SNEP PRESENTS

Southeast New England Program

EPA United States Environmental Protection Agency

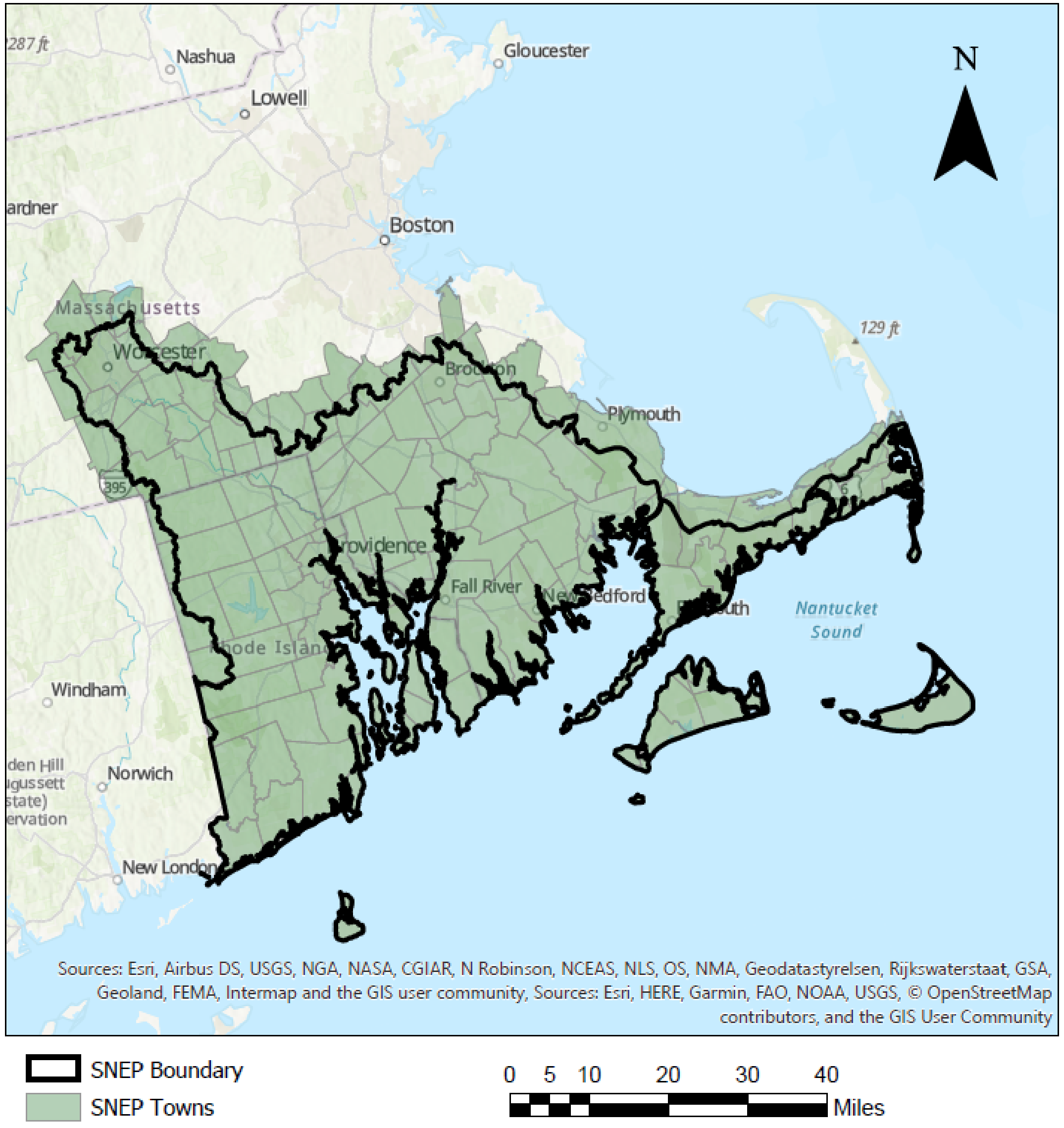
WEBINAR & DISCUSSION

Greenhouse Gas Mitigation and Adaptation Strategies: from Farm to Estuaries

July 14, 2022

The Southeast New England Program Boundary

United States Environmental Protection Agency



Updated 12/9/2020

The Southeast New England Program at EPA Region 1 is a bi-state geographic program that encompasses Rhode Island and southeastern Massachusetts. Our region includes:

133 Municipalities
12 Counties
3 Tribes
2 States
2 NEPs

SNEP
Southeast New England Program
www.epa.gov/SNEP

Website: www.epa.gov/snep | Email: SECoastalNE@epa.gov

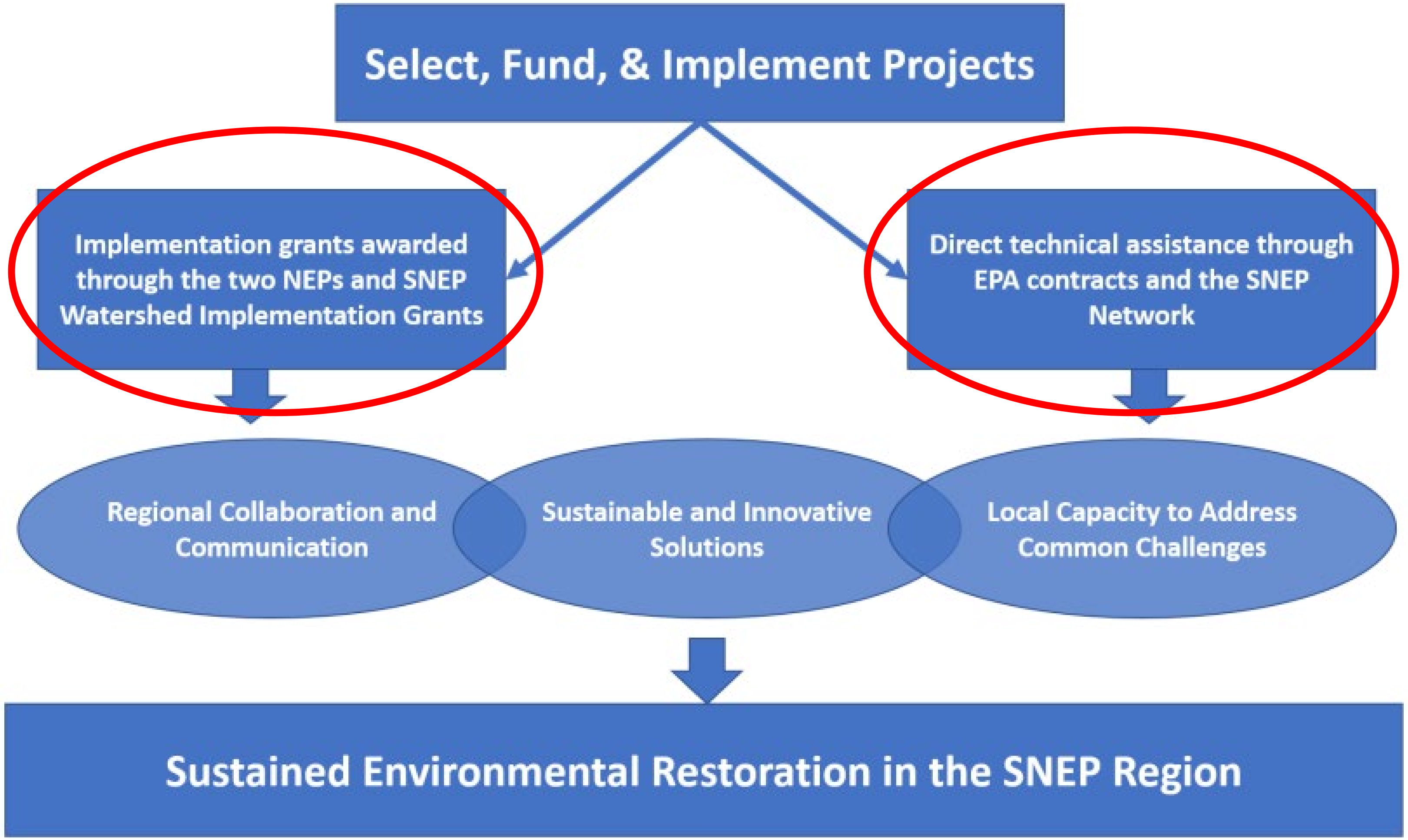
Background

- Program Vision:

  We envision a resilient ecosystem of safe and healthy waters, thriving watersheds and natural lands, and sustainable communities in the Southeast New England Program coastal watershed region by 2050

- The shared natural and human history of the region means each sub-region experiences common environmental challenges and will benefit from regional solutions.
- SNEP has established long-term Goals and Desired Outcomes to achieve this 2050 Vision. A set of actions and targets to guide those actions over the five-year span is included in our Strategic Plan.

The SNEP Process for Sustained, Regional, Environmental Restoration

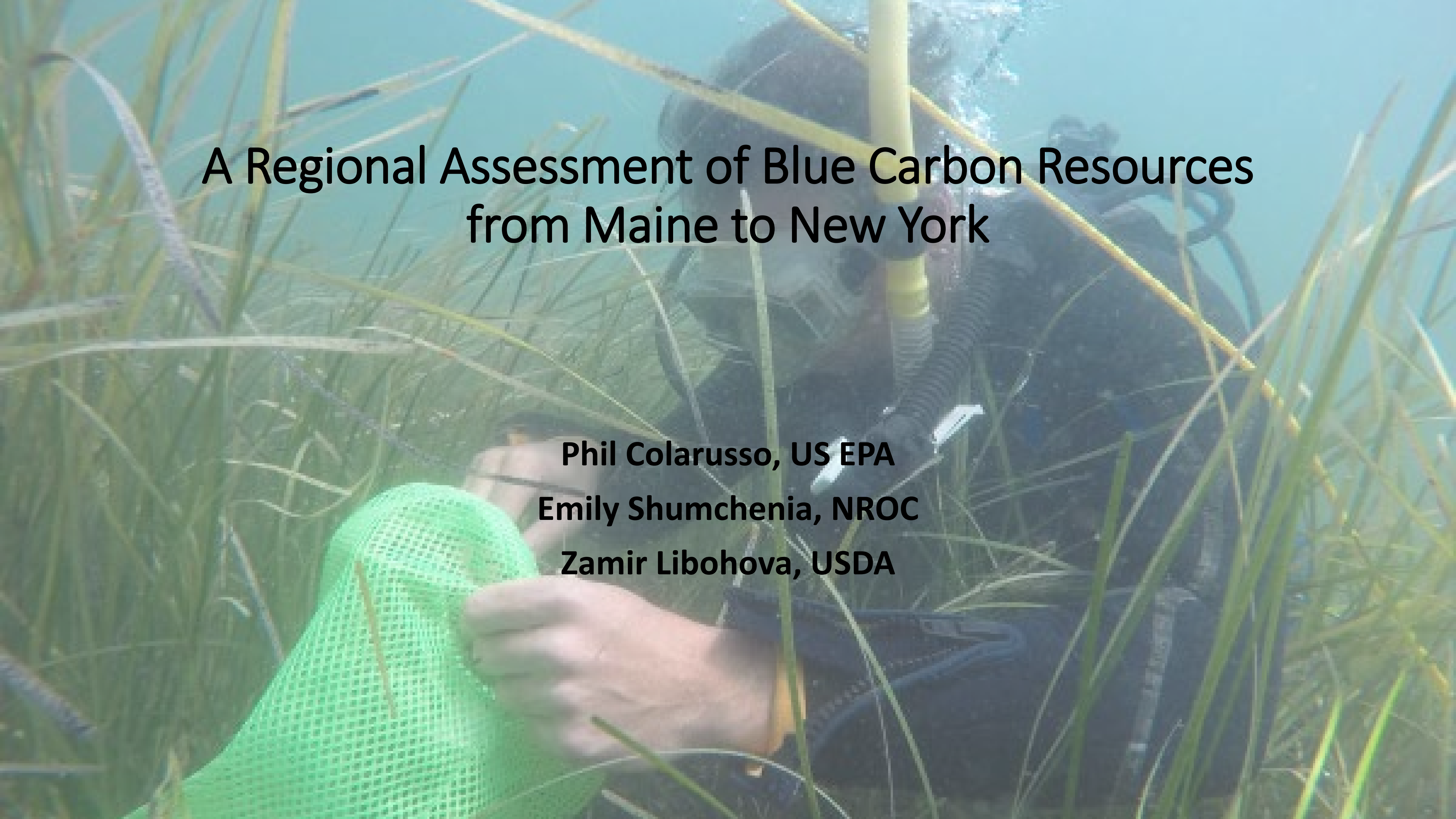


		100-year GWP			20-year GWP		
Greenhouse Gas (GhG)	Lifetime[a] (years)	AR4 (2007)	AR5 (2014)	AR6 (2021)	AR4 (2007)	AR5 (2014)	AR6 (2021)
CO_2	Multiple	1	1	1	1	1	1
CH_4 (non-fossil)	11.8 ± 1.8	25	28[b]-34[c]	27.2 ± 11[d]	21	84[b]-86[c]	80.8 ± 25.8[d]
N_2O	109 ± 10	298	265[b] -298[c]	273 ± 130[d]	310	264[b]-268[c]	273 ± 118[d]

[a]Compound lifetime values were reported in IPCC AR6.
[b]Non-inclusive of climate change feedback, as reported in AR5
[c]Inclusive of climate change feedback
[d]AR6 was the only report to include error ranges

Before We Begin:

- Please Mute your Microphones and Turn Off your Cameras
- This Webinar will be Recorded
- Please type questions in the chat box. They will be addressed towards the end of the discussion
- Automated Closed Captioning is Available through the Teams options (...) panel



A Regional Assessment of Blue Carbon Resources from Maine to New York

Phil Colarusso, US EPA

Emily Shumchenia, NROC

Zamir Libohova, USDA

Blue Carbon

- **Includes**
  - **Seagrass**
  - **Salt Marsh**
  - **Mangroves**

- **Does not yet include**
  - **Kelp**
  - **Macroalgae**
  - **Phytoplankton**
  - **Marine Mammal carcasses**

Convened a group of experts

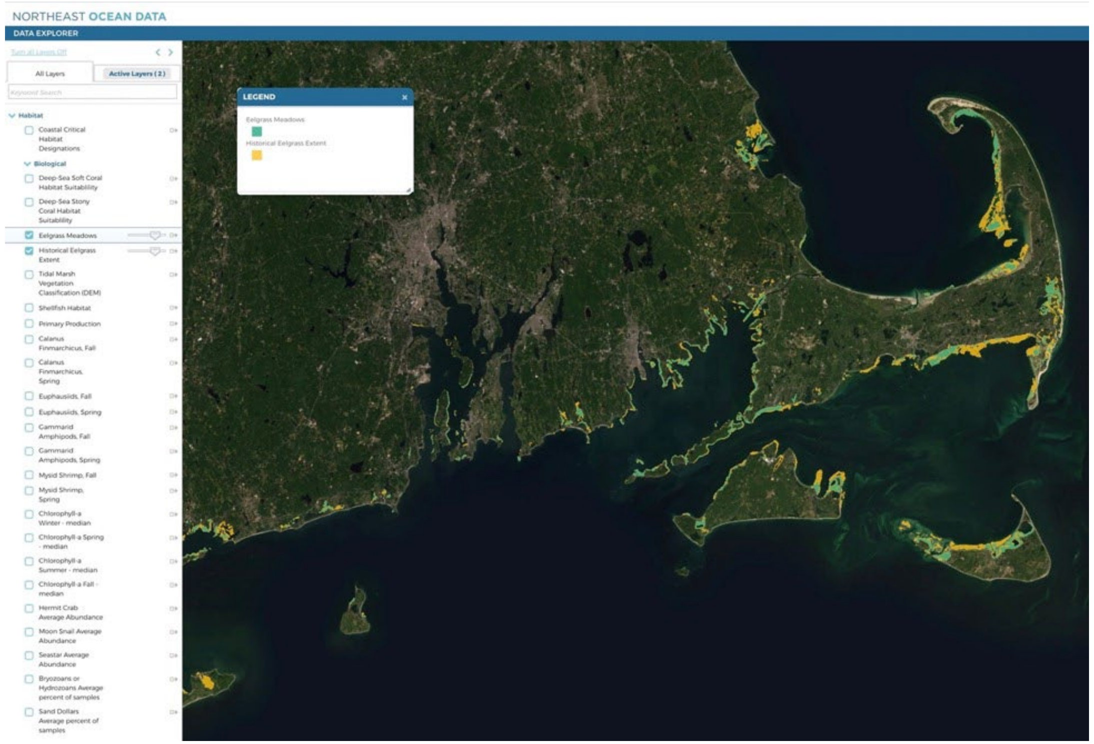
Angela Brewer
David Burdick
Gail Chmura
Megan Christian
Phil Colarusso
Steve Crooks
Meagan Eagle
Chris Elphick
Claire Enterline
Beverly Johnson

Kevin Kroeger
Beth Lawrence
Zamir Libohova
Kalle Matso
Trevor Mattera
Mike McHugh
Ivy Mlsna
Steve Monteith
Pam Morgan
Nick Napoli

Alyssa Novak
Maggie Payne
Kristen Puryear
Emily Shumchenia
Julie Simpson
Rob Tunstead
Megan Tyrrell
Rob Vincent
Brian Yellen

