COLLABORATIVE SCIENCE FOR ESTUARIES

WEBINAR SERIES

Richard Lathrop
Rutgers University

Lisa Auermuller
Jacques Cousteau NERR

Kaitlin Gannon
Jacques Cousteau NERR

Dina Fonseca
Rutgers University

Understanding the Interconnectedness of Climate Change, Salt Marsh Resilience, and Nuisance Mosquitoes

National Estuarine
Research Reserve System
Science Collaborative

Date: Tuesday, February 23, 2021
Time: 3:00-4:00 PM ET

National Estuarine Research Reserve System

LIST OF RESERVES

Great Lakes
1. Lake Superior, Wisconsin
2. Old Woman Creek, Ohio

Northeast
3. Wells, Maine
4. Great Bay, New Hampshire
5. Waquoit Bay, Massachusetts
6. Narragansett Bay, Rhode Island

Mid-Atlantic
7. Hudson River, New York
8. Jacques Cousteau, New Jersey
9. Delaware
10. Chesapeake Bay, Maryland
11. Chesapeake Bay, Virginia

Southeast
12. North Carolina
13. North Inlet-Winyah Bay, South Carolina
14. ACE Basin, South Carolina
15. Sapelo Island, Georgia
16. Guana Tolomato Matanzas, Florida

Gulf of Mexico
17. Rookery Bay, Florida
18. Apalachicola, Florida
19. Weeks Bay, Alabama
20. Grand Bay, Mississippi
21. Mission-Aransas, Texas

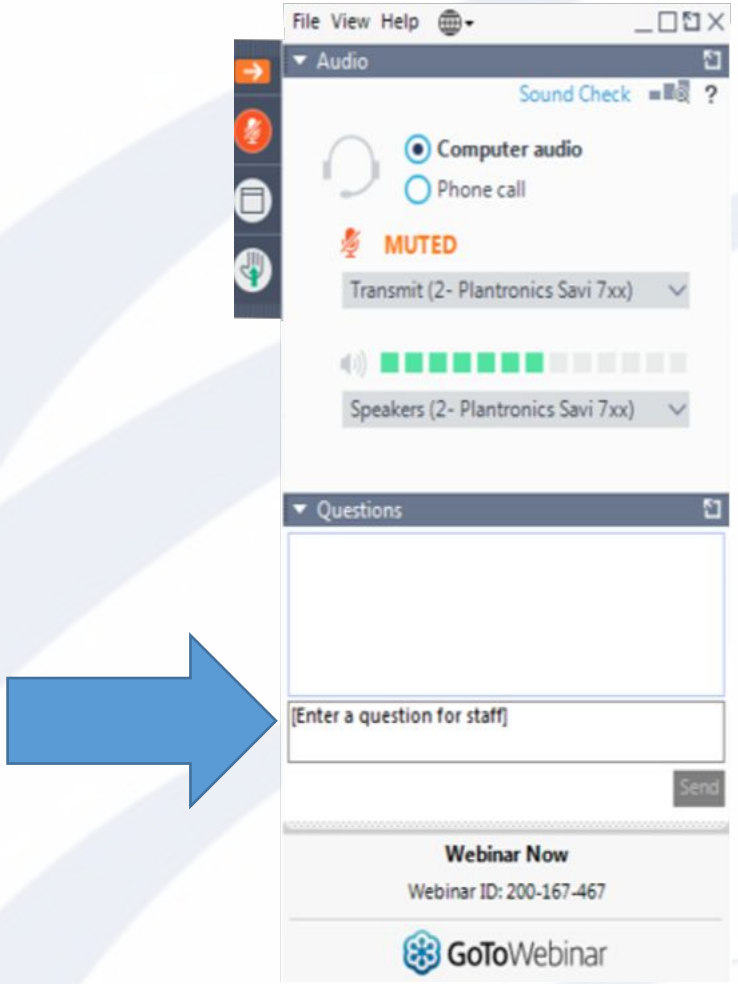
West
22. Tijuana River, California
23. Elkhorn Slough, California
24. San Francisco Bay, California
25. South Slough, Oregon
26. Padilla Bay, Washington
27. Kachemak Bay, Alaska

Pacific
28. He'eia, Hawai'i

Caribbean
29. Jobos Bay, Puerto Rico

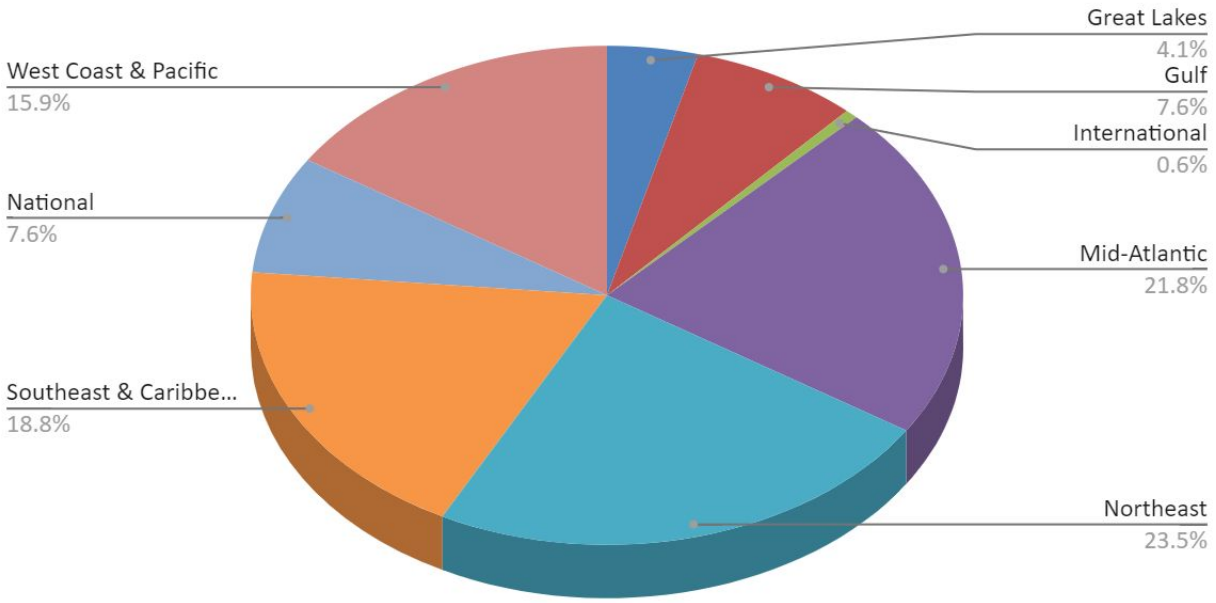
Have a question?

