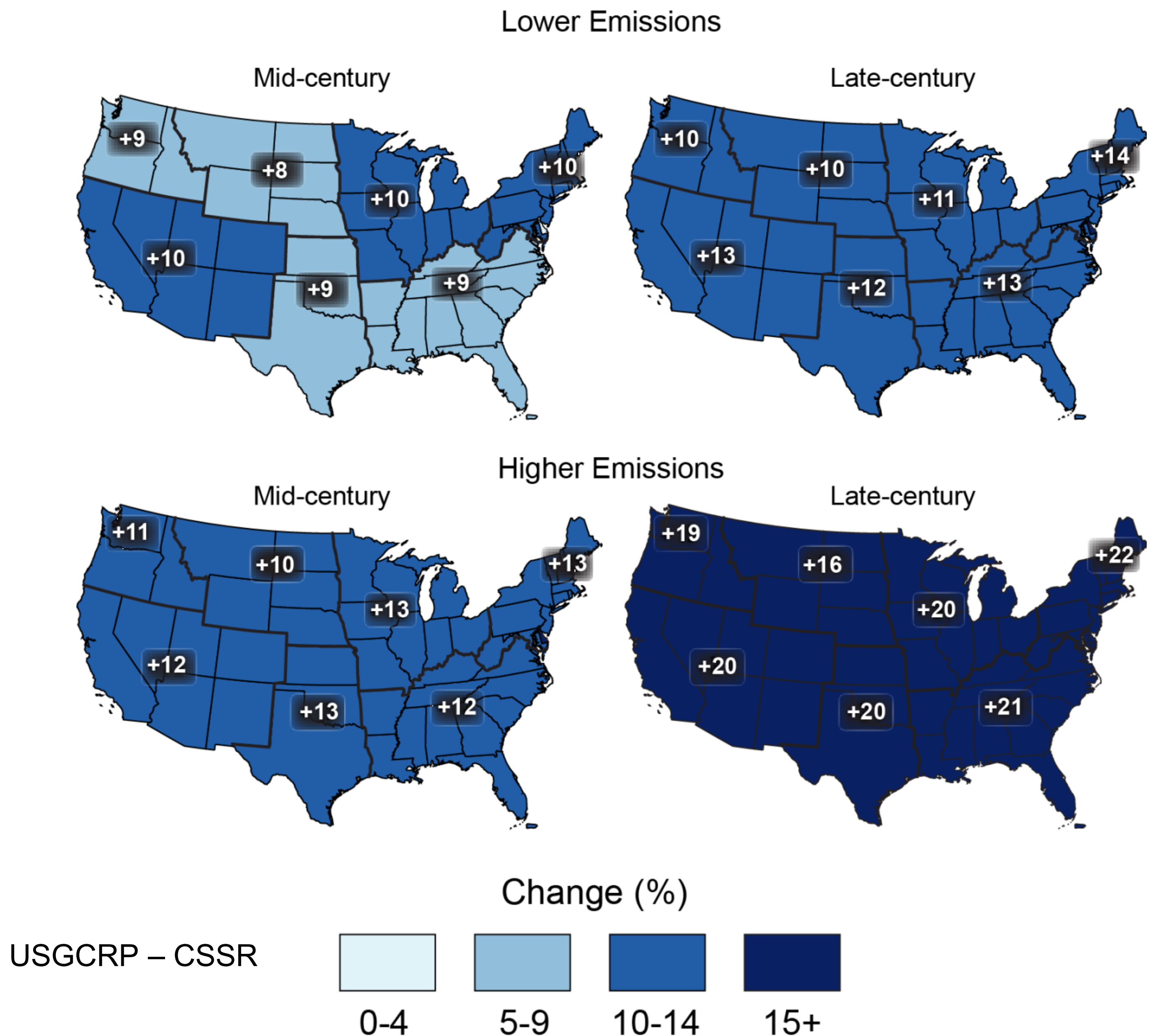
National Weather Service
Raleigh, North Carolina
09/18/2018 04:10 AM EDT

Follow Us:
weather.gov/raleigh

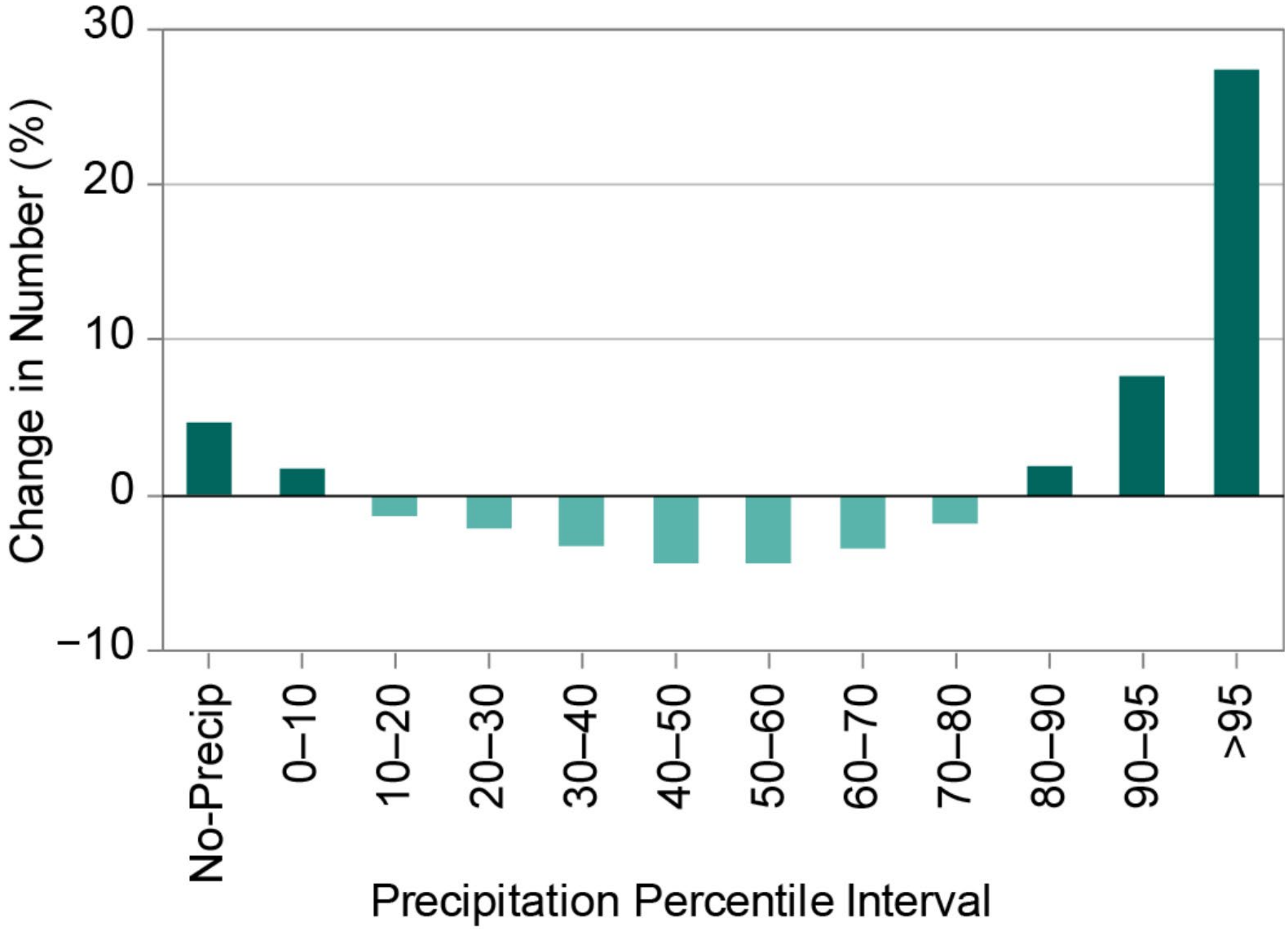
Projected Change in Seasonal Precipitation Late 21st Century, high emissions