Blue Carbon Stock Assessment

Mapping Workgroup

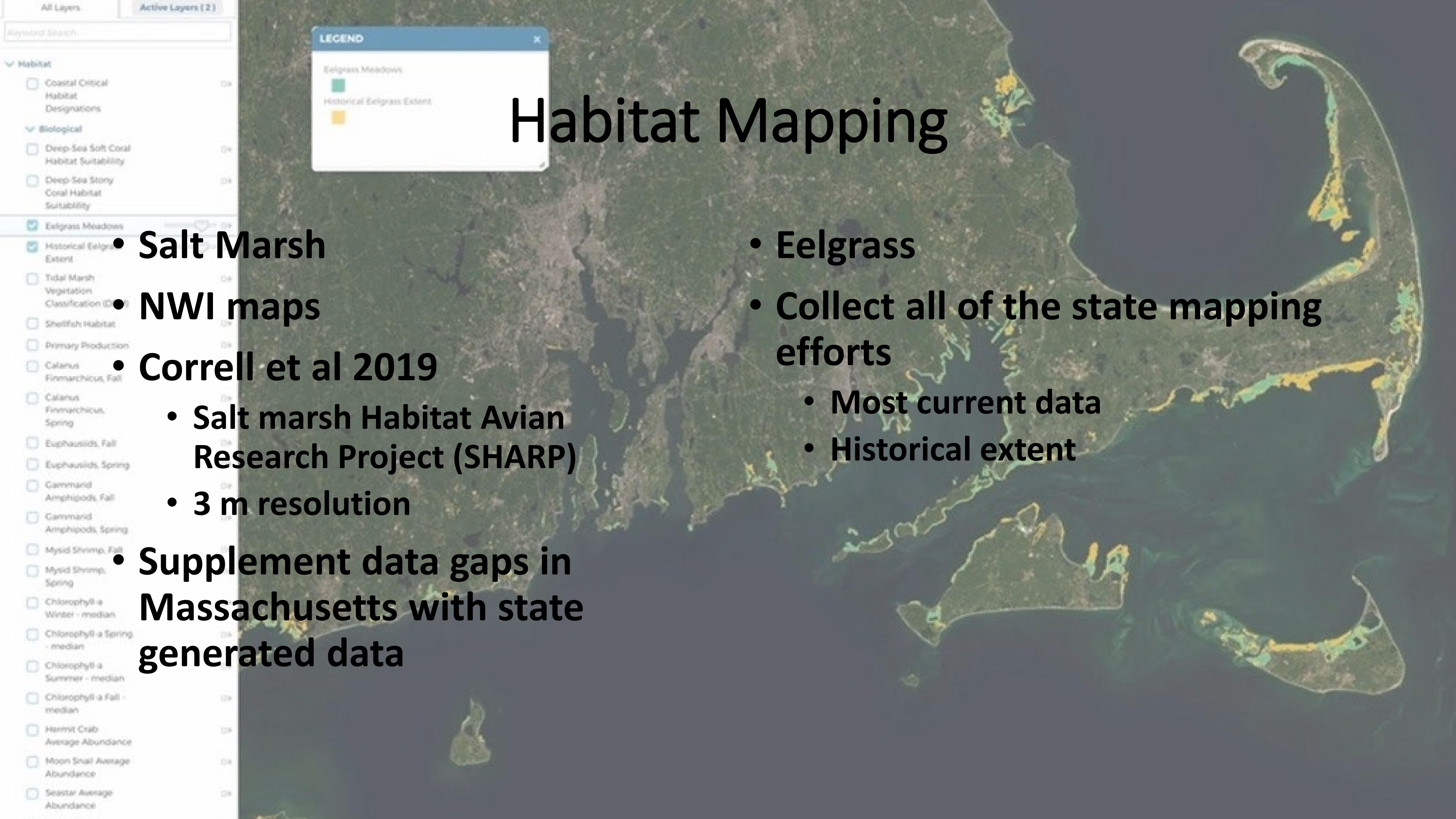


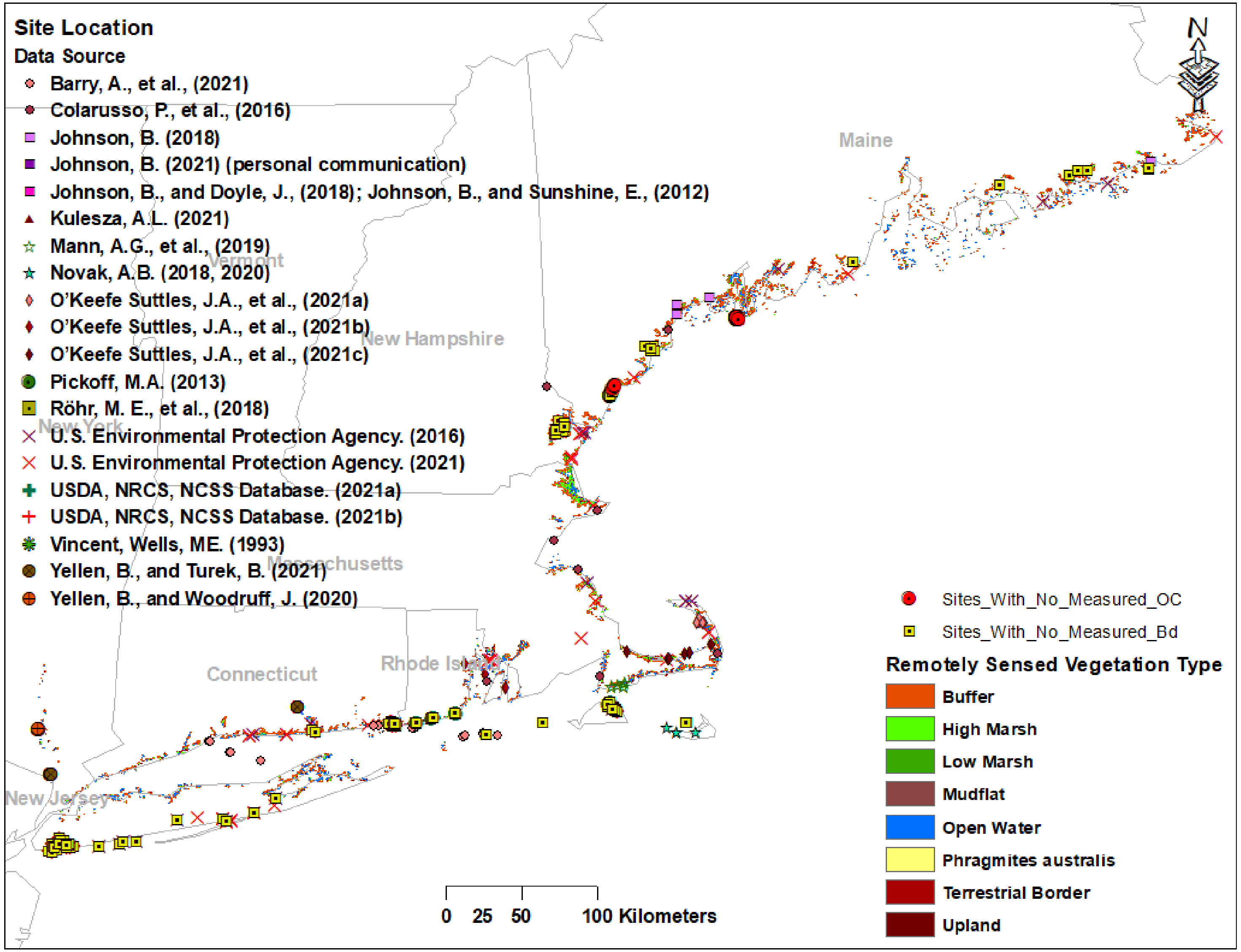
Sediment Carbon Workgroup

Habitat Mapping

- **Salt Marsh**
- **NWI maps**
- **Correll et al 2019**
  - **Salt marsh Habitat Avian Research Project (SHARP)**
  - **3 m resolution**
- **Supplement data gaps in Massachusetts with state generated data**

- **Eelgrass**
- **Collect all of the state mapping efforts**
  - **Most current data**
  - **Historical extent**





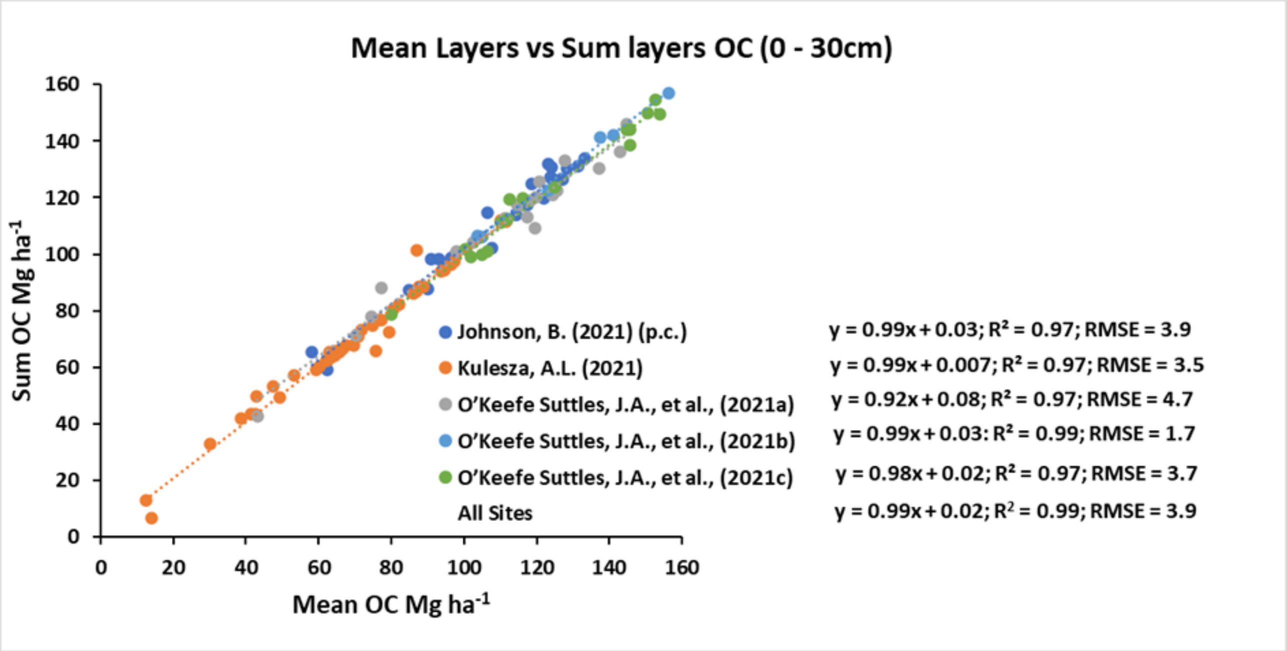
Soil Carbon Data

Merging the Soil Carbon Data

- **Verify core location and vegetation type**
- **Core lengths**
  - **Most were 30 cm**
- **Subsampling**
  - **No standard approach**
- **Different analytical methods**
  - **LOI vs Elemental analyzer**
- **Missing data**
  - **Develop correlation by habitat between carbon content and dry bulk density**

Merging the Soil Carbon Data

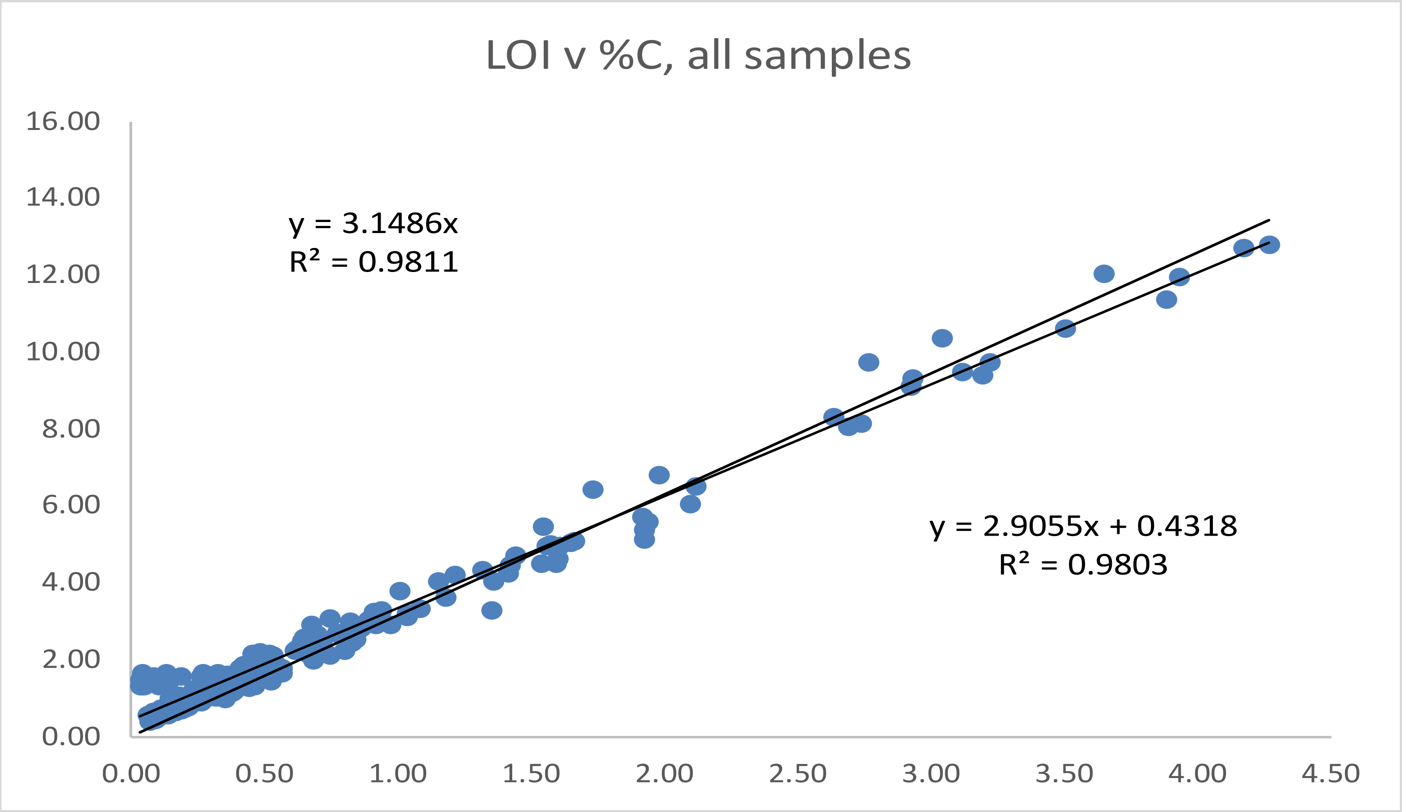
- **Core lengths**
  - **Most were 30 cm**
- **Subsampling**
  - **Average over the 30 cm vs adding average of each segment**



- **Both methods of calculation correlated well with each other.**
- **Average over 30 cm was selected.**

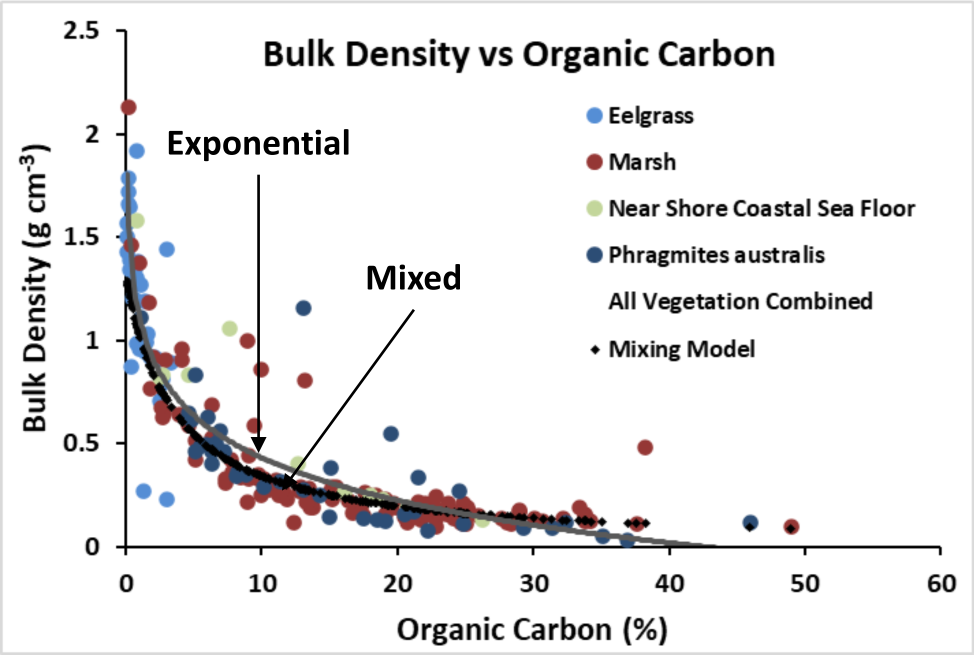
Merging the Soil Carbon Data

- LOI vs Elemental analyzer

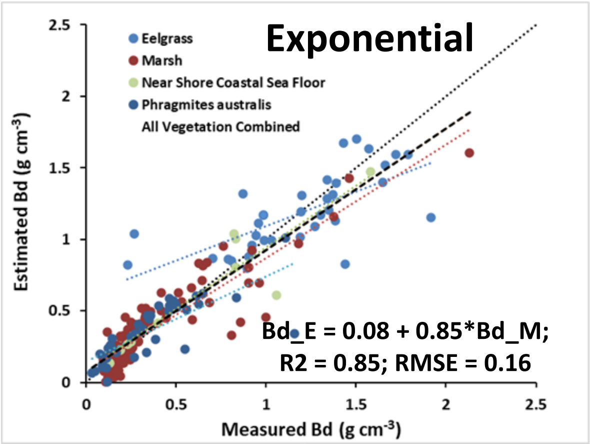


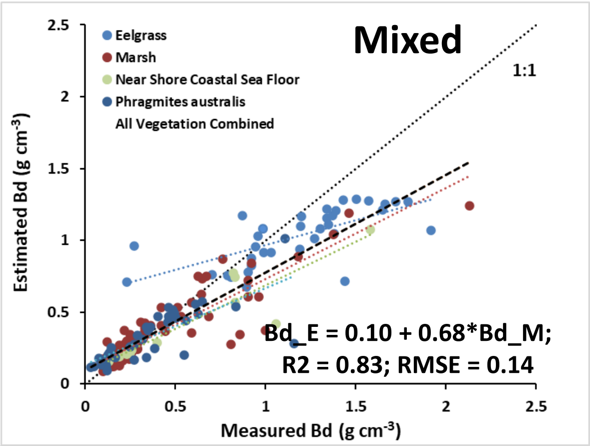
Merging the Soil Carbon Data

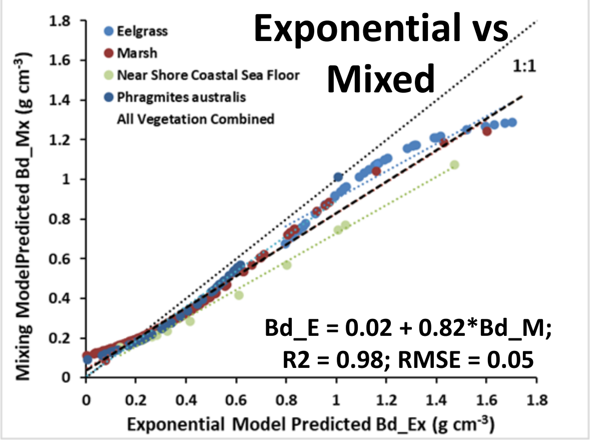
- **Missing data**
  - **Develop correlation by habitat between carbon content and dry bulk density**



Tested two models – Exponential and Mixed







Both models were similar. However, the mixed model had negative bias (underpredicting Bd)

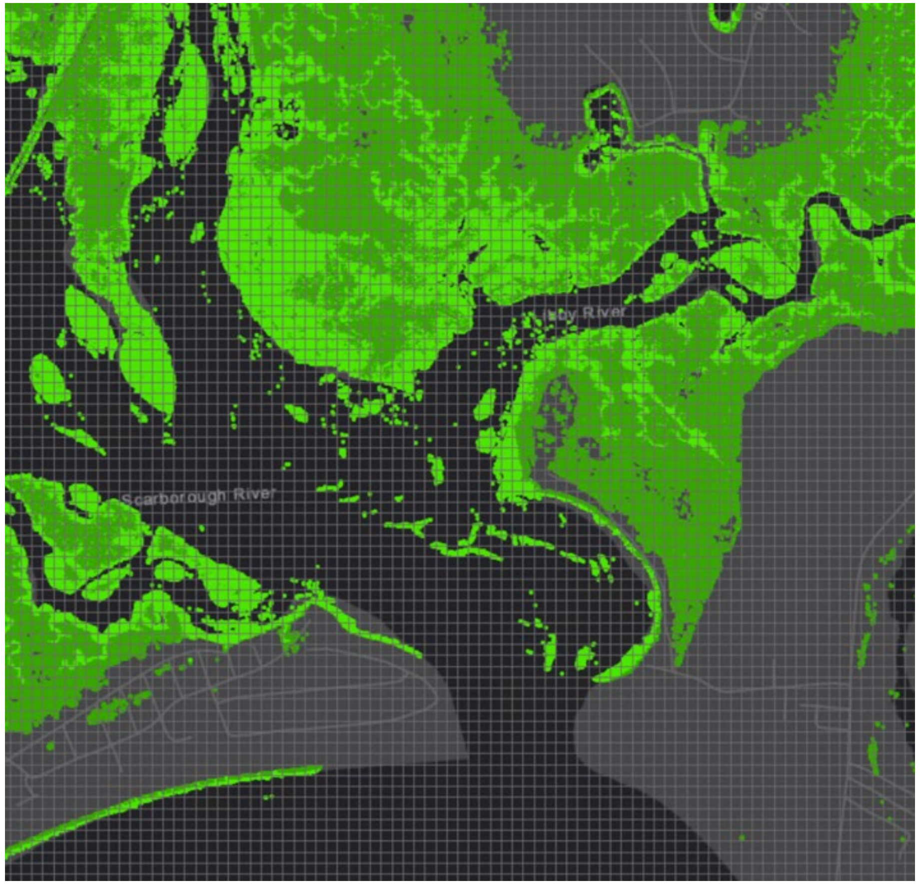
Assigning Carbon Density Values

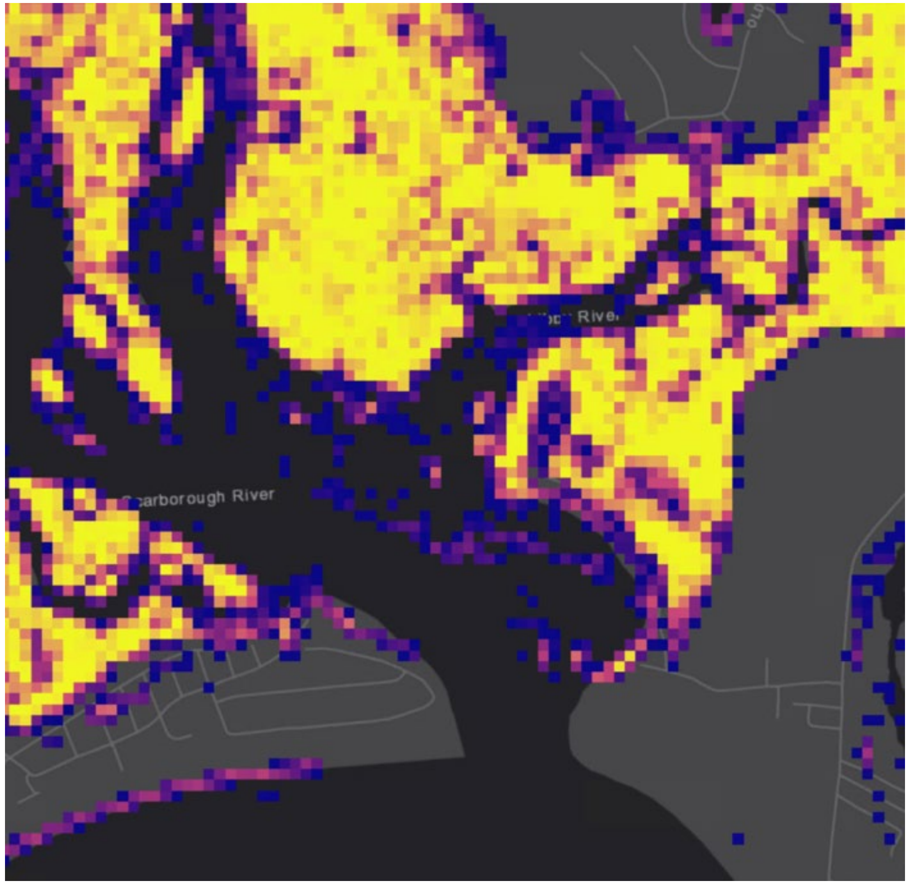
- **Vegetation classes (high vs low marsh)**
- **Latitude**
- **Exposure**