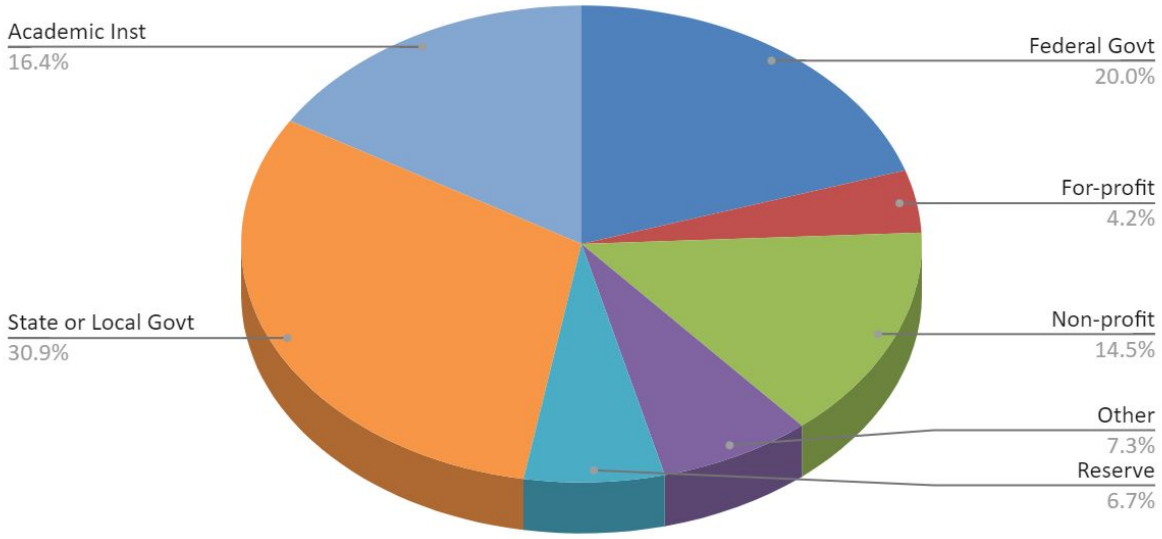
Use the “Questions” function to pose questions throughout the webinar.



National Estuarine Research Reserve System Science Collaborative

Today's audience (by registration)





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Presenters

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Rutgers University

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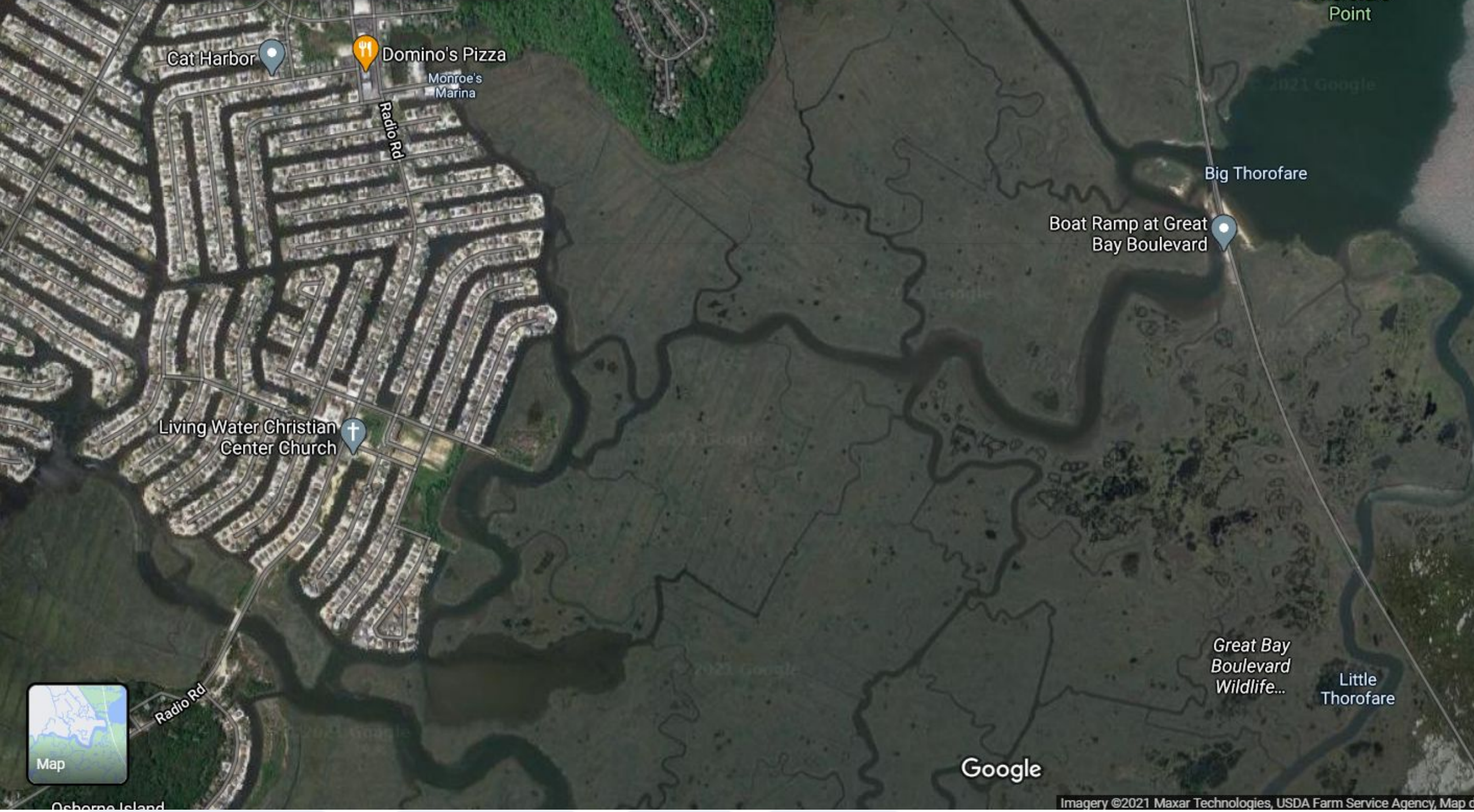
Dina Fonseca
Rutgers University