Projected Change in Daily, 20-year Extreme Precipitation



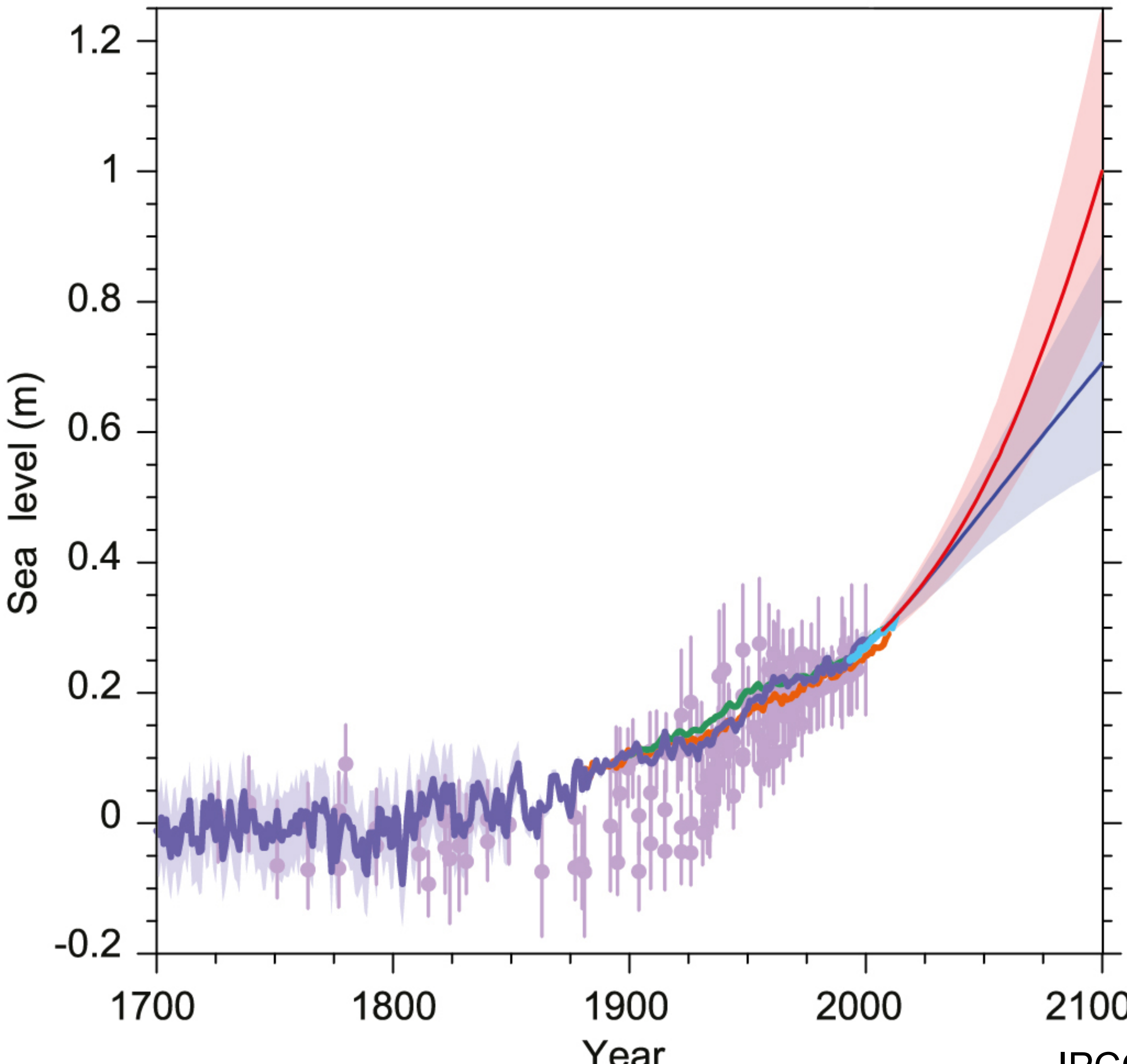
FEWER SHOWERS – MORE DELUGES



USGCRP – CSSR

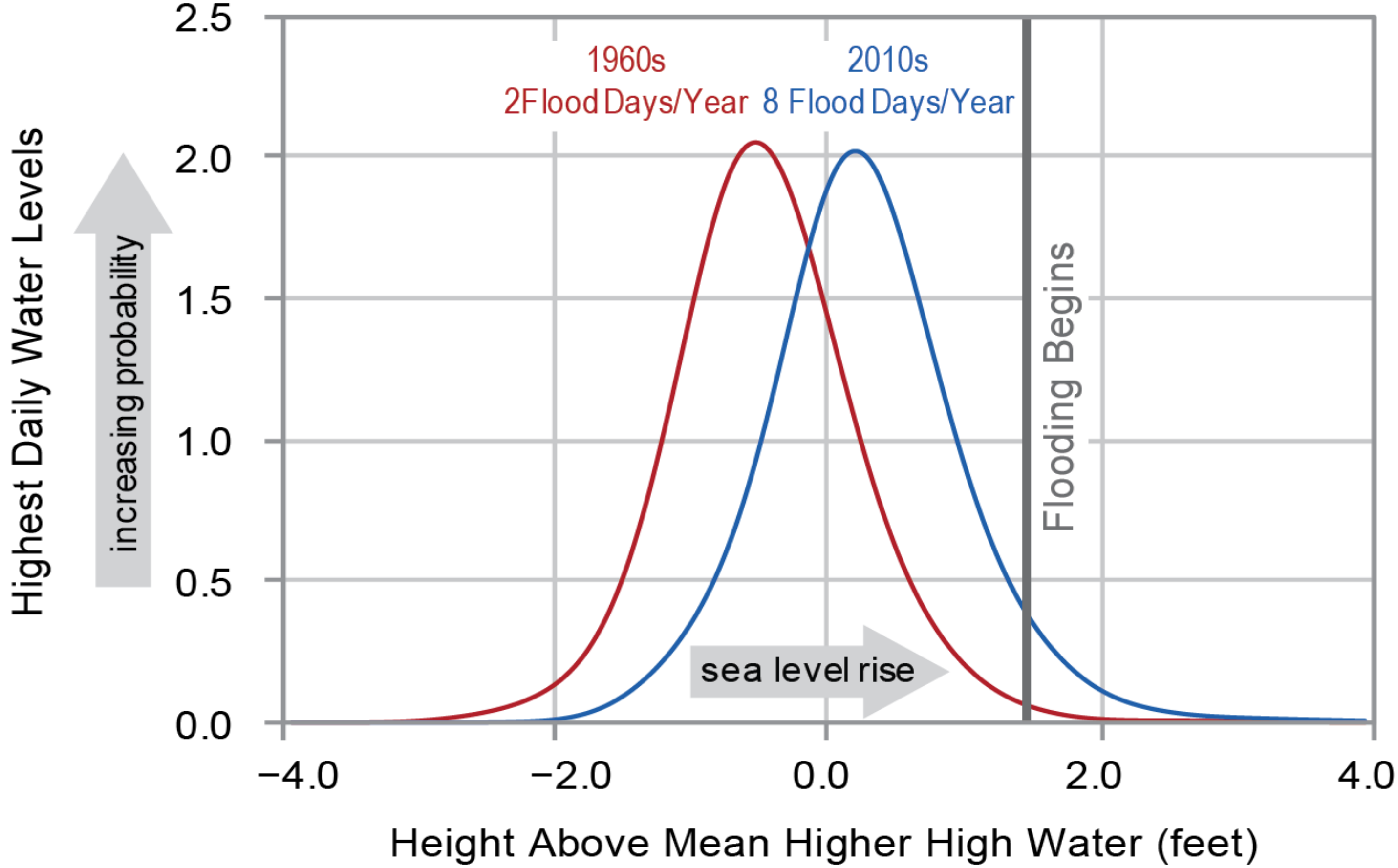

THE SEAS RISE
Photo Credit: Erica Henry

MELTING ICE AND EXPANDING OCEANS



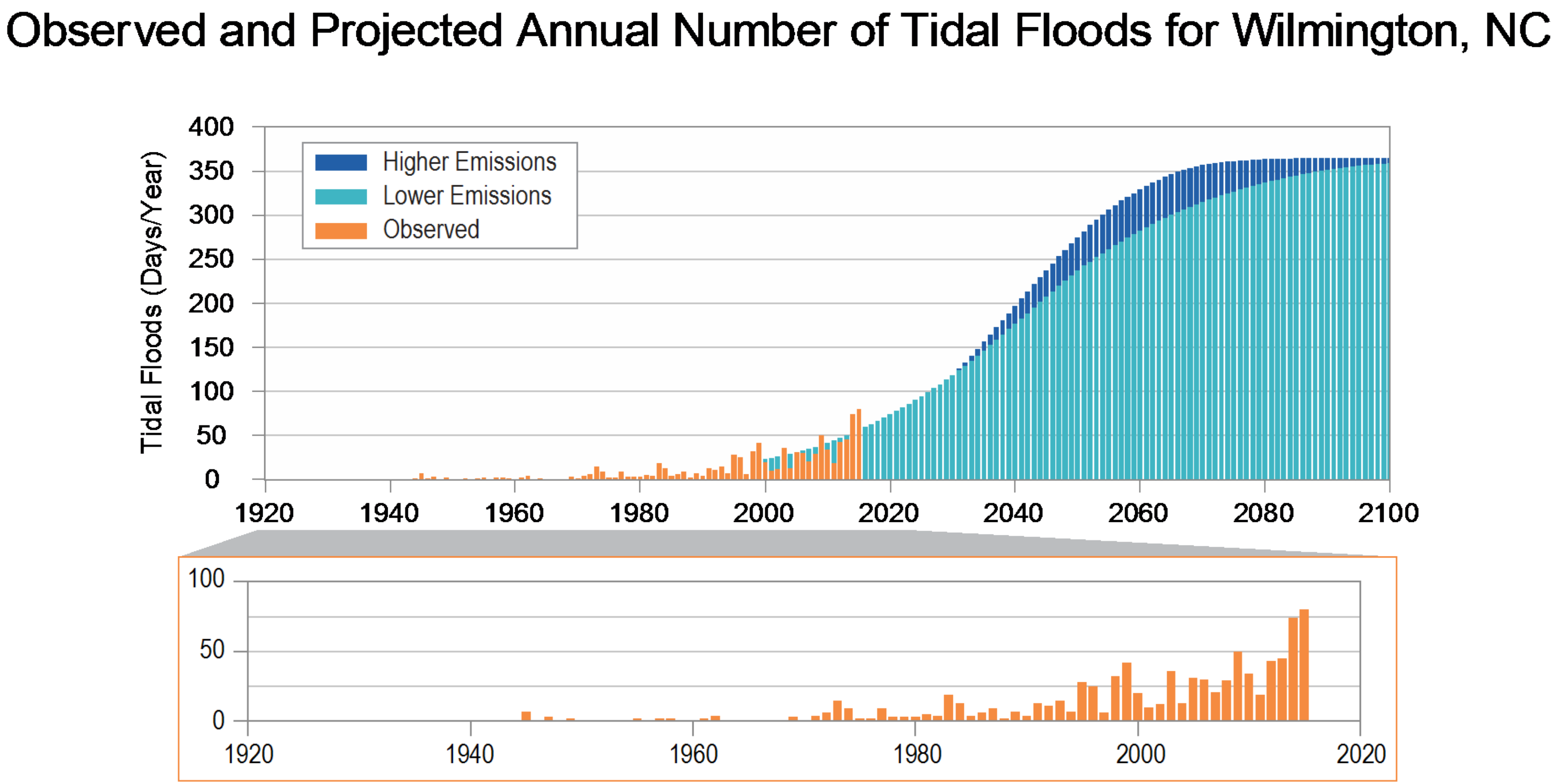
IPCC AR5

MORE ‘SUNNY DAY’ FLOODING



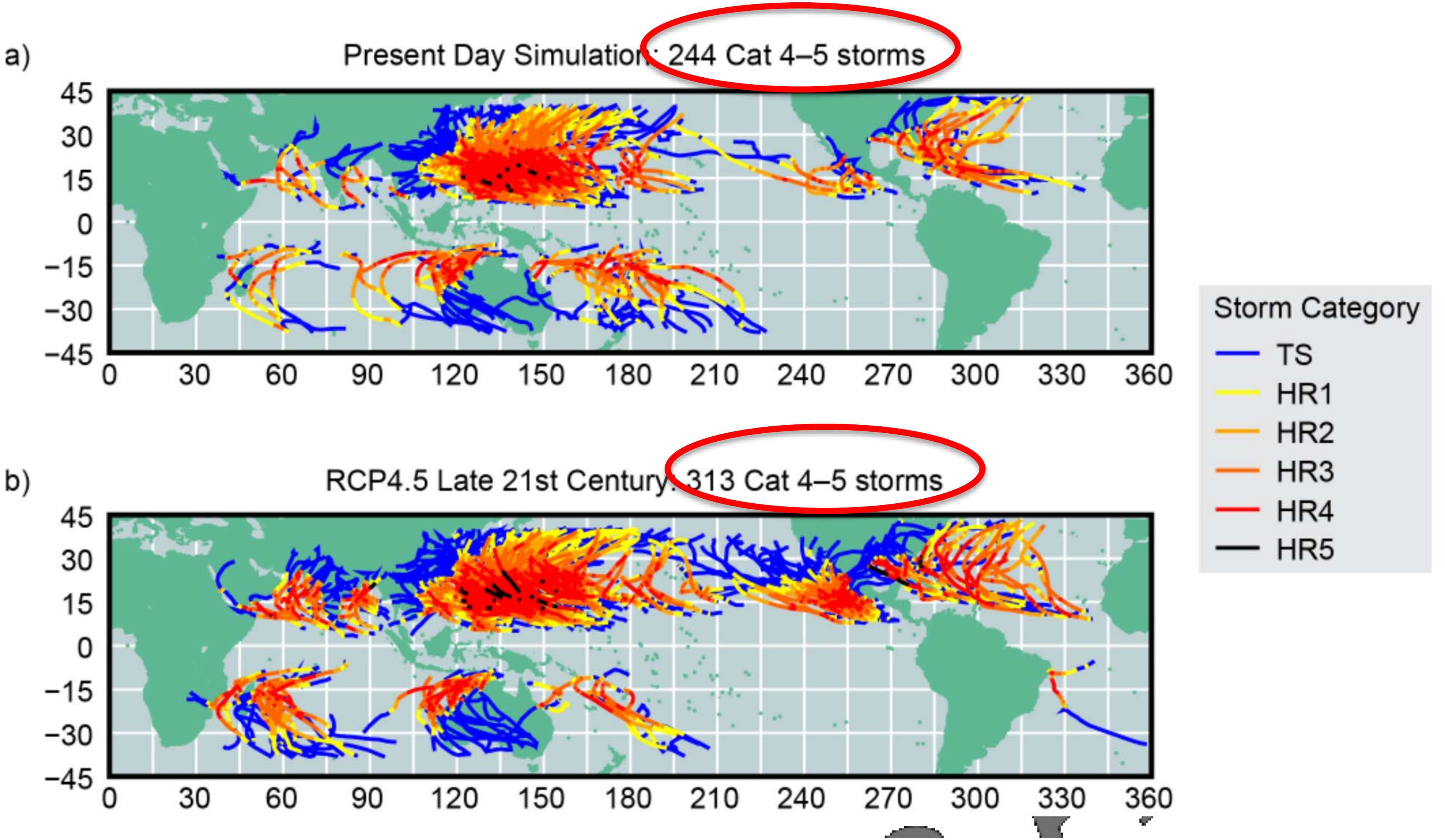
USGCRP – CSSR

Recurrent Flooding Becomes the Norm

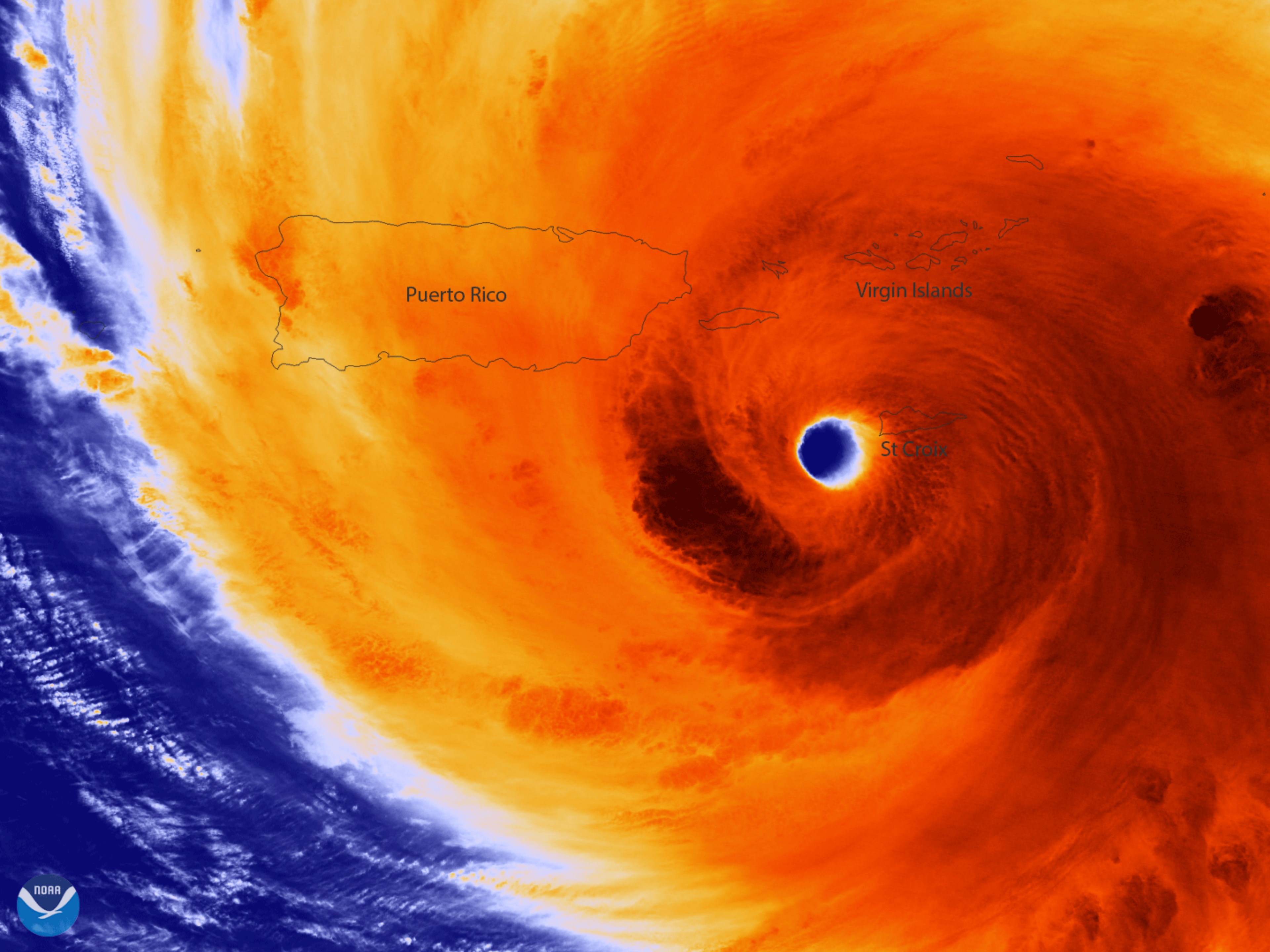


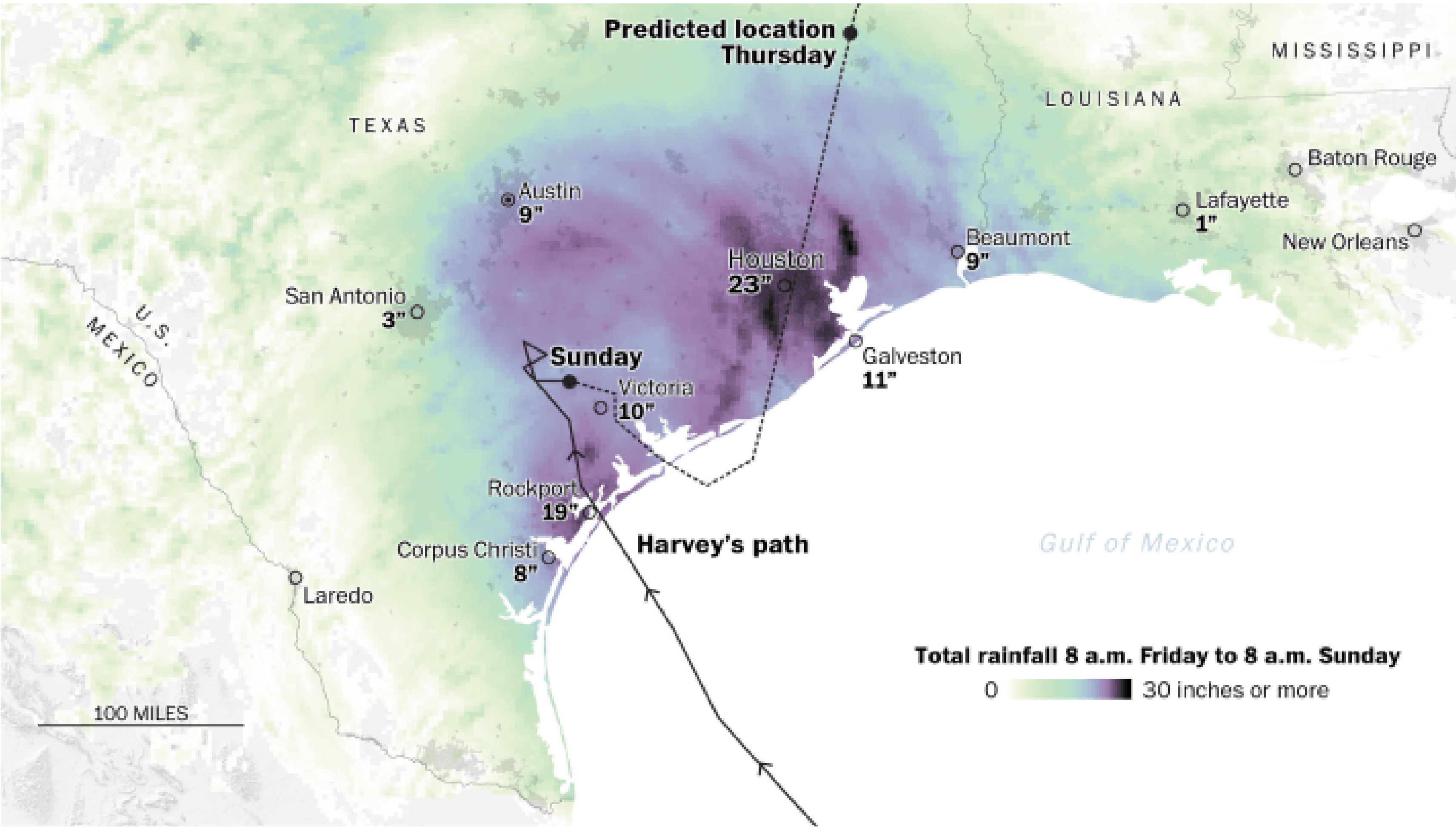
USGCRP – CSSR

Increased Chance of Stronger Hurricanes

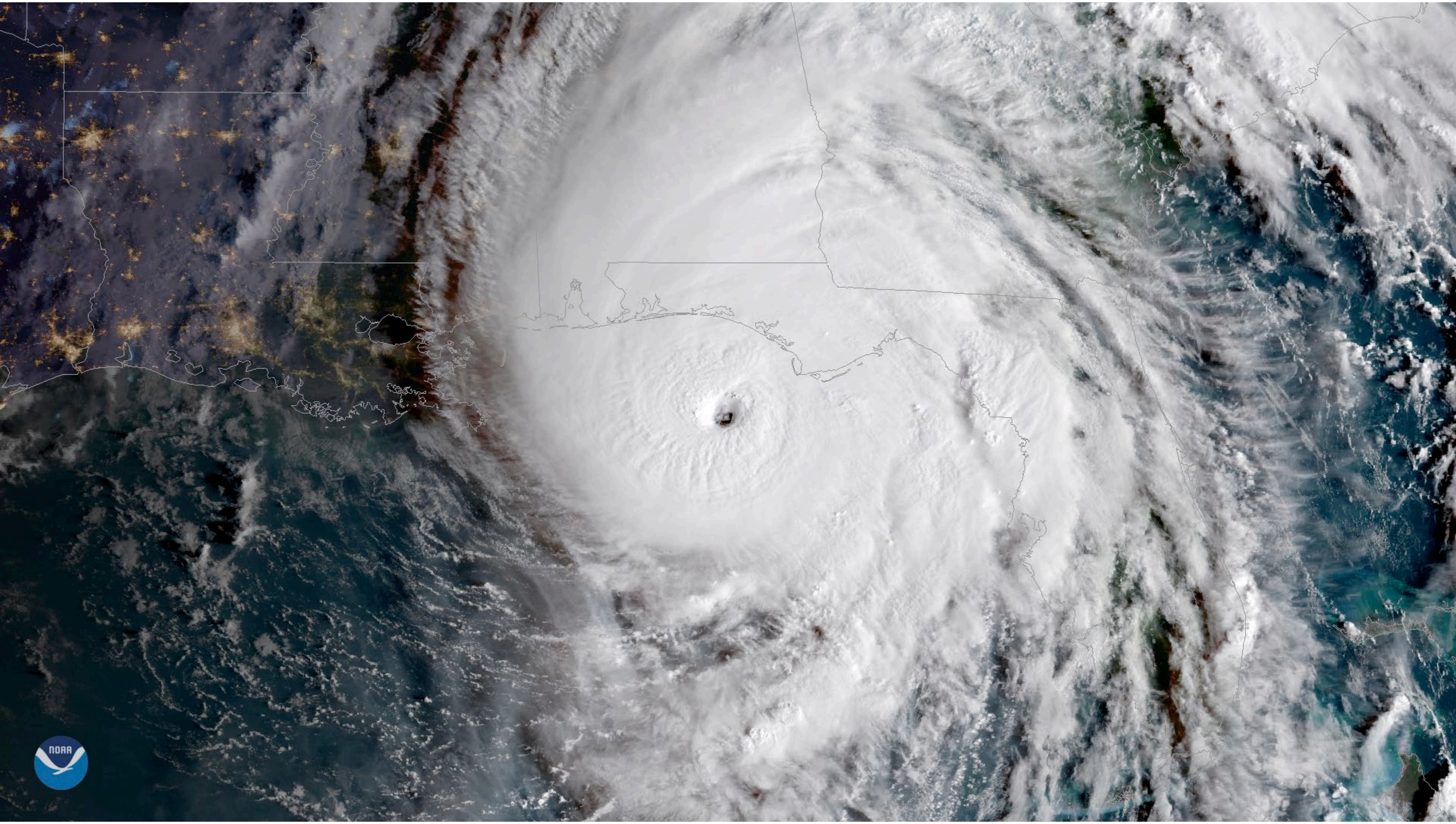


USGCRP – CSSR


Puerto Rico
Virgin Islands
St Croix
NOAA



Source: Washington Post



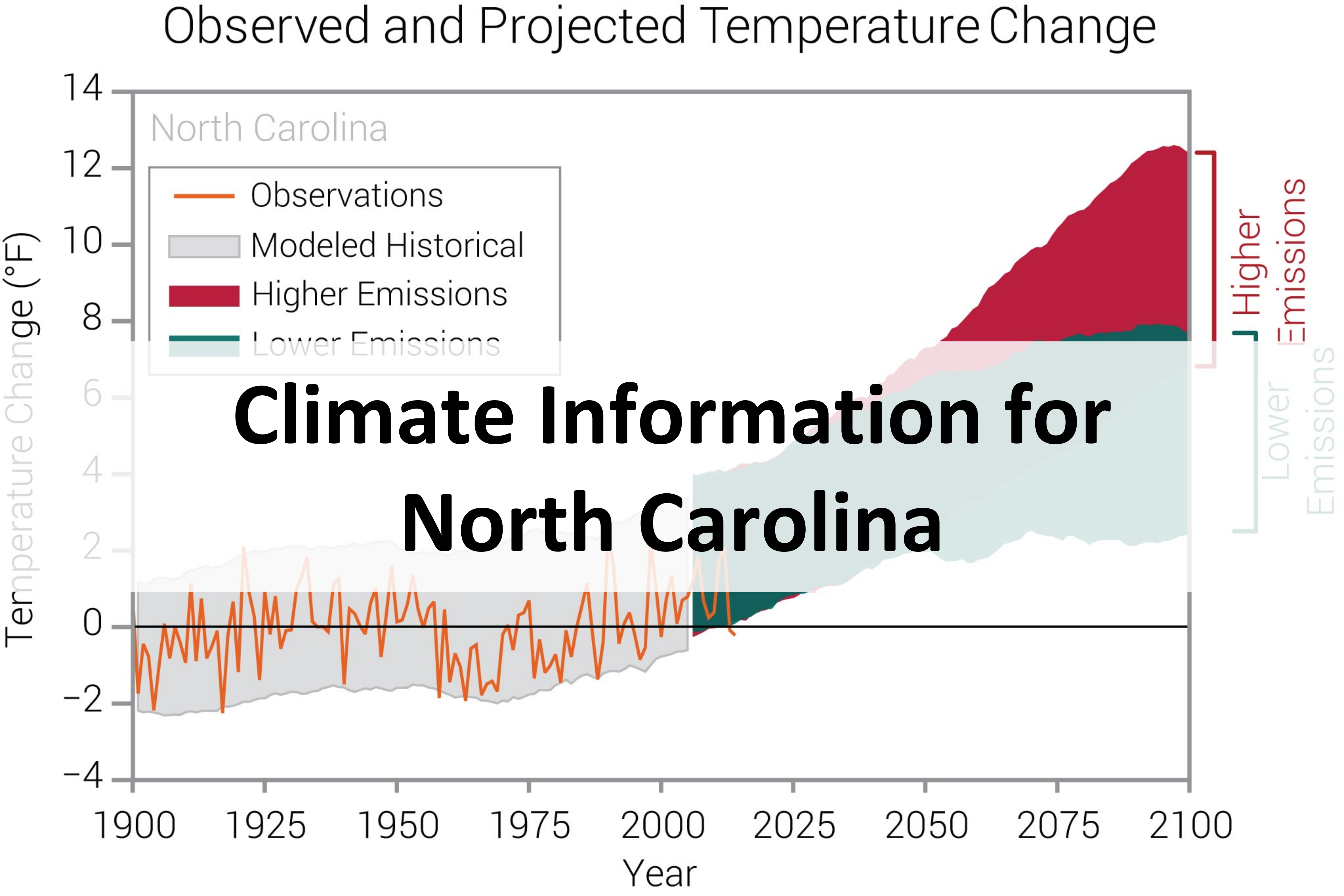
[Michael Landfall]

Has Extreme Weather Increased?

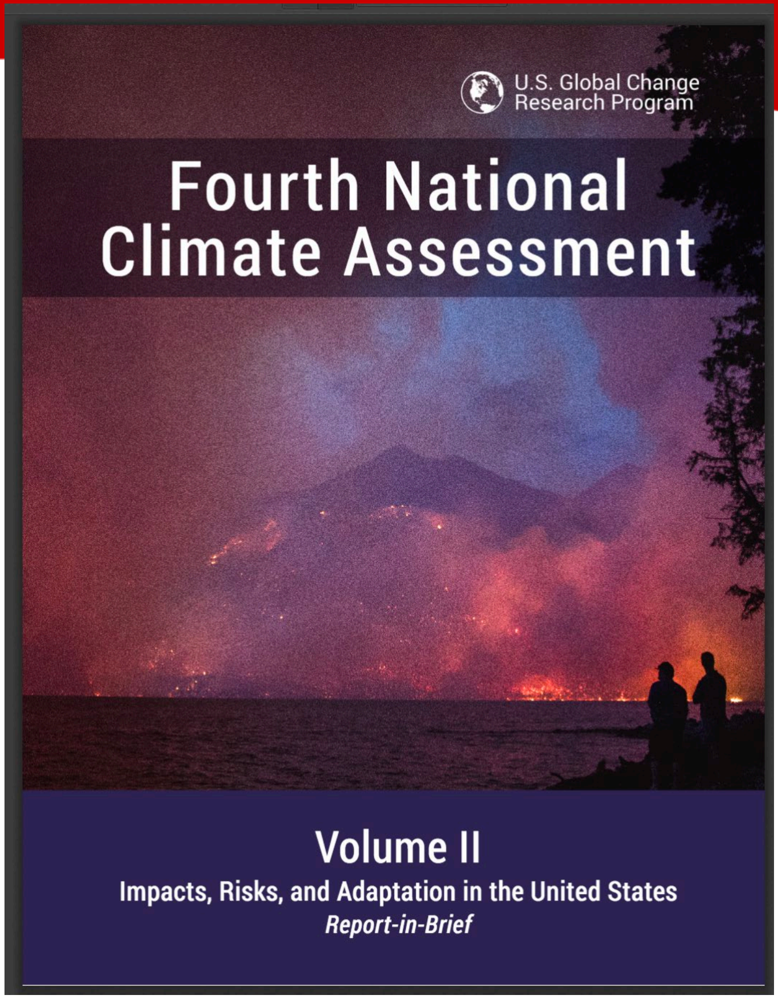
- Global **increase** in **heat** waves
- Global **decrease** in **cold** waves
- U.S. **increase** in **flood-producing rainfall** events
- All of the above are consistent with global warming

Future Changes in Extremes

- Drought – precip**???**, drying rates **UP**
- Hurricanes – total number**???**, Cat 3-5 **UP**
- Severe Thunderstorms (Hail, Tornadoes) – static stability **UP**, wind shear **DOWN,** total occurrences **UP**
- Heavy Rainfall - **UP**
- Winter Storms - **????**



Climate Information for North Carolina



science2017.globalchange.gov **nca2018.globalchange.gov**

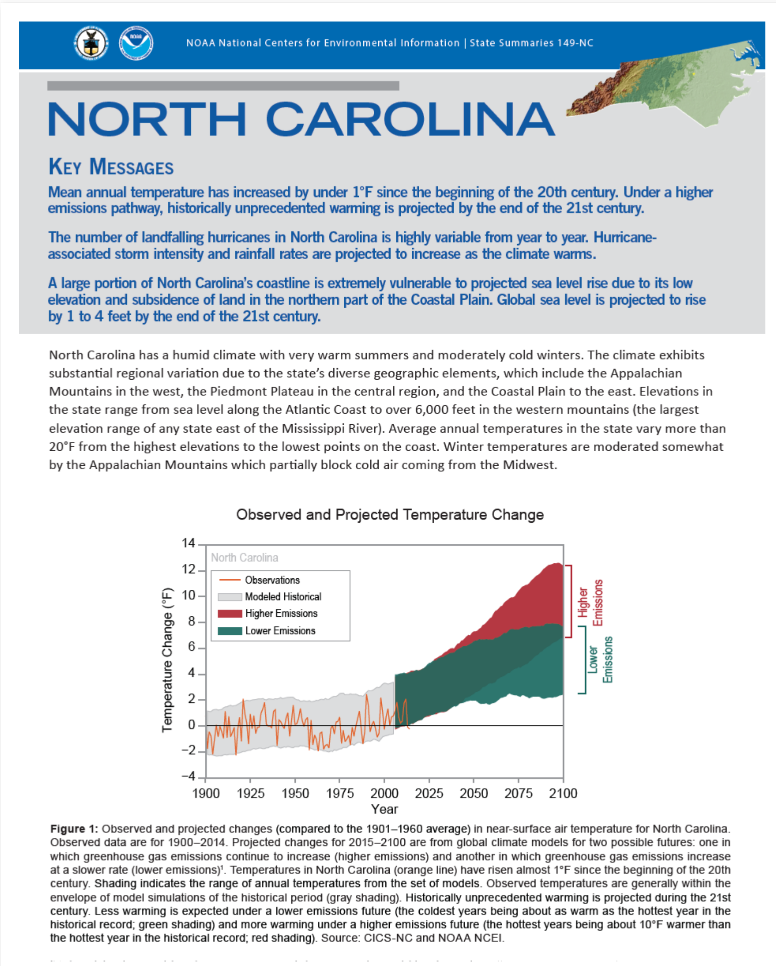
Climate Information for North Carolina

- **Temperature Information**
  - Seasonality
  - Heatwaves (days over/under xx degrees)
  - Frost free days
  - Humidity
- **Precipitation (seasonal totals, intensity)**
- **Seasonal climate changes**
- **Drought (PDSI)**
- **Sea Level Rise**
  - **NOAA Gridded Data Available**

- ❑ Flooding (storm, non-storm)
  - ❑ Nuisance Flooding
  - ❑ Runoff
  - ❑ Erosion
- ❑ Storms: Need to Define
- ❑ Wildfires
- ❑ Tornadoes
- ❑ Landslides / Mudslides

Climate in NC ---> Impacts informing Science Needs

NC State Summaries



NOAA National Centers for Environmental Information | State Summaries 149-NC

NORTH CAROLINA

Key Messages

Mean annual temperature has increased by under 1°F since the beginning of the 20th century. Under a higher emissions pathway, historically unprecedented warming is projected by the end of the 21st century.

The number of landfalling hurricanes in North Carolina is highly variable from year to year. Hurricane-associated storm intensity and rainfall rates are projected to increase as the climate warms.

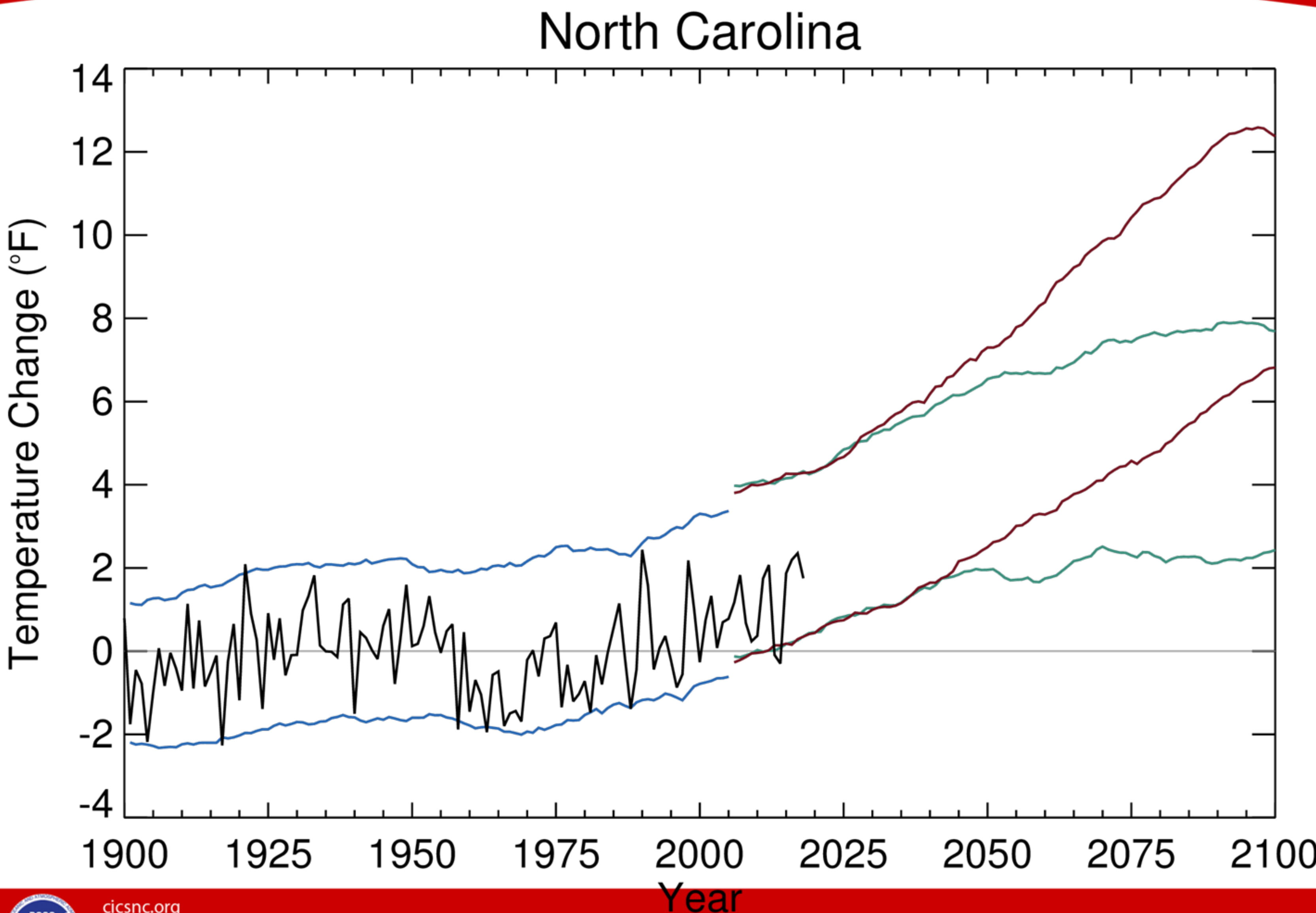
A large portion of North Carolina's coastline is extremely vulnerable to projected sea level rise due to its low elevation and subsidence of land in the northern part of the Coastal Plain. Global sea level is projected to rise by 1 to 4 feet by the end of the 21st century.

North Carolina has a humid climate with very warm summers and moderately cold winters. The climate exhibits substantial regional variation due to the state's diverse geographic elements, which include the Appalachian Mountains in the west, the Piedmont Plateau in the central region, and the Coastal Plain to the east. Elevations in the state range from sea level along the Atlantic Coast to over 6,000 feet in the western mountains (the largest elevation range of any state east of the Mississippi River). Average annual temperatures in the state vary more than 20°F from the highest elevations to the lowest points on the coast. Winter temperatures are moderated somewhat by the Appalachian Mountains which partially block cold air coming from the Midwest.

Figure 1: Observed and projected changes (compared to the 1901–1960 average) in near-surface air temperature for North Carolina. Observed data are for 1900–2014. Projected changes for 2015–2100 are from global climate models for two possible futures: one in which greenhouse gas emissions continue to increase (higher emissions) and another in which greenhouse gas emissions increase at a slower rate (lower emissions)[1]. Temperatures in North Carolina (orange line) have risen almost 1°F since the beginning of the 20th century. Shading indicates the range of annual temperatures from the set of models. Observed temperatures are generally within the envelope of model simulations of the historical period (gray shading). Historically unprecedented warming is projected during the 21st century. Less warming is expected under a lower emissions future (the coldest years being about as warm as the hottest year in the historical record; green shading) and more warming under a higher emissions future (the hottest years being about 10°F warmer than the hottest year in the historical record; red shading). Source: CICS-NC and NOAA NCEI.

- **What are the climate conditions for North Carolina**
- **What should be in a climate science assessment that is relevant to each of you:**
  - Identify science information needs that can assist in impacts and adaptation planning
  - How can we support with meaningful science based assessment and projection information
  - Variables and thresholds
  - Quantifiable metrics that you can identify

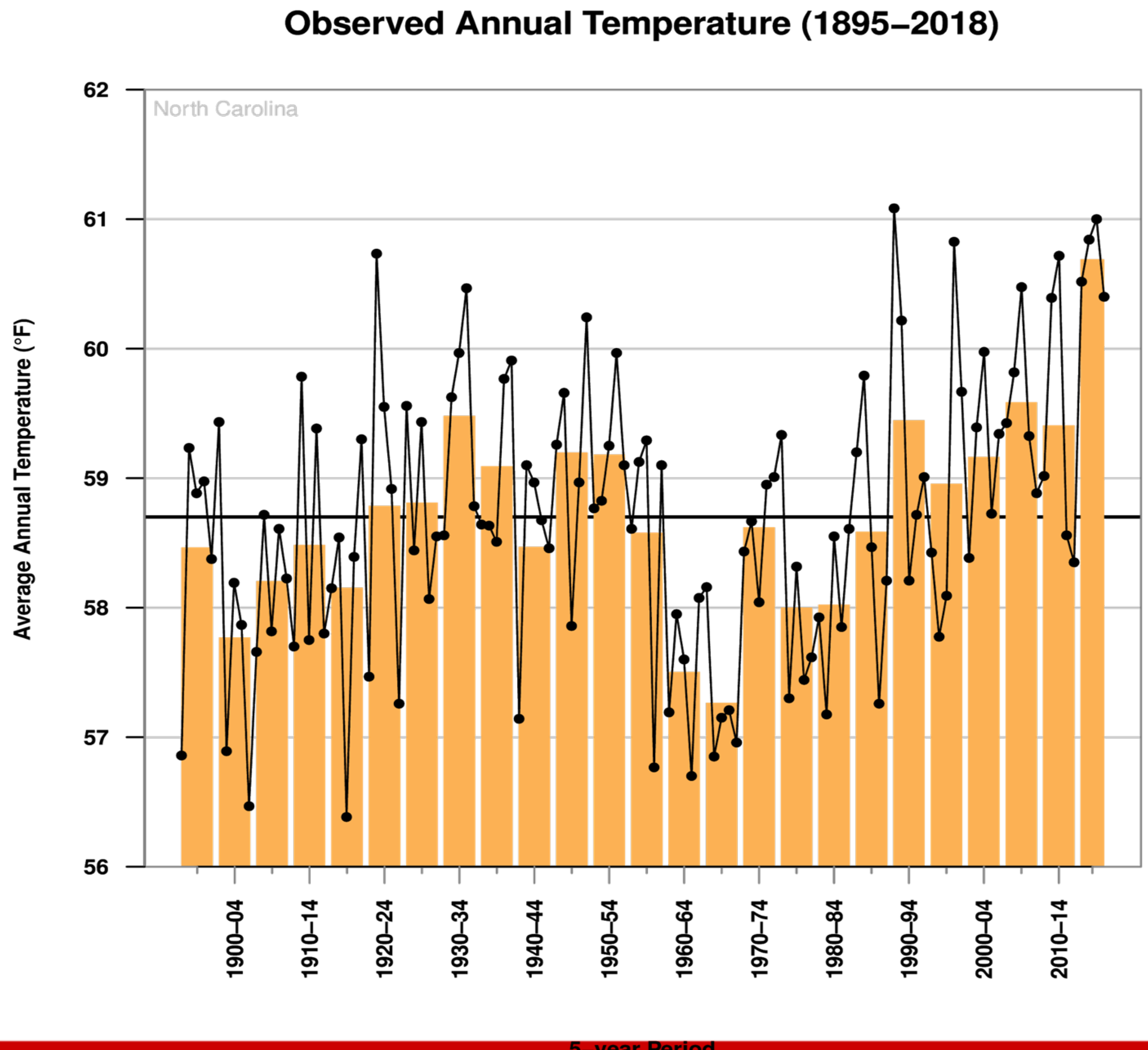
North Carolina Temperature Analysis



cicsnc.org
ncsu.edu
ncei.noaa.gov

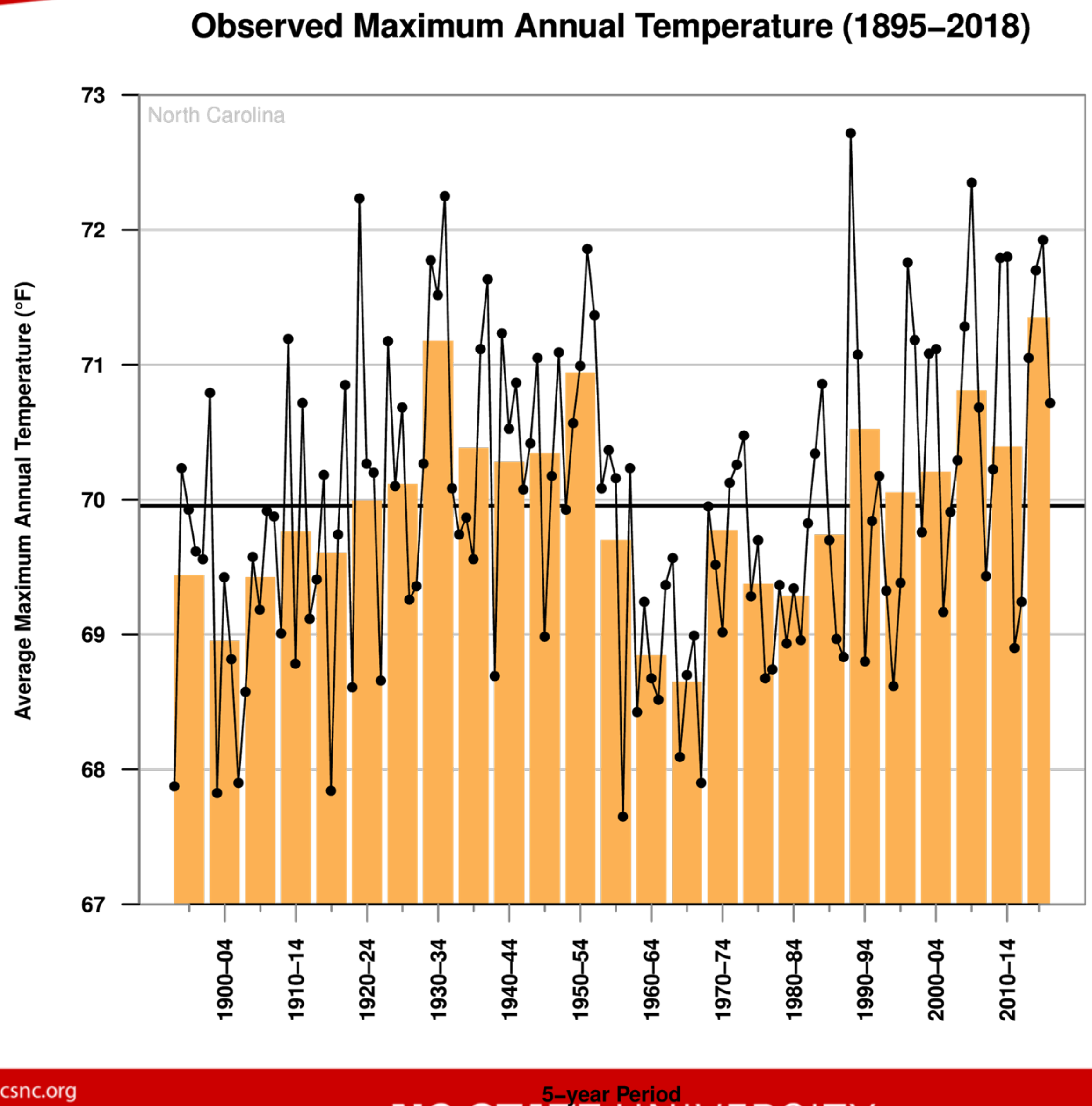
NC STATE UNIVERSITY

NC Observed Avg Temperature



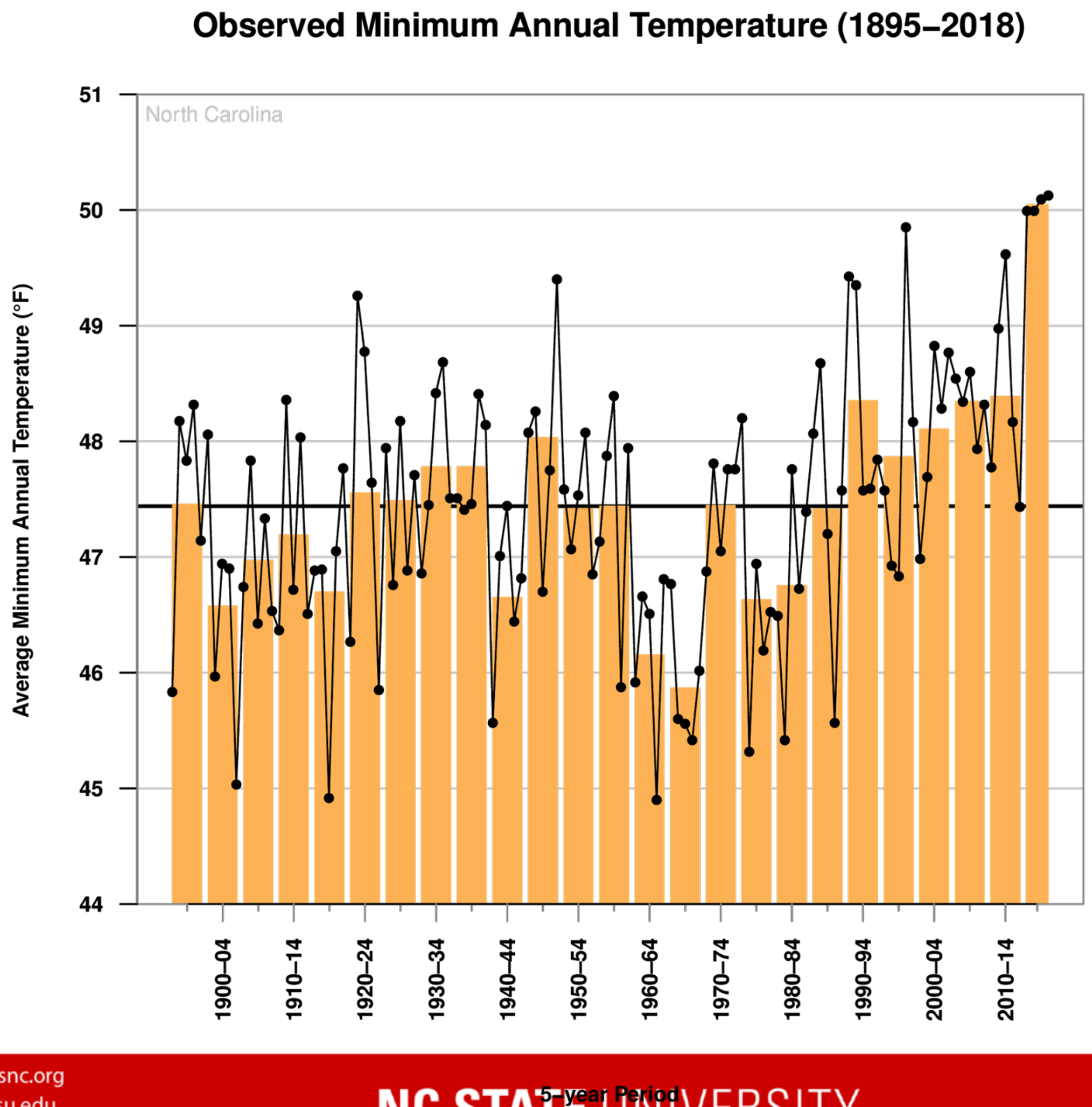
- available by fall, spring, summer and winter