- **Eelgrass**
  - **0.0115 g/cm3**
  - **3.46 kg/m2**
- **Salt Marsh**
  - **0.0345 g/cm3**
  - **10.38 kg/m2**
- **Phragmites**
  - **0.0364 g/cm3**
  - **10.94 kg/m2**

Developing blue carbon "heat maps"

Overlay a 30-meter grid and sum the carbon density values for all points within each grid cell

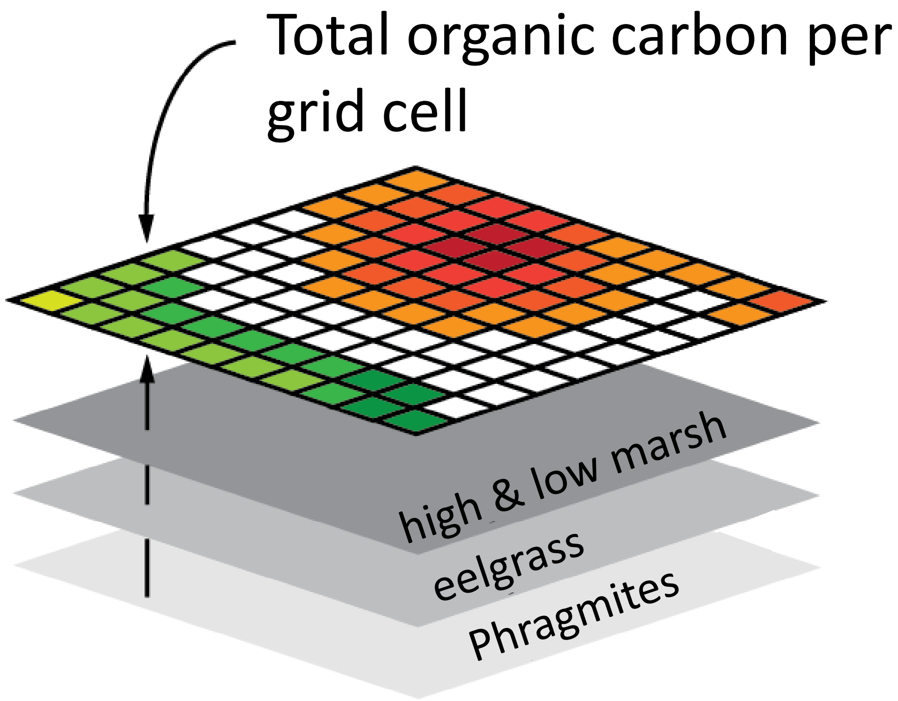




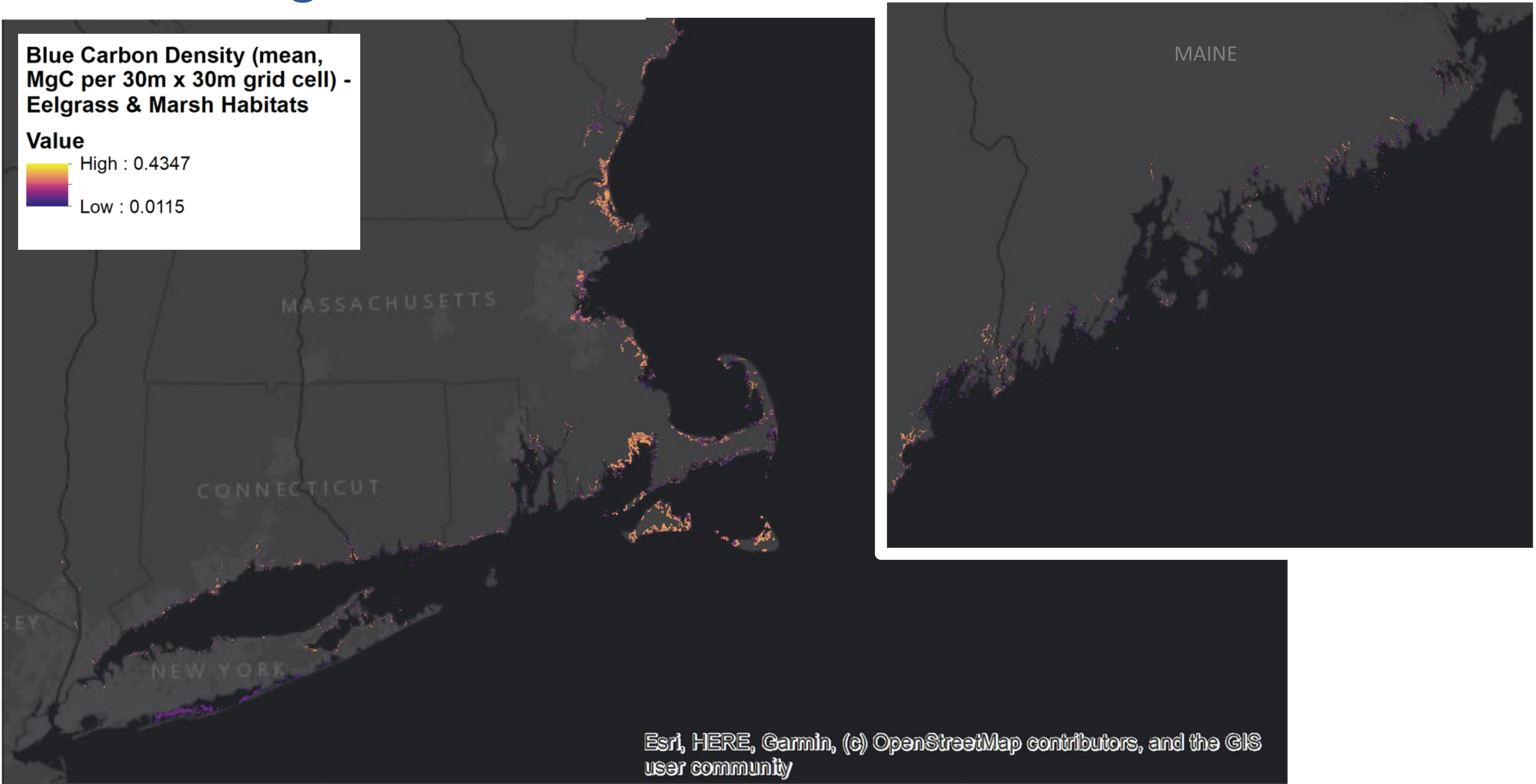
Developing blue carbon "heat maps"

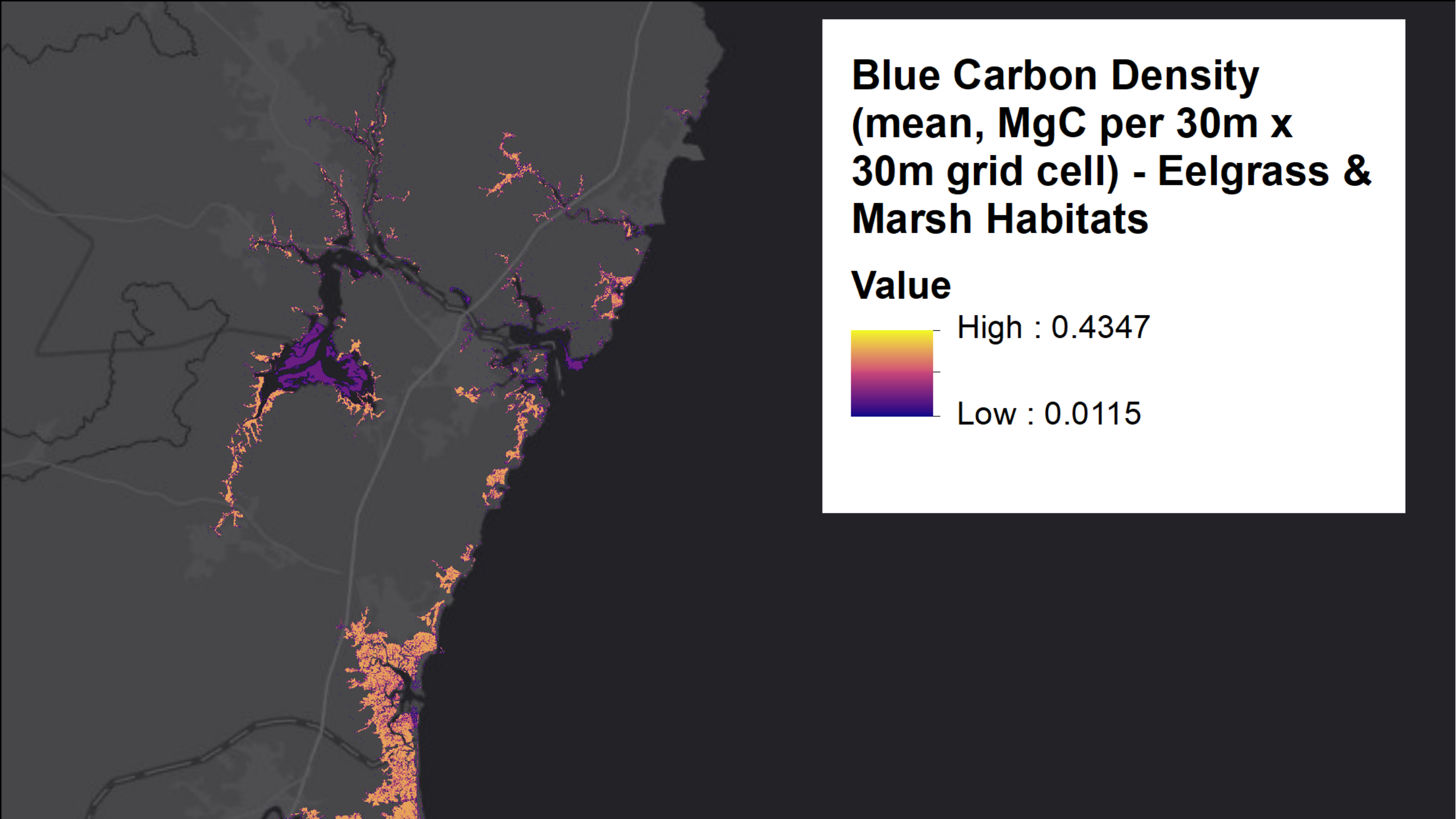
Repeat with each habitat layer (eelgrass, high & low marsh, Phragmites)

Stack and sum the values of each grid cell



Coastal vegetation blue carbon initiative




Blue Carbon Density (mean, MgC per 30m x 30m grid cell) - Eelgrass & Marsh Habitats
Value
High : 0.4347
Low : 0.0115

Coastal vegetation blue carbon initiative

HABITAT AREA (ACRES)

	Eelgrass	High/Low Marsh	Phragmites	Total
ME	21,666	31,779	547	53,992
NH	1,436	6,762	219	8,418
MA	19,115	64,975	28, 363	112,453
RI	1,038	4,043	259	5,340
CT	1,101	7,546	583	9,230
NY	19,642	8,072	1,075	28,789
TOTAL	63,998	123,177	31,047	218,222

Coastal vegetation blue carbon initiative

CARBON STOCKS (MgC)

	Eelgrass	High/Low Marsh	Phragmites	Total
ME	303,210	1,339,020	21,882	1,664,112
NH	20,097	280,260	10,941	311,298
MA	267,500	2,636,520	1,258,215	4,162,235
RI	14,525	166,080	11,000	191,546
CT	15,412	321,780	22,000	359,074
NY	274,881	343,540	43,764	661,185
TOTAL	896,625	5,086	1,368,625	7,349,450

How much carbon is 7,349,450 Mg?

- 18+ billion miles driven by an average car
- 1,430,016 homes’ energy use for 1 year
- 894 billion cell phones fully charged
- 2000 wind turbines running for a year
- 8.6 million acres of forest for a year
- 8 billion pounds of coal

Coastal vegetation blue carbon initiative

Potential next steps

- Retrospective blue carbon mapping with historical habitat data
- Expand the collection of coastal vegetation into additional habitats such as kelp and other attached macroalgae
- Characterize biodiversity value of coastal vegetation blue carbon hotspots

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Blue carbon data products will be announced here:

NORTHEAST OCEAN

www.northeastoceandata.org/news

Multiple stressor impacts on microbial community structure and biogeochemical cycling in tidal freshwater wetlands

Brian R. Donnelly
Northeastern University
July 14, 2022

Ecosystem Services

Under natural conditions, tidal freshwater wetlands:

- habitat for flora and fauna
- storm surge protection
- wave attenuation

Photo: Jeffrey Kontur

Ecosystem Services

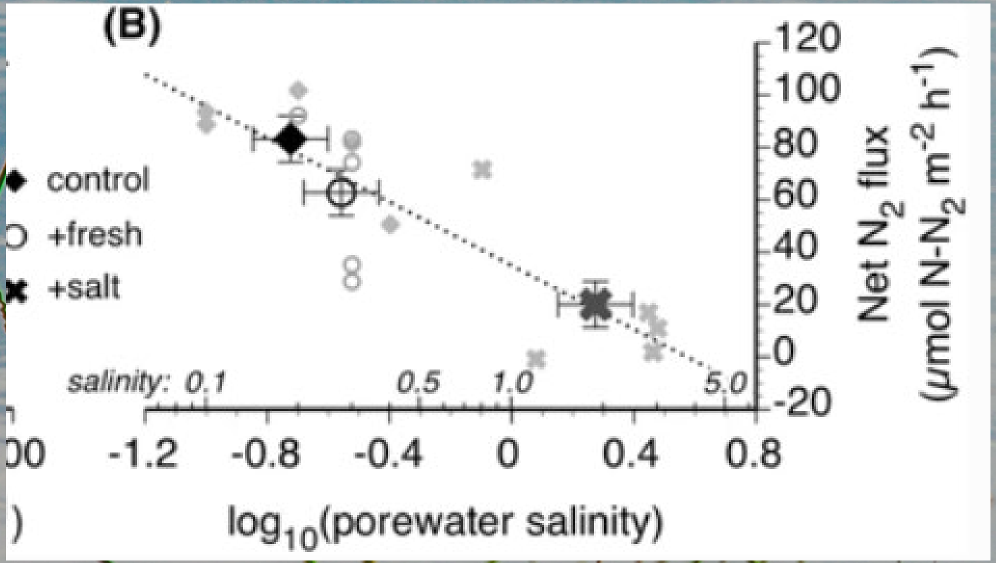
Under natural conditions, tidal freshwater wetlands:

- store carbon for long periods of time
- remove and recycle nutrients before they reach the coast

Photo: Jeffrey Kontur

Sea-level rise and climate variability are threatening these services.

- Saltwater intrusion causes shifts in biogeochemical cycling and microbial community structure by altering electron acceptor availability (Neubauer et al. 2019)
- Metabolic processes stimulated by increased sea surface temperatures (Kirschbomb 1995)
- Dominant nutrient removal processes are potentially hampered by salt addition

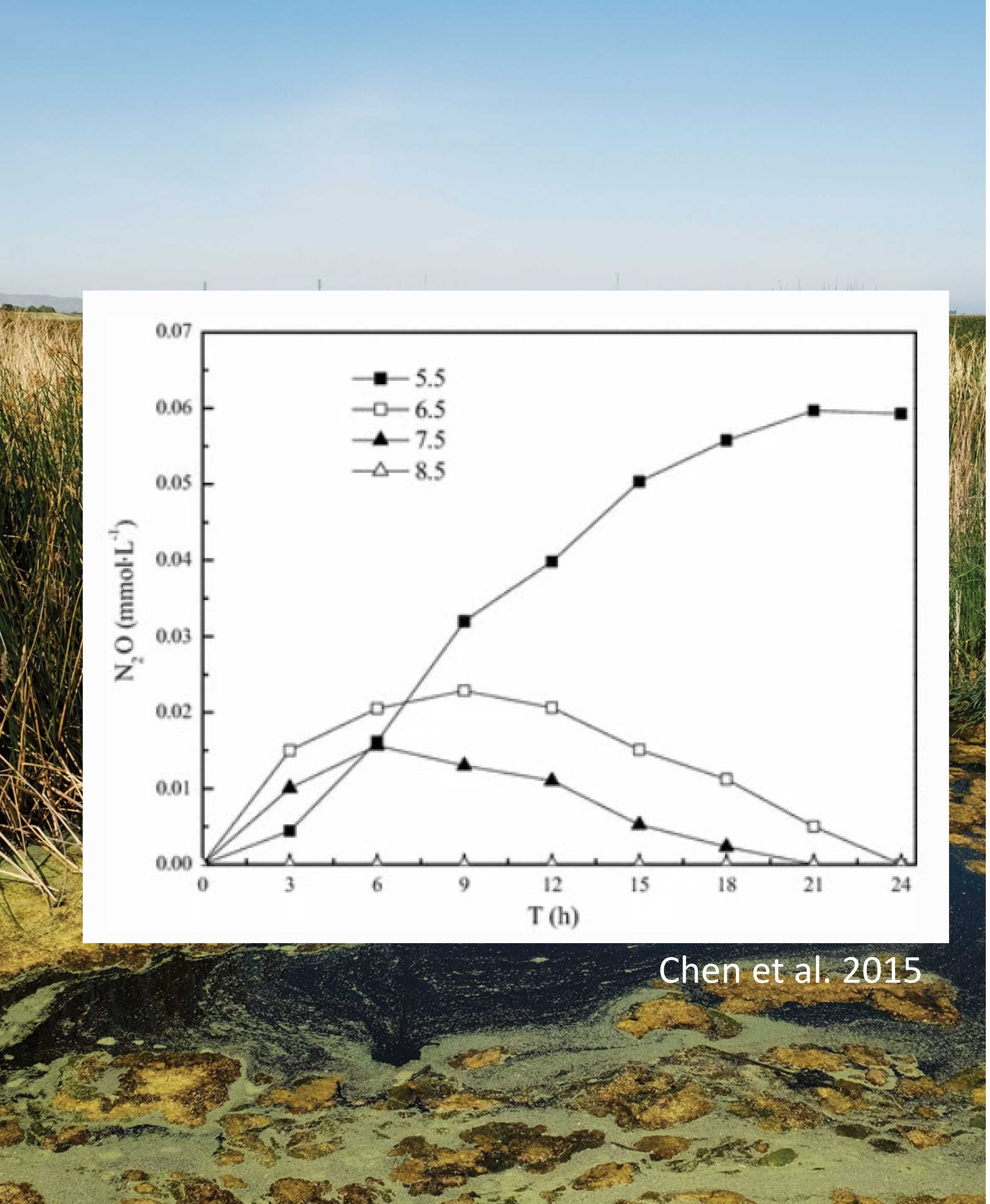


Neubauer et al. 2019

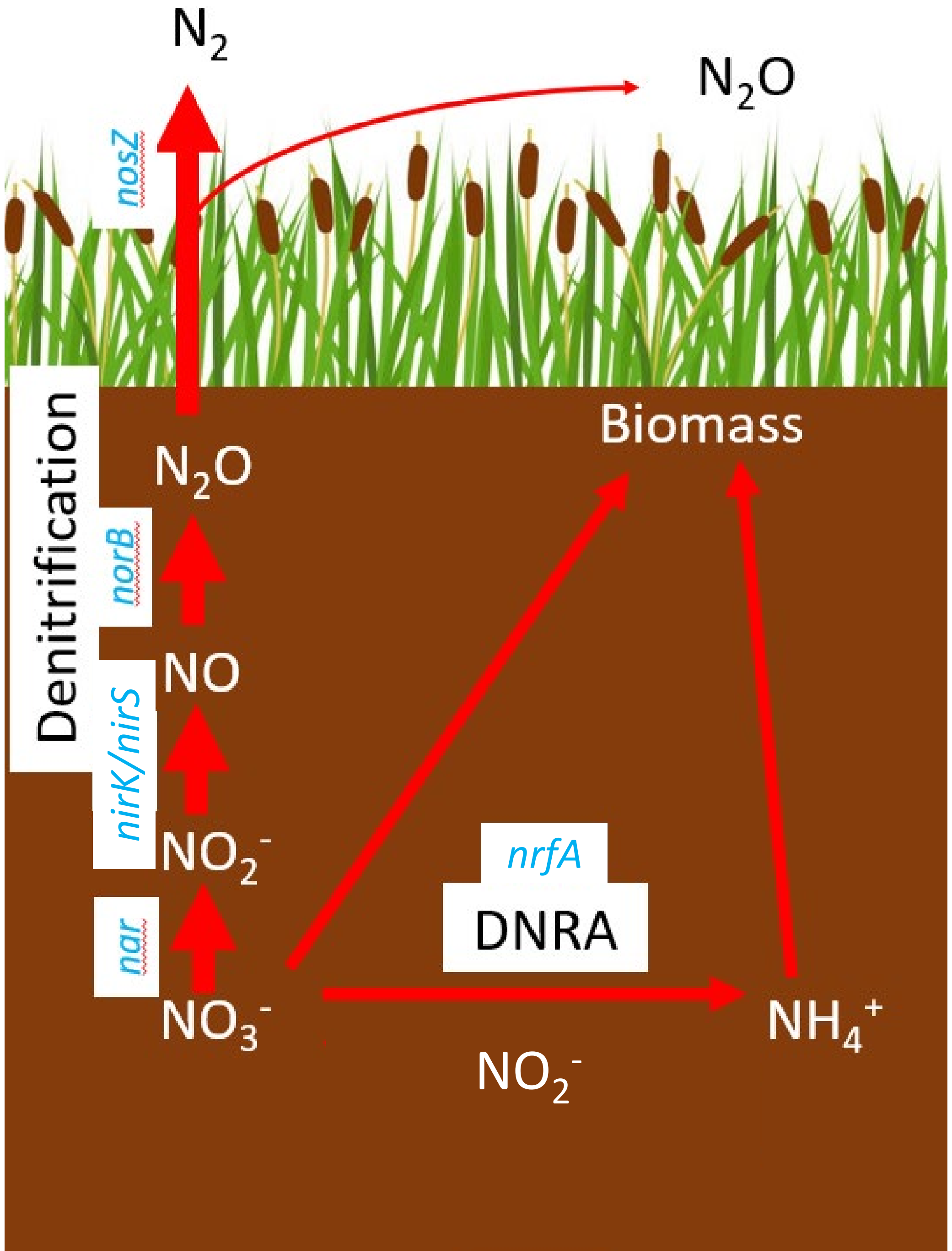
MULTIPLE STRESSOR

SEA-LEVEL RISE

SALINITY AND TEMPERATURE



0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
N_2O (mmol·L^{-1})
5.5
6.5
7.5
8.5
0
3
6
9
12
15
18
21
24
T (h)
Chen et al. 2015