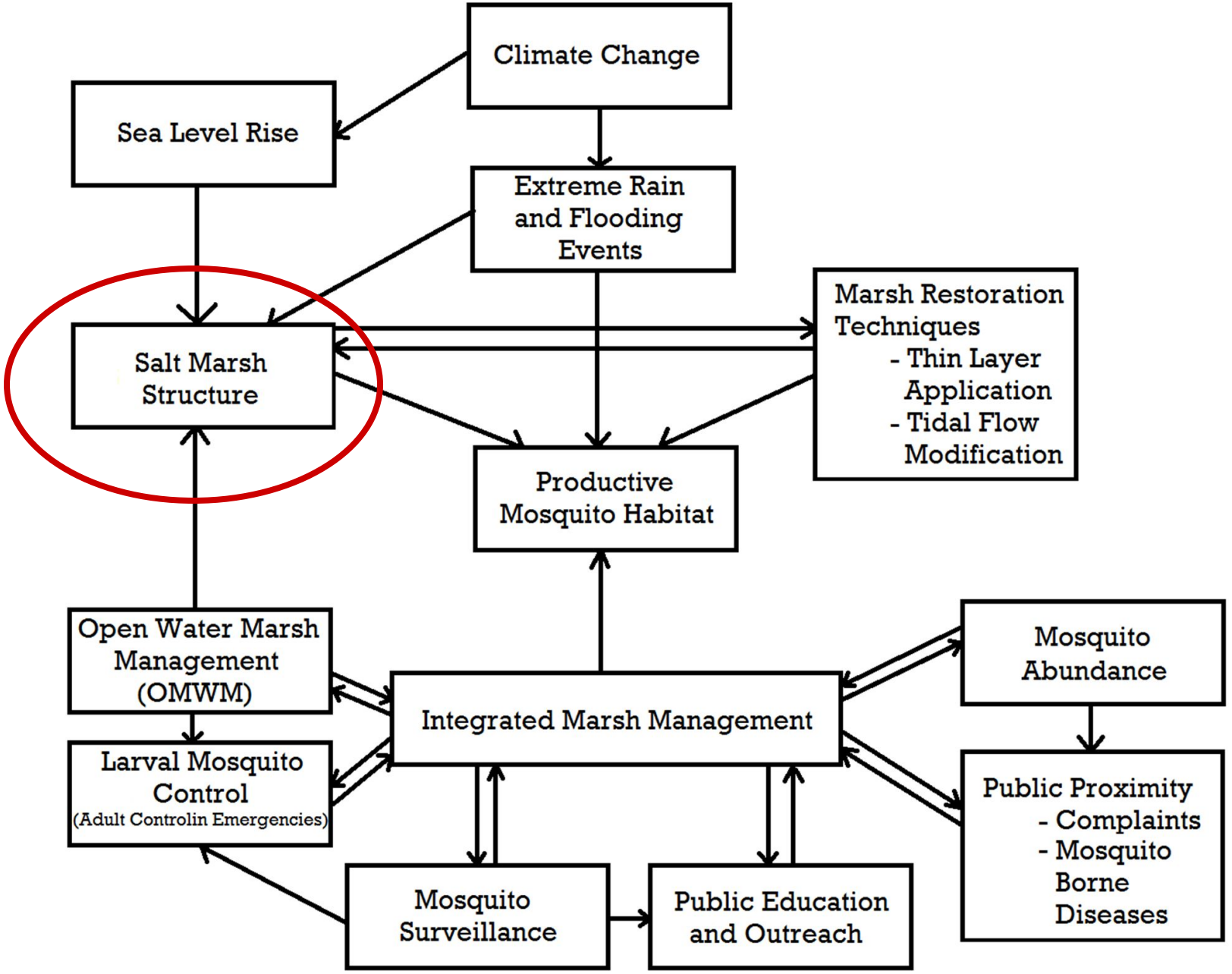
RUTGERS
THE STATE UNIVERSITY OF NEW JERSEY

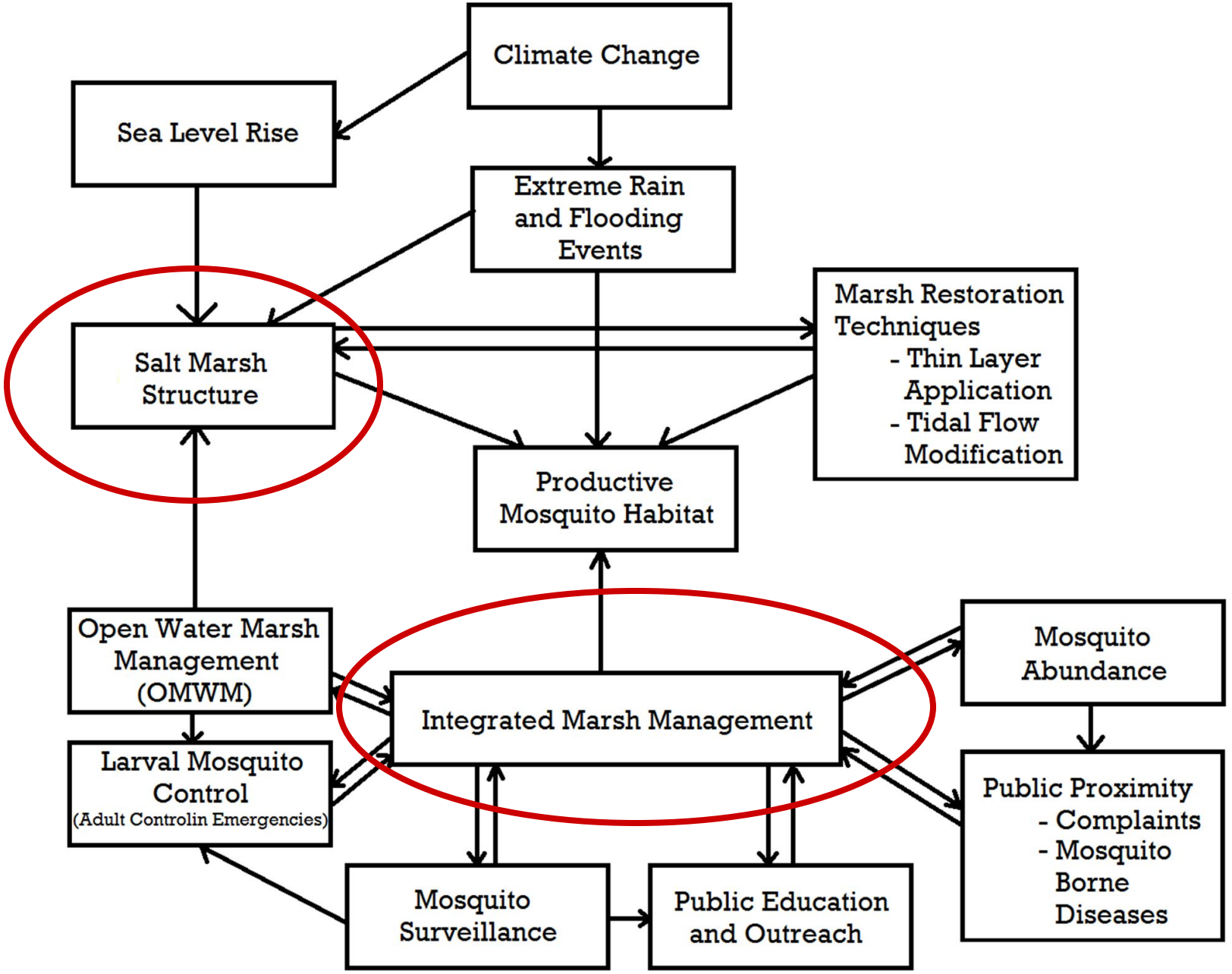
Grant F Walton
CRSSA
Center for Remote Sensing & Spatial Analysis