Average Max Temperature



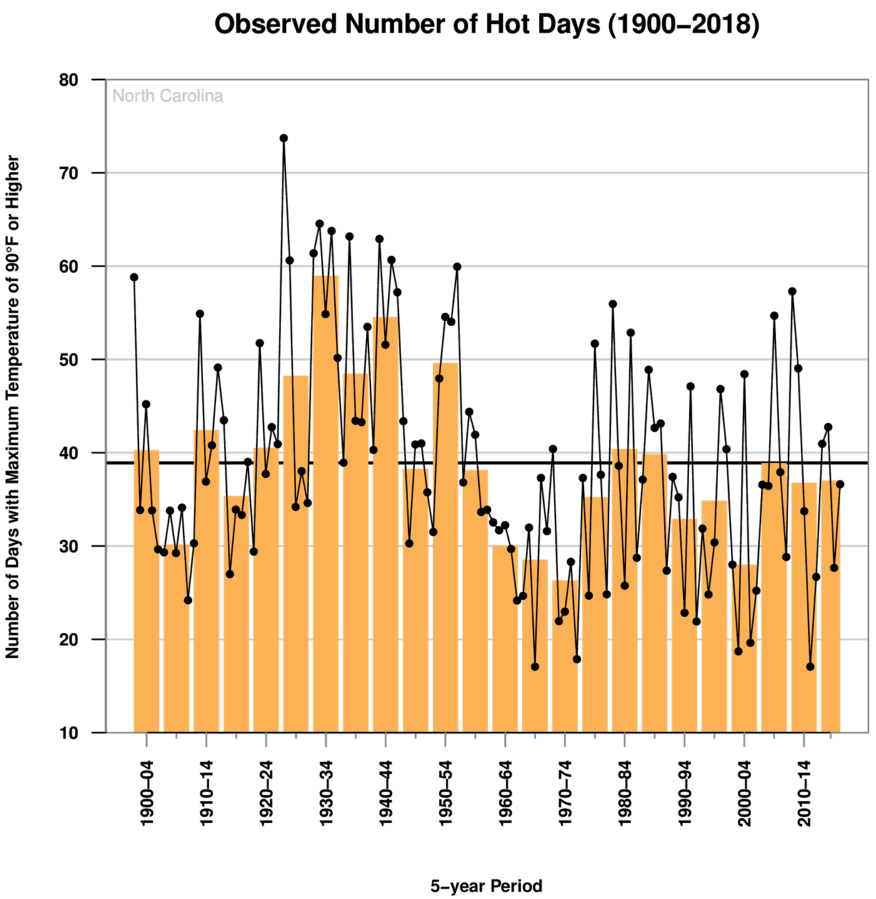
- available by fall, spring, summer and winter

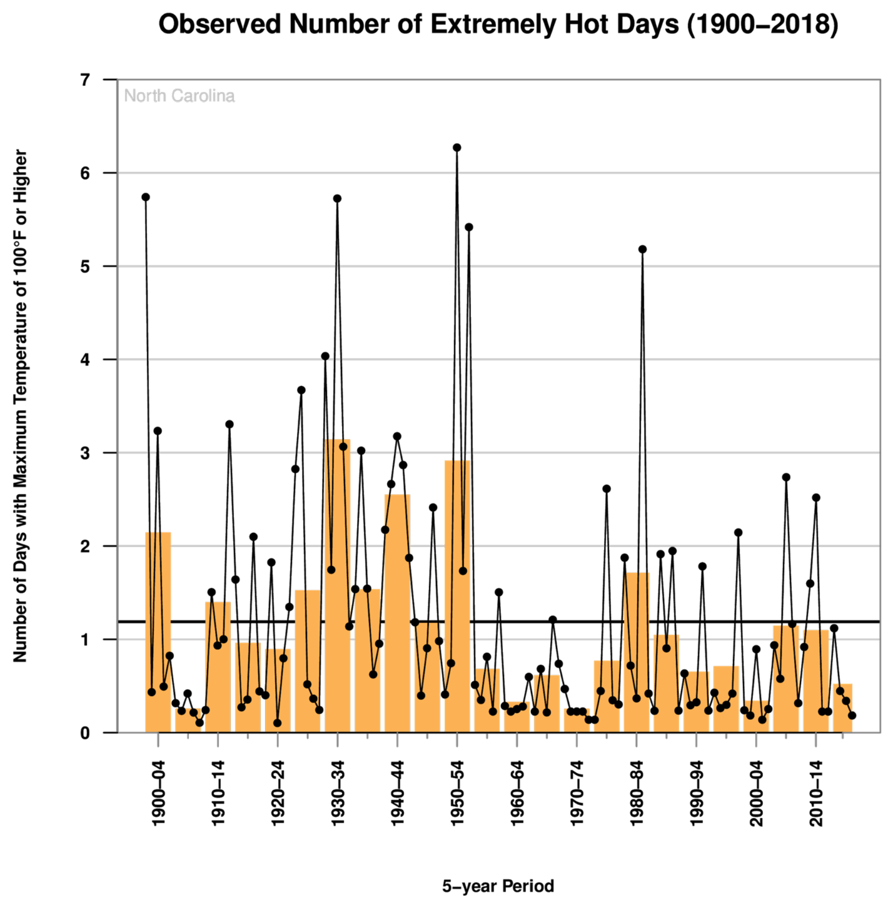
Average Min Temperature



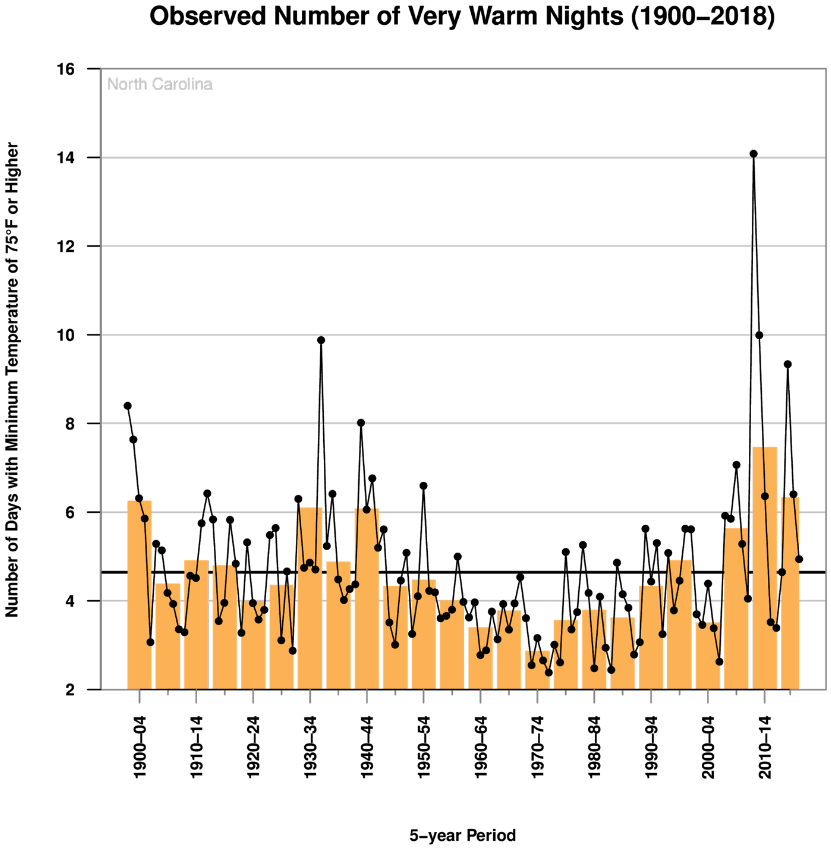
- available by fall, spring, summer and winter

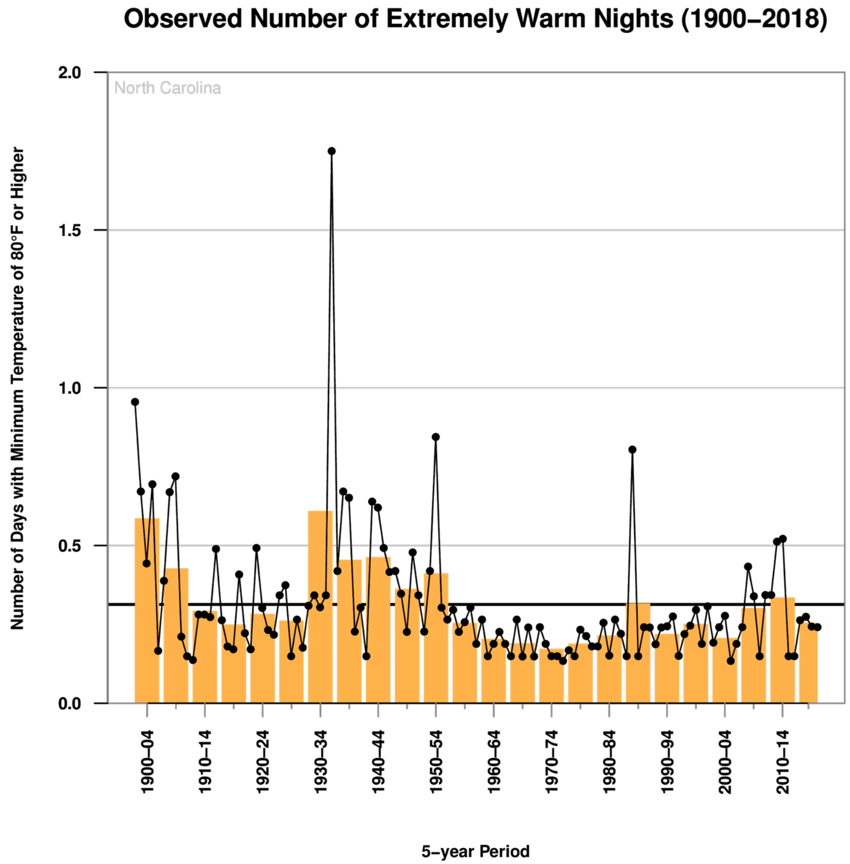
Observed Hot and Extreme Hot Days



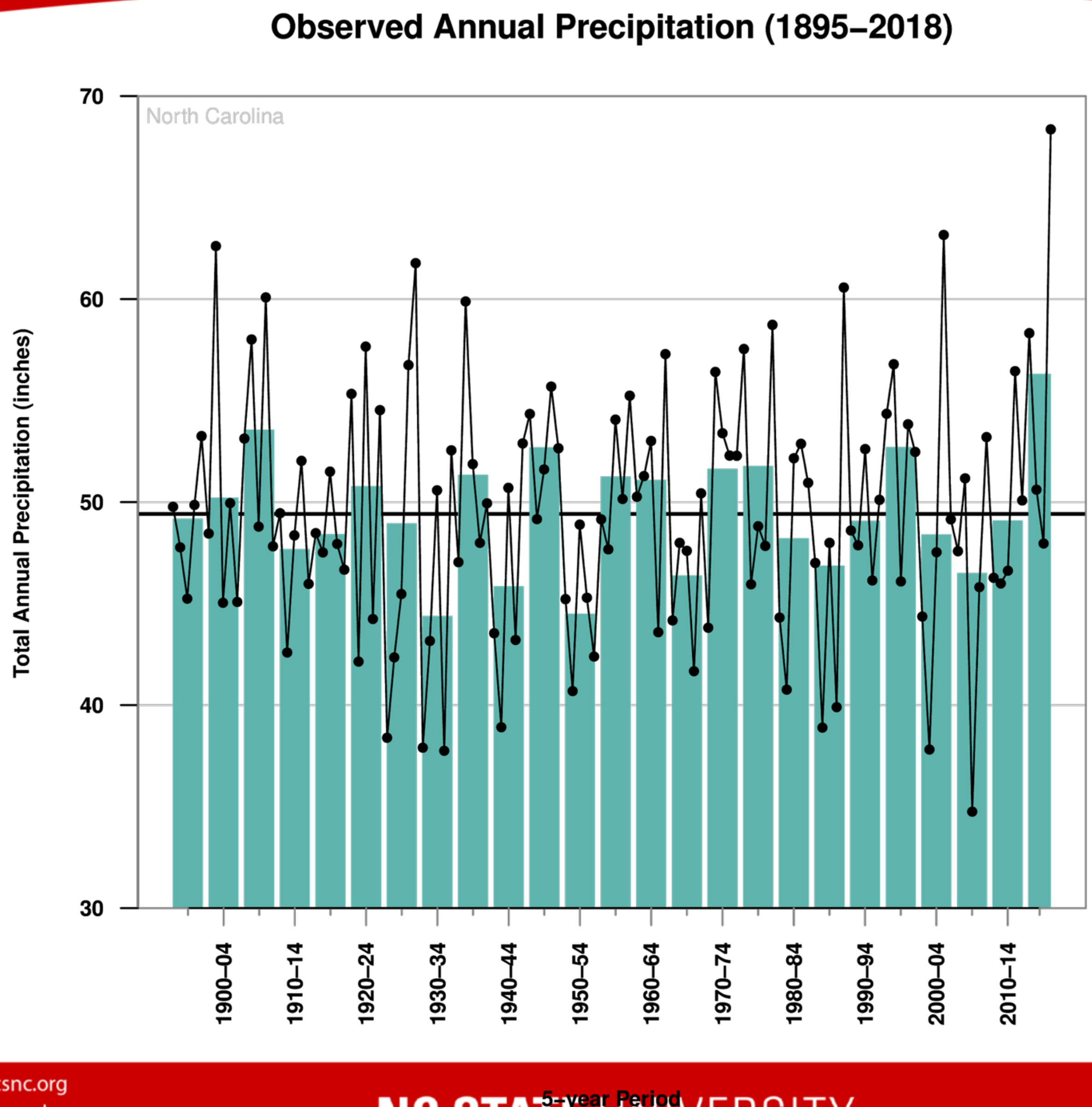


Warm Nights (1900-2018)