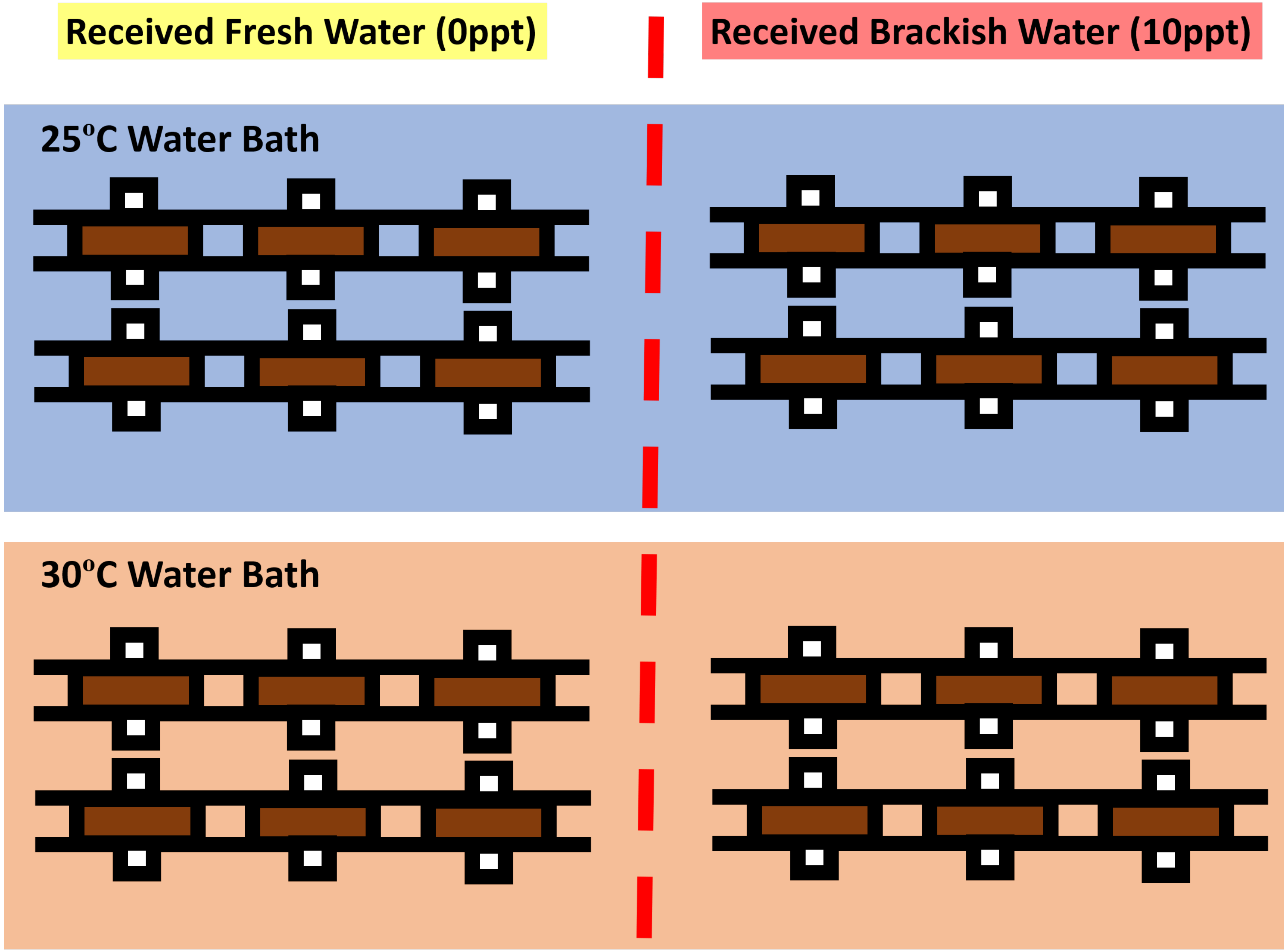
N_2
N_2O
nosZ
Denitrification
N_2O
norB
NO
nirK/nirS
NO_2^-
nar
NO_3^-
Biomass
nrfA
DNRA
NH_4^+
NO_2^-

OBJECTIVES

Photo: flyingarchitechture.com

Investigate shifts in the partitioning of dominant nitrate-reducing pathways to determine future nitrous oxide source potential of tidal freshwater wetlands.

STUDY SITE

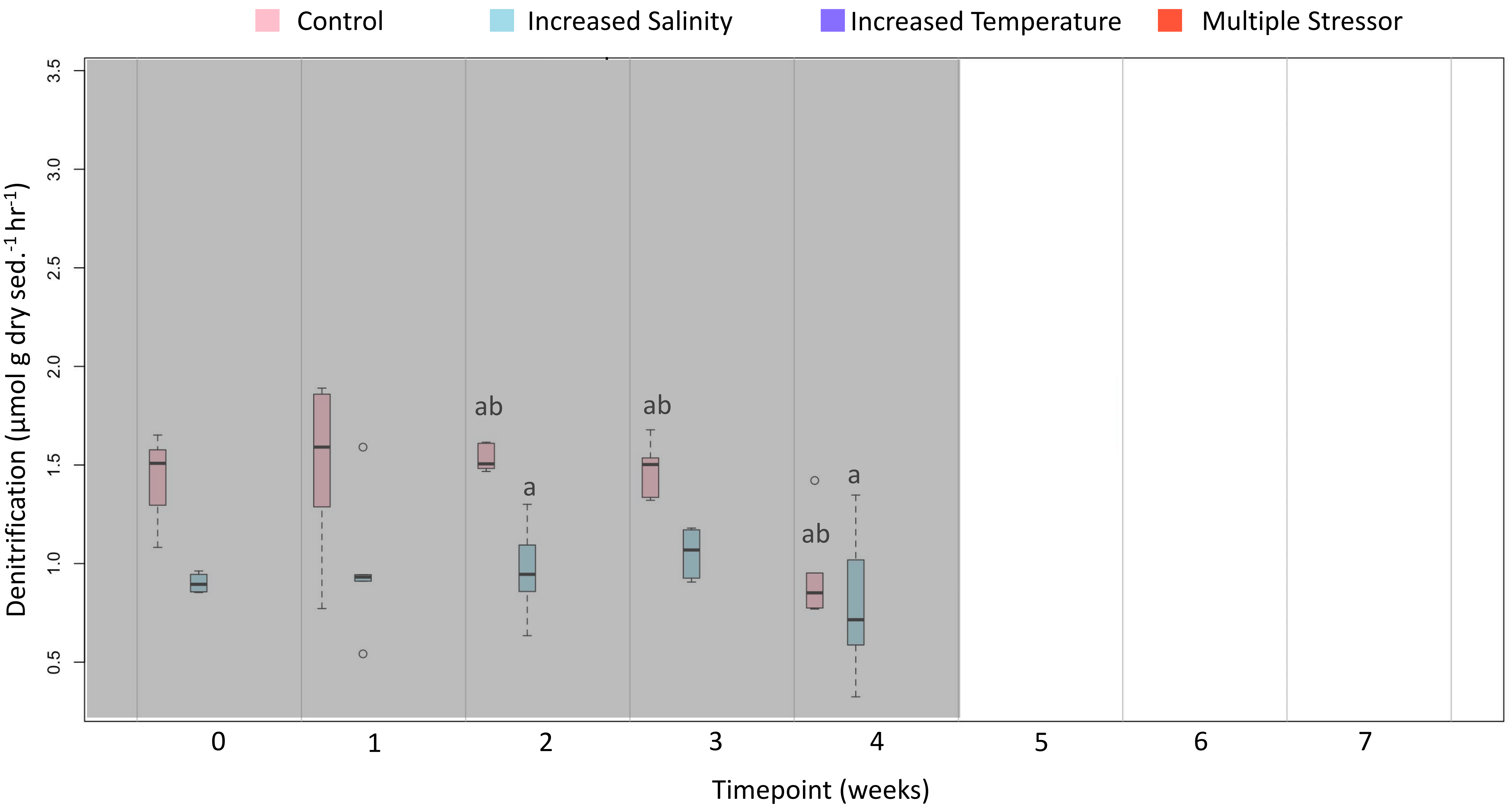


- Sediment cores brought back to the lab and packed into FTRs under anaerobic conditions
- FTRs placed in water baths of either 25ºC or 30ºC
- Each reactor given either fresh (0 ppt) or brackish (10 ppt), filter sterilized, anaerobic, site water, flowing at 0.08 ml min^{-1}
- Bromide as a conservative tracer to ensure uniform flow
- Spiked reservoirs to 500 μM ^{15}N-$NaNO_3^-$

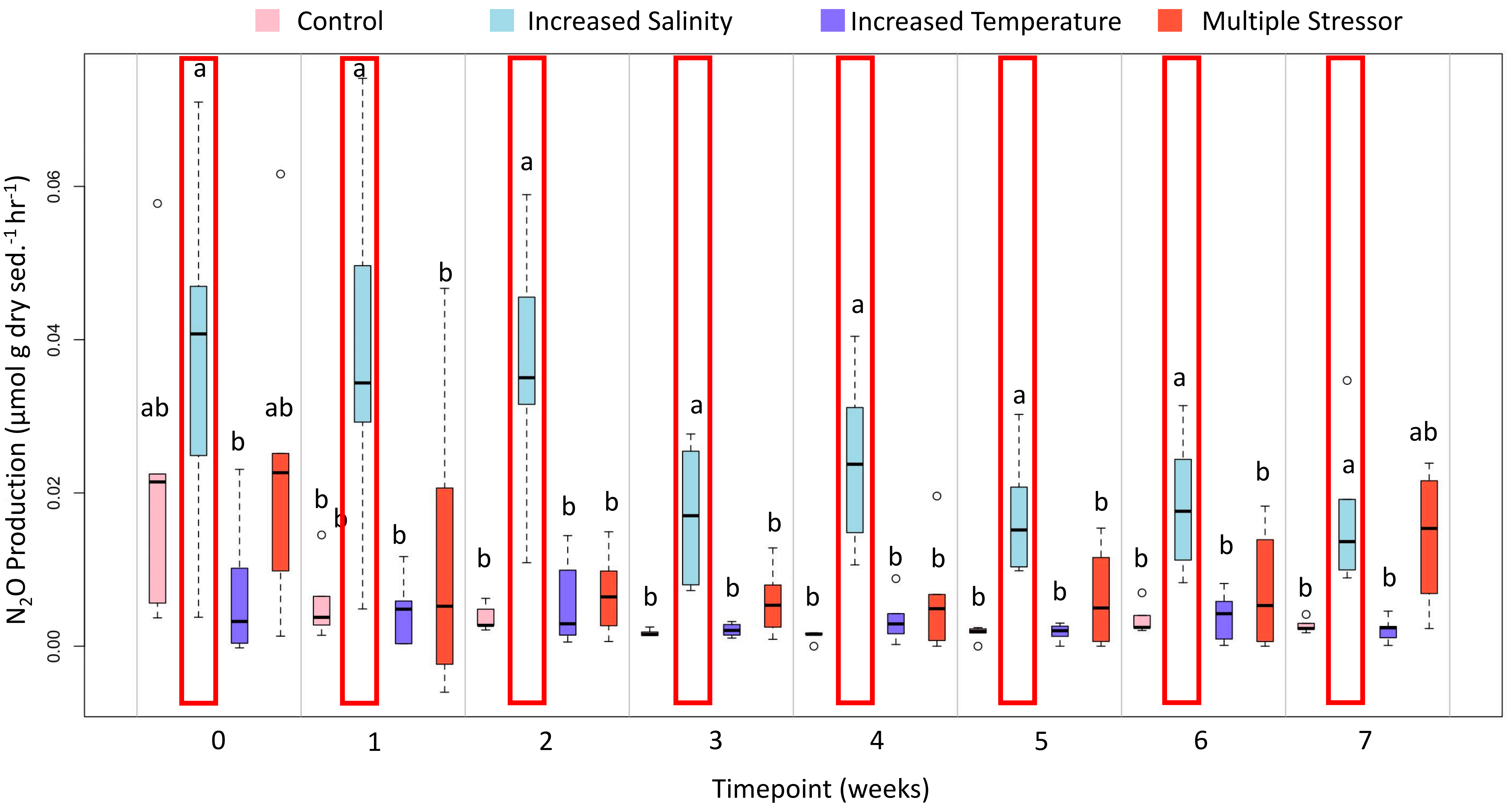
Biogeochemical Sample Collection And Rate Establishment

Established rates of the following at 8 timepoints across 45 days:

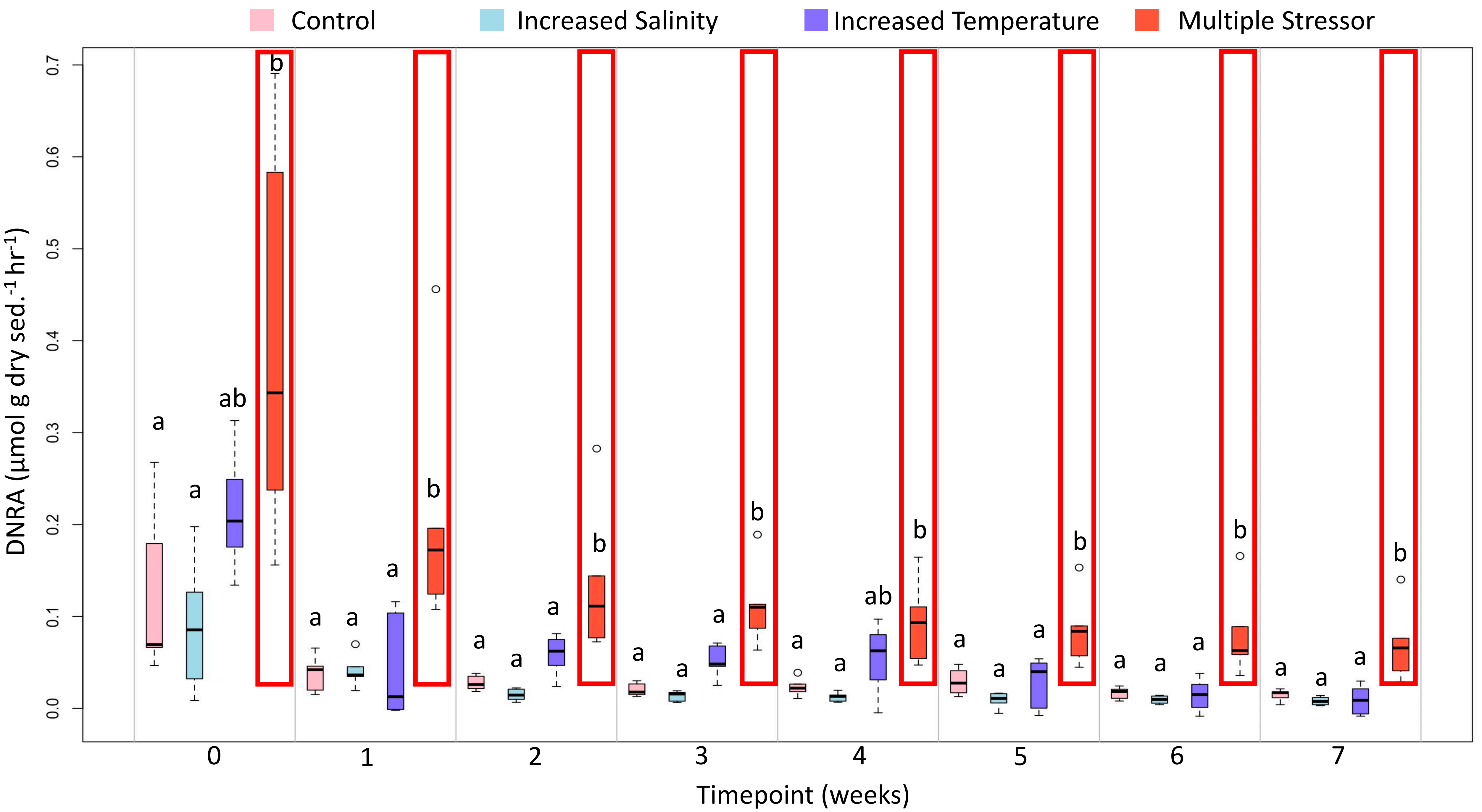
- Denitrification (DNF)
- N_2O Production (Incomplete DNF)
- Dissimilatory Nitrate Reduction to Ammonium (DNRA)
- Rates will be determined by:
  (Outflow-Inflow)/(residence time)



Control
Increased Salinity
Increased Temperature
Multiple Stressor
Denitrification (µmol g dry sed.$^{-1}$ hr^{-1})
3.5
3.0
2.5
2.0
1.5
1.0
0.5
ab
ab
a
a
ab
0
1
2
3
4
5
6
7
Timepoint (weeks)



Control
Increased Salinity
Increased Temperature
Multiple Stressor
N2O Production (µmol g dry sed.-1 hr-1)
0.00
0.02
0.04
0.06
Timepoint (weeks)
0
1
2
3
4
5
6
7



Control
Increased Salinity
Increased Temperature
Multiple Stressor
DNRA (µmol g dry sed.$^{-1}$ hr^{-1})
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
a
a
ab
b
a
a
a
b
a
a
a
b
a
a
a
b
a
a
ab
b
a
a
a
b
a
a
a
b
a
a
a
b
0
1
2
3
4
5
6
7
Timepoint (weeks)

Conclusions

Salinity was the main driver in potentially inhibiting DNF, but timepoint was an interacting factor as treatment means became similar over time

Salinity drove up nitrous oxide production, but not necessarily while in the presence of increased temperature

The multiple stressor treatment increased rates of DNRA, potentially because of the presence of sulfide

Next Steps

- Evaluate how these changes in N-cycling affect decomposition rates
- Investigate shifts in the overall and active microbial communities
- Functional gene sequencing to understand changes in nitrous-oxide-reducing microbial community
- Investigate the timepoint effect deeper by looking at how pulses and presses of these multiple stressors change microbial communities and biogeochemical cycling

Acknowledgements

- Stephanie Tsui
- Catherine Hexter
- Annie Murphy
- Phoebe Lettington
- North River Commission
- Hanover Conservation Commission
- National Science Foundation

United States Department of Agriculture

Climate Smart Agriculture in MA and RI

Elizabeth Marks, Biologist

USDA Natural Resources Conservation Service

July 2022

Climate Smart Agriculture and Forestry

UN Food and Agriculture Organization Definition:

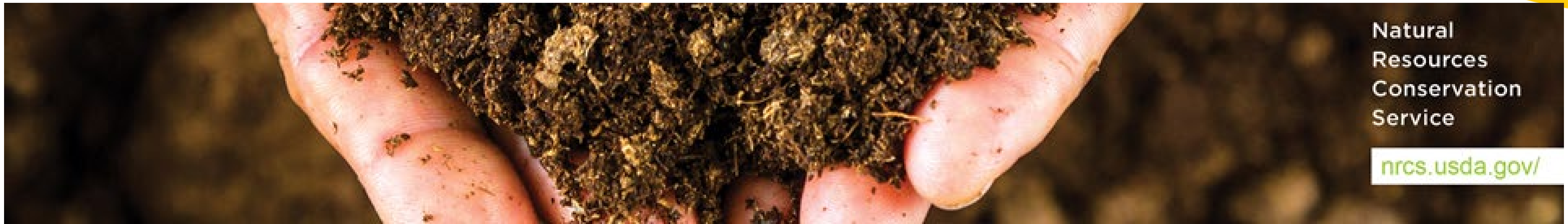
Agriculture that sustainably increases productivity, resilience (adaptation), reduces/removes GHGs (mitigation), and enhances achievement of national food security and development goals.