Jacques Cousteau
National Estuarine Research Reserve

Center for
VECTOR BIOLOGY
RUTGERS


Point
Cat Harbor
Domino's Pizza
Monroe's Marina
Radio Rd
Big Thorofare
Boat Ramp at Great Bay Boulevard
Living Water Christian Center Church
Great Bay Boulevard Wildlife...
Little Thorofare
Radio Rd
Map
Google
Imagery ©2021 Maxar Technologies, USDA Farm Service Agency, Map d


Climate Change
Sea Level Rise
Extreme Rain and Flooding Events
Salt Marsh Structure
Marsh Restoration Techniques
- Thin Layer Application
- Tidal Flow Modification
Productive Mosquito Habitat
Open Water Marsh Management (OMWM)
Integrated Marsh Management
Mosquito Abundance
Larval Mosquito Control
(Adult Controlin Emergencies)
Public Proximity
- Complaints
- Mosquito Borne Diseases
Mosquito Surveillance
Public Education and Outreach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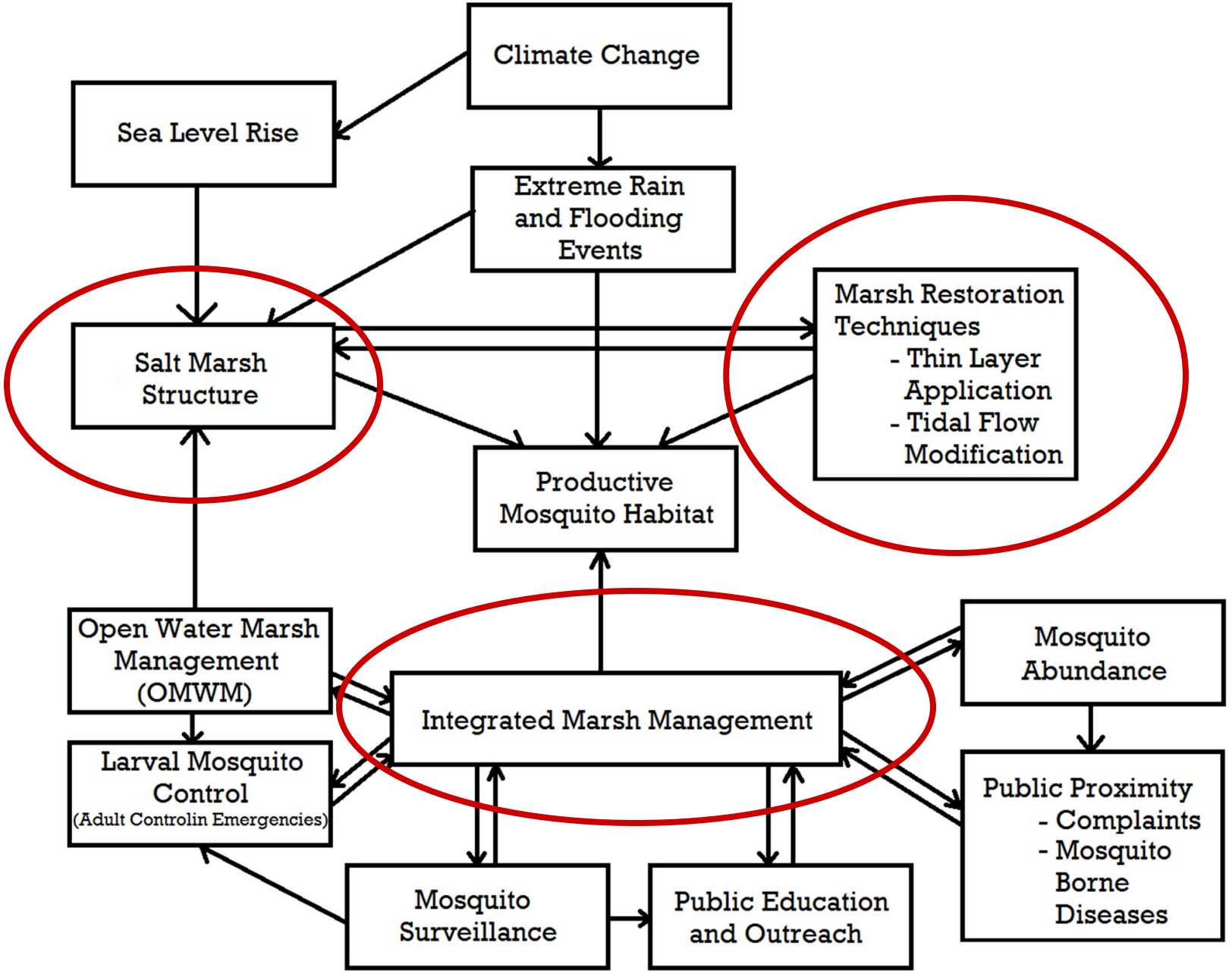
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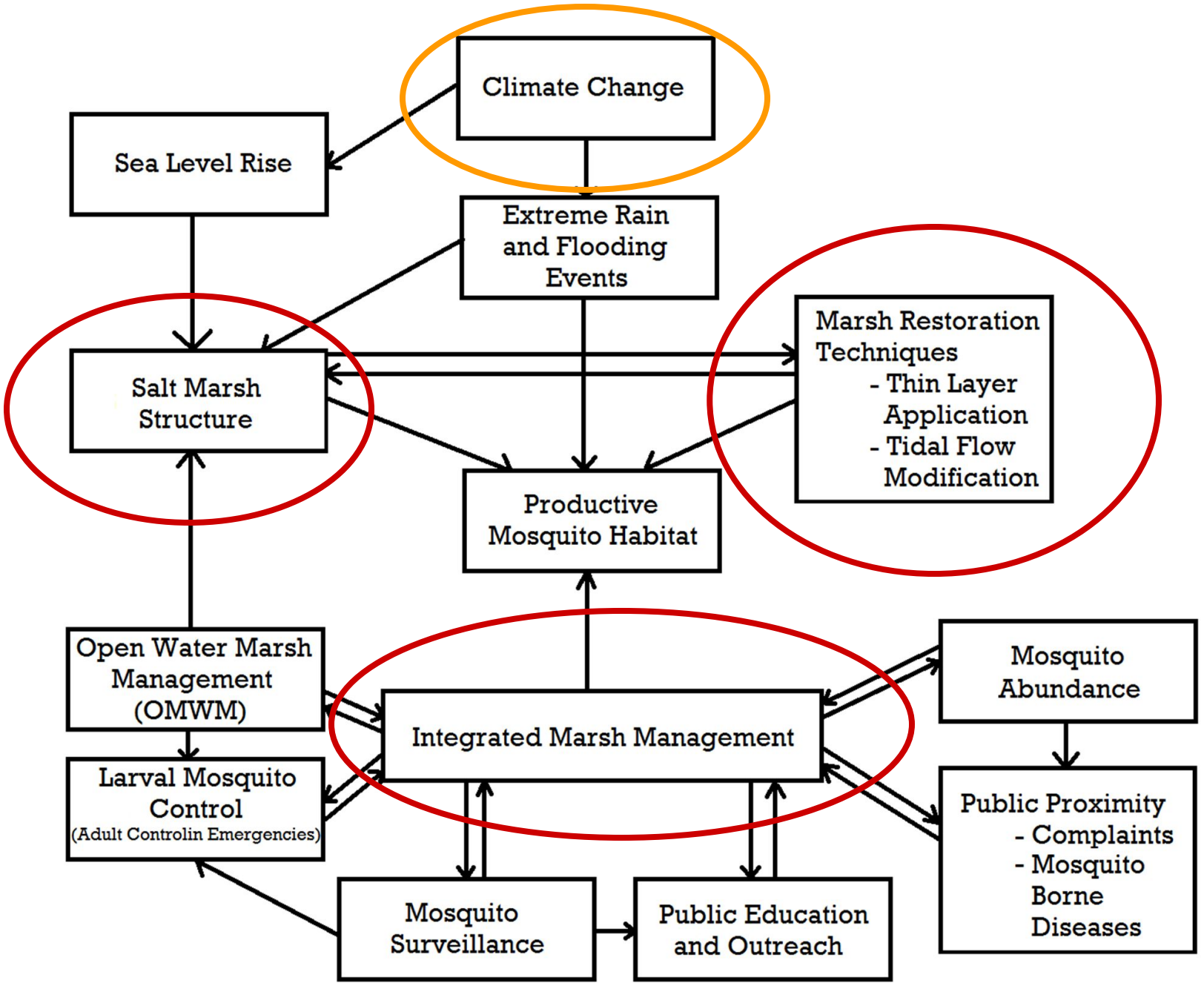
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MOSQUITO CONTROL PROFESSIONALS