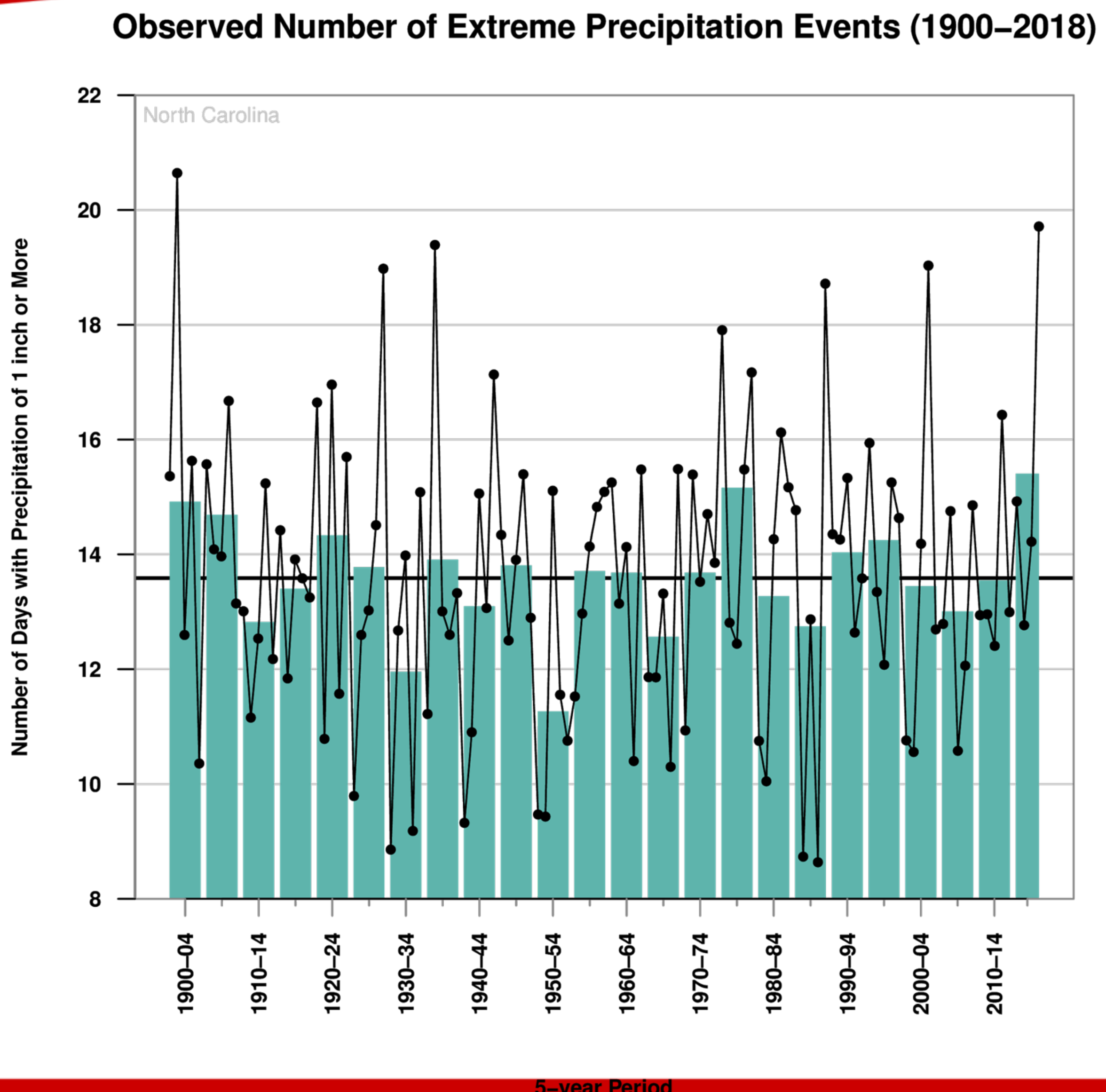




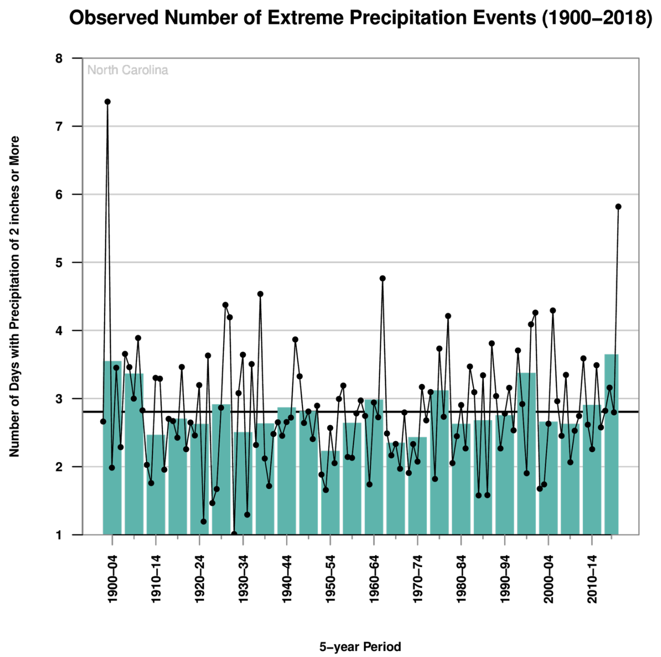
Precipitation

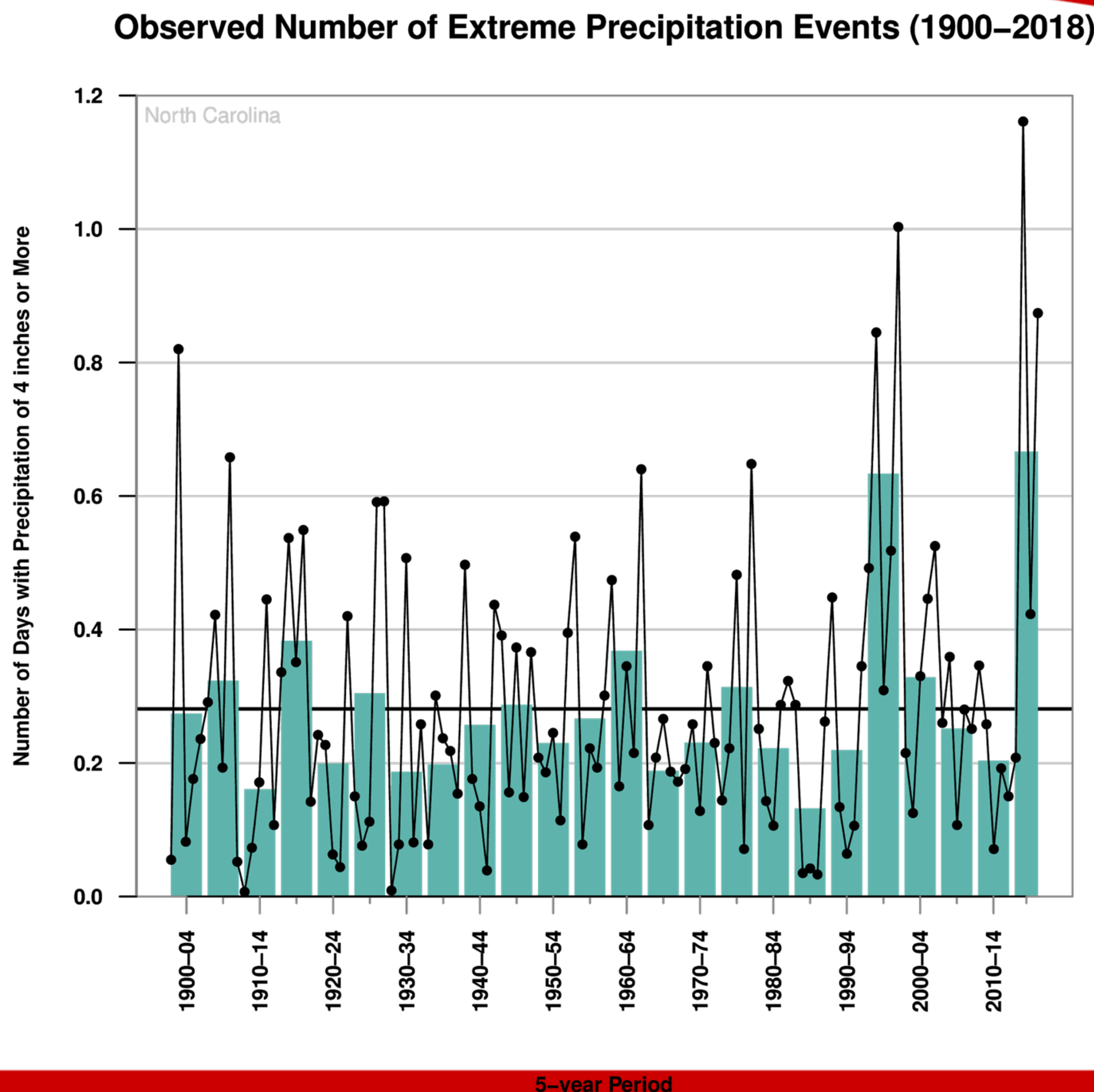


Precipitation - 1 inch

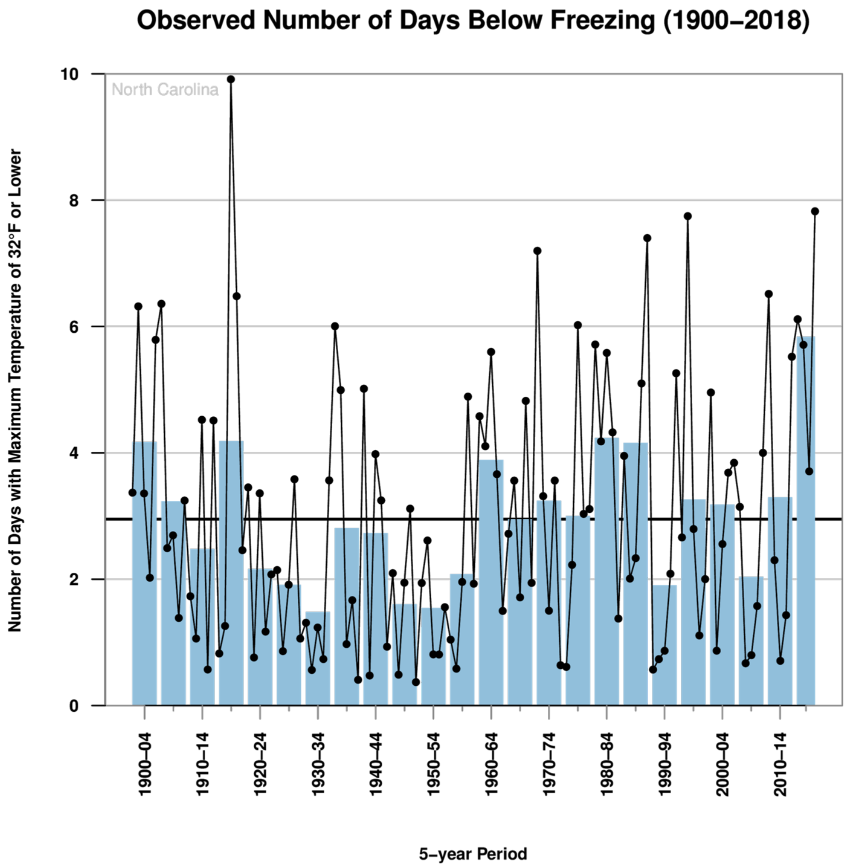


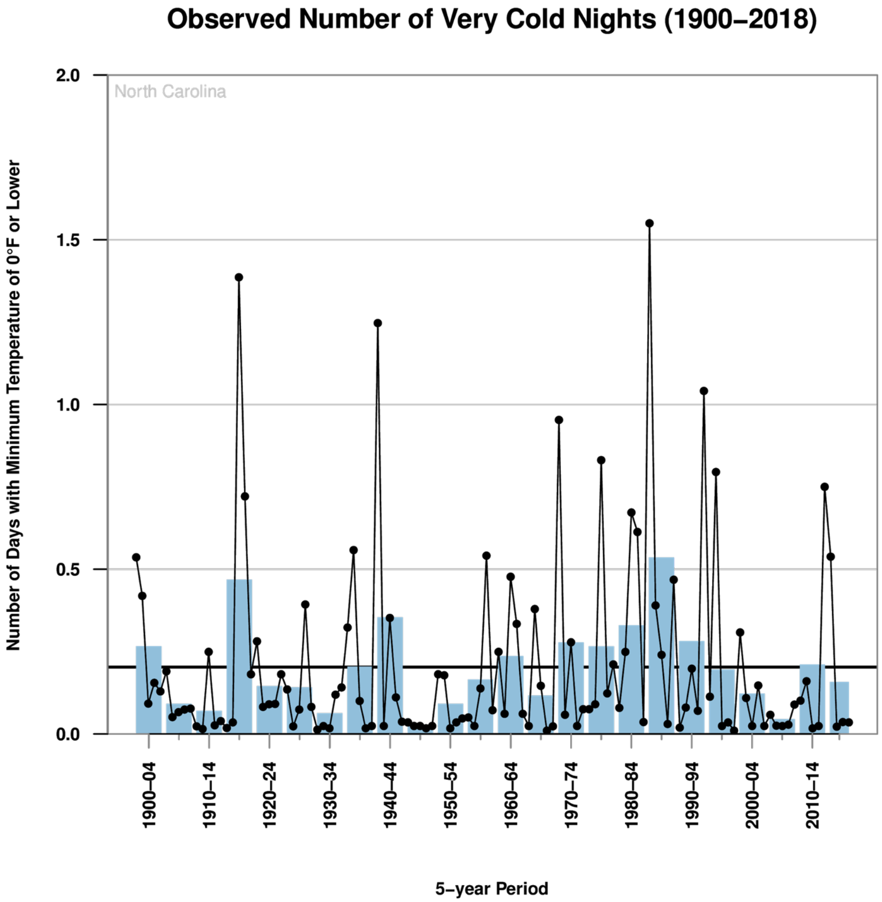
Precip - 2”, 3” and 4” available



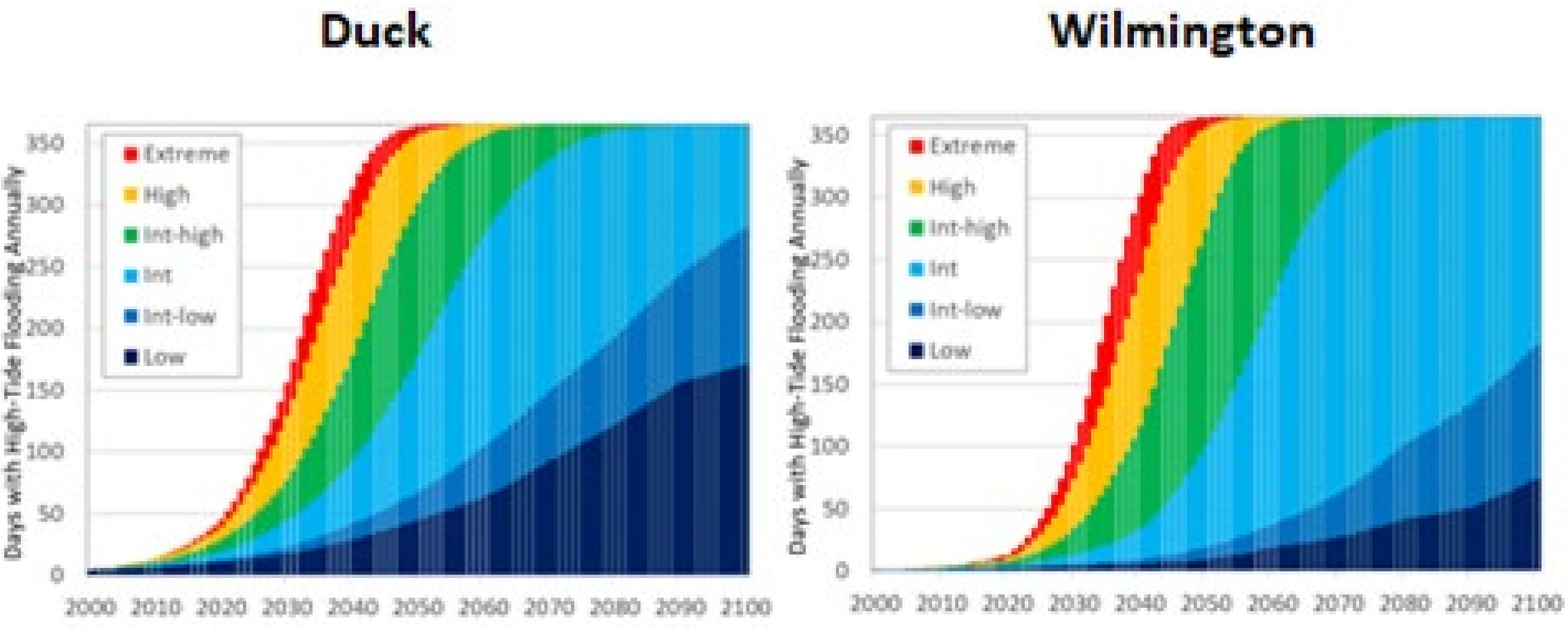


Very Cold Days and Nights



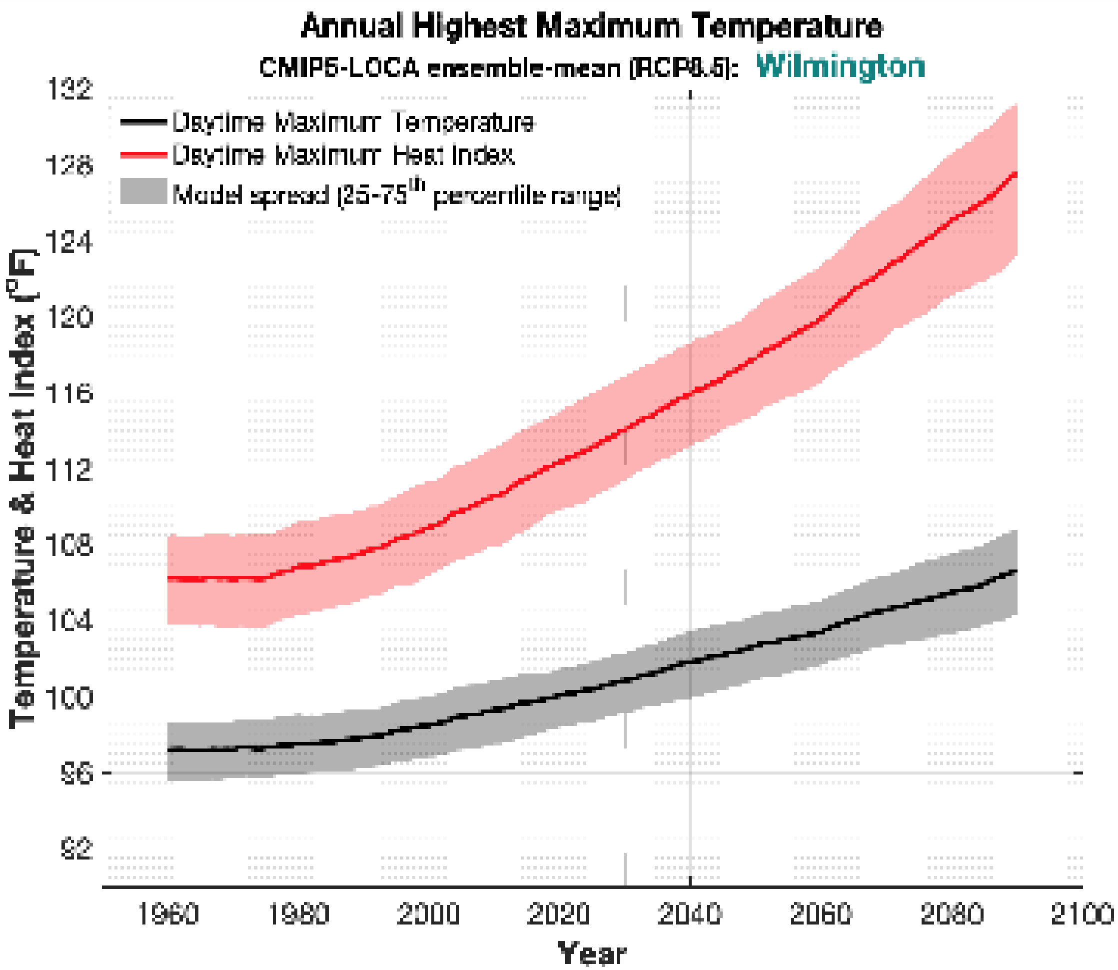


SLR Impact on Minor Flood Frequency



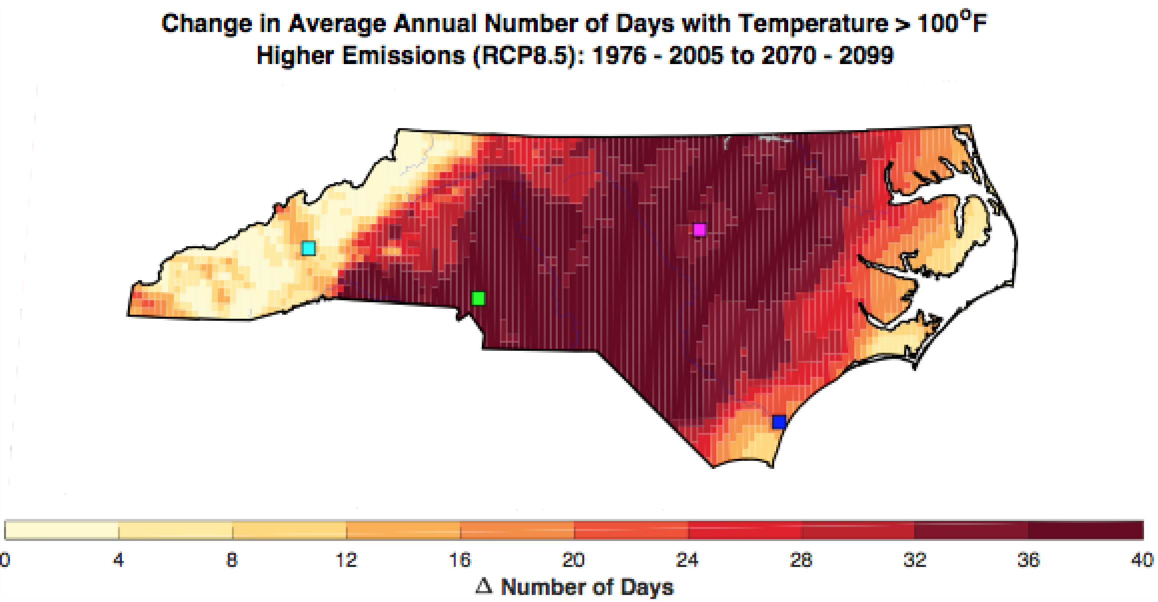
Sweet, W.V., G. Dusek, J. Obeysekera, J.J. Marra (2018) Patterns and Projections of High Tide Flooding Along the U.S. Coastline Using a Common Impact Threshold. NOAA Tech. Rep. NOS CO-OPS 86.

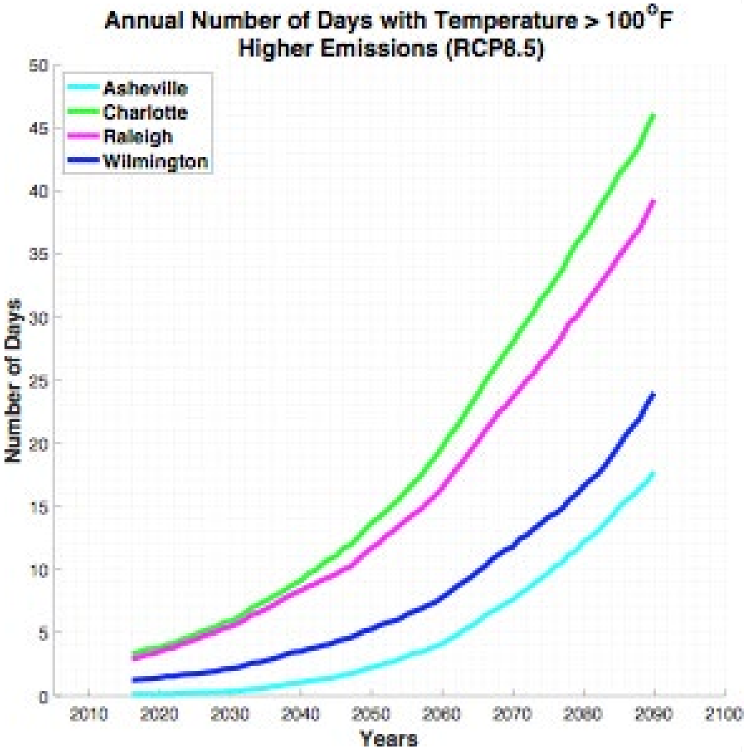
Time Series: Annual Hottest Day



Higher Emissions Scenario (RCP8.5)

Number of Days with T>100°F





Higher Emissions Scenario (RCP8.5)

Contacts

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Adam Terando – ajterando@ncsu.edu

Chris Weaver - chris cweaver@usgcrp.gov

APPENDIX

Heat Index: Warnings, Watches and Advisories

NWS Forecast Offices are tasked with issuing heat-related products as conditions warrant:

- **Excessive Heat Warning:** An Excessive Heat Warning is issued within 12 hours of the onset of extremely dangerous heat conditions. The general rule of thumb for this Warning is when the maximum heat index temperature is expected to be 105° or higher for at least 2 days and night time air temperatures will not drop below 75°; however, these criteria vary across the country, especially for areas not used to extreme heat conditions.
- **Excessive Heat Watches:** Heat watches are issued when conditions are favorable for an excessive heat event in the next 24 to 72 hours. A Watch is used when the risk of a heat wave has increased but its occurrence and timing is still uncertain.
- **Heat Advisory:** A Heat Advisory is issued within 12 hours of the onset of extremely dangerous heat conditions. The general rule of thumb for this Advisory is when the maximum heat index temperature is expected to be 100° or higher for at least 2 days, and night time air temperatures will not drop below 75°; however, these criteria vary across the country, especially for areas that are not used to dangerous heat conditions. Take precautions to avoid heat illness. If you don't take precautions, you may become seriously ill or even die.
- **Excessive Heat Outlooks:** Issued when the potential exists for an excessive heat event in the next 3-7 days. An Outlook provides information to those who need considerable lead-time to prepare for the event.

https://www.weather.gov/safety/heat-ww

Heat Index

Relative Humidity (%)

Temperature (°F)	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
80	77	78	78	79	79	79	80	80	80	81	81	82	82	83	84	84	85	86	86	87
81	78	79	79	79	79	80	80	81	81	82	82	83	84	85	86	86	87	88	90	91
82	79	79	80	80	80	80	81	81	82	83	84	84	85	86	88	89	90	91	93	95
83	79	80	80	81	81	81	82	82	83	84	85	86	87	88	90	91	93	95	97	99
84	80	81	81	81	82	82	83	83	84	85	86	88	89	90	92	94	96	98	100	103
85	81	81	82	82	82	83	84	84	85	86	88	89	91	93	95	97	99	102	104	107
86	81	82	83	83	83	84	85	85	87	88	89	91	93	95	97	100	102	105	108	112
87	82	83	83	84	84	85	86	87	88	89	91	93	95	98	100	103	106	109	113	116
88	83	84	84	85	85	86	87	88	89	91	93	95	98	100	103	106	110	113	117	121
89	84	84	85	85	86	87	88	89	91	93	95	97	100	103	106	110	113	117	122	
90	84	85	86	86	87	88	89	91	92	95	97	100	103	106	109	113	117	122	127	
91	85	86	87	87	88	89	90	92	94	97	99	102	105	109	113	117	122	126	132	
92	86	87	88	88	89	90	92	94	96	99	101	105	108	112	116	121	126	131		
93	87	88	89	89	90	92	93	95	98	101	104	107	111	116	120	125	130	136		
94	87	89	90	90	91	93	95	97	100	103	106	110	114	119	124	129	135	141		
95	88	89	91	91	93	94	96	99	102	105	109	113	118	123	128	134	140			
96	89	90	92	93	94	96	98	101	104	108	112	116	121	126	132	138	145			
97	90	91	93	94	95	97	100	103	106	110	114	119	125	130	136	143	150			
98	91	92	94	95	97	99	102	105	109	113	117	123	128	134	141	148				
99	92	93	95	96	98	101	104	107	111	115	120	126	132	138	145	153				
100	93	94	96	97	100	102	106	109	114	118	124	129	136	143	150	158				
101	93	95	97	99	101	104	108	112	116	121	127	133	140	147	155					
102	94	96	98	100	103	106	110	114	119	124	130	137	144	152	160					
103	95	97	99	101	104	108	112	116	122	127	134	141	148	157	165					
104	96	98	100	103	106	110	114	119	124	131	137	145	153	161						
105	97	99	102	104	108	112	116	121	127	134	141	149	157	166						
106	98	100	103	106	109	114	119	124	130	137	145	153	162	172						
107	99	101	104	107	111	116	121	127	134	141	149	157	167							
108	100	102	105	109	113	118	123	130	137	144	153	162	172							
109	100	103	107	110	115	120	126	133	140	148	157	167	177							
110	101	104	108	112	117	122	129	136	143	152	161	171								
111	102	106	109	114	119	125	131	139	147	156	166	176								
112	104	107	111	115	121	127	134	142	150	160	170	181								
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114	105	109	113	119	125	132	140	148	158	168	179									
115	106	110	115	121	127	134	143	152	162	173	184									
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119	109	114	121	128	136	145	155	166	178											
120	110	116	122	130	138	148	158	170	182											
121	111	117	124	132	141	151	162	174	187											
122	111	118	125	134	143	154	165	178												
123	112	119	127	136	146	157	169	182												
124	113	120	129	138	148	160	172													
125	114	121	130	140	151	163	176													

Extreme Danger	Heat stroke likely.
Danger	Sunstroke, muscle cramps, and/or heat exhaustion likely. Heatstroke possible with prolonged exposure and/or physical activity.
Extreme Caution	Sunstroke, muscle cramps, and/or heat exhaustion possible with prolonged exposure and/or physical activity.
Caution	Fatigue possible with prolonged exposure and/or physical activity.

How did we summarize NC information?

- Historical climate
- Future scenarios
- Projections of future climate use analyses of data from the Coupled Model Intercomparison Project Phase 5 (CMIP5).
- Datasets
  - NOAA NCEI's Climate Divisional Dataset (nClimDiv), version 2.
  - NOAA NCEI's Global Historical Climatology Network-Daily (GHCN-D), version 3.

For Example: Temperature

	Daily average temperature
	Daily maximum temperature
	Daily minimum temperature
	Annual number of days > 86°F
	Annual number of days > 90°F
	Annual number of days > 95°F
	Annual number of days > 100°F
	Annual number of days > 105°F
	Annual number of days > 110°F
	Annual number of days > 115°F
	Annual number of icing days
	Annual number of frost days
	Annual number of days with minimum temperature < 28°F
	Annual number of days with minimum temperature > 75°F
	Annual number of days with minimum temperature > 80°F
	Annual number of days with minimum temperature > 85°F
	Annual number of days with minimum temperature > 90°F
	Annual highest maximum temperature
	Annual lowest minimum temperature
	Annual highest 5-day maximum temperature
	Annual lowest 5-day minimum temperature
	Annual highest 5-day minimum temperature

Temperature (Cont'd)

Cooling degree days
Heating degree days
Growing degree days (base 50)
Modified growing degree days (base 50)
Date of the first fall freeze
Date of the last spring freeze
Length of the frost-free (growing) season
Length of the growing season (28°F threshold)
Length of the growing season (41°F threshold)
Annual number of days with maximum temperature lower than the 1st percentile
Annual number of days with maximum temperature greater than the 99th percentile
Annual number of days with minimum temperature lower than the 1st percentile
Annual number of days with minimum temperature greater than the 99th percentile

Precipitation

Annual total precipitation
Annual number of days > 1 inch
Annual number of days > 2 inches
Annual number of days > 3 inches
Annual number of days > 4 inches
Annual maximum number of consecutive dry days
Summer maximum number of consecutive dry days
Annual maximum number of consecutive wet days
Annual maximum 1-day precipitation
Annual maximum 5-day precipitation
Annual number of days with precipitation exceeding the 99th percentile
Annual total precipitation exceeding the 99th percentile

SUMMARY OF CSSR

- **Consensus** of the large majority of **climate scientists**
  - **CO_2 concentrations are increasing rapidly**
  - **The primary cause is burning of fossil fuels**
  - **CO_2 is a greenhouse gas and is having a warming influence on the earth**
  - **The earth is warming**
  - **Increasing concentrations of CO_2 and other greenhouse gases are most likely causing much, if not all, of the warming**
  - **All other explanations of warming are speculative at this point and not supported by strong scientific evidence**

Concluding Thoughts

- **What are the primary climate science uncertainties?**
  - **The amount of warming for a given increase in CO_2**
  - **A number of the specifics of possible changes in weather**
  - **Atmosphere-earth system is highly complex and our understanding of it is far from complete**

Concluding Thoughts

- **What are the impacts?**
  - **There are both good and bad consequences of global warming**
  - **Much more bad than good because human society and natural ecosystems have optimized around historical climate condition**

NC Executive Order 80 - Section 9

Initial Perspective on the NC Climate Science Activities

April 26, 2019

Kenneth E. Kunkel[1], David Easterling[2], Jenny Dissen[1], Otis Brown[1]

[1]*North Carolina Institute for Climate Studies, North Carolina State University, NOAA Cooperative Institute for Climate and Satellites*
[2]*NOAA National Centers for Environmental Information, US Global Change Research Program*

AGENDA

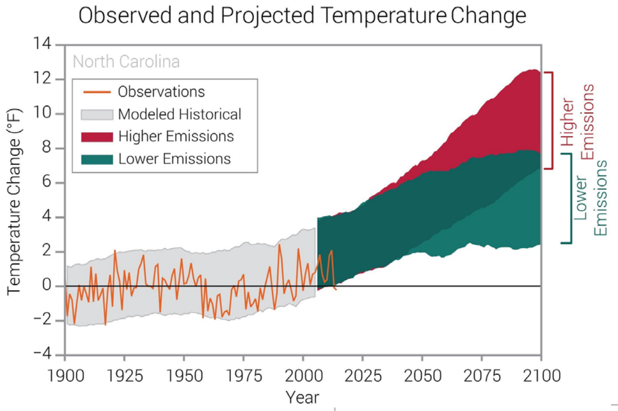
- **Perspectives on Assessments**
- **NCA4 Process**
- **NCICS Perspective on the Climate Science Assessment**

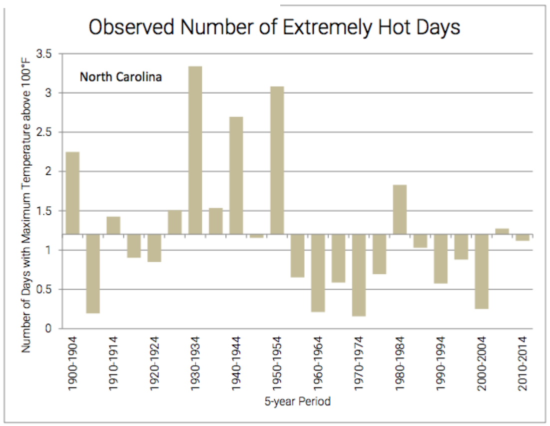
Science to Assessment

Develop → Apply

Science - Projections - Data

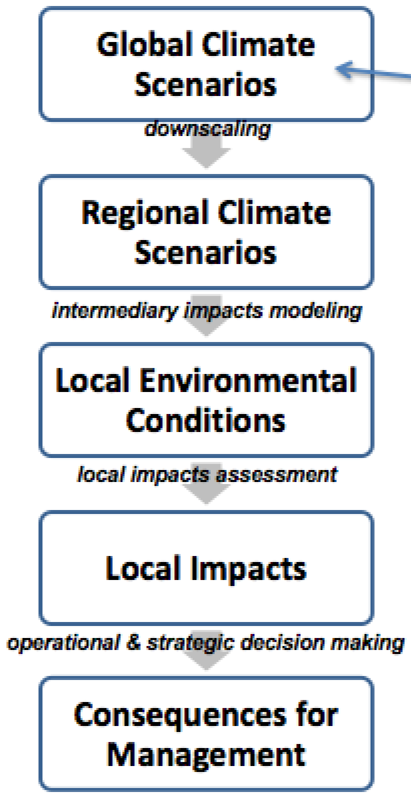
Interpretation - Guidance





Linear Process?

But first: Where should we start?



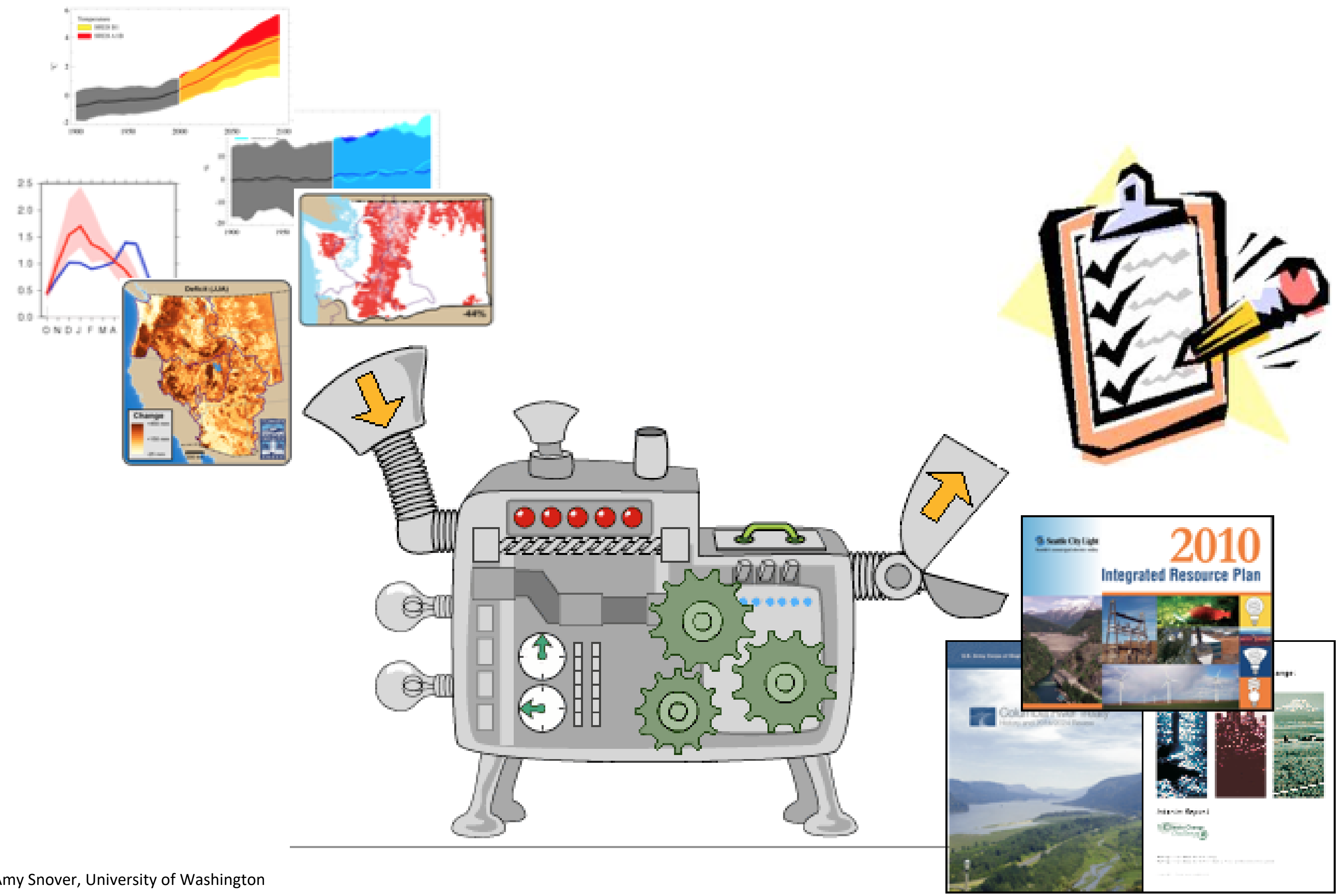
Uncertainty from: GCMs, emissions scenarios, climate variability

Key question: where/how is climate projected to change & what will the impacts be?

Key hazards/impacts
Coastal flooding
Inland flooding & drought
Wildfire
Storms

Source: Amy Snover, University of Washington

Wishful Thinking ...



Source: Amy Snover, University of Washington

Take Two: Where to Start?