Other terms:

- Climate Smart Farming
- Natural Climate Solutions
- Engineering with Nature
- Weather/Drought Resiliency
- Soil Health

NRCS has been helping producers be resilient to weather since Hugh Hammond Bennett and the dust bowl.

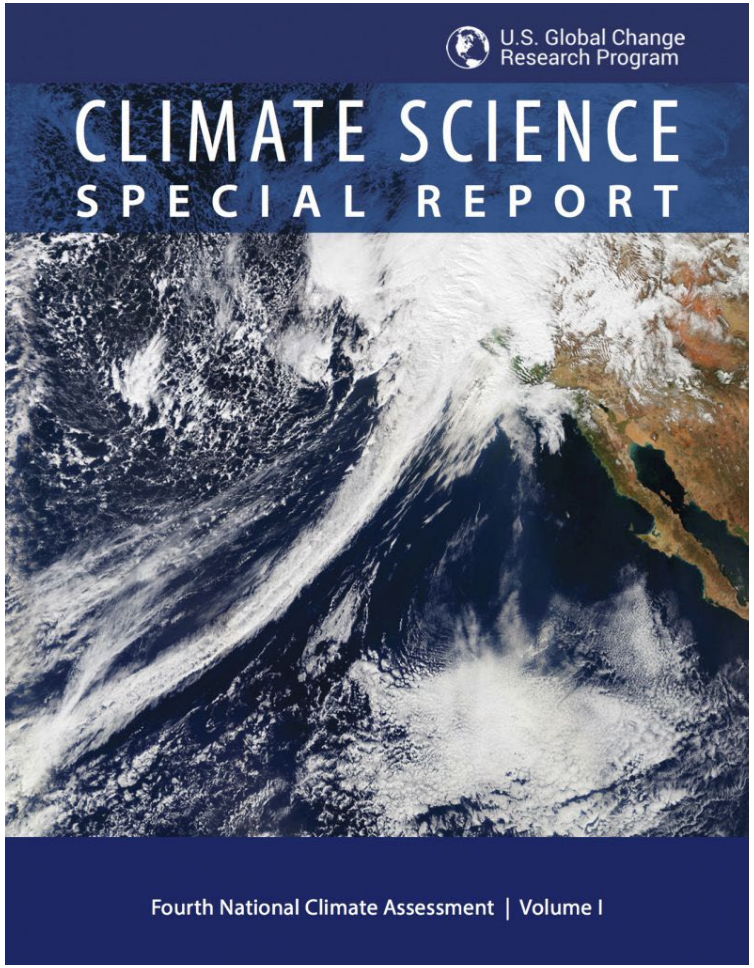
Climate Change Over the Last Century



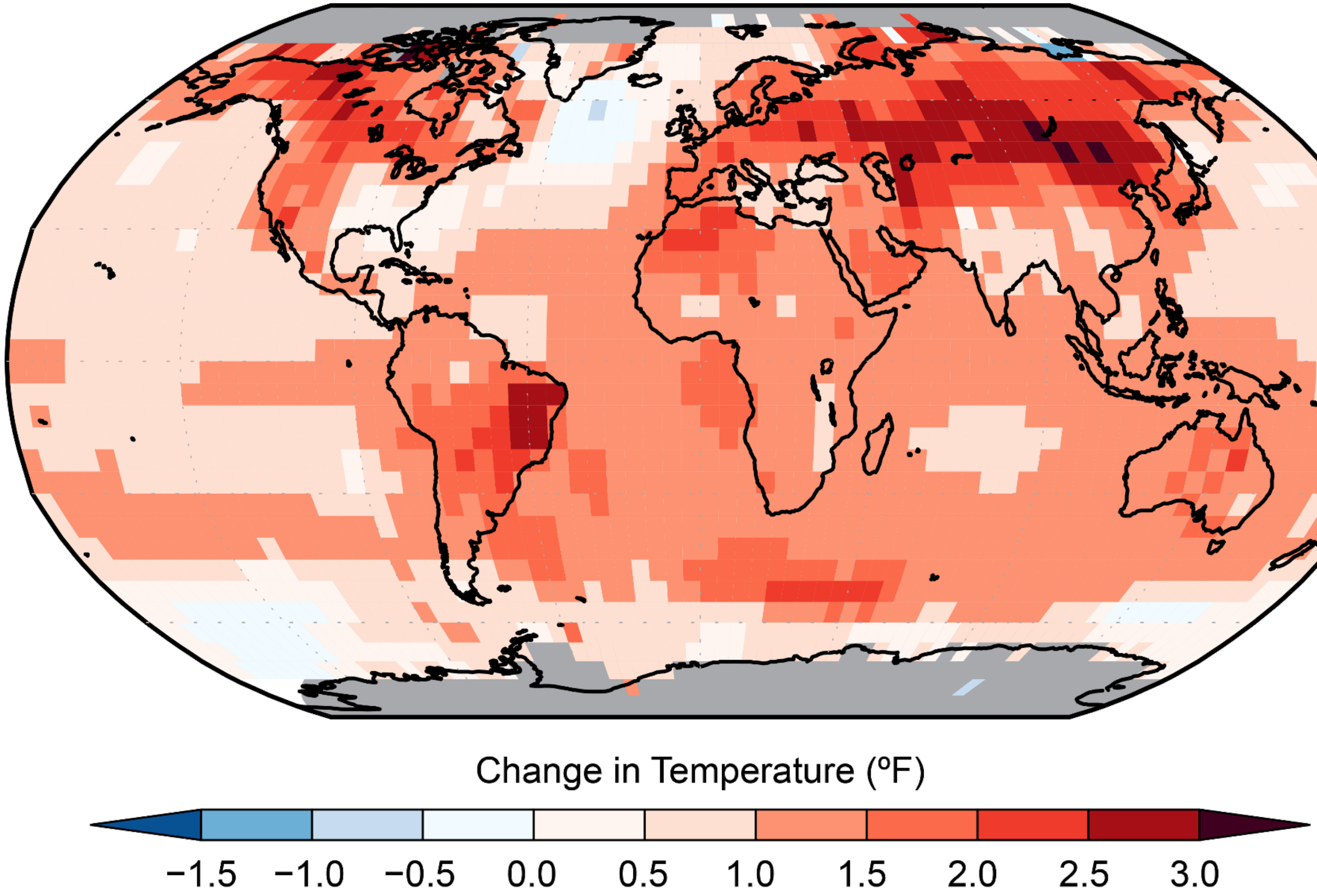
Fourth National Climate Assessment 2018

- 1,500 page congressionally mandated report done every four years by the US Global Change Research Program (federally funded).

- Lead agency: National Oceanic and Atmospheric Association, many other partner contributors including USDA

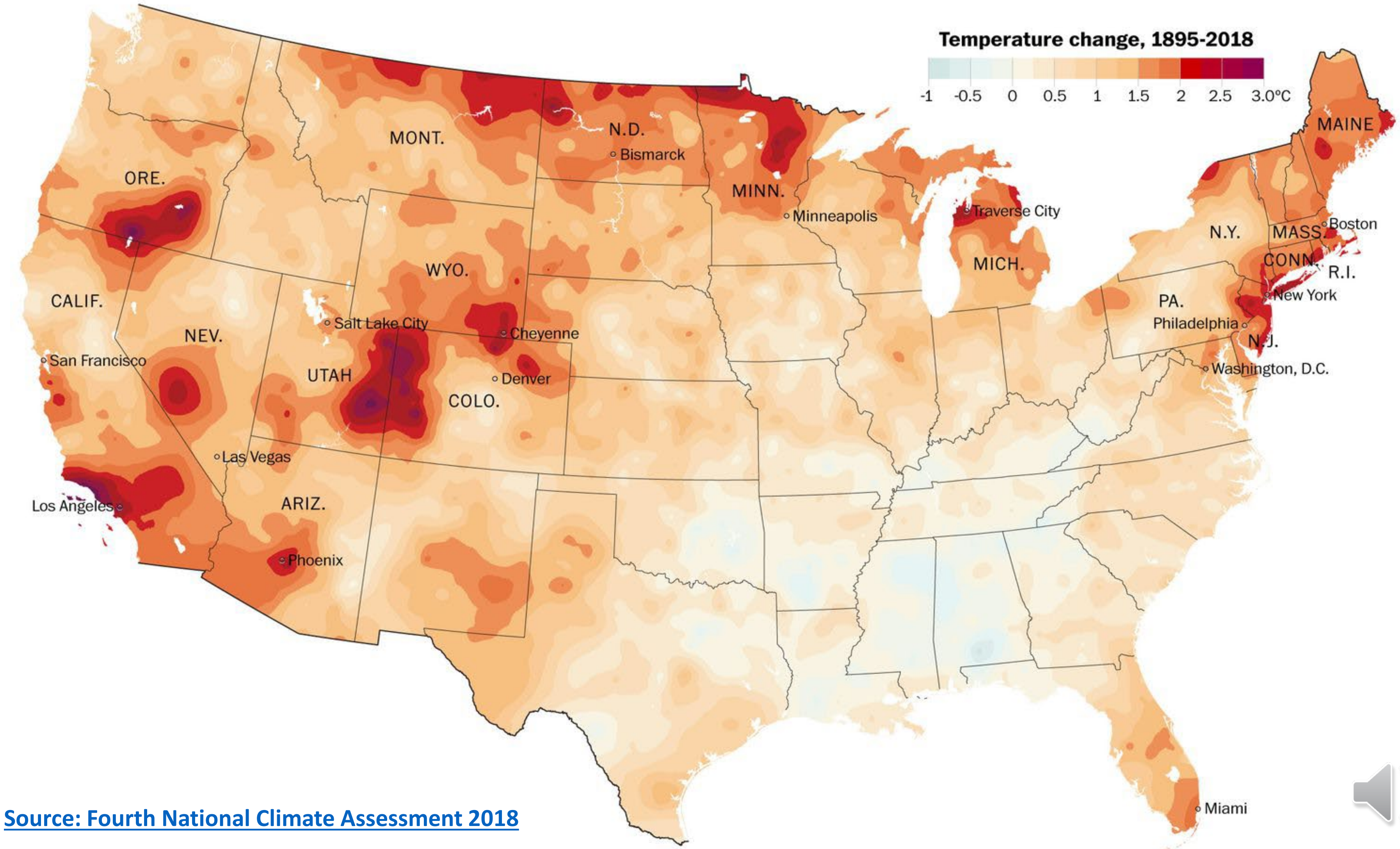


Observed: Average Global Rise in Temperature: 2.1° F (1° C) since 1880



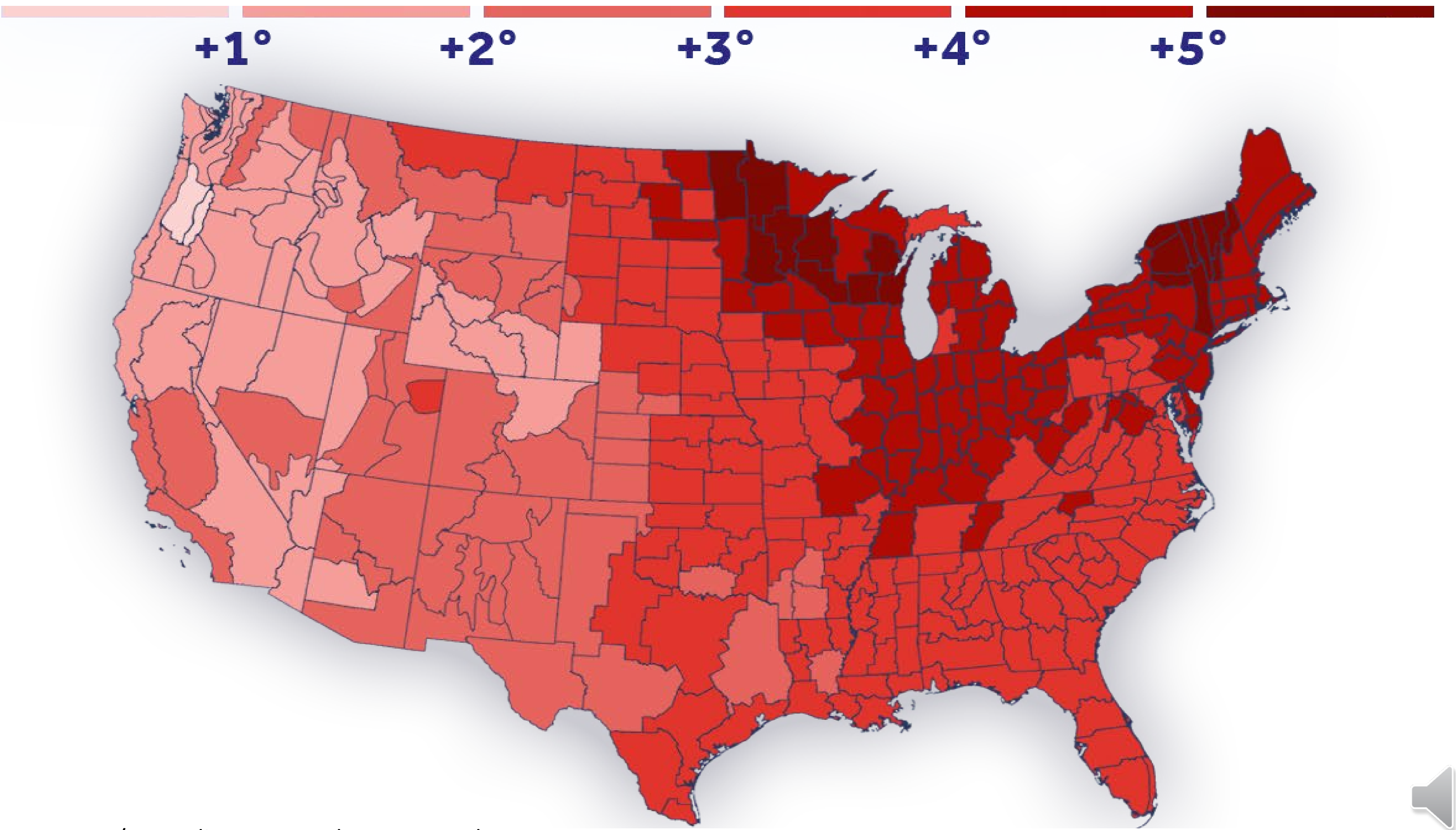
Source: Fourth National Climate Assessment 2018

Observed: U.S. Change in Temperature Since 1895



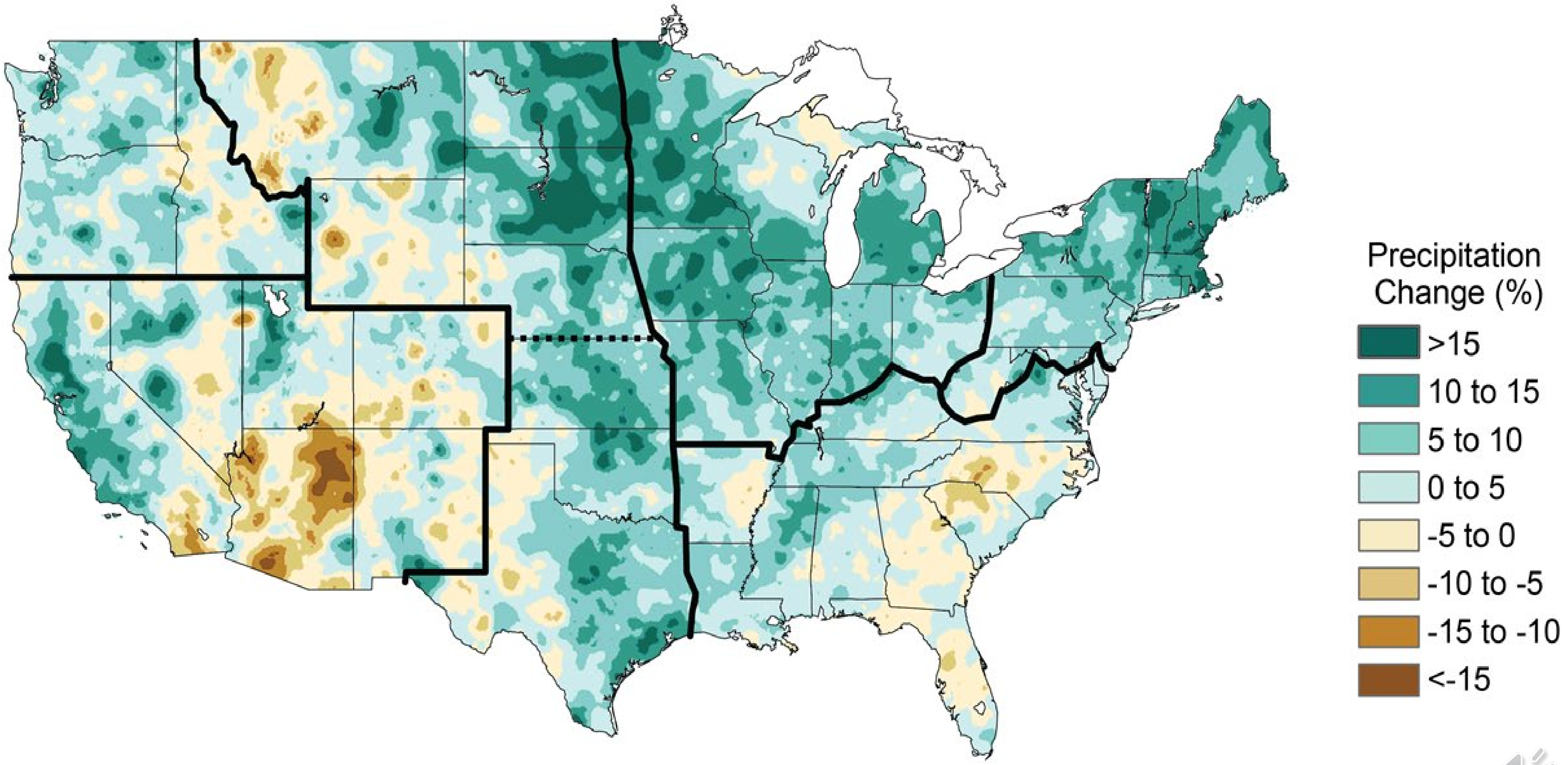
[Source: Fourth National Climate Assessment 2018]