- Scott Crans, State Office of Mosquito Control, NJDEP
- Michael Senyk & Joe Schmidt, Ocean County
- John Abdill, Jr., Atlantic County
- Erin Nooney, Burlington County
- Victoria Thompson & Vince Poulsen, Monmouth County
- Peter Bosak, Cape May
- Greg Williams, Hudson County
- Matt Bickerton & Warren Staudinger, Bergen County

LAND MANAGERS/RESTORATION

- Martha Maxwell-Doyle, Barnegat Bay Partnership NJ
- Peter Winkler, NJ Division of Fish & Wildlife, Bureau of Land Management

NERRS Science Collaborative

Project Team: Rutgers and JC NERR

Project Lead
Richard G. Lathrop, Jr. , PhD., Center for Remote Sensing & Spatial Analysis (CRSSA)

Mosquito Research
Dina M. Fonseca, Ph.D., Center for Vector Biology & Brian Johnson, Post Doc

NERRS Science Lead
Michael Kennish, Ph.D.

Technical Staff
Rachael Sacatelli, CRSSA
Ashley Goncalves & Julia Brennan, Center for Vector Biology

Collaborative Lead
Lisa Auermuller, JC NERR

Education Lead
Kaitlin Gannon, JC NERR

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Topics we will cover today:

1) High Resolution Mapping/Modeling.
2) Enhanced Monitoring of Mosquito Populations
3) Assistance with Education and Outreach