1. Vulnerability *of what?* …Identify the outcome variables of concern
2. Vulnerability *to what?* … Identify drivers of concern
3. Vulnerability *when?* … Specify the time period of assessment

Identify outcome variables of concern by considering system aspects such as:

- planning areas
- business lines
- management objectives
- reporting responsibilities
- facilities & operations
- geographic zones

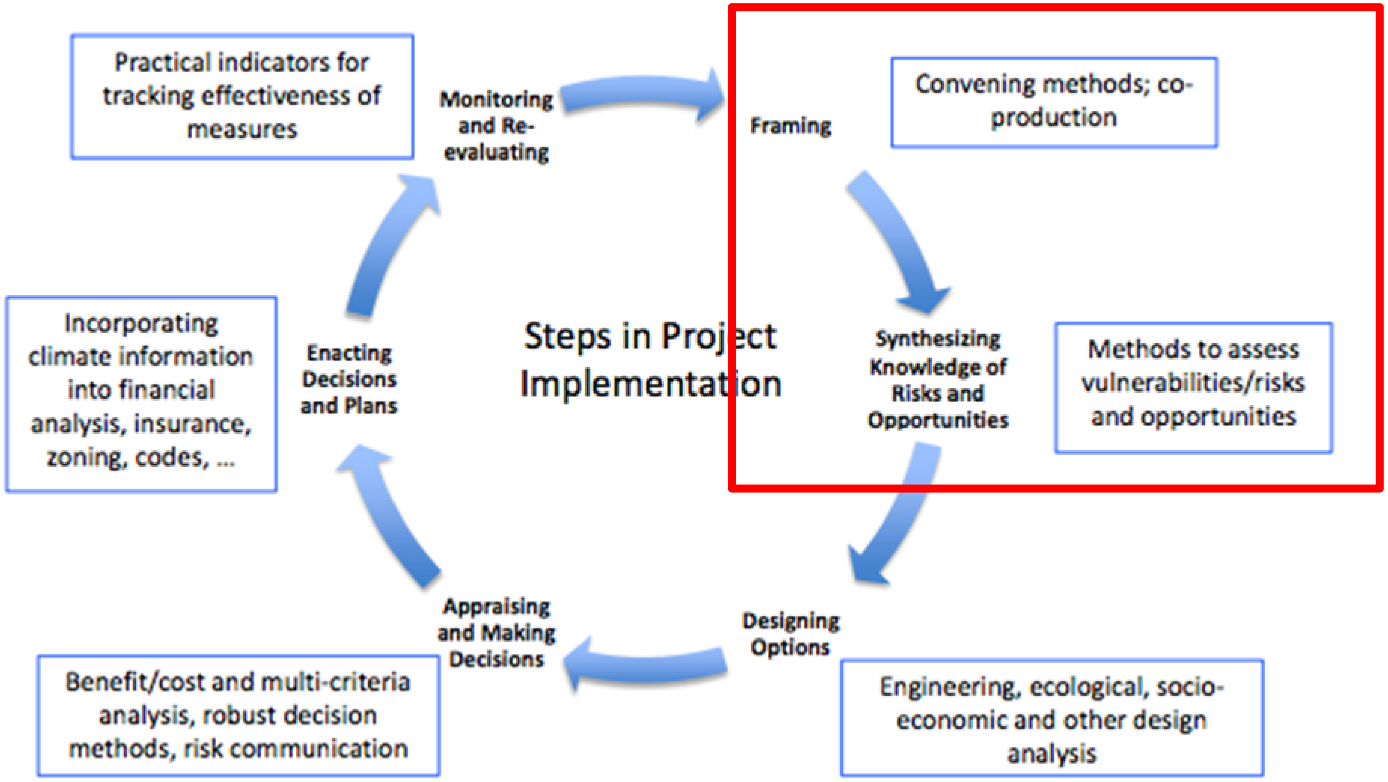
Source: Snover et al., *Cons. Bio., in press*

Lots of Expertise

	Information / Context	Expertise
1.	**Climate sensitivity** Variables of concern System sensitivity to changes in environmental conditions	**Subject matter expert**
2.	**Climate change** Ability to project changes Appropriate data sources (GCMs, downscaling, impacts models) Variability vs. trends	**Climate science** **Climate impacts science**
3.	**Risk management** Scenario & time horizon selection Best vs. worst case	**Policymaker** **Risk assessment**

Source: Snover et al., *Cons. Bio., in press*

NCA Process



Moss et al. 2019: Evaluating Knowledge to Support Climate Action: A Framework for Sustained Assessment; Report of an Independent Advisory Committee on Applied Climate Assessment (https://journals.ametsoc.org/doi/pdf/10.1175/WCAS-D-18-0134.1)

Our Approach Thus Far

Frame the Issue	Science / Knowledge	Scenarios and Risk Assessment	Adaptation / Resilience Planning
• Consider various program / activities • List relevant space and time scales • Consider decisions	• Climate variability and change • Climate projections	• Primary drivers and impacts • Scenarios • Options	• Priority actions • Partnerships • Planning
• Agreement on space and time and issues • Discuss limitations	• Summary of literature and expertise in NC • Science based best available information • Limitations or gaps in science	• Evaluate futures • Input to science agenda • Risk profiles by sector / subject areas	• Adaptation and resilience strategy and plan • Agreement with stakeholders

For Example:

CLIMATE CHANGE INFORMATION	IMPACTS
Temperature / Extreme Heat	**Observed effects due to climate change**
Daily average temperature Daily maximum temperature Daily minimum temperature Annual number of days > 86°F Annual number of days > 90°F Annual number of days > 95°F Annual number of days > 100°F Annual number of days > 105°F Annual number of days > 110°F Annual number of days > 115°F Annual number of days with minimum temperature < 28°F Annual number of days with minimum temperature > 75°F Annual number of days with minimum temperature > 80°F Annual number of days with minimum temperature > 85°F Annual number of days with minimum temperature > 90°F Annual highest maximum temperature Annual lowest minimum temperature Annual highest 5-day maximum temperature Annual lowest 5-day minimum temperature Annual highest 5-day minimum temperature	Fire events - Increased wildfire frequency and intensity
	Drought - crop damages
	Heat waves → increase in mortality
	Heat waves → increase in energy use
	Impacts on tourism
	Diseases in humans
	Phonological changes in crops germination changes are changing to extreme events
	Displacement of populations
	Energy supply (generation, production and delivery impacts)
	Heat stress - on construction and outdoor workers
	Warmer temperature at nights increases humidity → mosquitos
	Air quality and human health

EXISTING ASSETS / PROGRAMS / ACTIVITIES UNDER VARIOUS DEPTS

How have your program specific resources affected by climate change?

How do you see it affecting your programs, activities and assets

HUMAN SYSTEMS

NATURAL SYSTEMS

INFRASTRUCTURE AND BUILT ENVIRONMENT

ECONOMY

POLICIES

SCIENCE/ DATA NEEDS

Does the current information give enough context or indication? What science / data is needed?

- What space and time scale matters?
- What geography breakdown is relevant?
- How do these data summaries inform your decision or analysis context?
- Are there other needs, for data, science that impacts X, Y, Z?

Current Process

Available Science Information

NC Stressors List

Marc

April

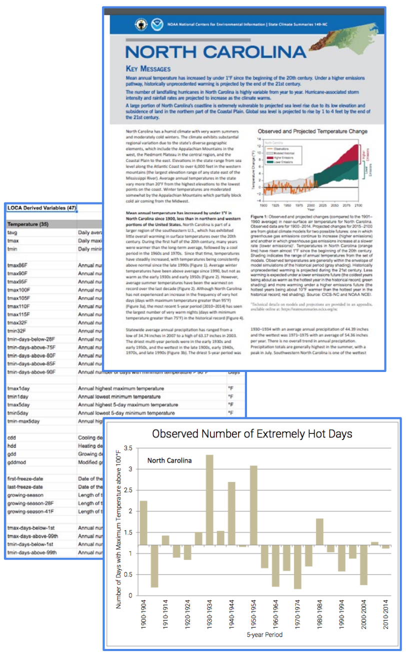
Cabinet Designee Input

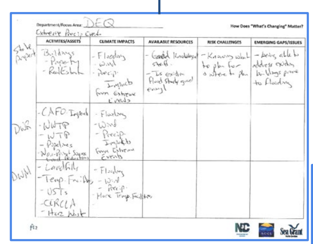
Science and Data Gap Analysis

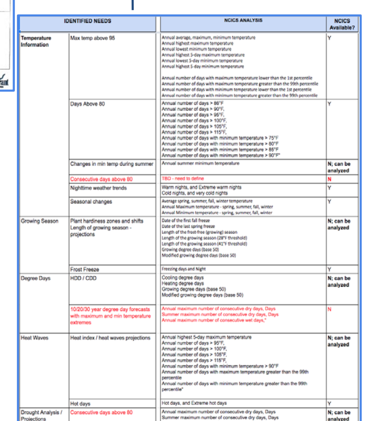
April

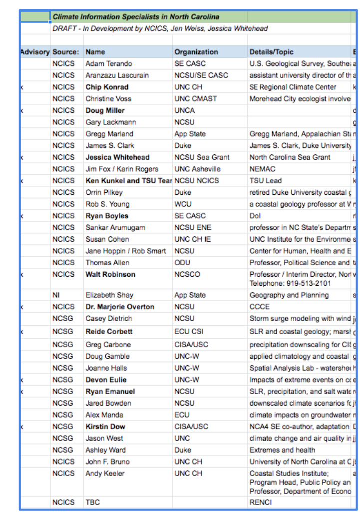
Ongoing

Science and Impacts Experts







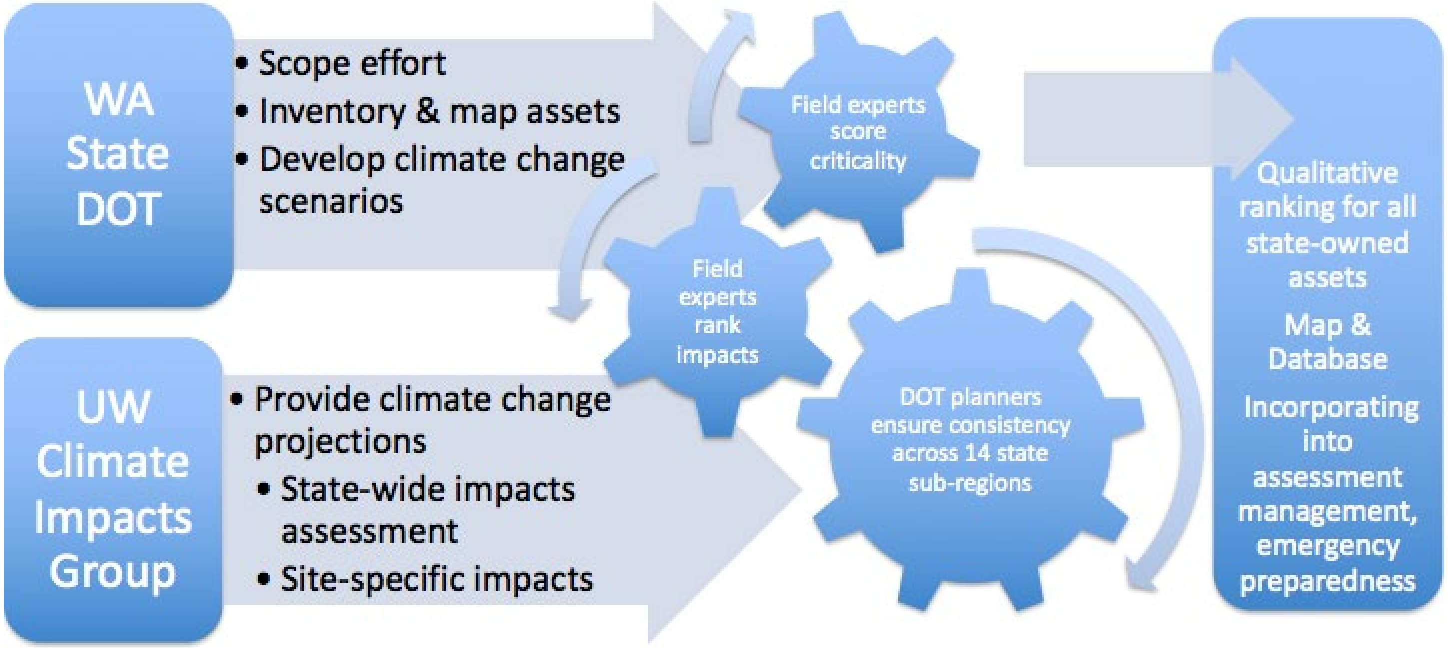


Appendix

Project Scope	WA State DOT
Vulnerability of what?	State-owned transportation infrastructure
To what?	Warming, precipitation changes, sea level rise, increased risk of flooding, landslides, inundation, wildfire
When?	2040s (temp, precipitation) 2′, 4′, 6′ sea level rise

"What does climate change mean for WSDOT infrastructure and operations?"

Climate Vulnerability of Washington State's Transportation Infrastructure



www.wsdot.wa.gov/SustainableTransportation/adapting.htm

How did we summarize NC information?

- Historical climate
- Future scenarios
- Projections of future climate use analyses of data from the Coupled Model Intercomparison Project Phase 5 (CMIP5).
- Datasets
  - NOAA NCEI's Climate Divisional Dataset (nClimDiv), version 2.
  - NOAA NCEI's Global Historical Climatology Network-Daily (GHCN-D), version 3.

For Example: Temperature

	Daily average temperature
	Daily maximum temperature
	Daily minimum temperature
	Annual number of days > 86°F
	Annual number of days > 90°F
	Annual number of days > 95°F
	Annual number of days > 100°F
	Annual number of days > 105°F
	Annual number of days > 110°F
	Annual number of days > 115°F
	Annual number of icing days
	Annual number of frost days
	Annual number of days with minimum temperature < 28°F
	Annual number of days with minimum temperature > 75°F
	Annual number of days with minimum temperature > 80°F
	Annual number of days with minimum temperature > 85°F
	Annual number of days with minimum temperature > 90°F
	Annual highest maximum temperature
	Annual lowest minimum temperature
	Annual highest 5-day maximum temperature
	Annual lowest 5-day minimum temperature
	Annual highest 5-day minimum temperature

Temperature (Cont'd)

Cooling degree days
Heating degree days
Growing degree days (base 50)
Modified growing degree days (base 50)
Date of the first fall freeze
Date of the last spring freeze
Length of the frost-free (growing) season
Length of the growing season (28°F threshold)
Length of the growing season (41°F threshold)
Annual number of days with maximum temperature lower than the 1st percentile
Annual number of days with maximum temperature greater than the 99th percentile
Annual number of days with minimum temperature lower than the 1st percentile
Annual number of days with minimum temperature greater than the 99th percentile

Precipitation

Annual total precipitation
Annual number of days > 1 inch
Annual number of days > 2 inches
Annual number of days > 3 inches
Annual number of days > 4 inches
Annual maximum number of consecutive dry days
Summer maximum number of consecutive dry days
Annual maximum number of consecutive wet days
Annual maximum 1-day precipitation
Annual maximum 5-day precipitation
Annual number of days with precipitation exceeding the 99th percentile
Annual total precipitation exceeding the 99th percentile

Natural and Working Lands

How Natural and Working Lands Contribute to climate goals and resilience to future storms in NC

Lydia Olander, Nicholas Institute, Duke University
with input from other subgroup leads
Tanja Vujic, Rick Savage, Mark Megalos

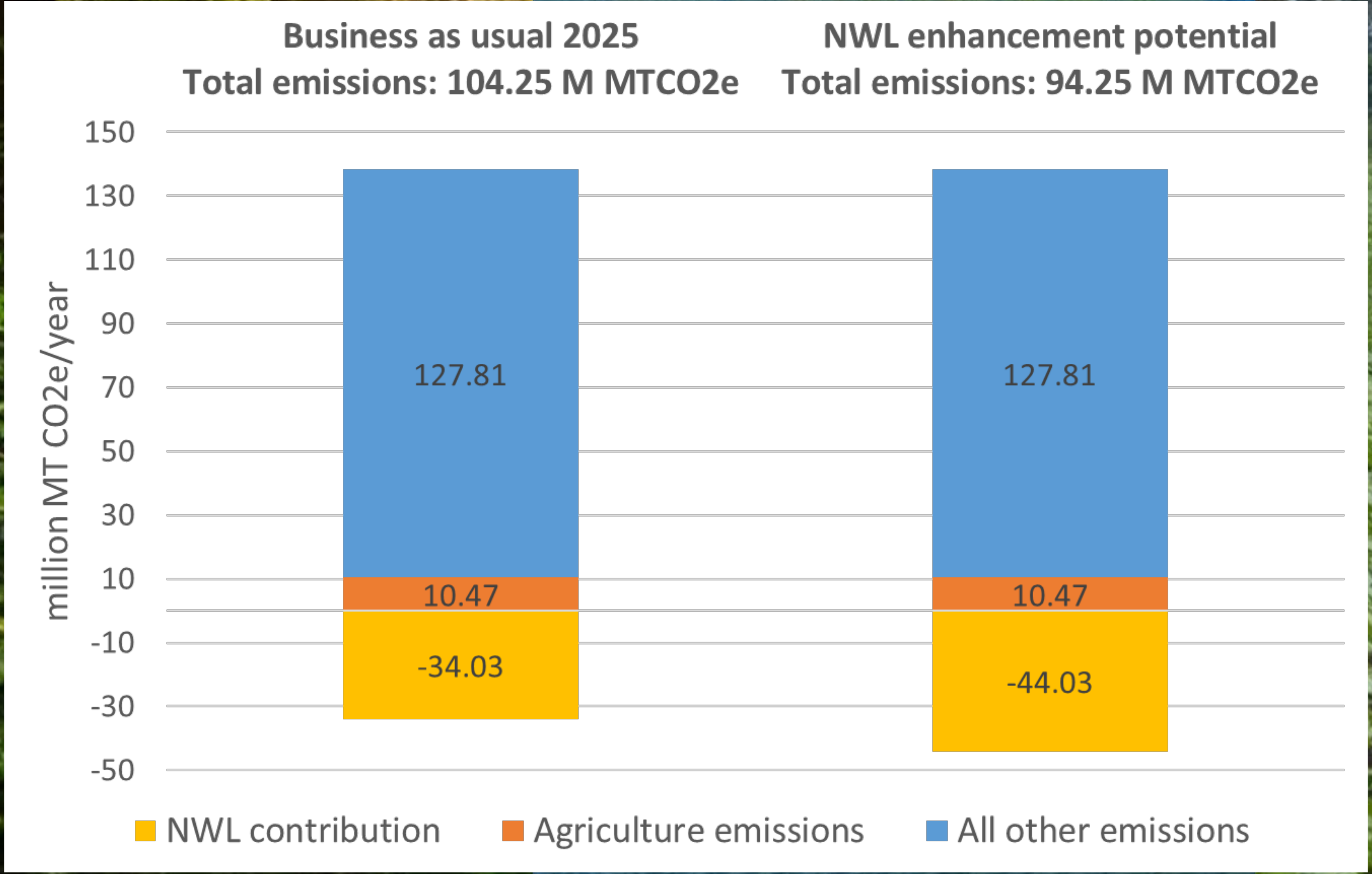
Raleigh Cultural Resources Auditorium

April 26, 2019

What this talk will cover

- How Natural and Working Lands (NWL) can contribute to state carbon reduction goals (EO80 targets)
- Show details on what this looks like for forests, agriculture, and coastal habitats
- Overview of NWL working group convened by DEQ and the Governor's office
- Highlights of subgroup work
- Timeline of NWL products to support EO80

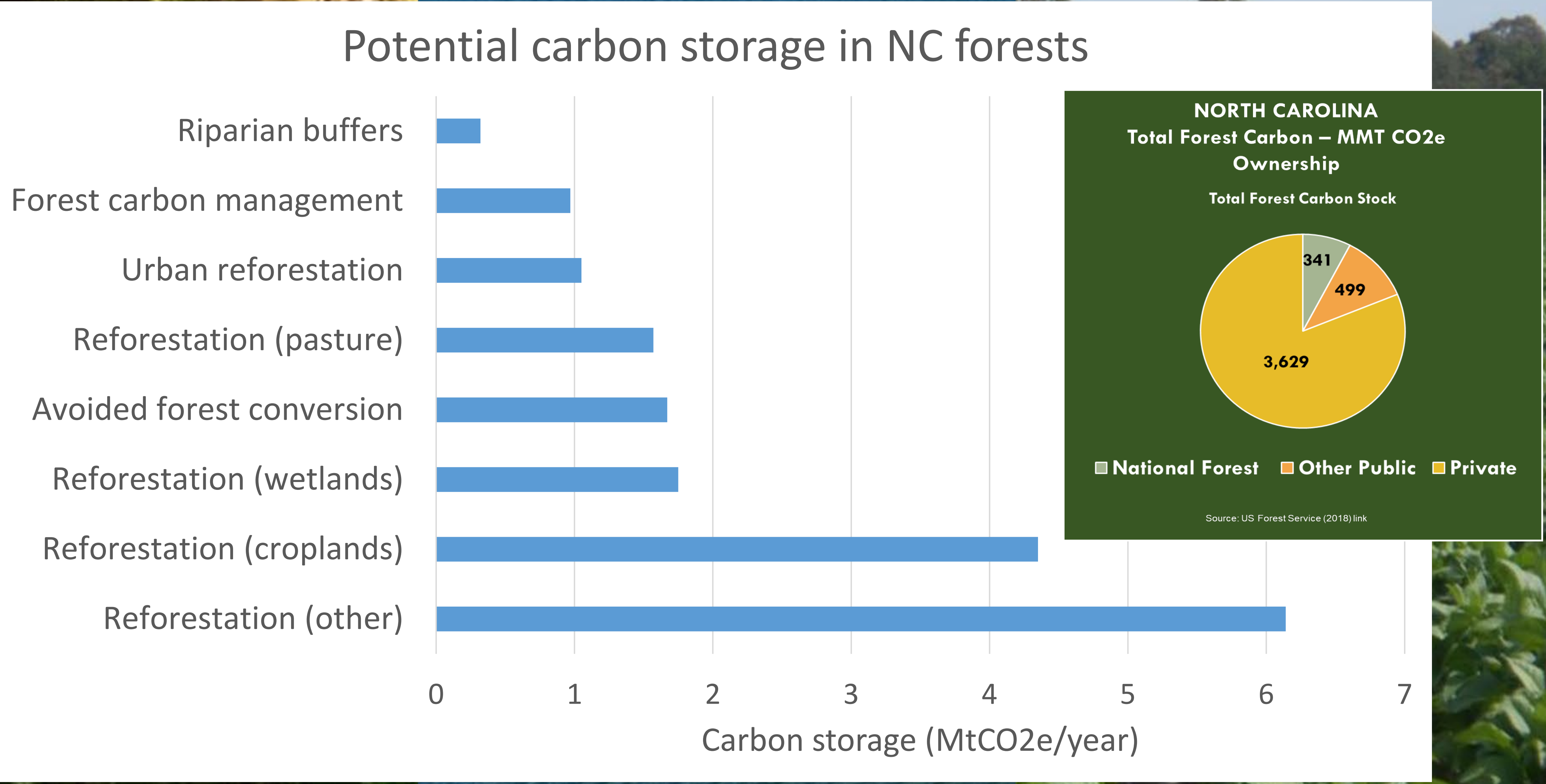
NWL Contributions to GHG Emission Reductions and Future Reduction Goals

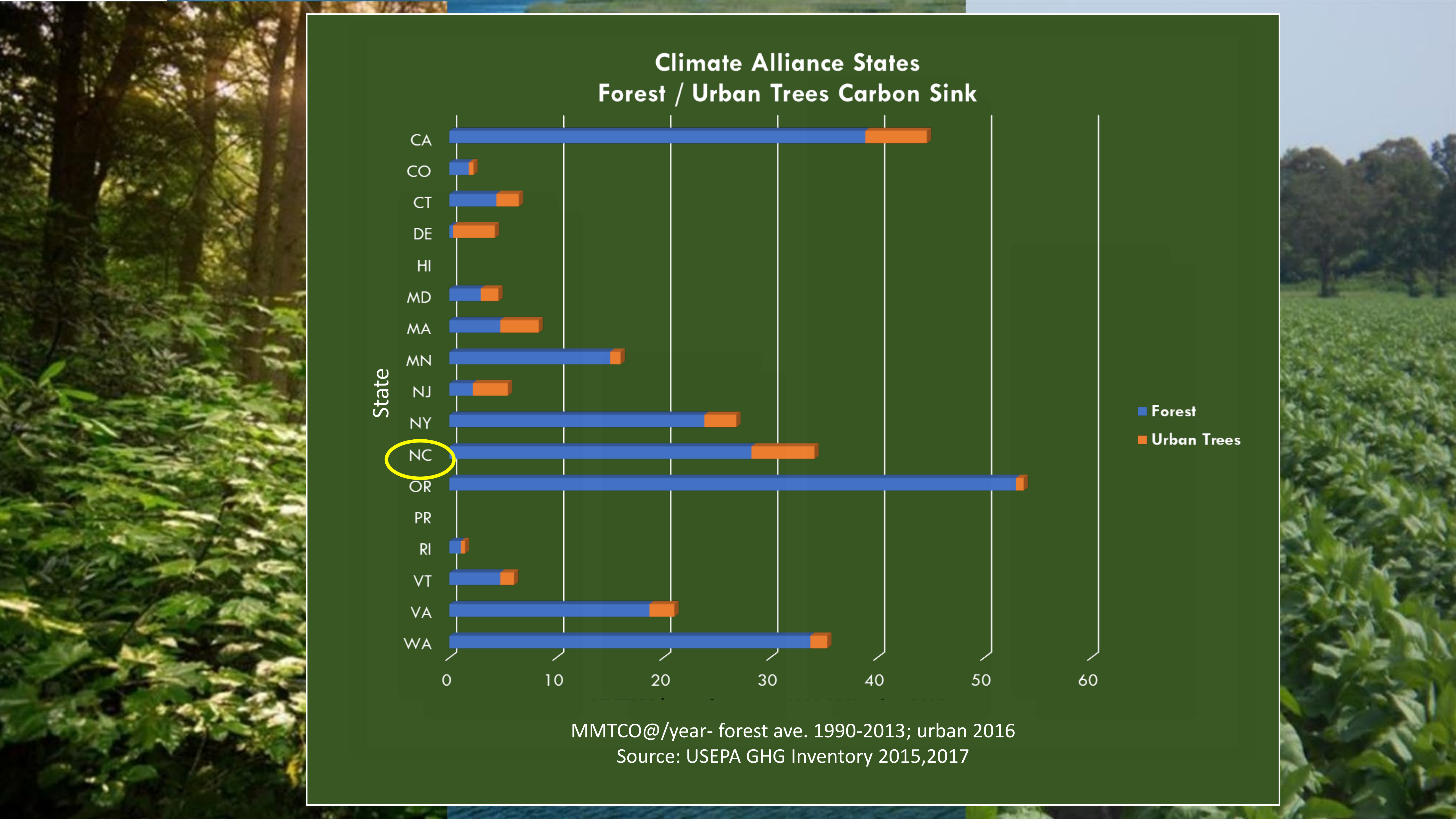


EO80’s 2025 Goal: 91.248M MTCO2e/year

FORESTS in NC

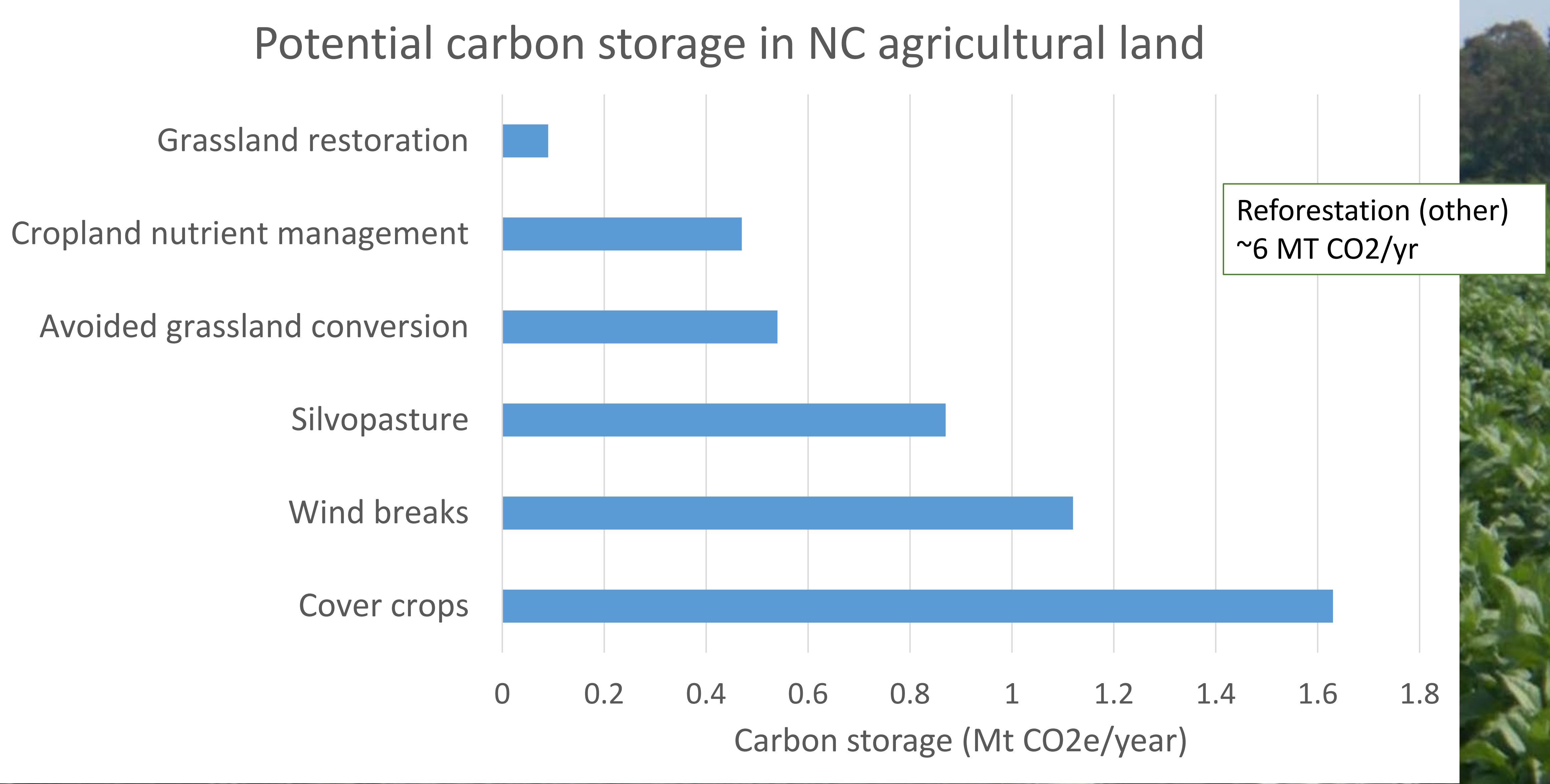
Graph from The North Carolina Opportunity Assessment
Inset USFS 2018



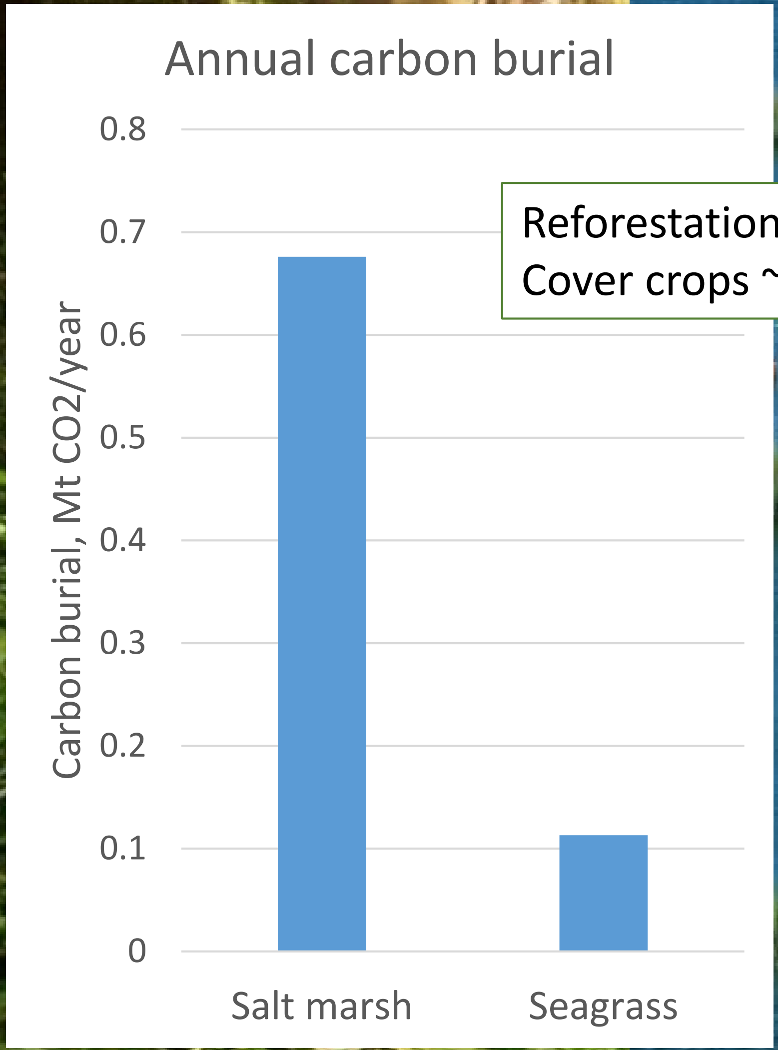

Climate Alliance States
Forest / Urban Trees Carbon Sink
State
CA
CO
CT
DE
HI
MD
MA
MN
NJ
NY
NC
OR
PR
RI
VT
VA
WA
0
10
20
30
40
50
60
Forest
Urban Trees
MMTCO@/year- forest ave. 1990-2013; urban 2016
Source: USEPA GHG Inventory 2015,2017