Not All Seasons Are Warming at the Same Rate: Winter Warming Since 1970



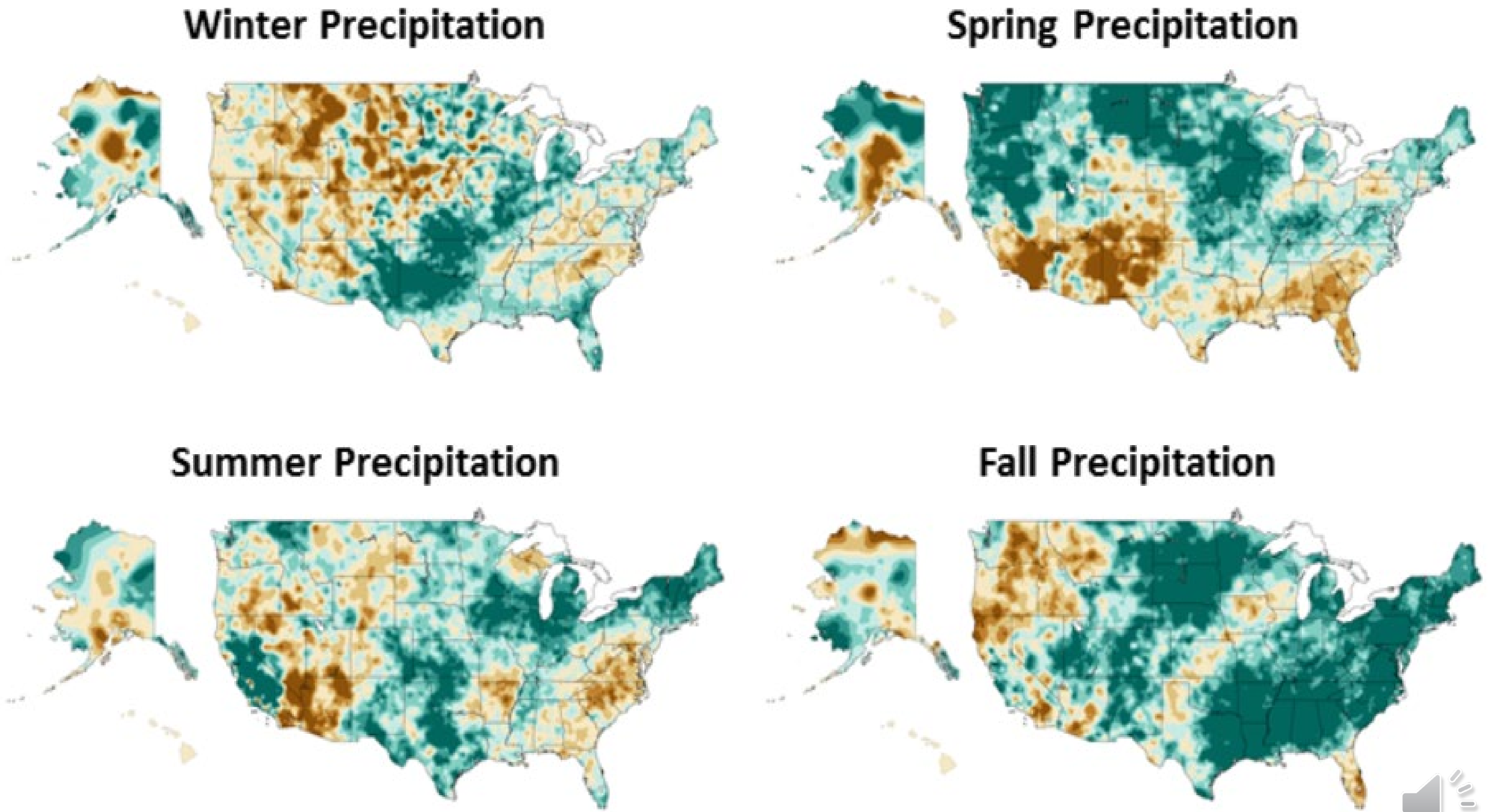
Source: NOAA/NCEI Climate at a Glance Dec-Feb

Average Observed US Rainfall Change Since 1895



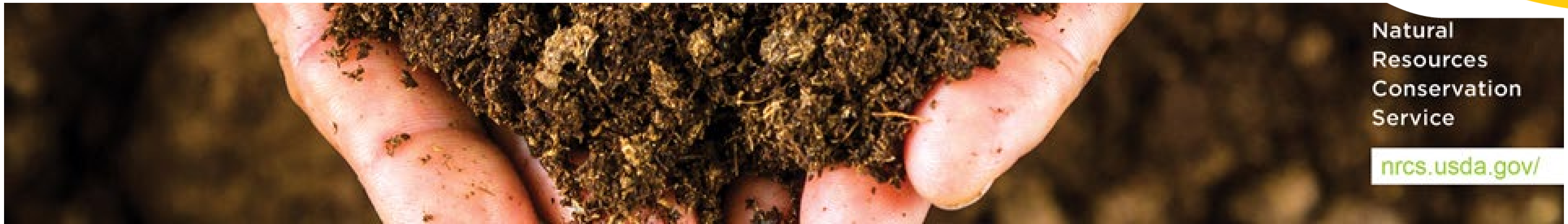
Source: Fourth National Climate Assessment 2018

Observed US Rainfall Change Since 1895 by Season



Source: Fourth National Climate Assessment NOAA NCEI

Changes at the State Level



NOAA State Climate Summaries

Excellent 4-5 page fact sheets for each state summarizing climate trends that are occurring.

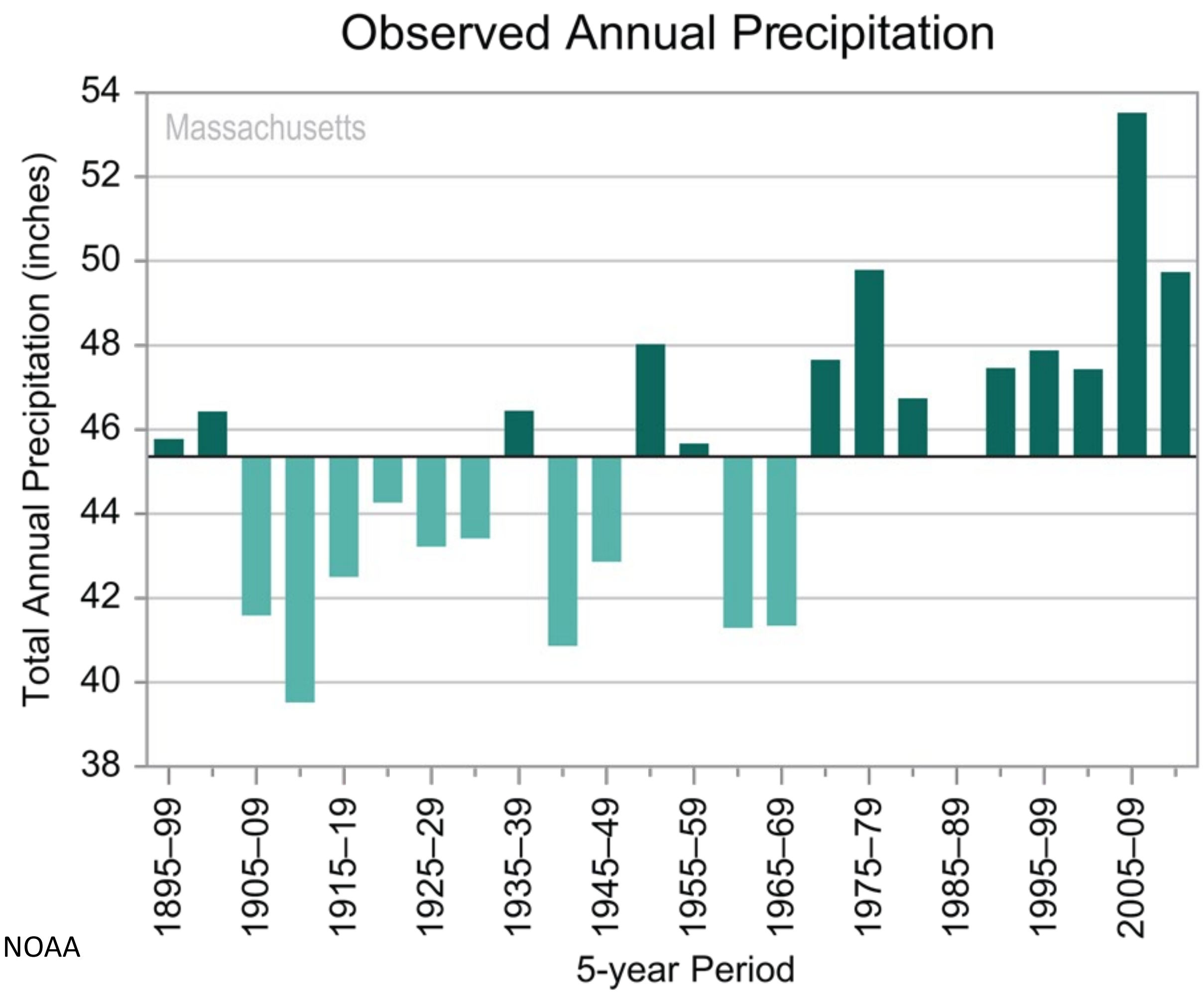
Visit: statesummaries.ncics.org

Massachusetts

- Average temperatures have increased almost 3° F since 1900 with associated increases in heat wave intensity and decreases in cold wave intensity.
- Warmer winters and increased rain in winter and spring means longer mud season and delayed planting.
- Average rainfall has increased 17% since 1895.
- Extreme rain events (over 2”) has increased 99% since 1950.
- Sea levels has risen 10” since 1880; higher than the global rise of 8”.

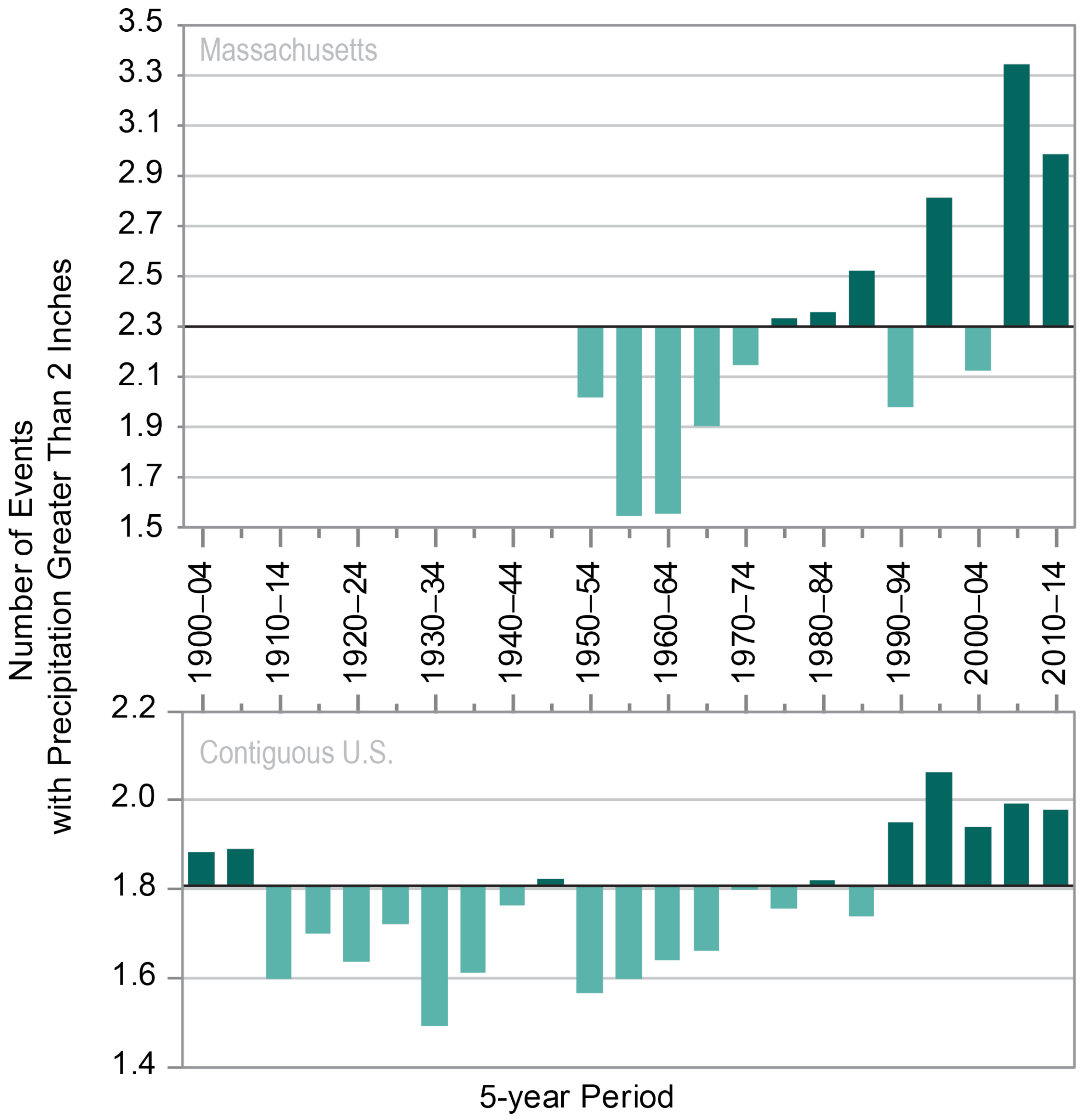
Source: NOAA

Massachusetts: Most recent 10 years have been wettest on record



Source: NOAA

Observed Number of Extreme Precipitation Events

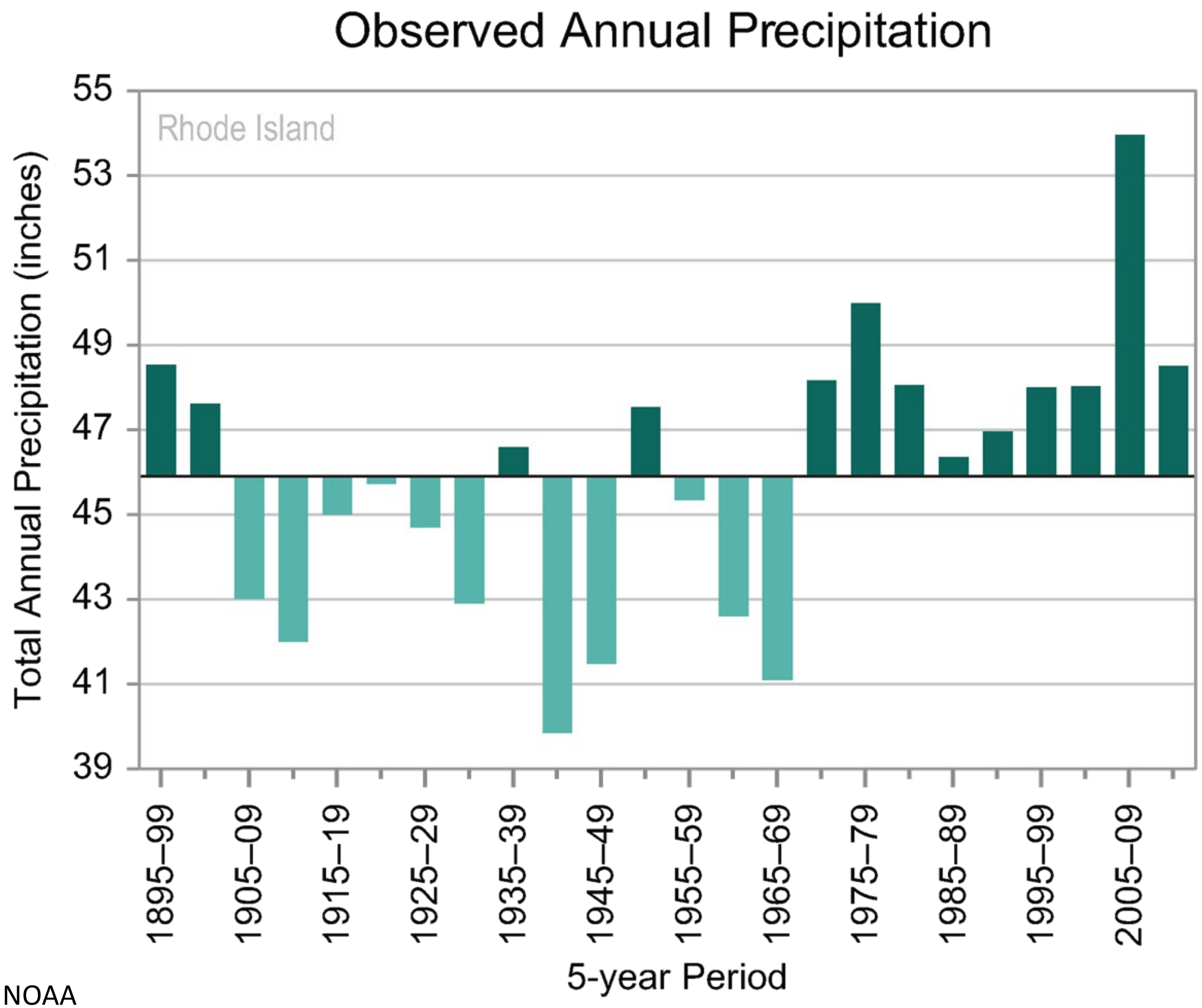


Rhode Island

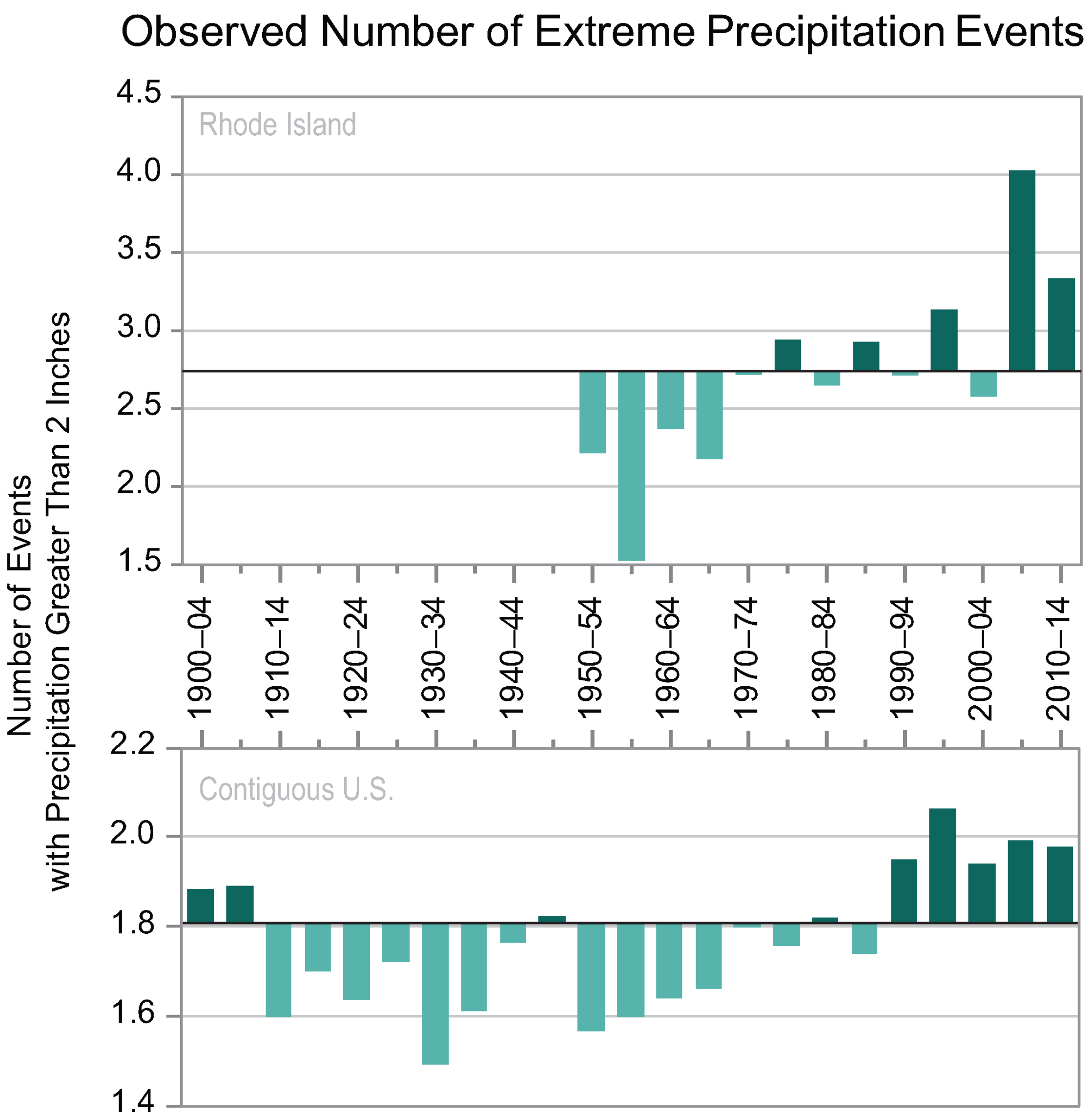
- #1 Fastest warming state in the Continental US: Average temperatures have increased over 3° F since 1900.
- Warmer winters and increased rain in winter and spring means longer mud season and delayed planting.
- Average rainfall has increased 13% since 1895.
- Extreme rain events (over 2”) has increased 50% since 1950.
- Sea levels has risen 9” since 1930; higher than the global rise of 8” (since 1880).