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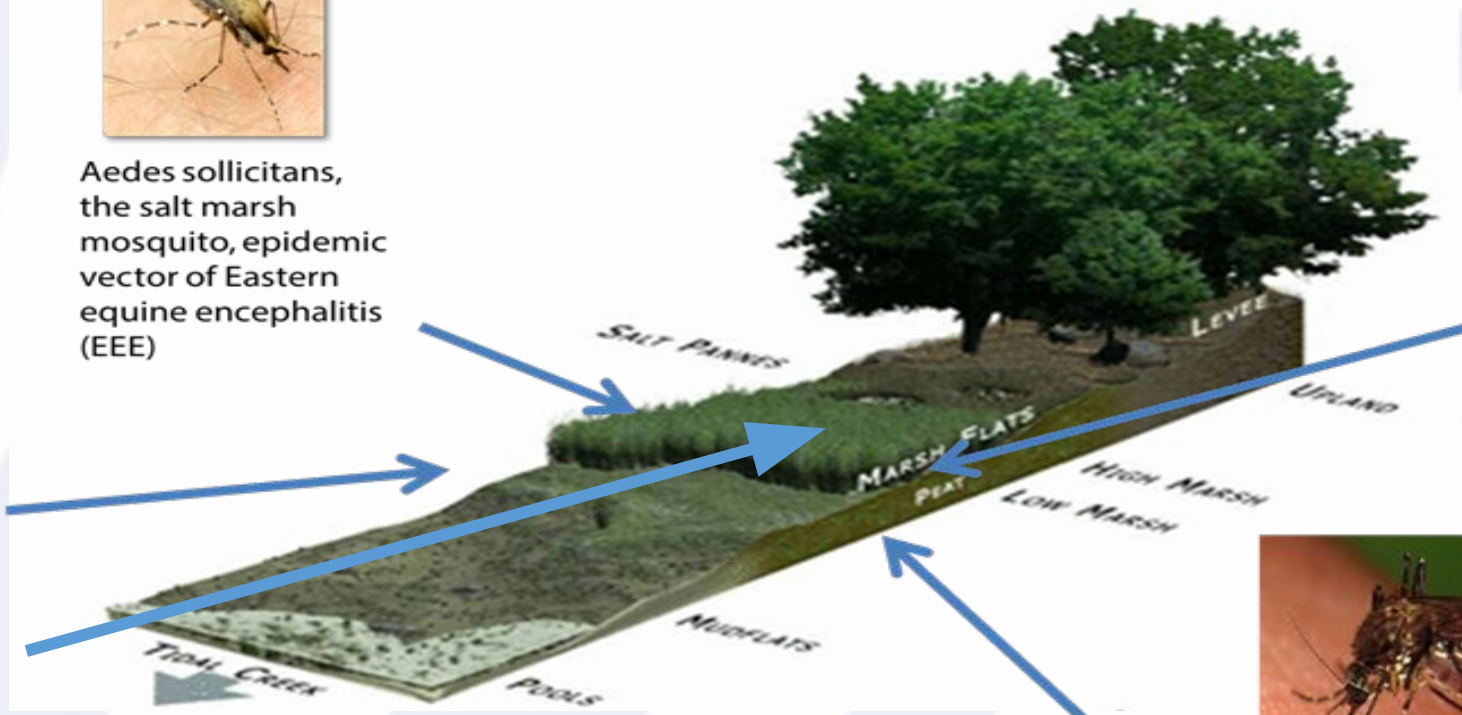
How will a change in the coastal marsh landscape affect mosquito population ecology?

Aedes sollicitans, the salt marsh mosquito, epidemic vector of Eastern equine encephalitis (EEE)

Anopheles bradleyi, a vector of human malaria, *Plasmodium vivax*

Aedes cantator*, brown saltmarsh mosquito, *WNV and EEE vector

Culex salinarius, the unbanded salt marsh mosquito, WNV vector



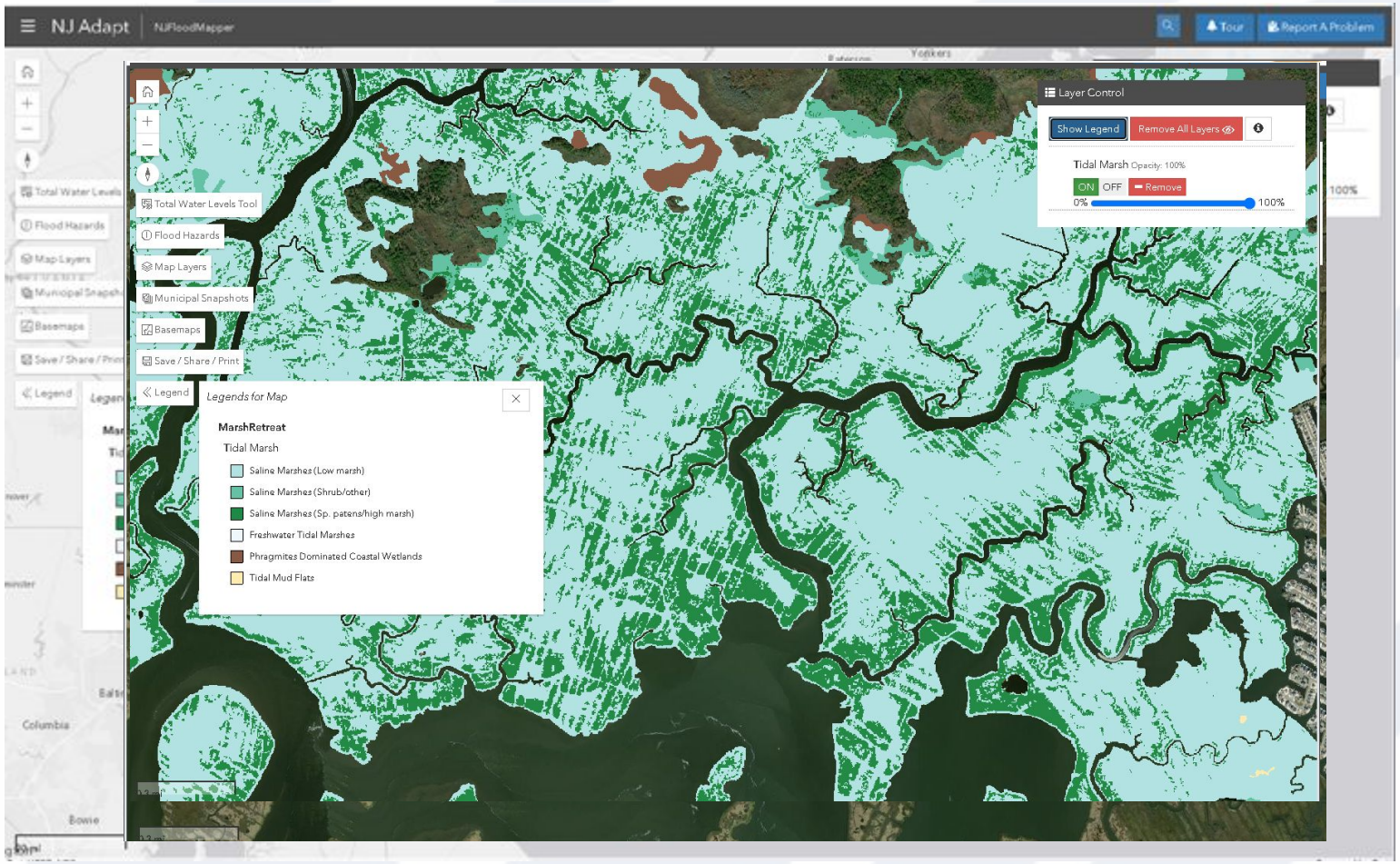
Graphic source: oceanservice.noaa.gov/education

Aedes taeniorhynchus, the black salt marsh mosquito, EEE vector

NJFloodMapper (version 3.0)

Tidal Marsh: includes *Spartina patens/Distichlis spicata*-dominated high marsh as separate category. Classified from USDA NAIP imagery.