AGRICULTURE in NC

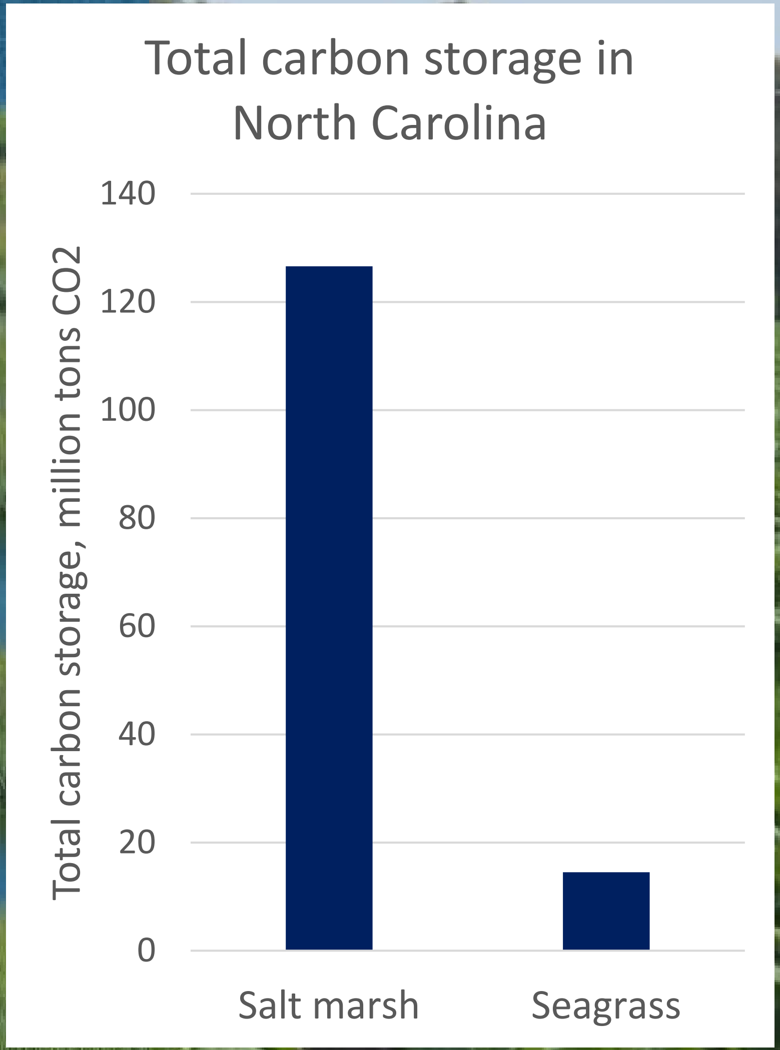
Graph from The North Carolina Opportunity Assessment



COASTAL SYSTEMS in NC



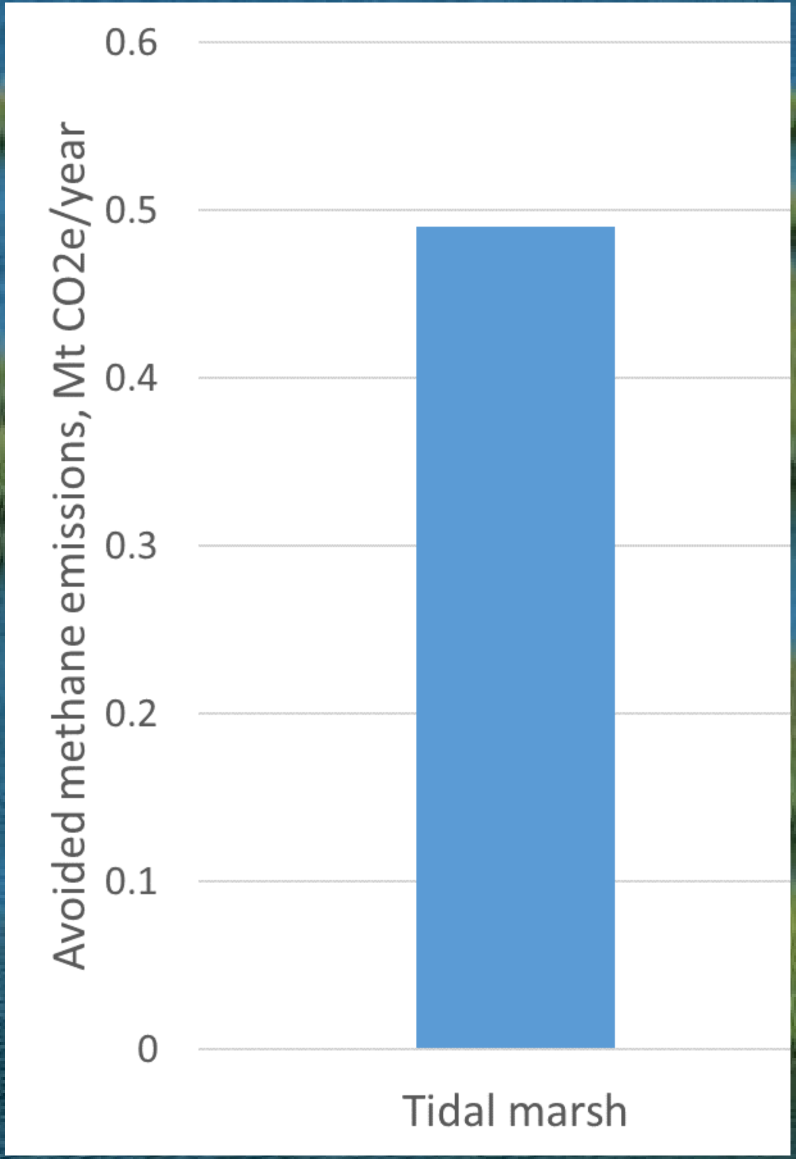
Reforestation (other) ~6 MT CO_2/yr
Cover crops ~1.6 MT CO_2/yr



Warnell and Olander 2019 estimates based on Siikamäki et al. (2013), Salt marsh extent from National Wetlands Inventory; and Seagrass extent from NC DEQ dataset (2006-2008 imagery)

COASTAL SYSTEMS in NC

Tidal marshes with restricted tidal flows (due to dikes, transportation infrastructure, or other barrier) release more methane than natural tidal marshes. Restoring natural flows reduces methane emissions.



Reforestation ~6 MT CO_2/yr
Cover crops ~1.6 MT CO_2/yr

Salt Marsh ~0.7 MT CO_2/yr
Sea grass ~0.1 MT CO_2/yr

Graph from The North Carolina Opportunity Assessment

Natural and Working Lands (NWL)Group

- Members of federal, state, and local agencies, NGOS, Universities, regional partnerships, …. have come together to develop a plan for how NC can promote **carbon sequestration and storage** on our NWLs.
- Consider NWL carbon opportunities that will bring additional **resilience benefits** (reduced flooding, nutrient and pollutant loading, saltwater intrusion, wildfires, etc…)
- **Develop a plan** – what habitats, where to target and what programs and funding can support this work.

Subgroups

- *Floodplains and wetlands*
- *Pocosin wetlands*
- *Coastal habitats (blue carbon)*
- Agriculture
- Forestry
- Urban

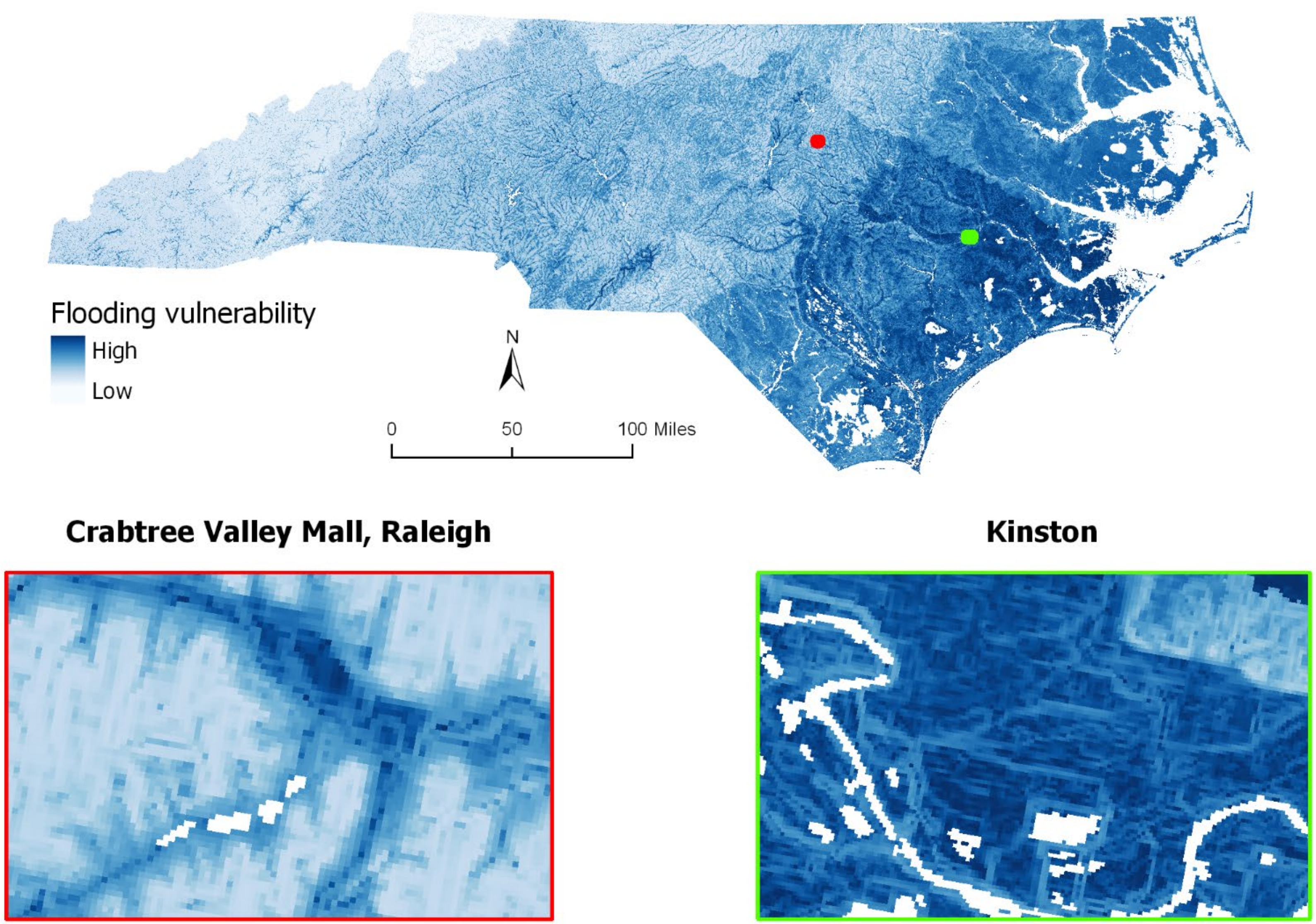
- Financing and programs (resilience, conservation, c market, etc…)

Targeting for resilience benefits (overlay with C)

- *Floodplains and wetlands*
  - *Opportunities assessment (active flood area extent and protection; wetland protection and reforestation)*
  - *Flood and water quality benefits (literature review estimates and site specific case studies)*
- *Pocosin wetlands*
  - *Reduced local flooding, saltwater intrusion and peat burning wildfire (respiratory health benefit)*
- *Coastal habitats (blue carbon)*
  - *Relative importance of natural habitats in offering protection to coastal communities*

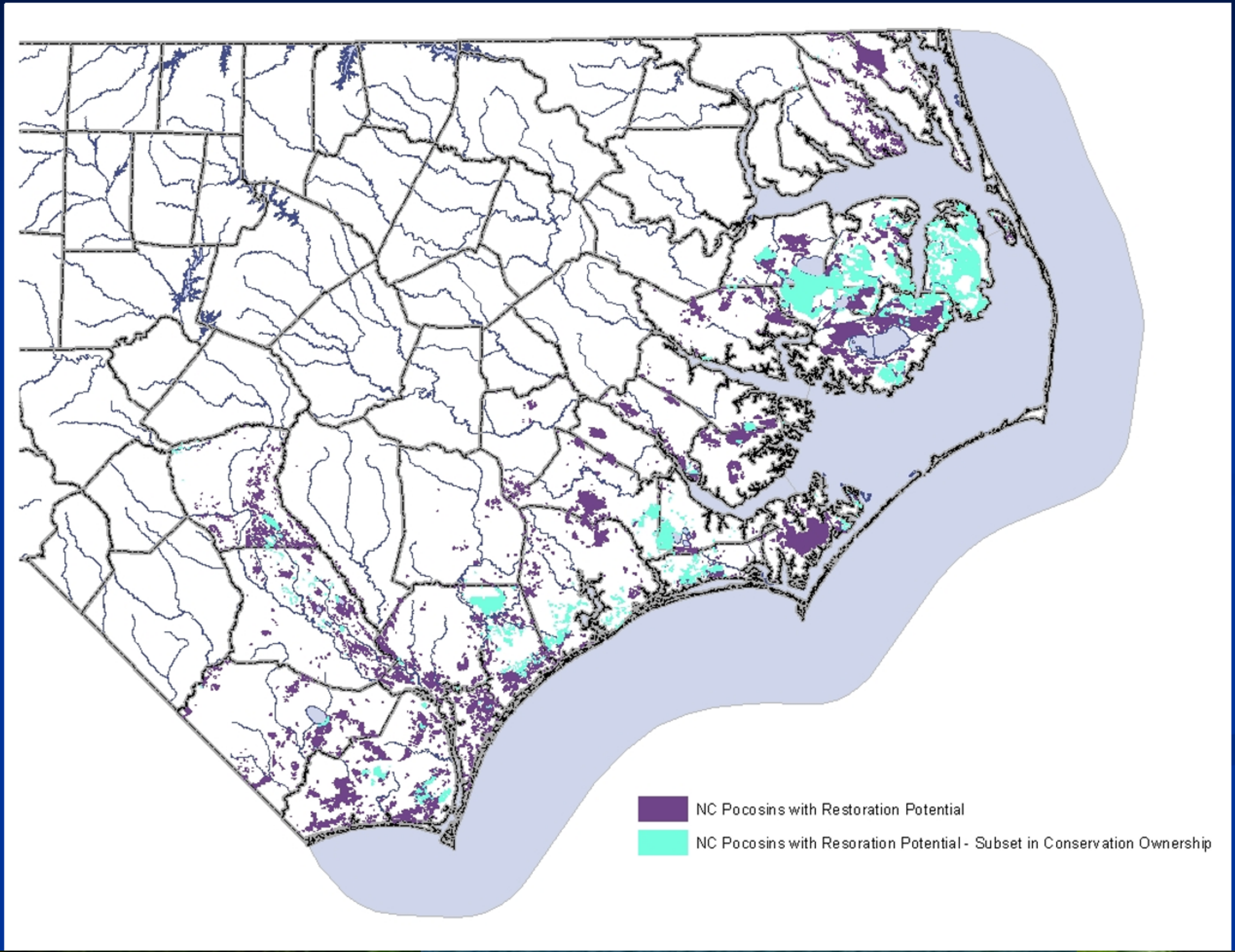
Floodplains and wetlands

River flooding vulnerability



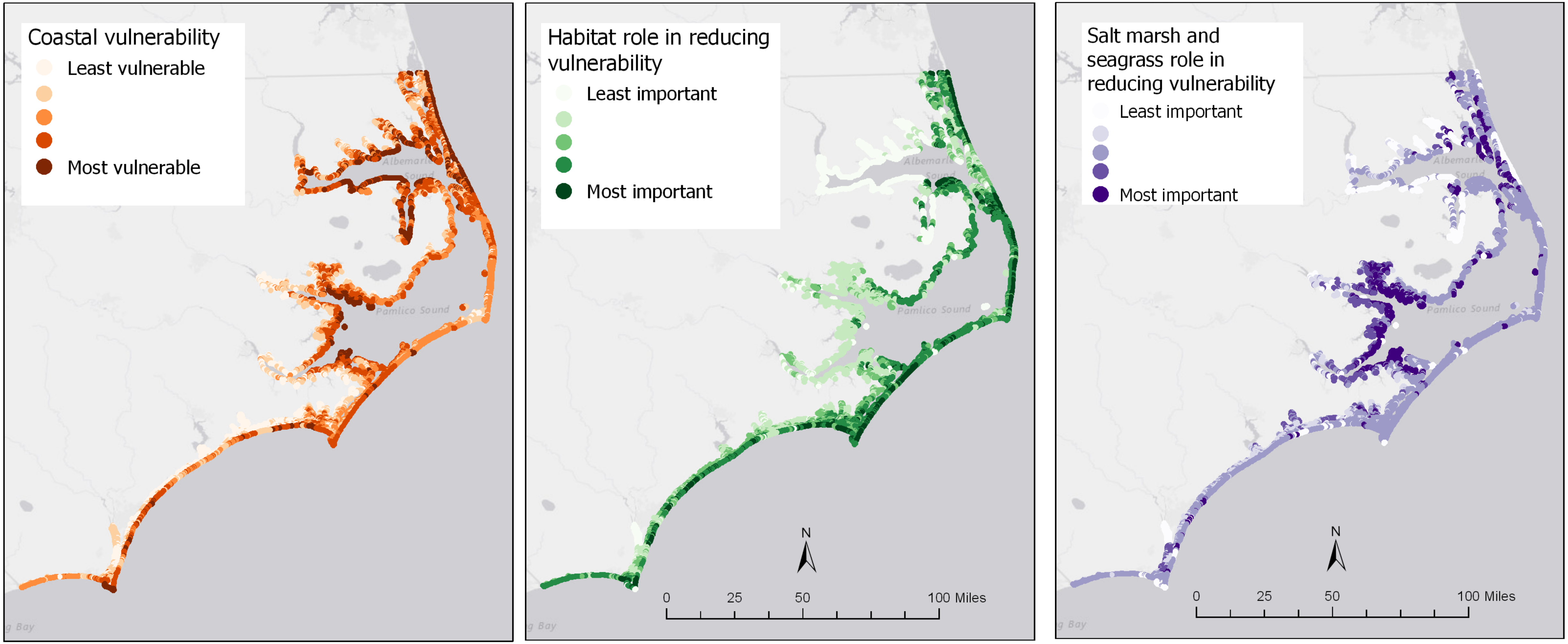
Warnell and Olander 2019.
draft methodology

NC Pocosins with Restoration/Enhancement Potential



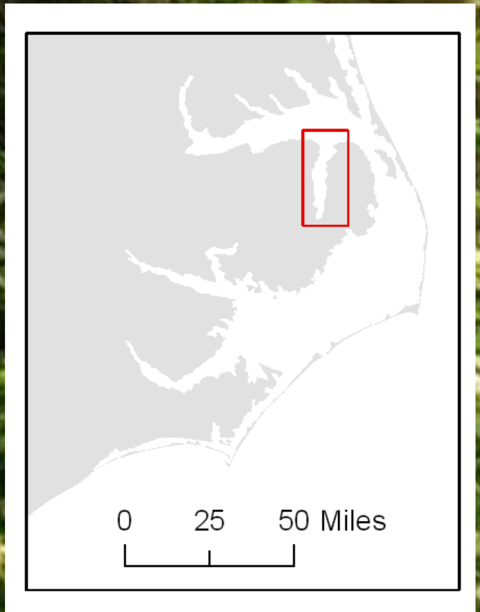
From Sara Ward

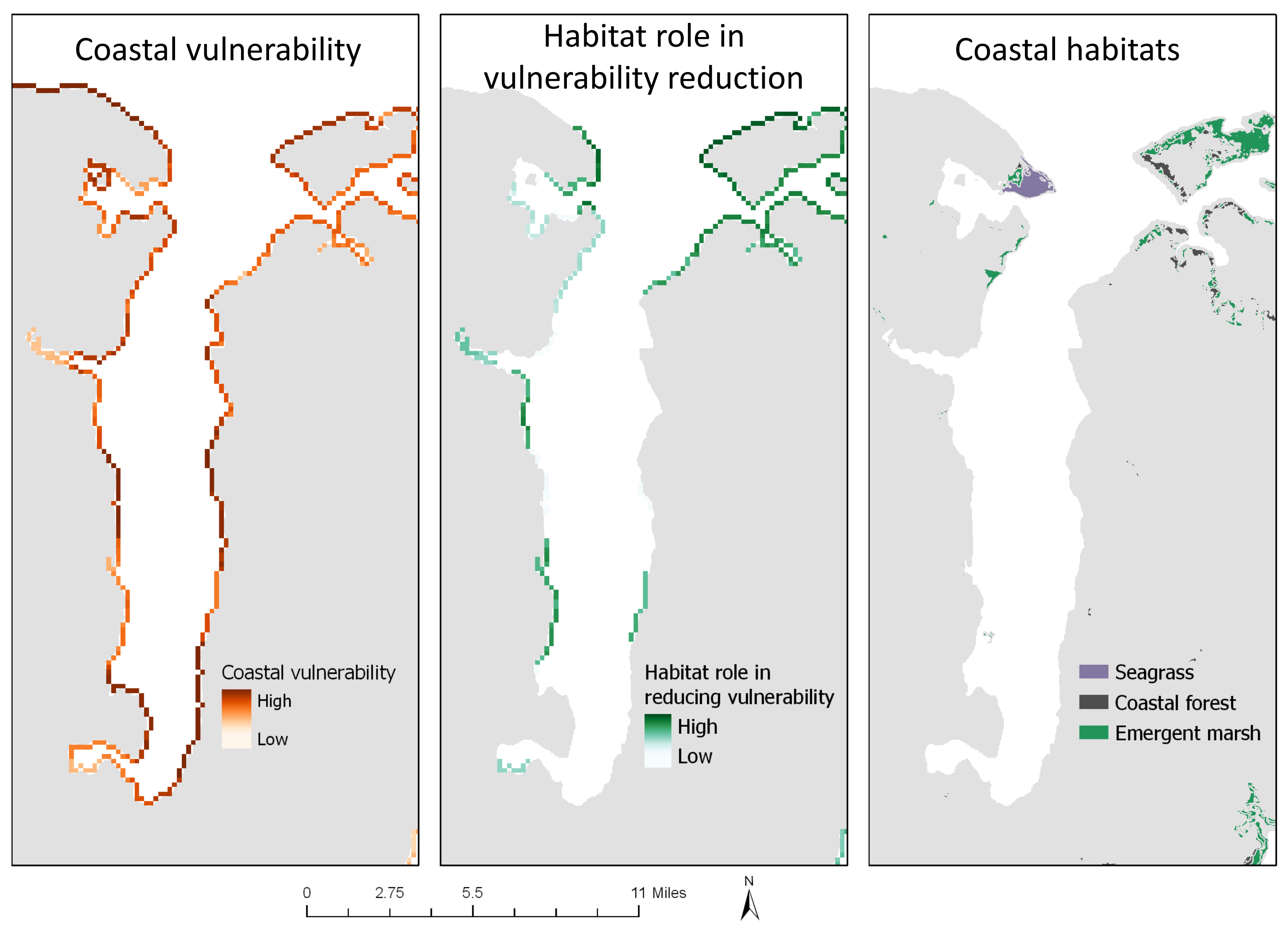
Coastal habitats



Arkema et al. 2013; model updated 2019 by Warnell, Hamilton, and Olander

Coastal habitats





Urban lands – opportunities for C

- Reduce or eliminate food waste from restaurants, grocery stores, etc. – use food banks or compost.
- Flood plain from buyouts and restoration.
- Increase urban tree canopy and greenspace to sequester carbon, reduce urban head island effect, etc.
- Increase green Infrastructure with the same benefits of trees plus addressing with storm water

Policy and Financing for land management

- Tax and program incentives
  - Public lands – e.g., reinstate Conservation Tax Credit, increase funding and streamline Agricultural Development a& Farmland Preservation
  - Private lands – e.g., expand Present-Use-Valuation program to industrial lands; expand Wildlife Conservation Program Tax for non-timber products and carbon benefits.
- Education opportunities
  - e.g., estate planning program to promote land retention; climate resiliency training for forest owners
- Resources:
  - e.g., Ballot funding initiatives for conservation/preservation; DOD funding

Financing for land management (Cont.)

- Grant Opportunities
  - Federal
    - e.g. Hazard Mitigation Grant Program (FEMA), Conservation Innovation Grants (NRCS)
  - State
    - e.g Watershed Restoration Grants (Division of Water Resources), Cost Share Programs (NC Dept. of Ag.)
- Private finance
    - e.g. Voluntary Carbon Market (GreenTrees), Urban Tree Planting (North Carolina Urban Forest Council)

NWL timing

- Now — Subgroups are working on refining priorities for C and resilience benefits and exploring funding options
- Aug 2019 — Draft results
- Nov 2019 — Draft Short-term action plan
- Jan 2020 — Final Plan for inclusion in EO80 Risk Assessment & Resiliency Plan
- Sept 2020 — Long term NWL Action Plan


QUESTIONS?

Meeting of the NC Climate Change Interagency Council

April 26, 2018

Natural and Working Lands Inventory

Paula Hemmer, Division of Air Quality

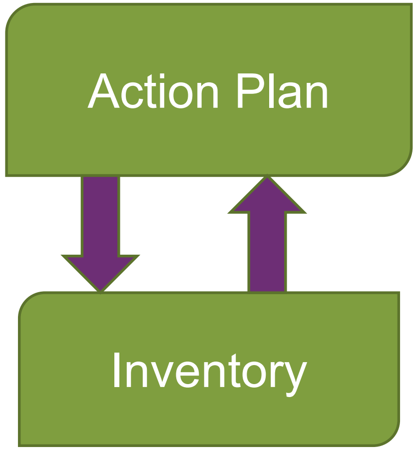
Purpose of the Inventory

1) Develop GHG Estimates

- Build scientific understanding of each source/sink category
- Estimate carbon emissions or sequestration for various activities
- Identify key sources/sinks and trends that impact GHGs

2) Support Development of Mitigation Options

- Determine carbon sequestration potential from each NWL sector
- Support choosing cost-effective mitigation actions => Action Plan
- Measure changes to inventory & progress toward goals from actions
- *Potentially use verified offsets as financial mechanism*



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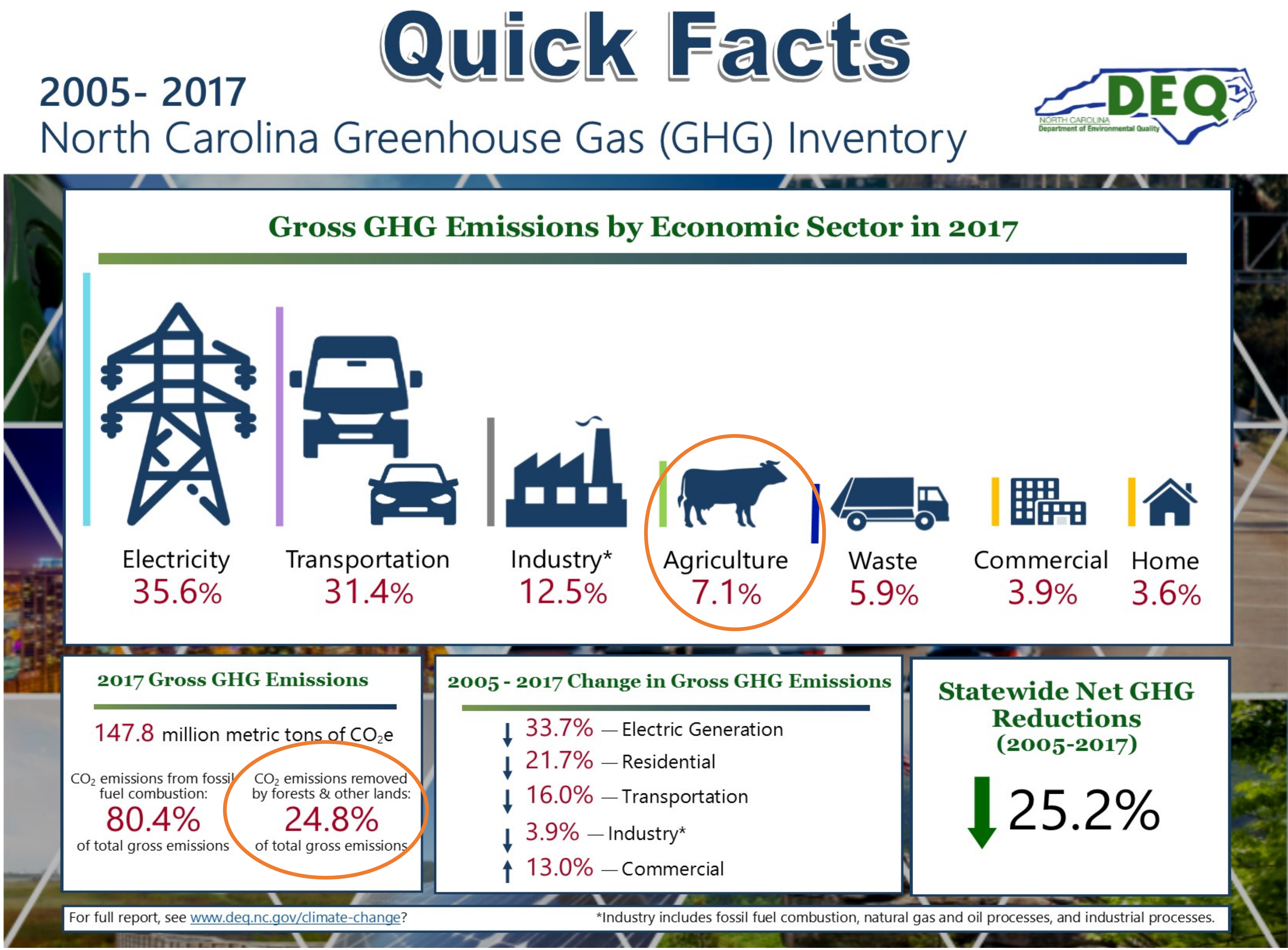
Department of Environmental Quality

GHG Emissions (MMT CO2E)	2017
Electricity Use	52.60
RCI Combustion*	20.92
Transportation	46.43
Agriculture	10.53
Waste Management	8.77
Industrial Processes	7.18
Natural Gas and Oil Systems	1.35
Gross Emissions	**147.79**
Land Use/Land Use Changes	-34.03
Net Emissions	113.76

**Residential Commercial and Industrial*

NWL is key sector



Activities Estimated for North Carolina Inventory

Activity Estimates for:

- Carbon flux from forest management
- Carbon flux from urban and rural settlements
- Carbon flux from landfilled yard and food waste
- Fertilization and liming of soils
- Forest fires
- Agriculture

Carbon Flux = net change in carbon from year to year:

- clearing an area of forest to create cropland
- restocking a logged forest
- allowing a pasture to revert to grassland
- long-term storage of carbon in lumber, etc.