Source: NOAA

Rhode Island

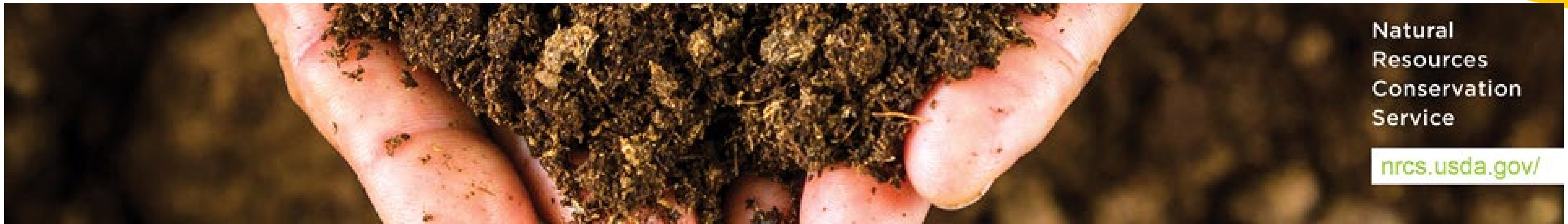


Source: NOAA


Observed Number of Extreme Precipitation Events
Rhode Island
Contiguous U.S.
Number of Events
with Precipitation Greater Than 2 Inches
4.5
4.0
3.5
3.0
2.5
2.0
1.5
2.2
2.0
1.8
1.6
1.4
1900–04
1910–14
1920–24
1930–34
1940–44
1950–54
1960–64
1970–74
1980–84
1990–94
2000–04
2010–14

USDA USDA United States Department of Agriculture

Climate Win-Wins Improve Soil Health



Improve Soil Health

- Increase Organic Matter
- Improve Soil Structure (Disturb Less)
- Keep Soils Covered
- Keep Plants Growing Throughout the Year

Soil Organic Matter:
Multiple Climate Smart Farming Benefits!

- Enhances infiltration and allows more of the soil mass to hold water: 1% organic matter can hold up to 20,000 gallons of water per acre. Improves soil structure which helps with infiltration.
- Reduces erosion: Increasing SOM from 1 – 3% can reduce erosion 20-33%.
- Provides food for living organisms.
- Enhances soil microbial biodiversity and activity which can help in the suppression of diseases and pests.
- Reservoir of nutrients: releases 20-30 lbs of N, 4.5 – 6.5 lbs of P2O2, and 2-3 lbs S per year.
- Improves cation exchange capacity – holds more nutrients.

Solution: Increase Organic Matter

- Organic matter increases in soil mainly through roots – 1/3 to 1/2 of grass roots die each year leaving behind organic matter and channels for water and air.
- Top dress or inject organic matter from manure or plant residues.
- Soil organic matter volatilizes more rapidly into the air (from biological activity) when tillage slices and clods exposing more areas to oxygen.

Soil Organic Matter: Protects Yields and Reduces Insurance Claims Under Drought

Counties in US with higher SOM are associated with greater yields, lower yield losses, and lower rates of crop insurance payouts under drought. During severe drought, an increase of 1% of OM was associated with a corn yield increase of 32.7 bu per acre and a 36% reduction in the mean proportion of liabilities paid.

Daniel Kane et al 2021 Environ. Res. Lett 16 044018. Soil organic matter protects US maize yields and lowers crop insurance payouts under drought.

United States Department of Agriculture

Problem: Increased Rainfall and Large Storm Events Results in More Ponding and Runoff

Solution: Disturb the Soil Less; Reduce Compaction with Living Roots and Biological Communities

- No-Till
- Reduced-Till
- Shallow-Till
- Zone-Till/Strip-Till
- Ridge-Till
- Strategic-Till

Same Soil – Untilled vs Tilled

No Till/Reduced Till Soils Less Likely To Run-off and Leach; Holds Nutrients Better

Reduced Till Soil | Multiple Till Soil | No Till Soil

Solution: Maintain paths created by roots and living organisms

USDA NRCS The Science of Soil Health: Nightcrawlers and Soil Water Flow https://youtu.be/OcpXeSRGdXA

http://soilandwater.bee.cornell.edu/Research/pfweb/educators/intro/macroflow.htm

Problem: Increased Soil Temperatures

High Soil Temperature Can:

- Speed up biological activity which volatizes organic matter.
- Discourage or kill beneficial soil organisms.
- Alter root growth and nutrient uptake which affects yield.
- Influence soil evaporation rate – more water is lost the higher the temperature is.

Effects of Cover on Soil Temperature

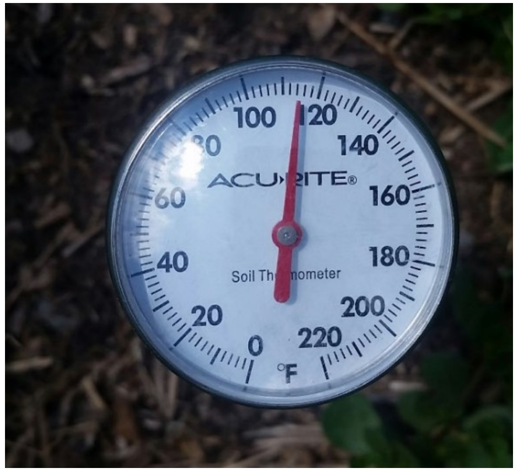
At 1” depth – same day Chatham, NY Farm – 45 degree difference

Ambient Temperature: 93° F

Tall Pasture (8-10”): 83° F

Mulched Veggie Beds: 90° F

Overgrazed Pasture (<1”): 108° F



Bare Soil: 115° F

Black Plastic: 128° F

Solution: Covered Soil – Cover Crops

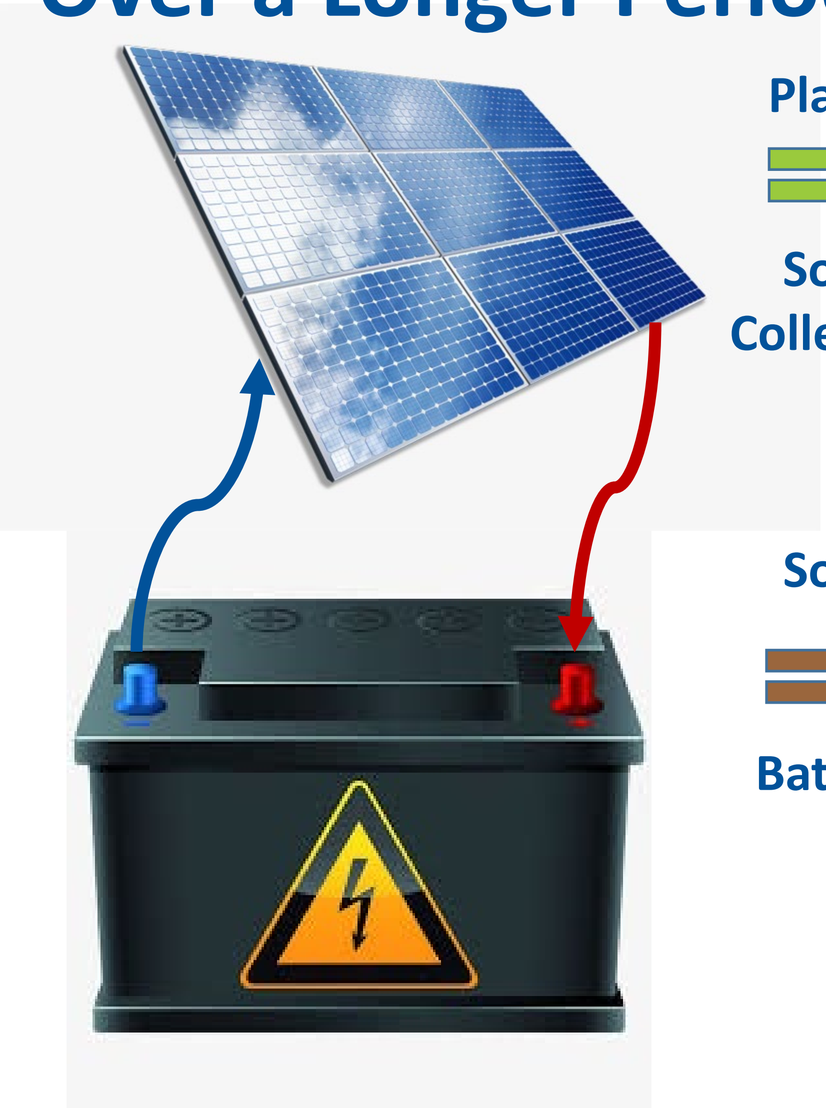
- Buffers soil temperature and moisture: cooler and dryer in the spring, cooler and wetter in the summer than bare soil.
- Improves energy flow by capturing sun rays.
- Provides living roots (food source) over a larger part of the growing season.

Solution: Cover Soil With Mulch or Plants

Photo: Lovin' Mama Farm

Winter Annual Cover Crop

Improve Energy Flow and Soil Carbon Over a Longer Period



Plants

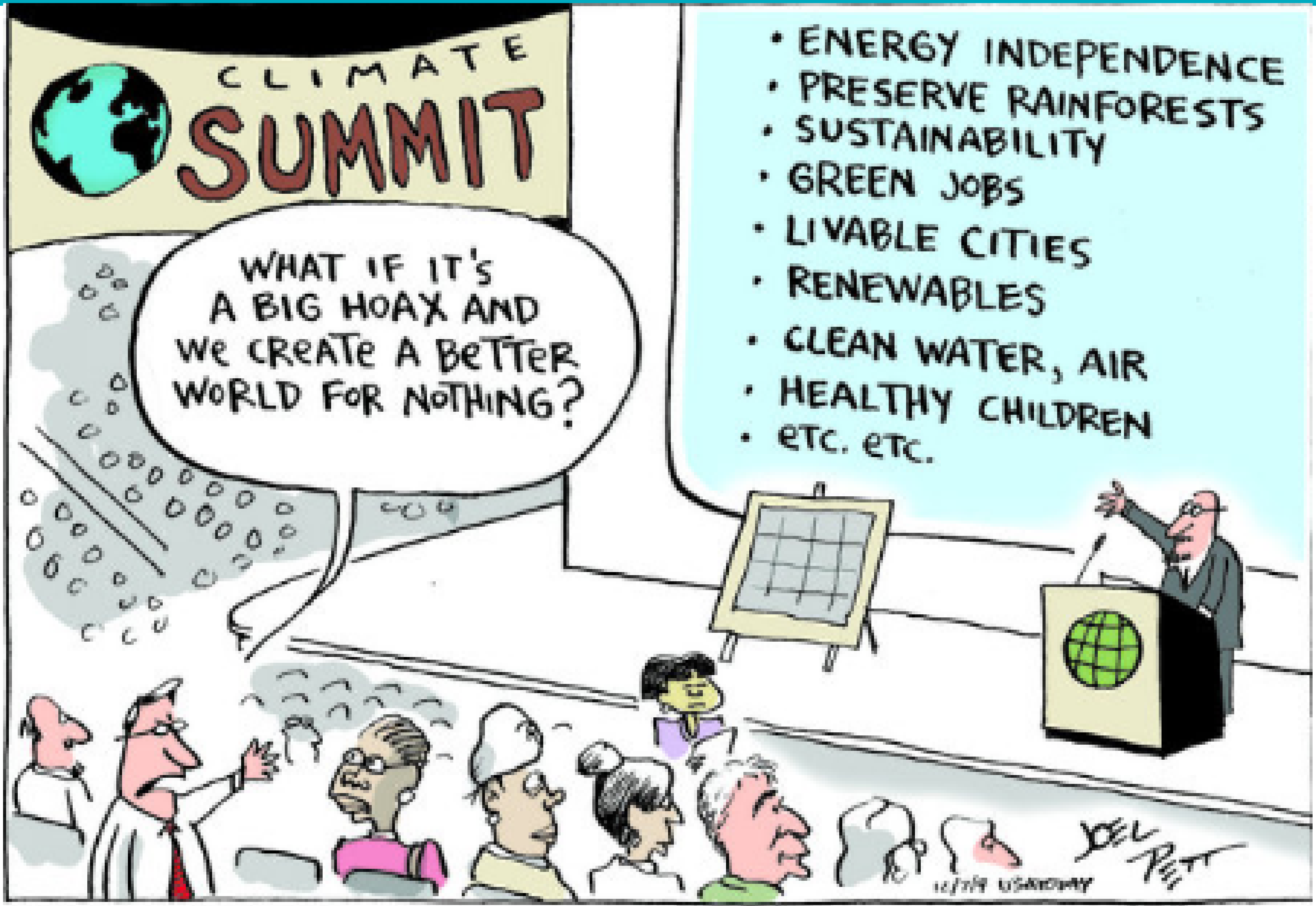
=

Solar Collectors

Soil

=

Battery


CLIMATE SUMMIT
WHAT IF IT'S A BIG HOAX AND WE CREATE A BETTER WORLD FOR NOTHING?
• ENERGY INDEPENDENCE
• PRESERVE RAINFORESTS
• SUSTAINABILITY
• GREEN JOBS
• LIVABLE CITIES
• RENEWABLES
• CLEAN WATER, AIR
• HEALTHY CHILDREN
• etc. etc.

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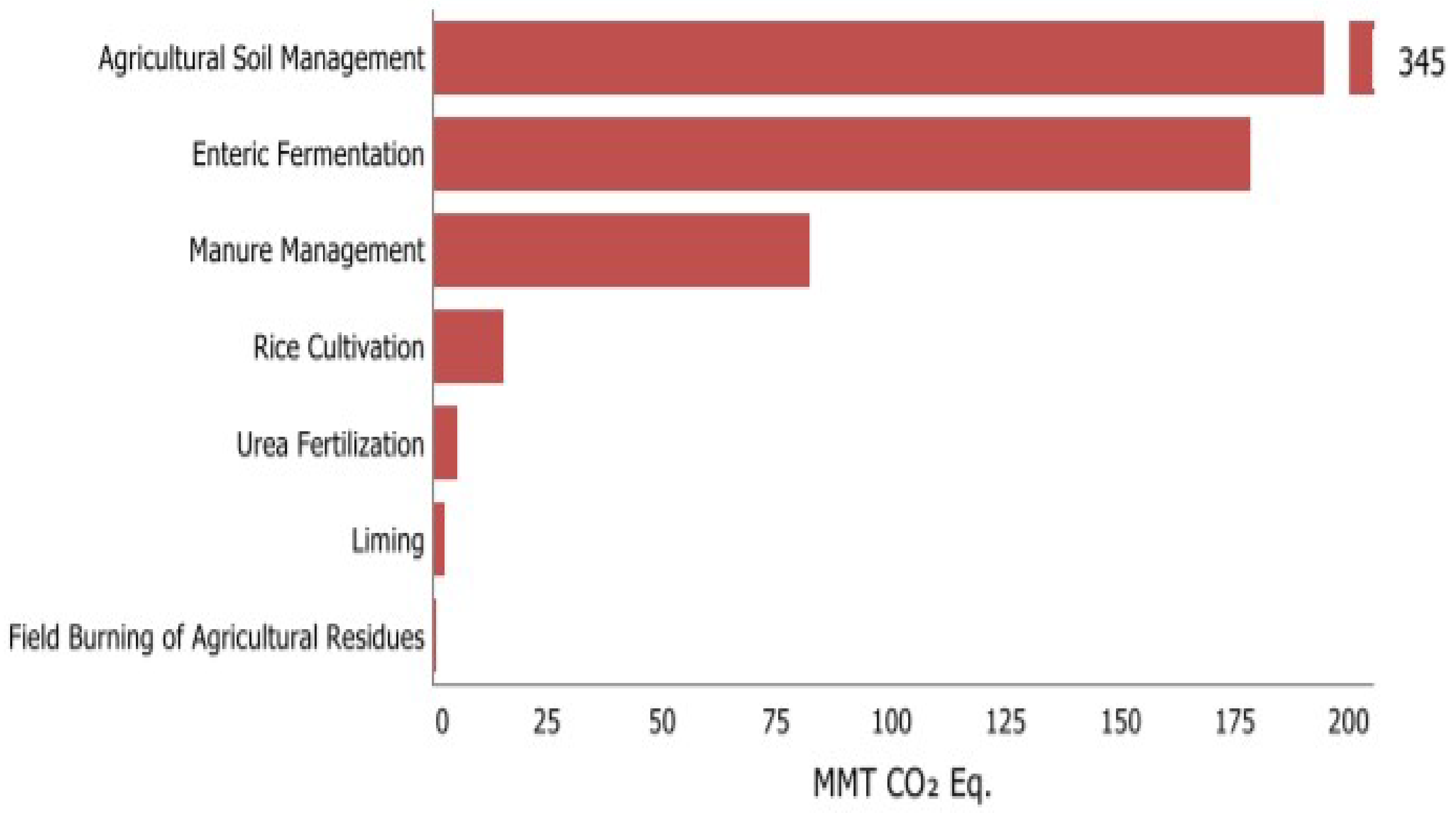
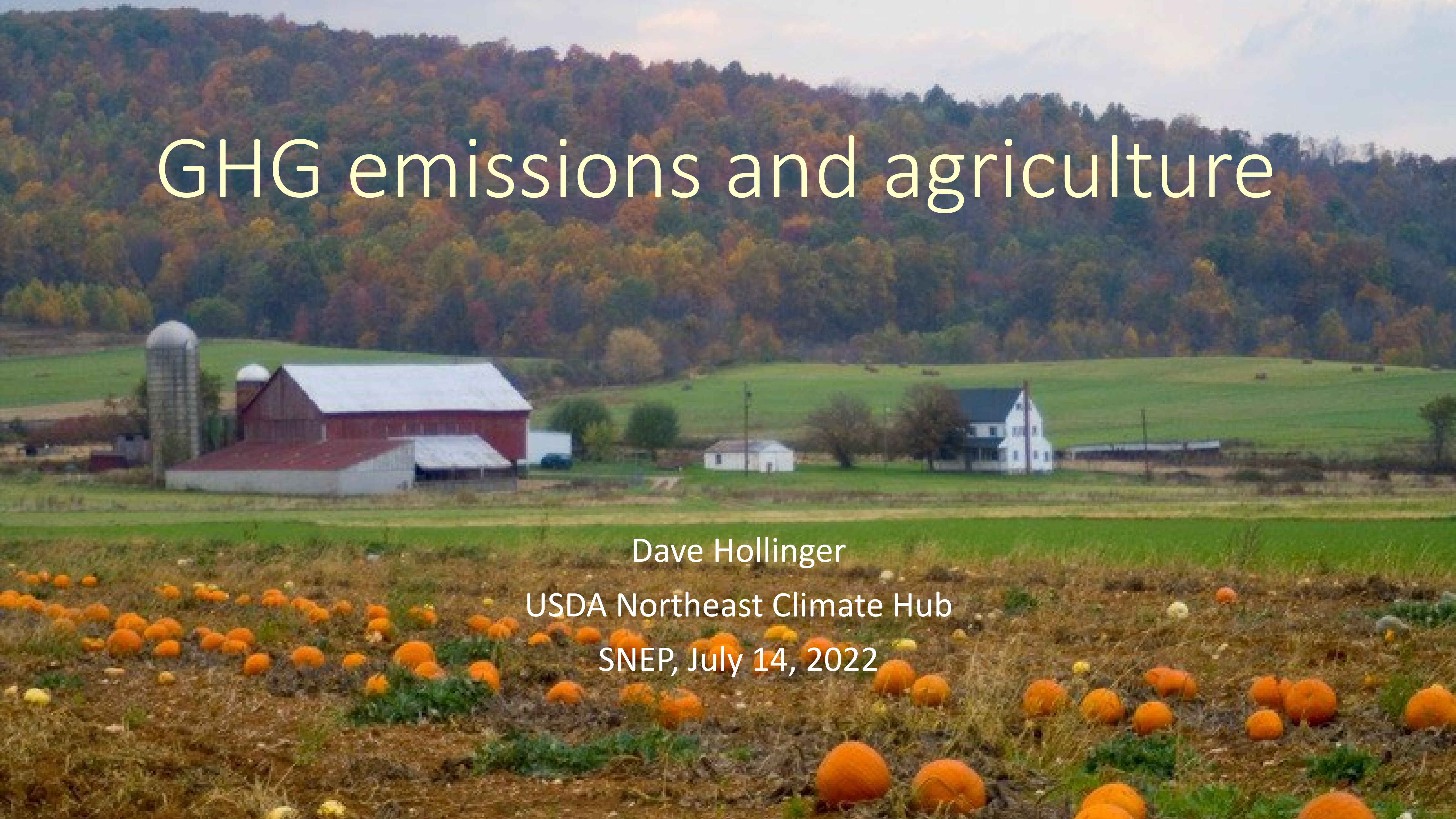
Greenhouse Gas Emissions from Agriculture



[Source: EPA US Inventory of Greenhouse Gas Emissions and Sinks 1990-2019]



GHG emissions and agriculture

Dave Hollinger

USDA Northeast Climate Hub

SNEP, July 14, 2022

Climate Mitigation:
Practices that reduce Greenhouse Gas emissions or store CO_2 from the air

Climate Smart Practices

Climate Adaptation:
Practices that increase resilience to climate extremes and change

Adaptation benefits the farmer ($$)

- Reduce impact of drought, excess rain
- Take advantage of climate changes

Mitigation benefits the planet

- May be no direct financial benefit to the farmer

How do we benefit both?