Marsh retreat: Models change in Marsh and Adjacent Coastal forest as of 2050



Njfloodmapper.org

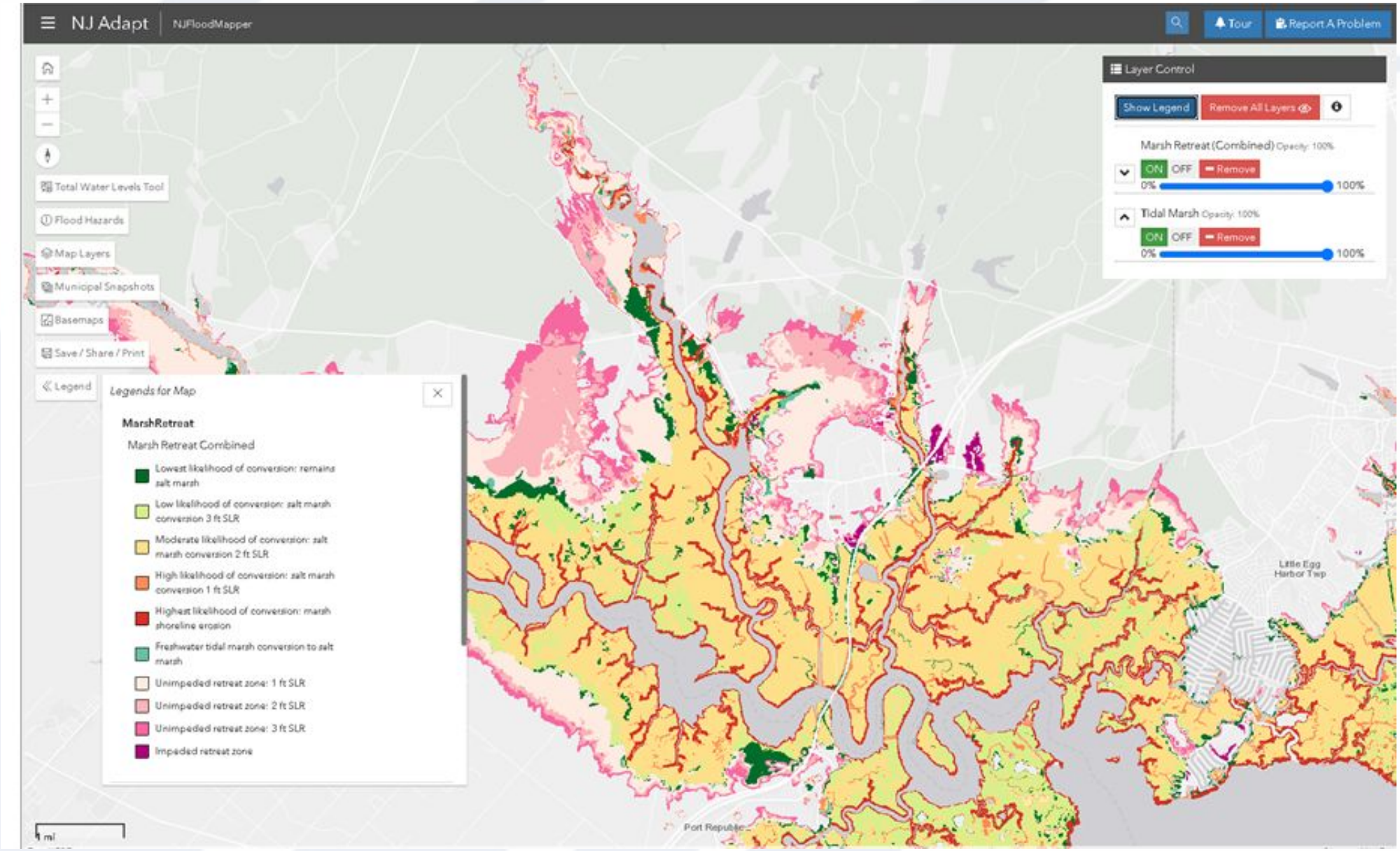
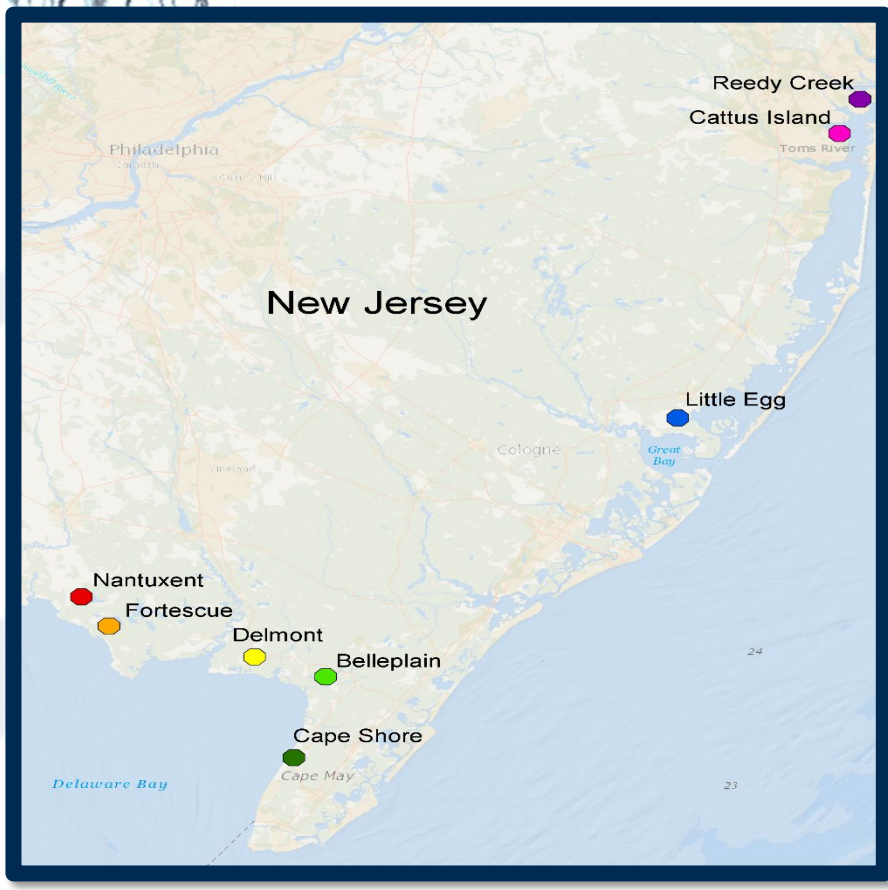