NORTH CAROLINA
Department of Environmental Quality

Methods for Estimating Emissions

1) DAQ utilized *accepted* tools/methods for estimating GHGs

   US EPA State Inventory Tool

   - Based on methods in EPA US GHG Inventory (Chapters 5 & 6)*
   - Downscaled to state level *where possible*
   - Not all NWL Sectors are estimated
   - Forest Carbon Flux estimated using sophisticated USDA statistical tools

2) DAQ utilized *readily available, accepted* data sets

   - Obtained Federal data down-scaled to the state level from USDA and US EPA
   - Obtained State-specific data where Federal data not available or not adequate
   - Forest Carbon Flux data includes
     a. Federal remote imagery data,
     b. NCFS plot level forest attribute data and
     c. NCFS forest health survey data

Challenging to quantify *anthropogenic* emissions/sinks for this sector

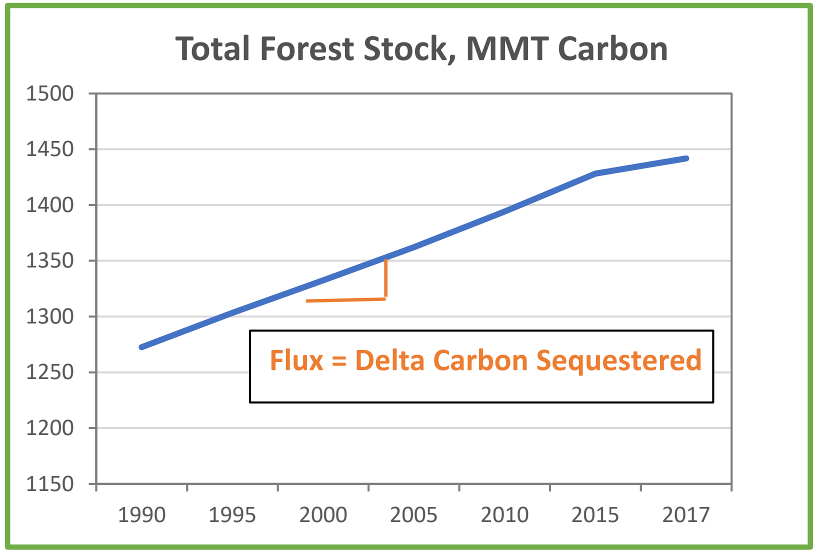
* US EPA is reporting emissions to meet international agreements. Therefore, it uses methods published in the 2006 Intergovernmental Panel on Climate Change Guidelines for National Greenhouse Gas Inventories.

NORTH CAROLINA Department of Environmental Quality

Forest Carbon Stock: Based on New 5-Yr Survey Cycle Data from NCFS & USDA

<u>Net</u> Forest Carbon Stocks (MMT Carbon) and Forest Area (million acres)

Forest Stocks and Area	1990	1995	2000	2005	2010	2015	2017	Percent Change 1990-2017
Aboveground Biomass	365.3	392.0	417.1	442.7	469.9	498.6	510.1	
Belowground Biomass	72.7	78.4	83.7	89.1	94.8	100.7	103.1	
Dead Wood	65.3	65.6	65.9	66.2	66.5	66.8	66.9	
Litter	45.9	44.9	44.0	43.1	42.3	41.6	41.3	
Soil Organic Carbon	723.3	722.5	721.8	721.2	720.7	720.4	720.3	
Total Forest Carbon Stocks (MMT Carbon)	**1,273**	**1,303**	**1,333**	**1,362**	**1,394**	**1,428**	**1,442**	**13%**
Total Forest Area (Million Acres)	**18.51**	**18.58**	**18.64**	**18.71**	**18.78**	**18.84**	**18.87**	**2%**



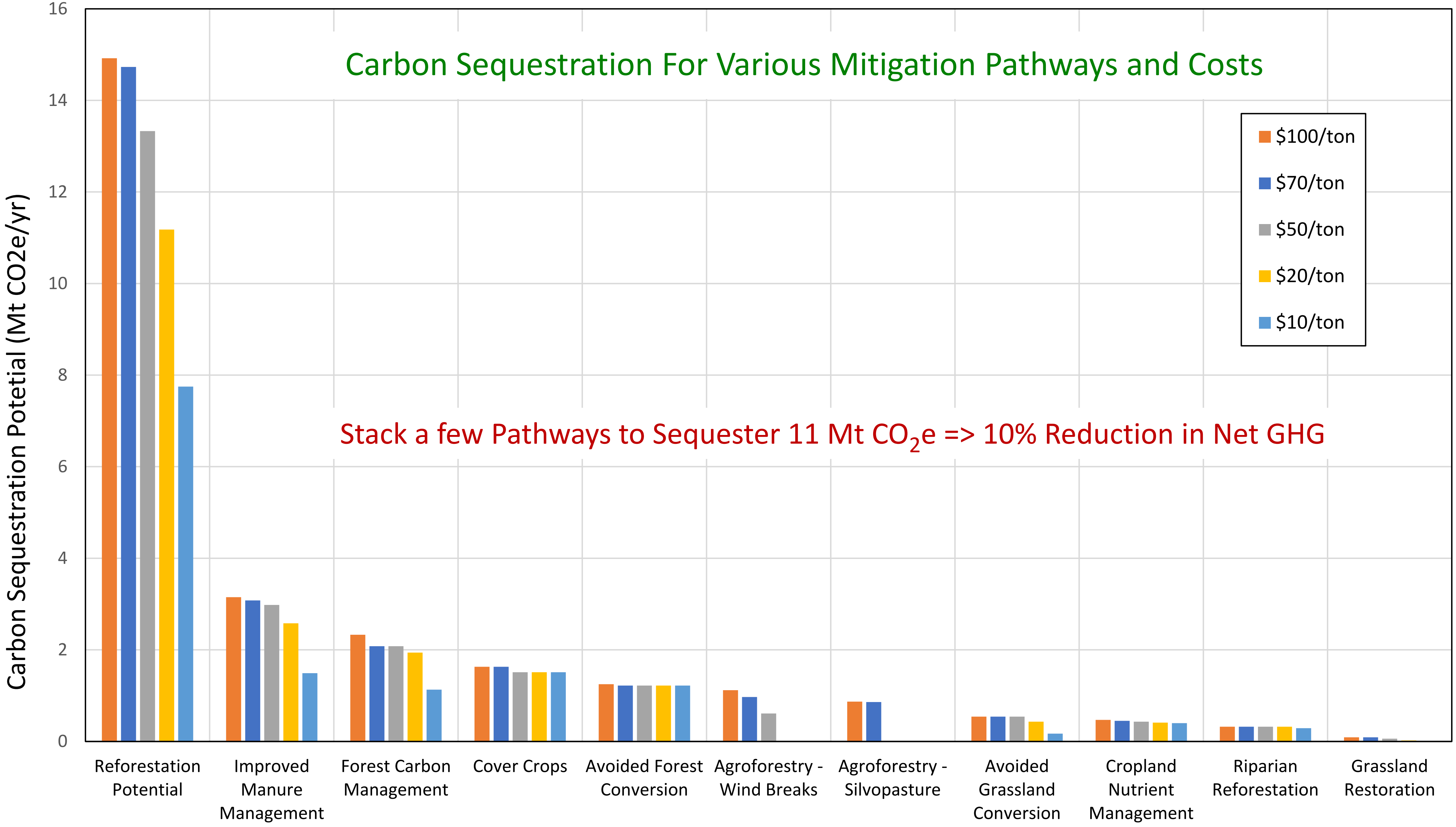
Better
Forest Management

North Carolina Land Use Inventory: Sinks and Emissions in MMT CO2e

Source/Sink	1990	2005	2012	2015	2017	Percent Change 2005-2017
Forest Carbon Flux	-35.31	-35.17	-38.11	-37.91	-37.77	-7%
Aboveground Biomass	*-19.89*	*-19.04*	*-21.23*	*-21.10*	*-21.01*	
Belowground Biomass	*-4.23*	*-4.00*	*-4.41*	*-4.37*	*-4.34*	
Dead Wood	*-0.20*	*-0.22*	*-0.22*	*-0.22*	*-0.21*	
Litter	*0.70*	*0.61*	*0.50*	*0.52*	*0.53*	
Soil Organic Carbon	*0.60*	*0.44*	*0.20*	*0.21*	*0.22*	
Wood Products	*-12.28*	*-12.96*	*-12.96*	*-12.96*	*-12.96*	
Landfill Yard and Food Waste	-0.64	-0.31	-0.35	-0.33	-0.33	
Agricultural Soil Carbon Flux	-0.23	0.75	1.47	1.48	1.48	
Urban Trees	*Not estimated*					
Carbon Sinks	**-36.17**	**-34.73**	**-36.99**	**-36.76**	**-36.62**	**-5%**
Liming of Soils	0.03	0.00	0.00	0.00	0.00	
Urea Fertilization	0.007	0.011	0.006	0.007	0.007	
Forest Fires	0.40	1.99	2.95	2.52	2.52	
N_2O from Settlement Soils	0.09	0.07	0.07	0.07	0.07	
GHG Emissions	**0.53**	**2.07**	**3.03**	**2.60**	**2.60**	**25%**
Net Carbon Sink	**-35.64**	**-32.66**	**-33.97**	**-34.16**	**-34.03**	**-4%**

Wood Used for Combustion:

- Removed from carbon stock
- Does not enter long-term storage



Source: http://mitigationpathways.s3-website-us-west-1.amazonaws.com/

QUESTIONS?

Happy National Arbor Day

Paula Hemmer
NC Division of Air Quality
919-707-8708

NORTH CAROLINA
Department of Environmental Quality

Restoring Pocosin Wetlands: A Land Based Solution to Support North Carolina's Climate and Resiliency Goals

NC CLIMATE CHANGE INTERAGENCY COUNCIL MEETING

NORTH CAROLINA STATE ARCHIVES, RALEIGH, NC

SARA WARD, U.S. FISH AND WILDLIFE SERVICE (CO-CHAIR, POCOSINS NWL GROUP)

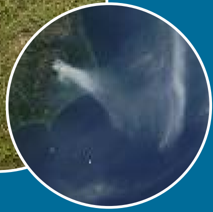
APRIL 26, 2019

Key Points

Pocosin can help meet the State’s climate and resiliency goals while delivering meaningful “co-benefits”

A science-based standard process exists to quantify and verify climate benefits

Available resources and financing mechanisms create opportunities for landowner and land manager engagement



Additional measures to build climate and resiliency benefits on and adjacent to pocosins are available

What are pocosins?

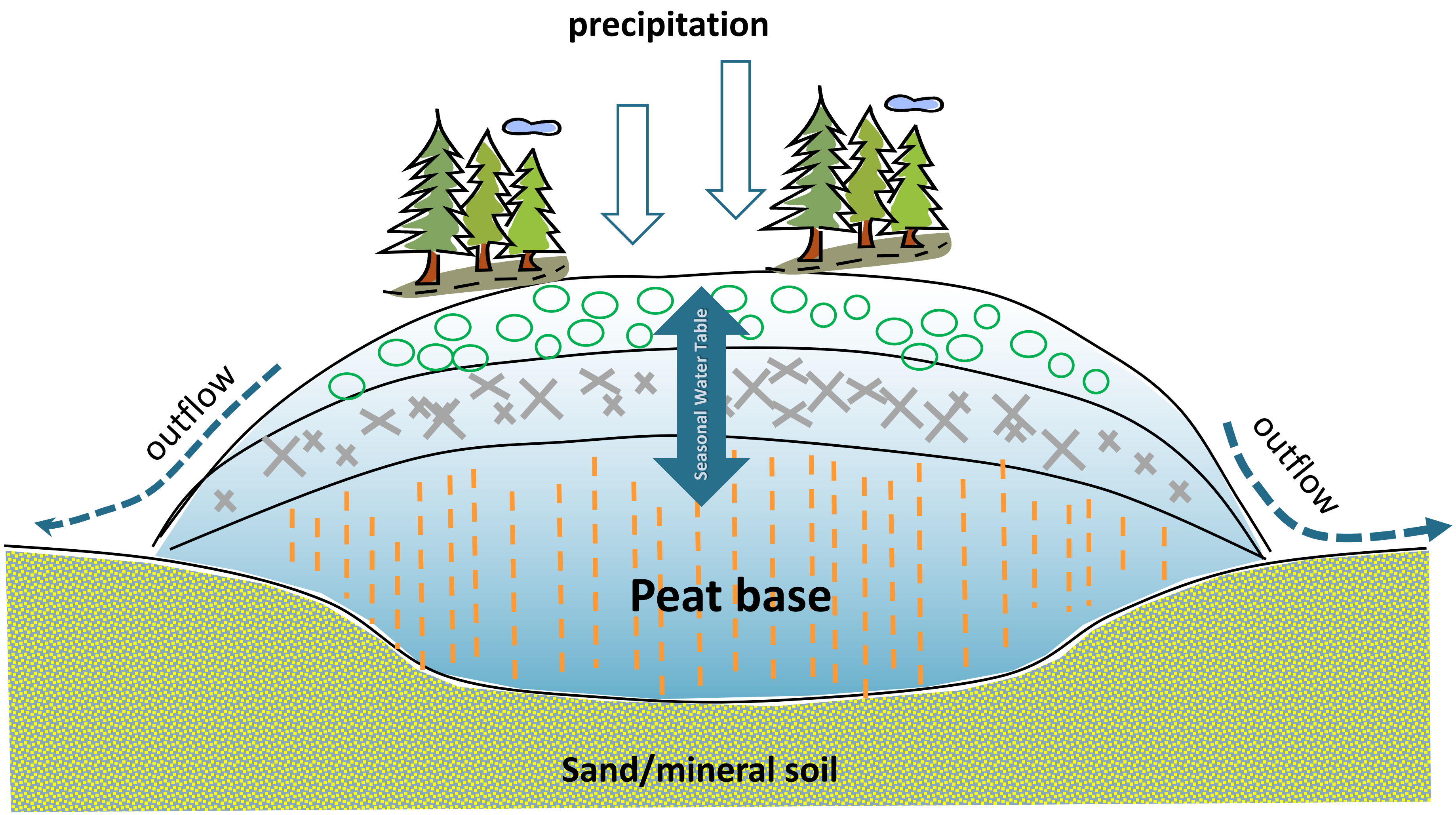
- Fire-dependent, southeastern shrub bog wetlands
- Seasonally-saturated, poorly drained when unaltered
- Thick peat soils (Histosols) act as carbon “sponge”
- Peat depth exceeds 4 meters


Peat soil profile


Healthy Pocosin Wetlands, Photos: USFWS

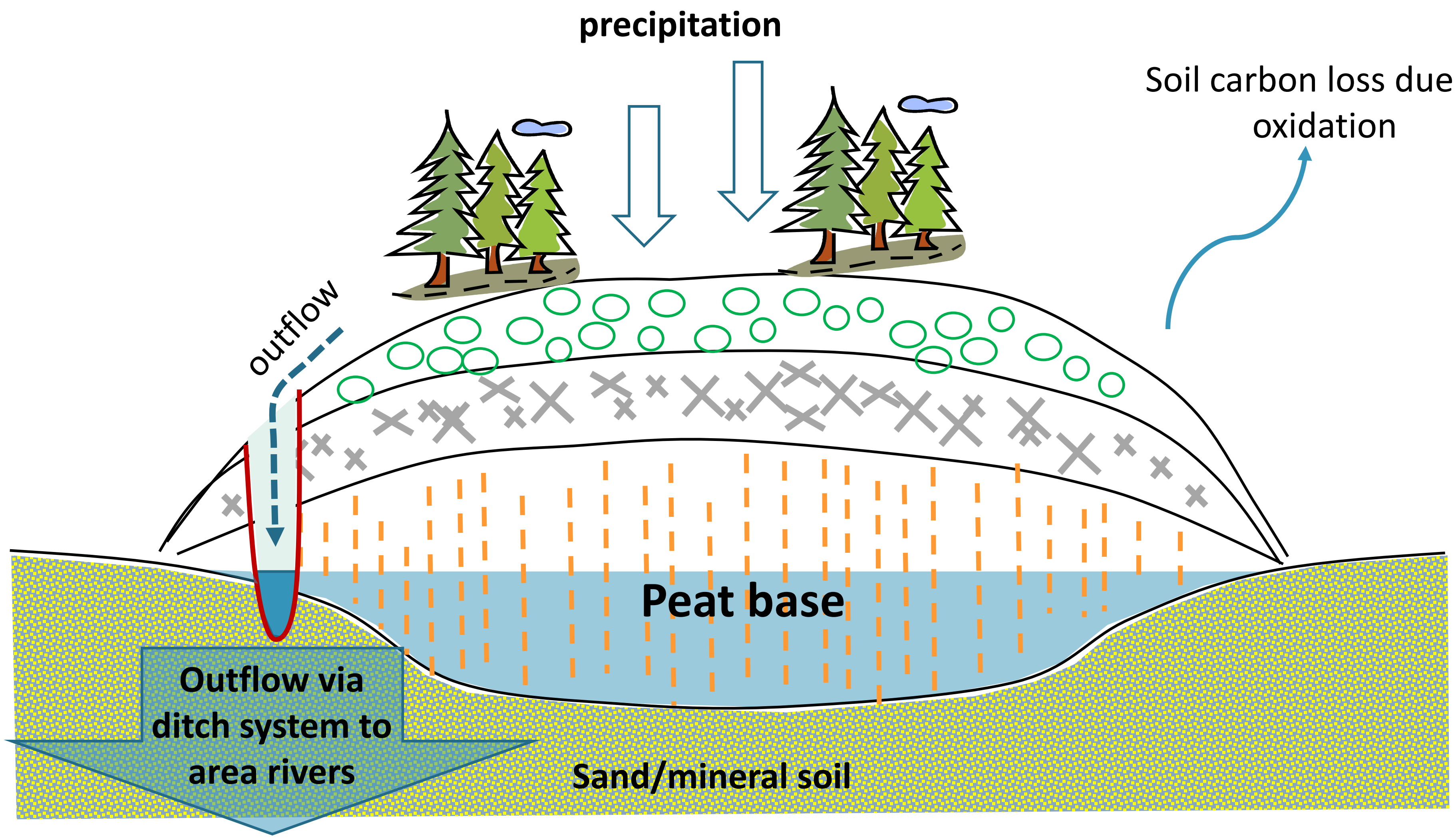
Pocosin: Swamp on a Hill

Pre Alteration: flow over & through the land to river



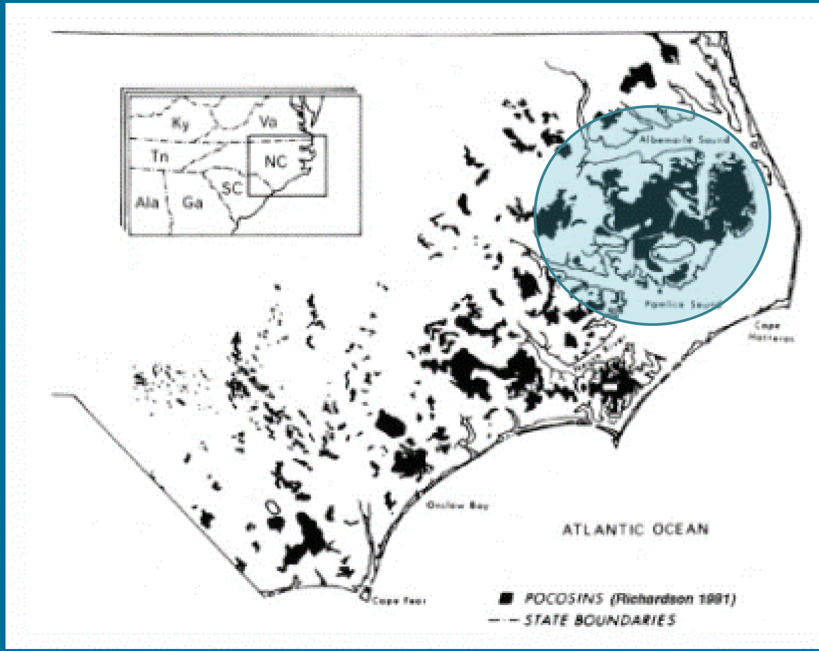
Pocosin: Swamp on a Hill

Post Alteration: flow through ditch system to river (to a point)

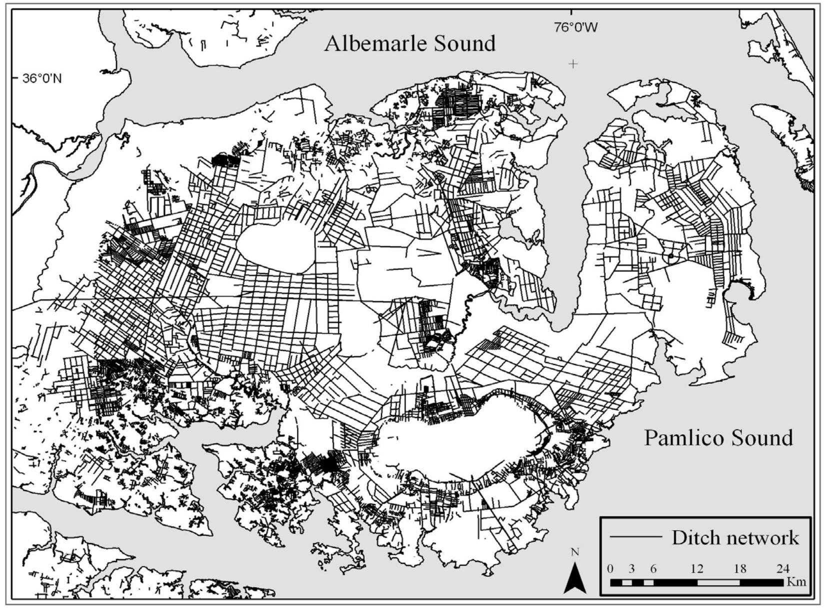


Drainage: climate threat & restoration opportunity

70% loss of NC pocosins since 1962 via ditching



1962 pocosins (Richardson 2003)



Poulter, Duke Univ.

- Peat loss via oxidation and subsidence as water table is lowered
- Greater susceptibility to wildfire/rapid peat loss via combustion
- Carbon (greenhouse gas) release to the atmosphere

"THE LAND SECTOR IS THE ONLY SECTOR THAT CAN SWITCH FROM BEING A NET SOURCE OF CARBON TO A NET SINK"

- TNC, Global Lands Report

DRAINED CONDITION

Loss of carbon by oxidation

(SOURCE)

RESTORED CONDITION

Carbon sequestration

(SINK)

Carbon partnerships leverage resources

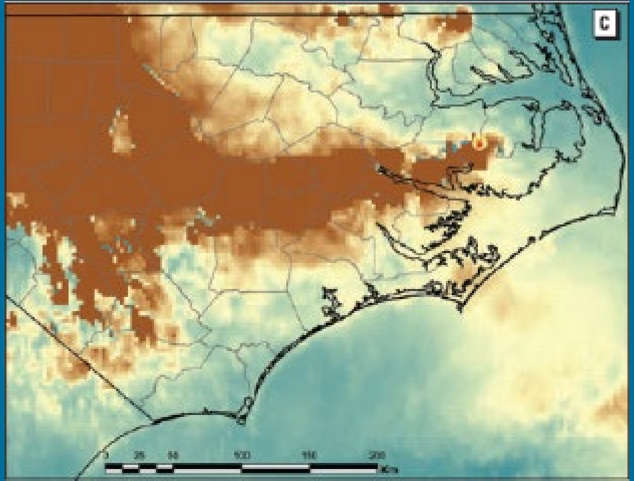
Rewet combustible soils and habitat

Preventing catastrophic loss of soil carbon

Co-benefits of pocosin restoration

Much more than carbon sequestration:

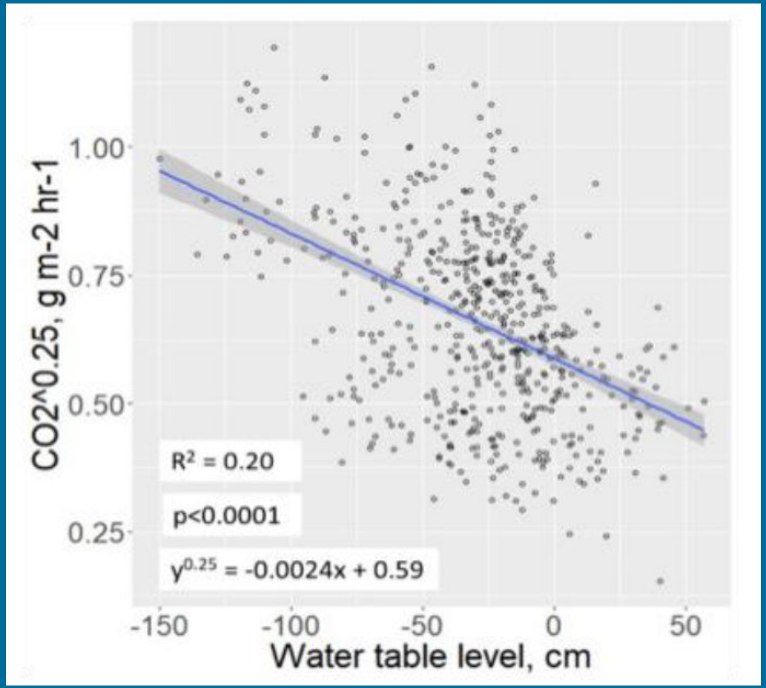
- Enhances habitat
- Protects estuarine water quality
- Conserves peat (and elevation) in SLR vulnerable areas
- Reduces frequency and intensity of wildfires
- Lessens flooding from storms
- Limits saltwater intrusion in low elevation areas
- Minimize human community impacts



2008 Evans Rd Fire affected areas beaches and urban areas in June 2008. Rappold et al. *Env. Health Perspect.*, 2011

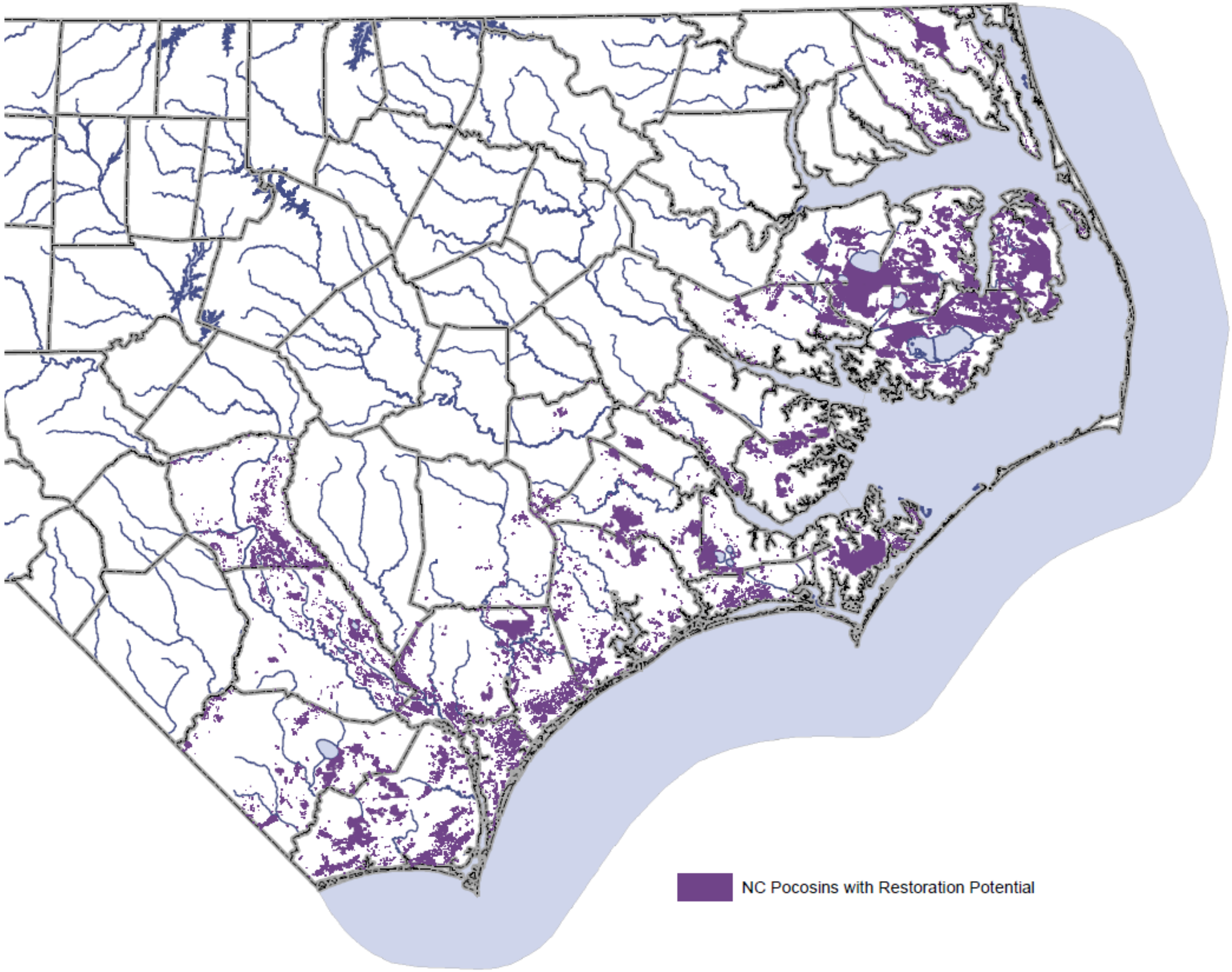
Meaningful climate impact & scope

- Climate impact estimated at 1,080 metric t CO_2^{-e} per acre over 100 years
- Peatlands cover only 3% of world's land area but contain two times the carbon stock of forest biomass worldwide
- Represents 20-30% of the world's soil carbon (Nahlik et al 2016)
- Peatland soil carbon pool nearly equal to overall atmospheric CO_2 (Turetskey et al 2015)
- In other words, great carbon sink potential!