Benefiting the farmer and the planet:

- Practices with Co-benefits (e.g., healthy soils)
- Federal/State Incentives (e.g., Farm Bill Conservation Programs such as through NRCS, Mass. agrivoltaics)
- State and private voluntary carbon markets
- Increased consumer demand for climate-friendly products

Top US Agriculture Greenhouse Gases: methane (CH_4) and nitrous oxide (N_2O)

% total Ag CO2e (source, EPA 2022)

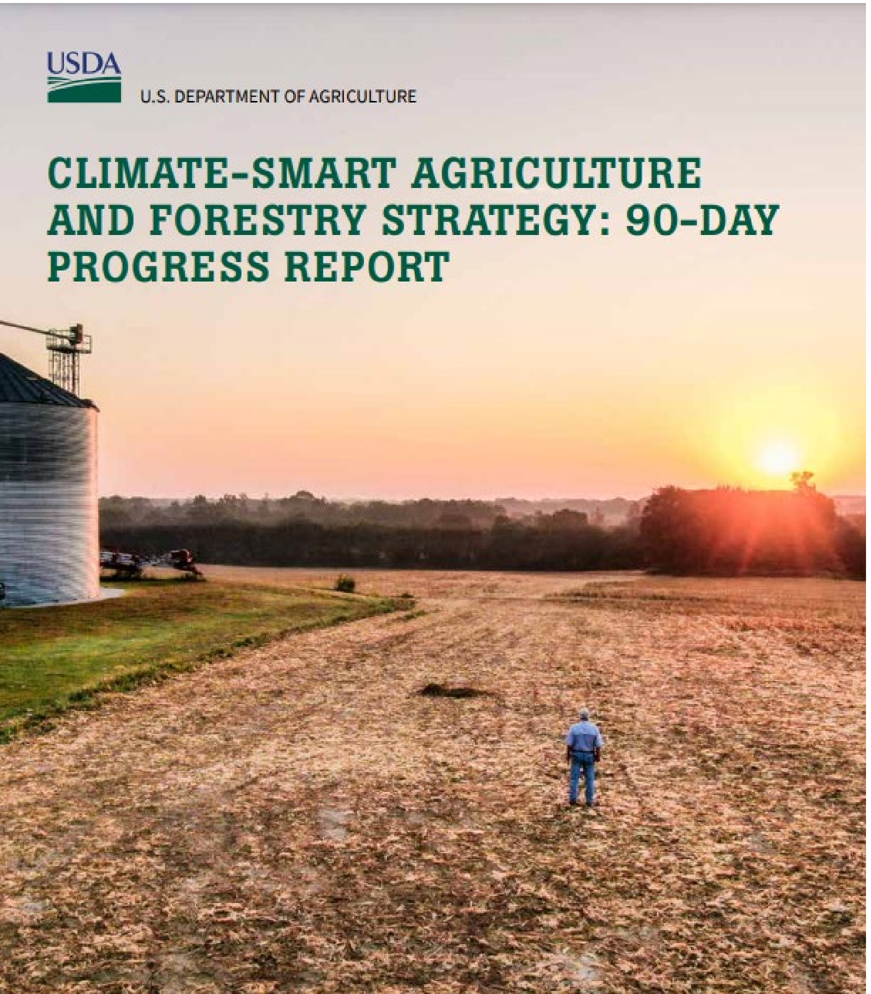
Agriculture accounts for 10% of US GHG emissions

Manure CH_4
10%

Enteric CH_4
30%

Soil N_2O
53%

“Climate-Smart” (Mitigation) Practices:



Practices to Reduce nitrous oxide

- Nutrient management
- Enhanced efficiency fertilizers
- Manure management

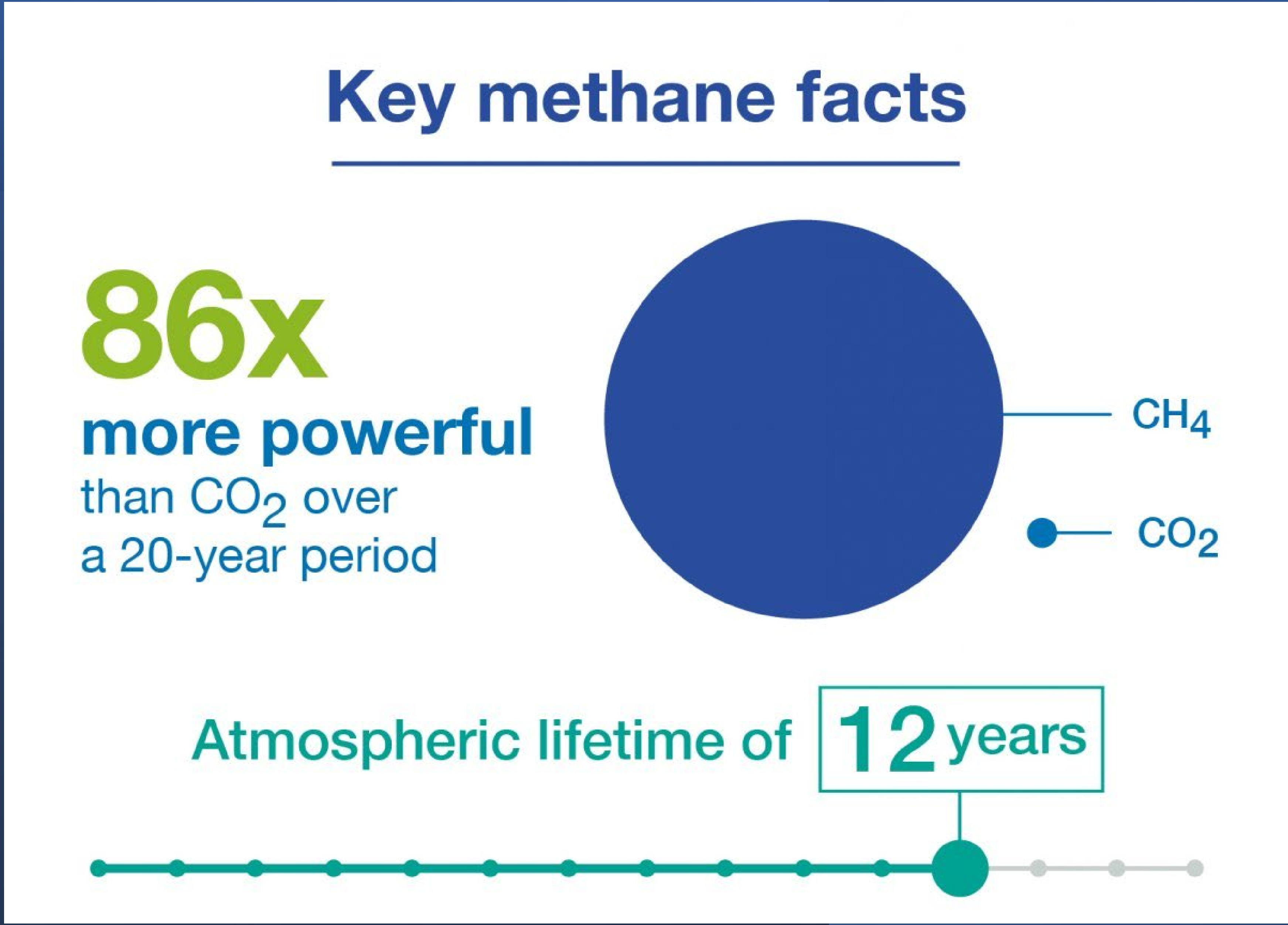
Practices to Reduce methane emissions

- Manure management
- Animal feed management
- Alternate wetting & drying of rice fields

Practices to store carbon

- Cover crops
- Low-till or no-till
- Pasture practices (e.g. rotational grazing)
- Soil amendments such as biochar
- Buffers, wetland, grassland management
- Agroforestry
- Afforestation, reforestation
- Sustainable forest management

Reducing methane emissions can have a quick impact



Reducing methane from manure: Cover and flare or mini-digestors

Manure CH_4

10%

Use: Low

Potential: High

https://cals.cornell.edu/news/dairy-farm-manure-cover-and-flare-systems-reduce-odors-and-methane

Funding available from NRCS

Co-benefits:

- Odor control
- Water exclusion

Reducing methane from ruminants

Enteric CH_4
30%

- Feed manipulation (↑ digestibility)
- Additives (3-NOP, fats & oils, seaweed, etc.)
- Breeding of animals & rumen microbiome

Use: Very Low
Potential: Moderate

Arndt et al. 2022. Proceedings of the National Academy of Sciences, 119(20), e2111294119.

Reducing nitrous oxide emissions from fertilizer

Soil N_2O
53%

4R's of nutrient management

- **R**ight fertilizer source at the
- **R**ight rate, at the
- **R**ight time and in the
- **R**ight place

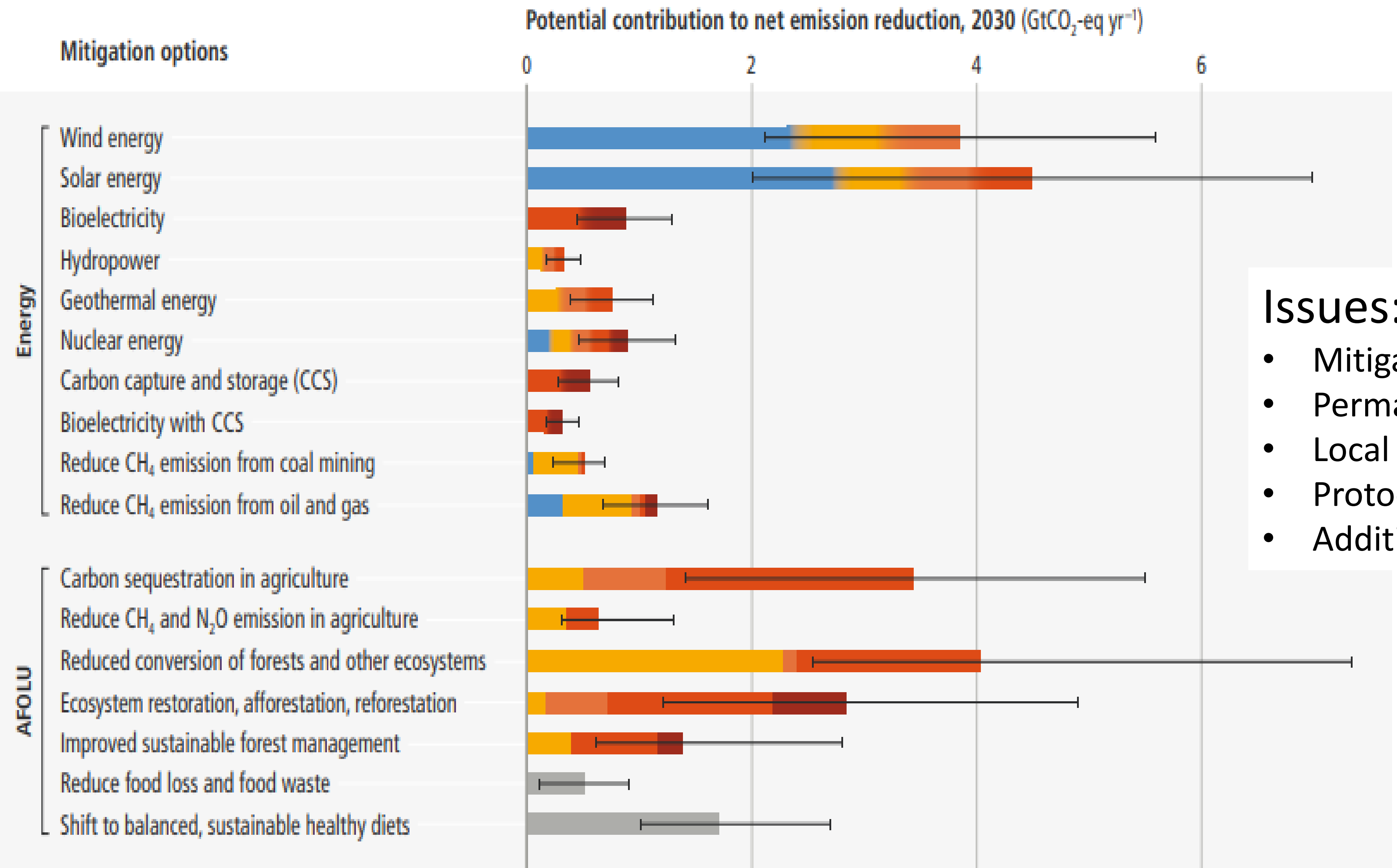
Use: Low
Potential: High

- Additives (prevent N loss: N-Serve, AGROTAIN, etc.)

Co-benefits:

- Increased Yield
- Decreased cost
- Decreased runoff

Potential Role of Storing Carbon on Land (IPPC AR6, 2022)



Issues:

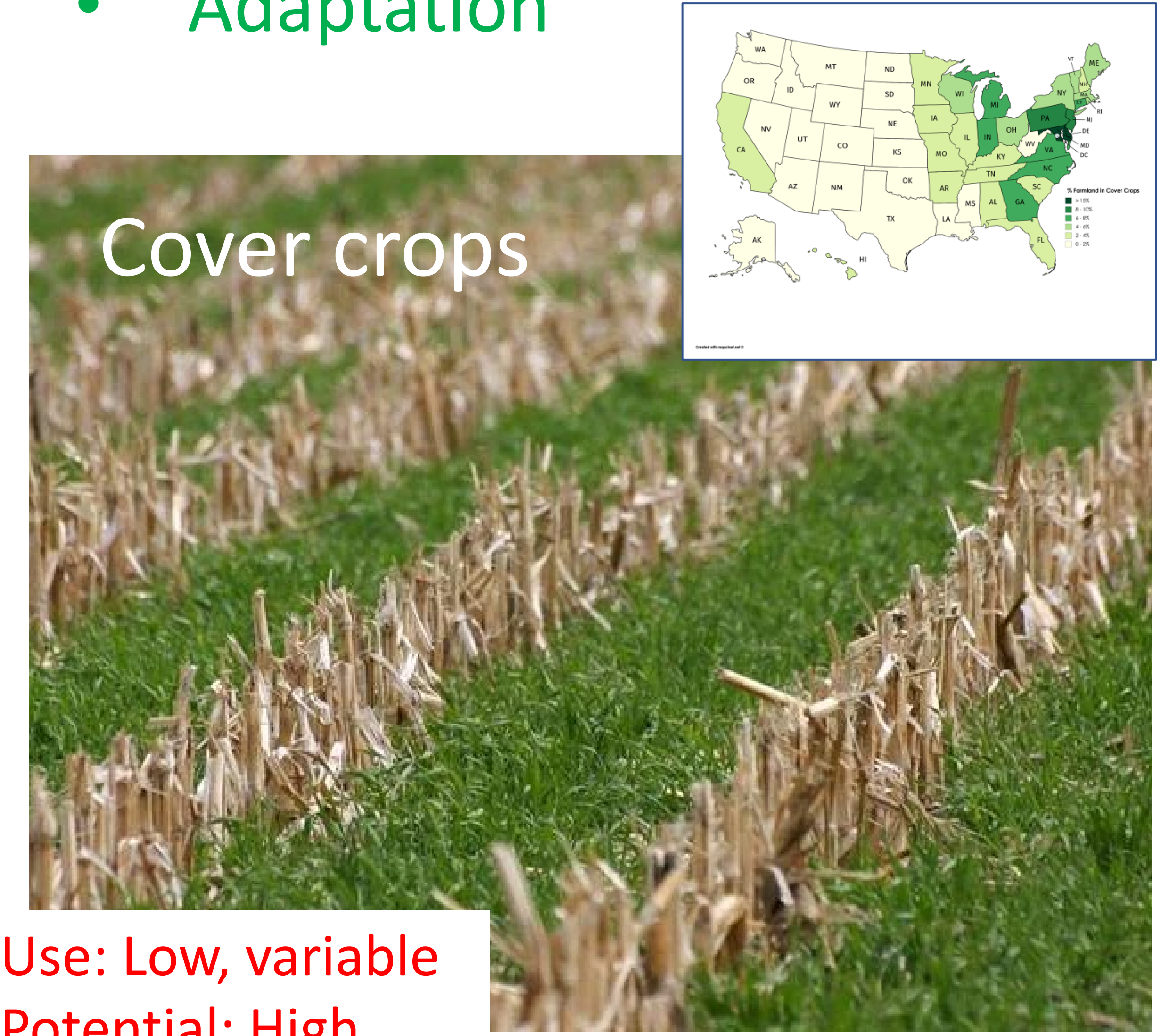
- Mitigation potential
- Permanence/durability
- Local climate impacts
- Protocols and crediting
- Additionality & leakage

Cover crops and No till store carbon in soils:

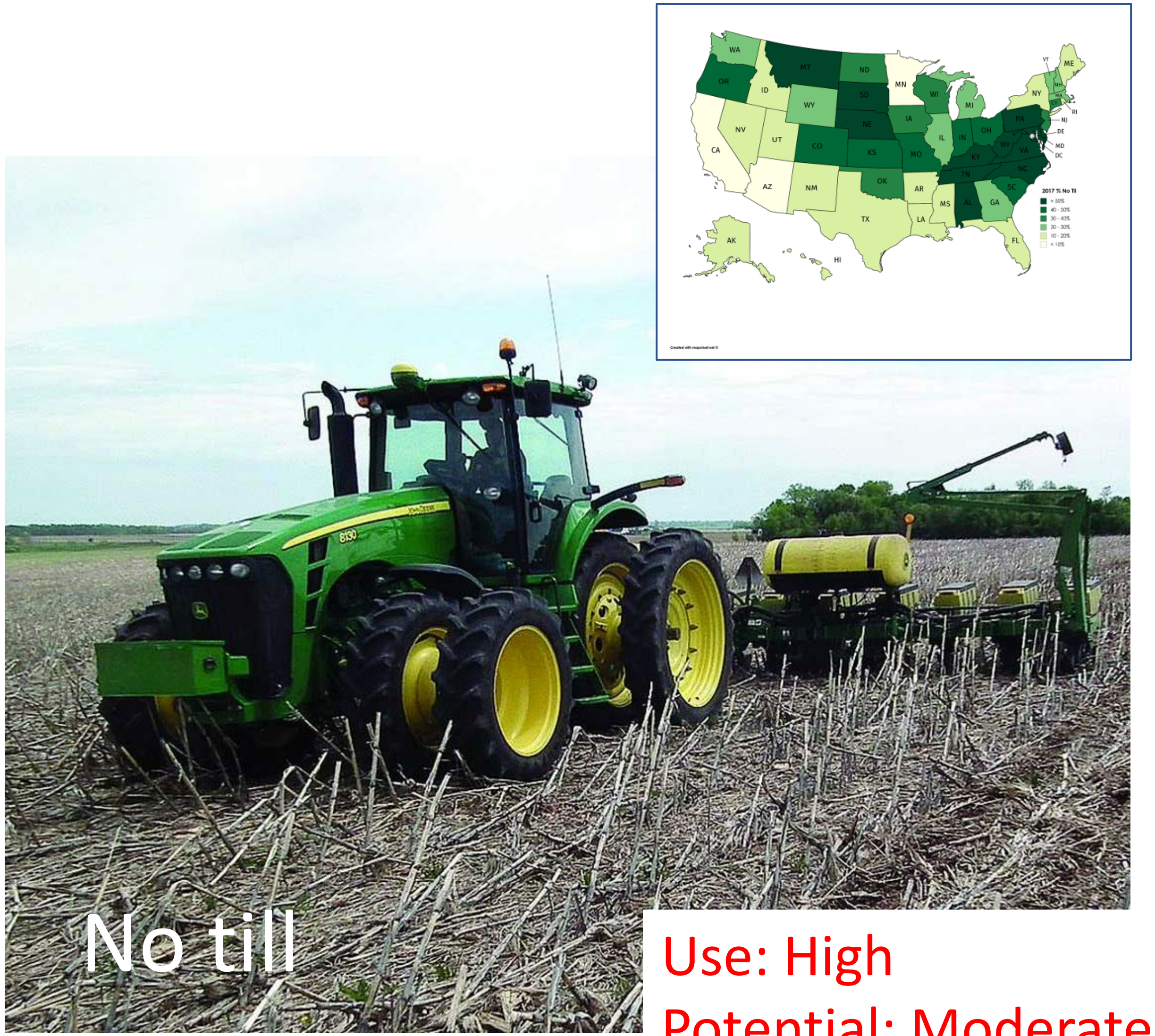
Co-benefits:

- Adaptation

Poeplau & Don, 2015. Agric., Ecosystems, and Env. 200:33-41



Use: Low, variable
Potential: High



Use: High
Potential: Moderate

United States Environmental Protection Agency

Southeast New England Program

Q&A

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Please indicate who your question is for

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