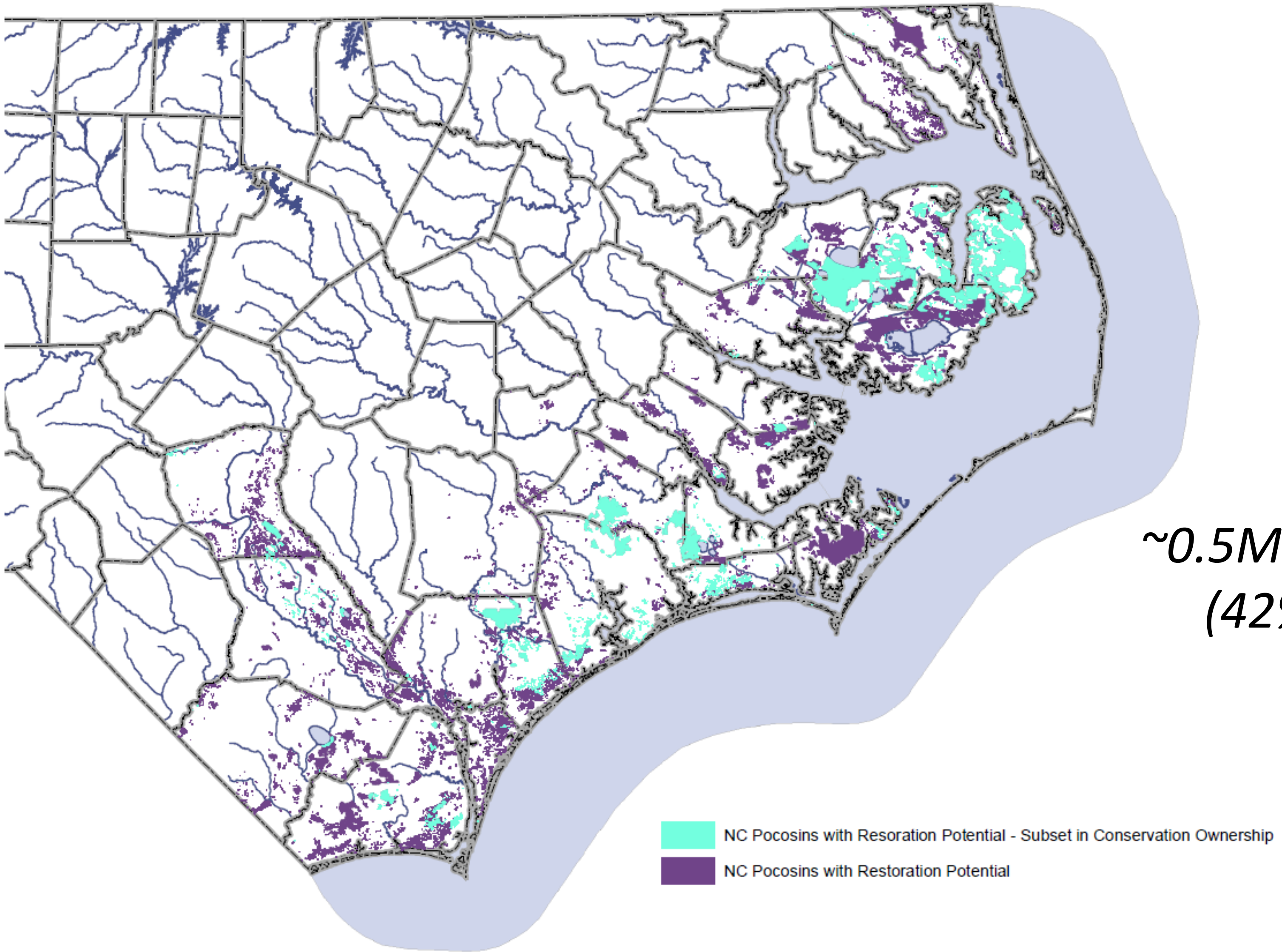


Emissions reductions are related to increasing water table during restoration

NC: Scope of opportunity

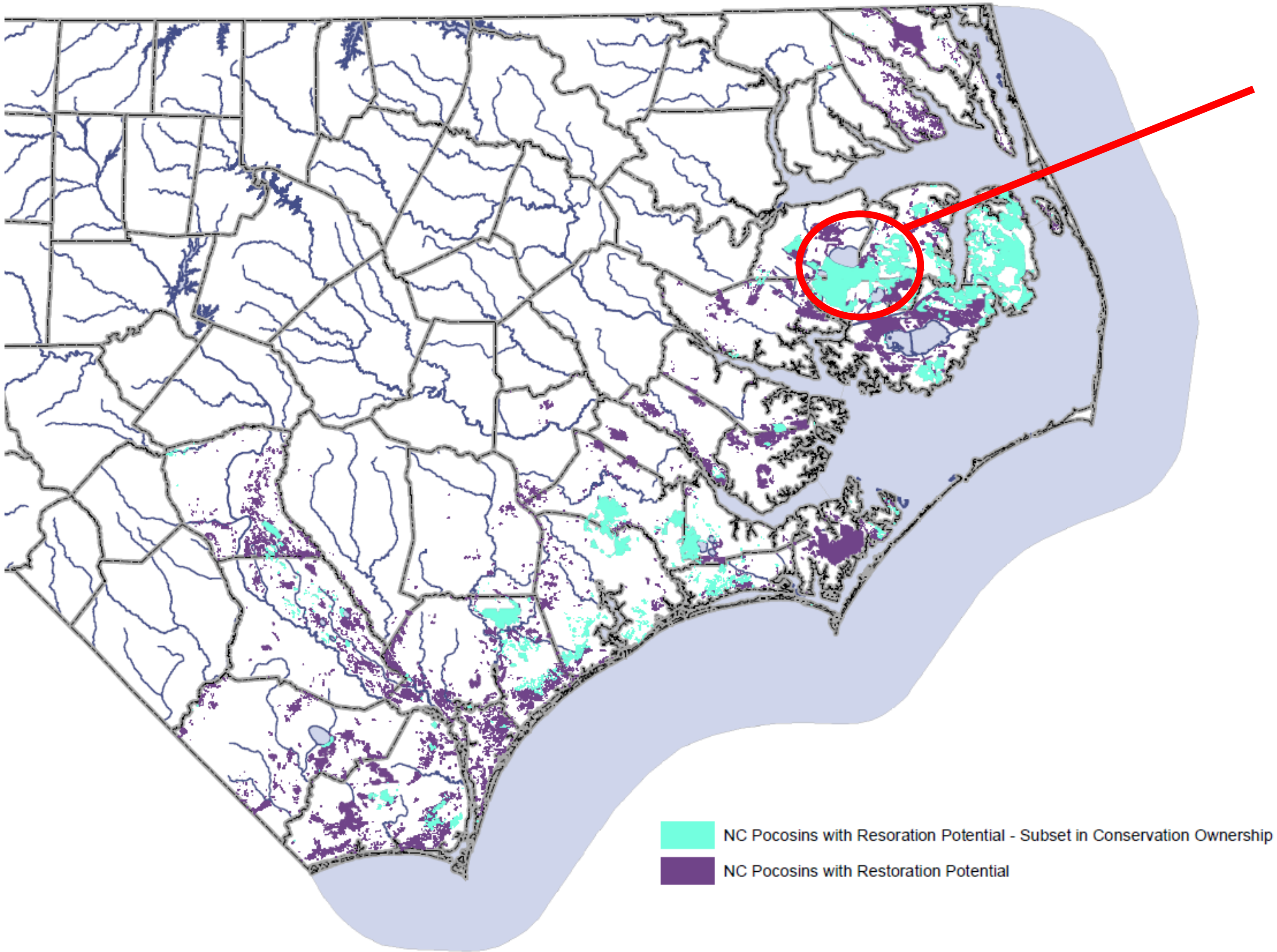


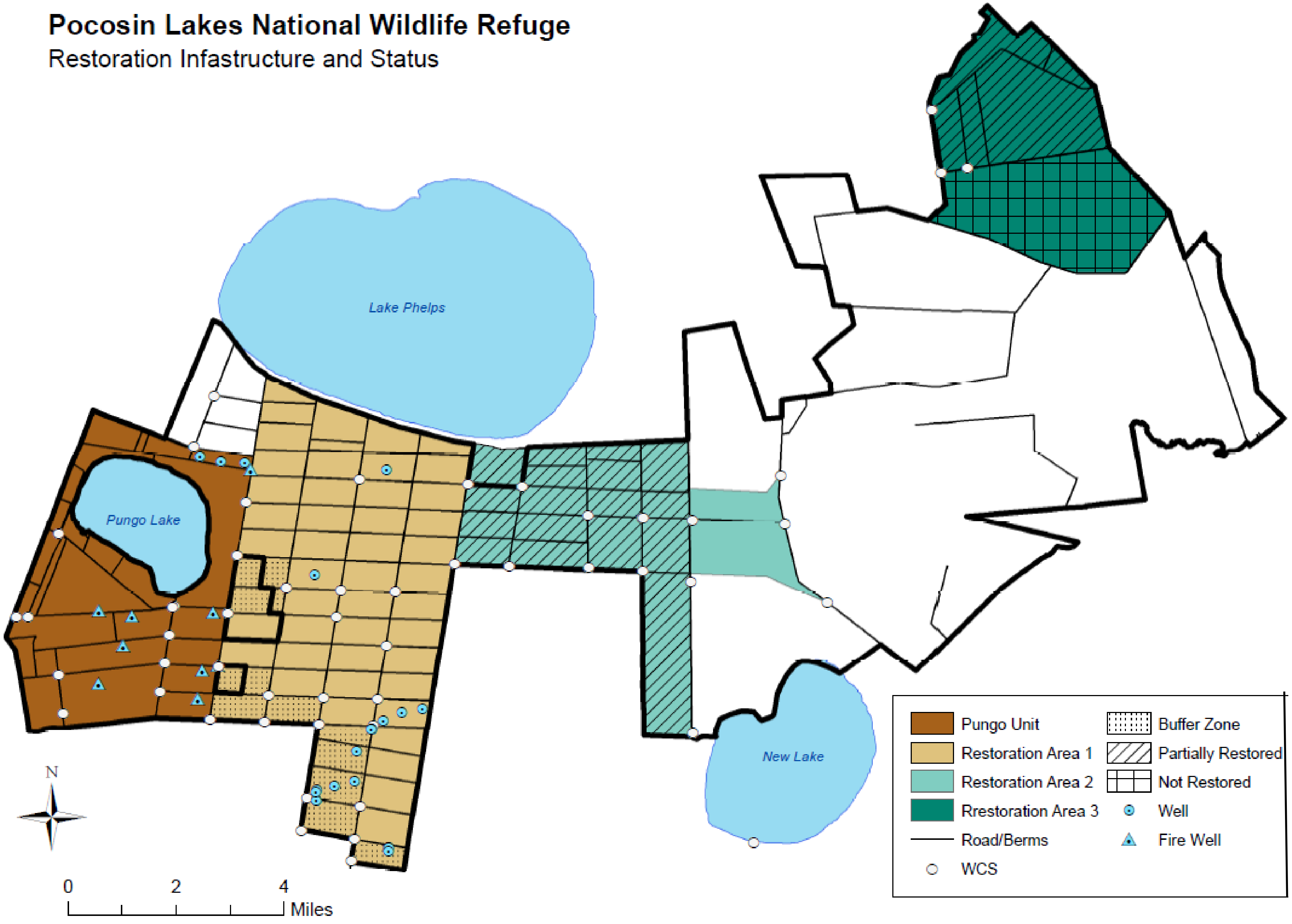
NC: Scope of opportunity



~0.5M ac restoration need in NC alone
(42% in conservation ownership)

Pocosin Lakes NWR example





32 million t CO_2-e sequestered on <u>~30,000 acres</u> at Pocosin Lakes NWR to date

Resources – standard method to verify benefit

American Carbon Registry

METHODOLOGY FOR THE QUANTIFICATION, MONITORING, REPORTING AND VERIFICATION OF GREENHOUSE GAS EMISSIONS REDUCTIONS AND REMOVALS FROM

RESTORATION OF POCOSIN WETLANDS

VERSION 1.0

October 2017

WINROCK

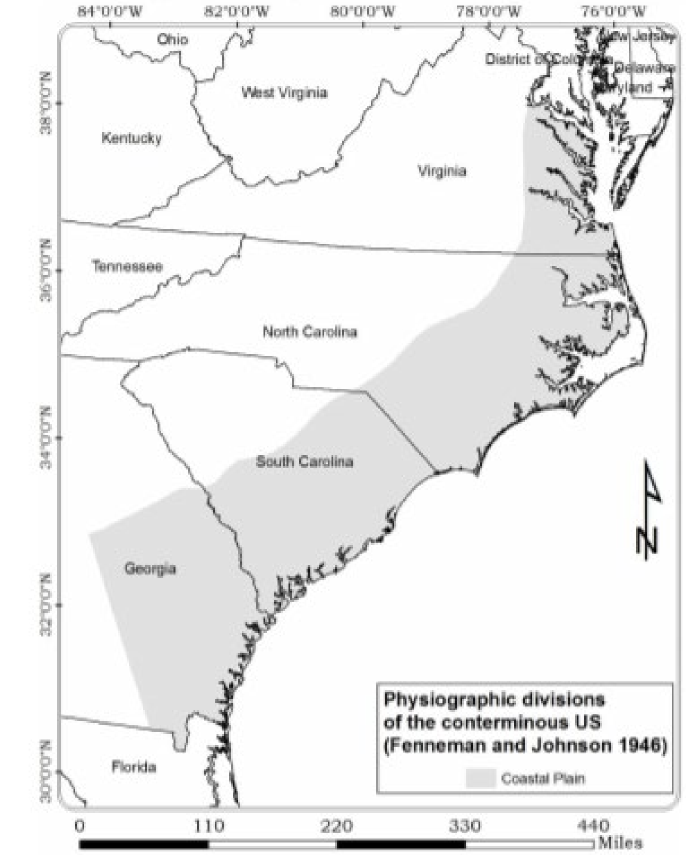


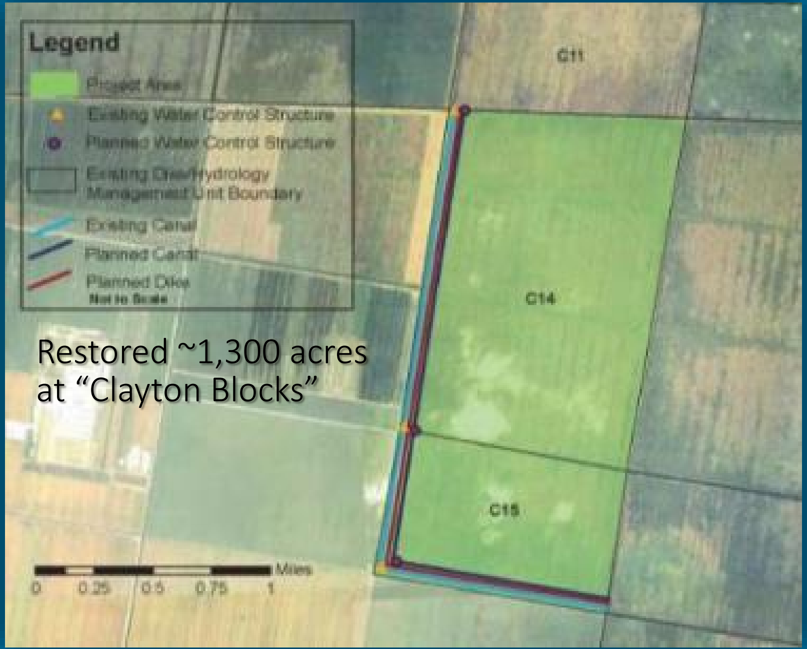
Figure 1: Area of Applicability (Shaded) of the Methodology – Coastal Plain of Virginia, North Carolina, South Carolina and Georgia

- Applicability area and conditions defined for previously drained pocosins
- Option to address avoided wildfire carbon losses
- TNC and TerraCarbon developed with funding by Duke Energy

Resources – proof of concept as "road map"

Pocosin Lakes NWR Carbon Sequestration Demo Project

- Developed and applied ACR methodology for quantifying benefits
- Road map for others (private landowners or public land managers)
- It takes a village…partners are available to help!

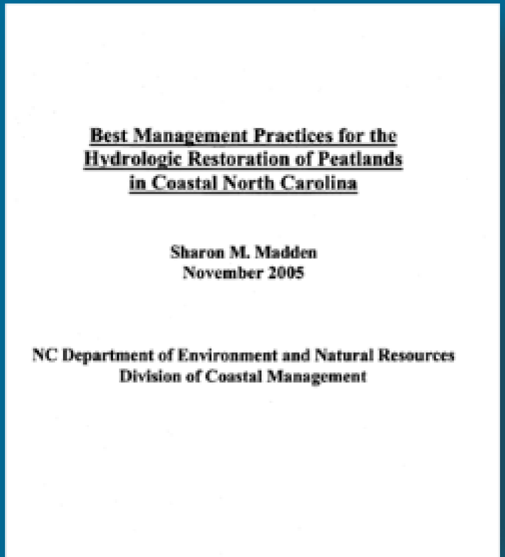


Photos: TNC

Photo: DUWC

Resources and Financing

- Voluntary market financing (ACR approach)
- Relative low cost
- Available design BMPs and expertise
- Stacking opportunities/landowner incentives
- Government funding sources
  - State (NCDEQ funded 10K ac of restoration at PLNWR as nutrient reduction project)
  - Federal (USFWS Refuge/Coastal, USDA, USDOD, NOAA, others?)
- Grant funding (resiliency/adaptation, post-storm recovery, NGOs)
- Corporate
  - Voluntary climate responsibility
  - Future airline targets



Best Management Practices for the Hydrologic Restoration of Peatlands in Coastal North Carolina

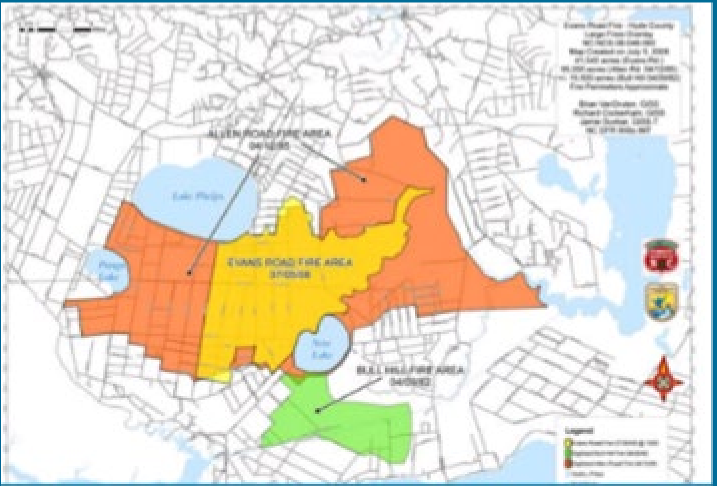
Sharon M. Madden
November 2005

NC Department of Environment and Natural Resources
Division of Coastal Management

Cost of inaction – catastrophic fire

- Repeat catastrophic fires have significant suppression burden to state and federal government
- Peat is exhaustible resource
  - 9,000+ years to form
  - support unique habitats
  - rapid loss
- Peat has market value

At $10/ton C, peat worth up to $139M was lost during Allen Rd and Evans Road fires combined



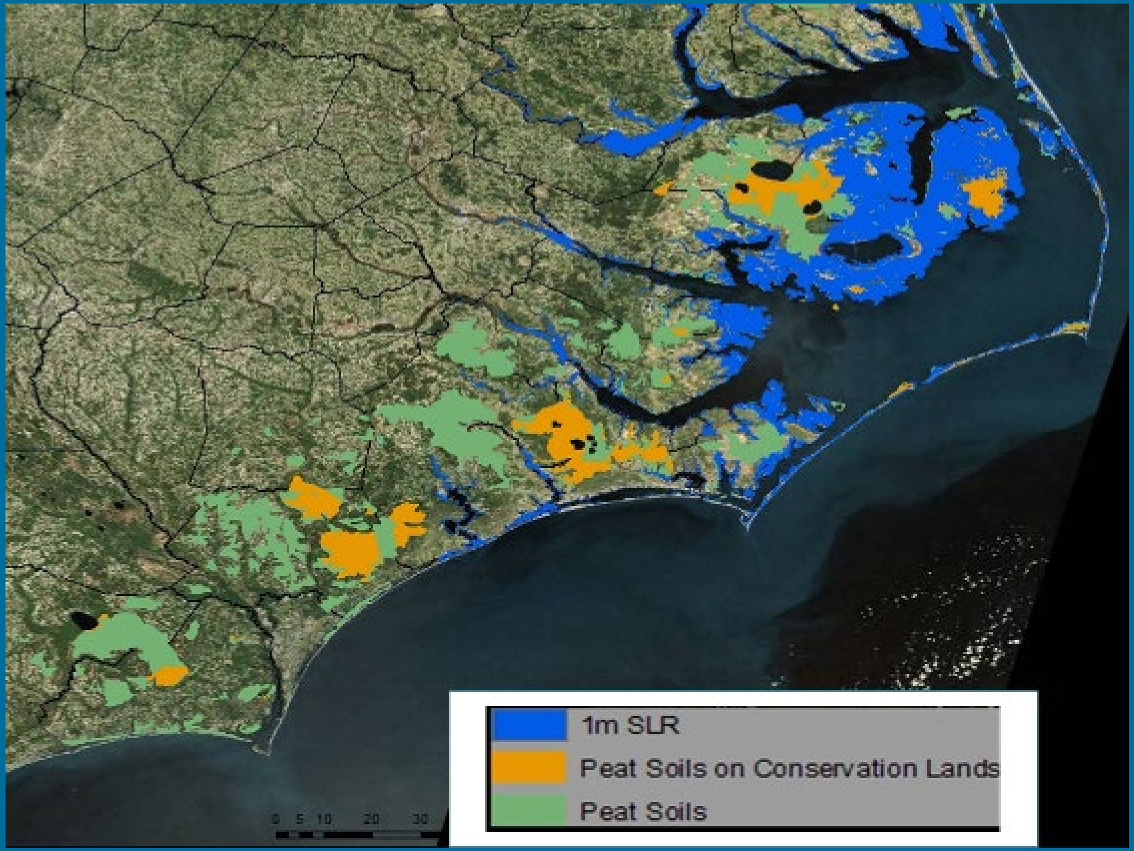
Predicted return interval = 50-150+ yrs; actual is MUCH shorter post drainage

4 Fires on Refuges in 3 yrs: 38,000 ha burned; $58M cost; > 1.5 m soil loss

Measures to build climate / resiliency benefits

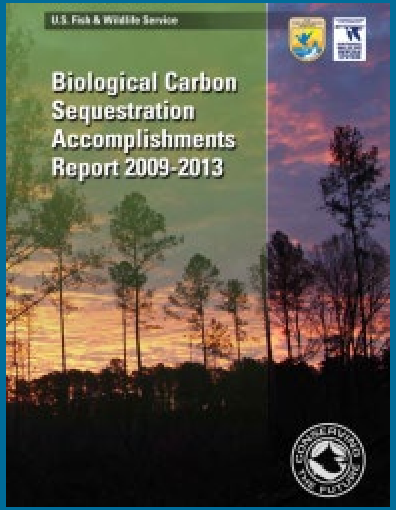
NWL identifying actions/recommendations to:

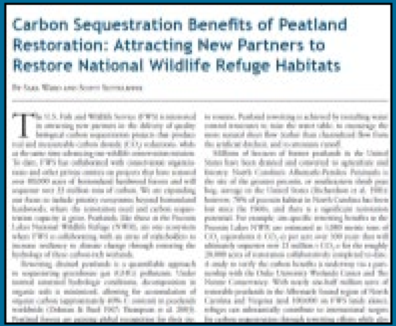
- Address catastrophic fire crediting
- Reduce peat loss due to saltwater intrusion and sea level rise via ecological engineering
- Implement soil retention practices on agricultural lands near pocosins
- Attenuate storm flooding using restoration infrastructure
- Enhance restoration via forestry practices



Credit: TNC

Stay tuned. . .





ADDITIONAL POCOSIN RESTORATION INFO

Thank You!

Pocosin Lakes NWR Restoration climate impact:

- Restoration overview
- FWS Peatland Restoration Video
- Ward and Settelmeyer. National Wetlands Newsletter Article. 2014
- Additional FWS project info (White paper)
- Carbon verification study (DUWC)
  - Final report: https://nicholas.duke.edu/wetland/FWSreport13.pdf
  - Wang, H., C.J. Richardson, and M. Ho. 2015. Dual controls on carbon loss during drought in peatlands.
  - Wang, H., C.J. Richardson, M. Ho, and N. Flanagan. 2016. Drained coastal peatlands: A potential nitrogen source to marine ecosystems under prolonged drought and heavy storm events-A microcosm experiment.

American Climate Registry "Methodology for the Quantification, Monitoring, Reporting and Verification of Greenhouse Gas Emissions Reductions and Removals from Restoration of Pocosin Wetlands". Version 1.0. 2017

Contact – Sara_Ward@fws.gov; 252-473-1132 x.243

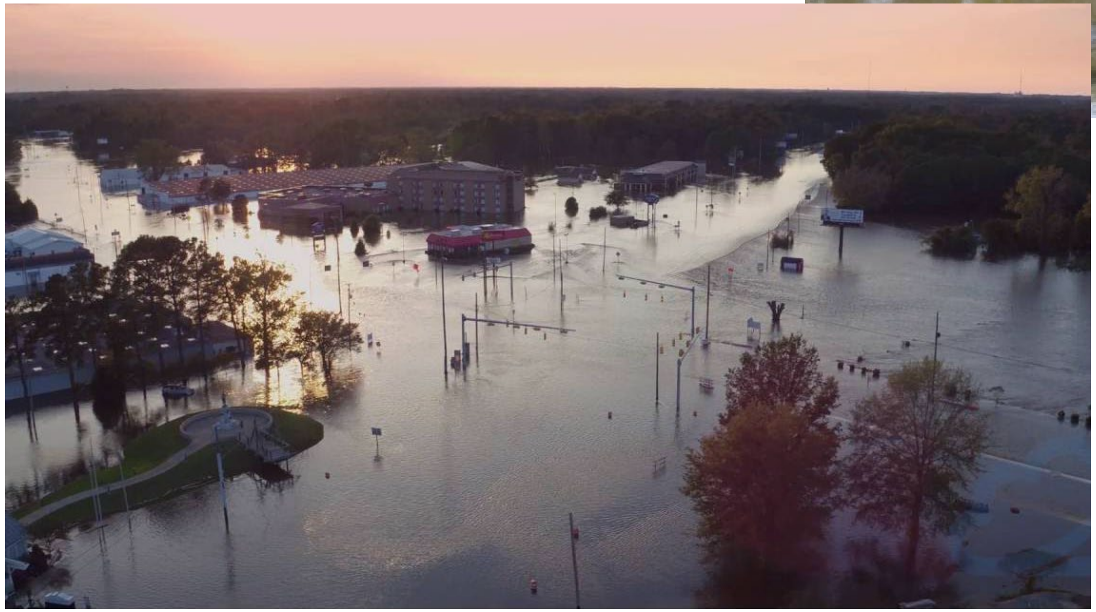
Investing in nature-based solutions for resilient communities and landowners

Will McDow

EDF ENVIRONMENTAL DEFENSE FUND™
Finding the ways that work


Welcome
To
KINSTON
HOME OF NC GLOBAL TRANSPARK
abc11.com
7:30 63°


STOP



Resilience is…

Ability to increase or maintain "safe operating space" within thresholds

Connected systems; requires shared solutions

…the capacity of socio-ecological systems

to support human and natural well-being

as climate change and other stressors

interact unpredictably over time.

Support = self-correcting, adapting, positive reinforcement, restored & maintained

Well-being assumes continued or improved functions and processes

"Climate change puts other stressors on steroids"


"When storms are becoming more destructive, it's not enough to pick up the pieces. We must take action to prevent this kind of devastation in the future."
- Gov. Cooper, Feb 6, 2019

DEQ Division of Mitigation Services (DMS)

Will McDow

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Public Engagement