Photo by Jennifer Walker

A LOOK AT UPLAND SALT MARSH EDGE MIGRATION IN NEW JERSEY,

Rachael Sacatelli, Jan 2020, RU MS thesis

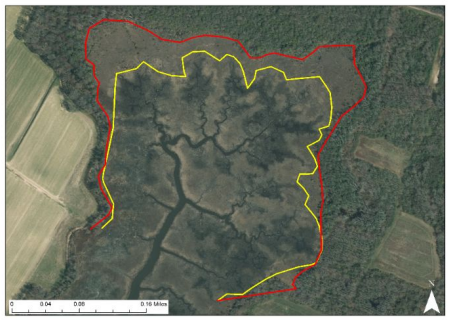
Study Sites



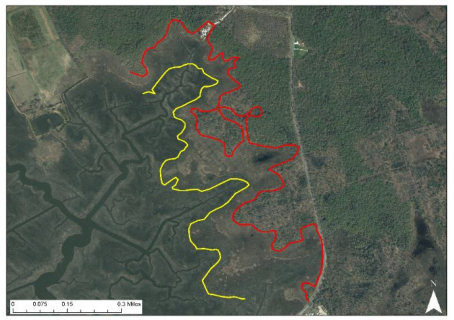
1940 and 2015 Treelines

1940 Treeline
2015 Treeline

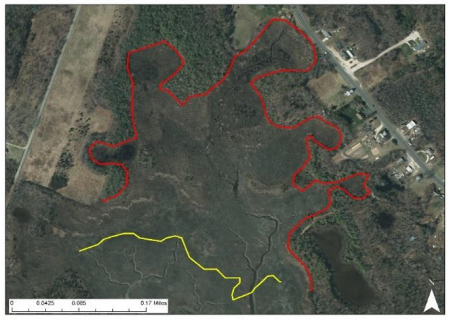
Nantuxent



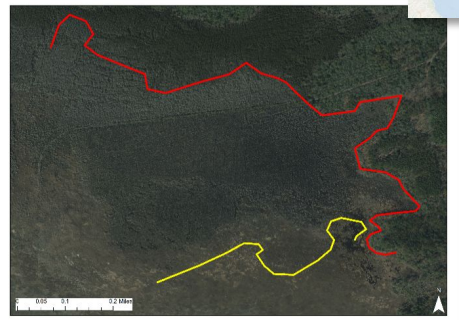
Fortescue



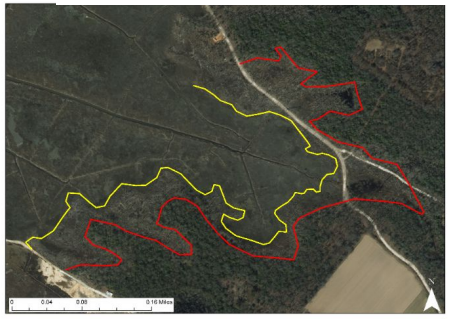
Delmont



Belleplain

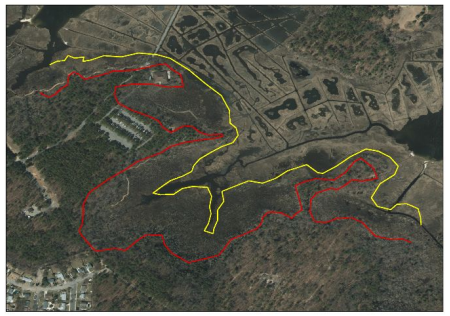


Cape Shore

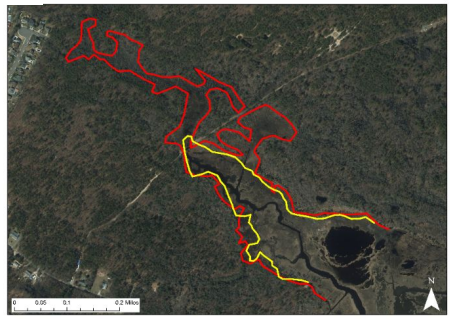


Little Egg

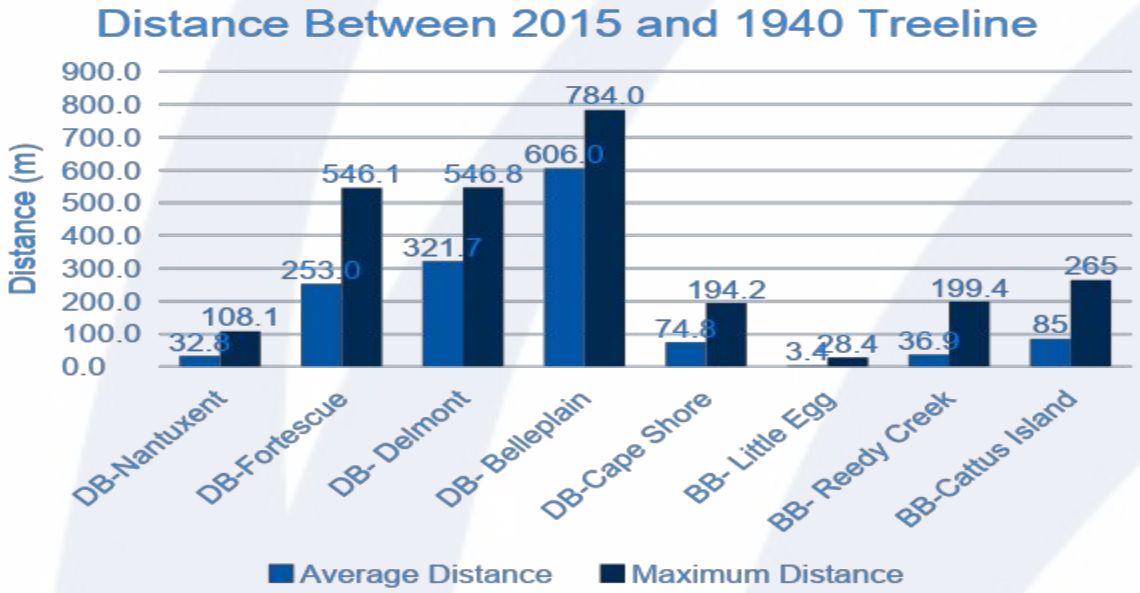
Cattus Island

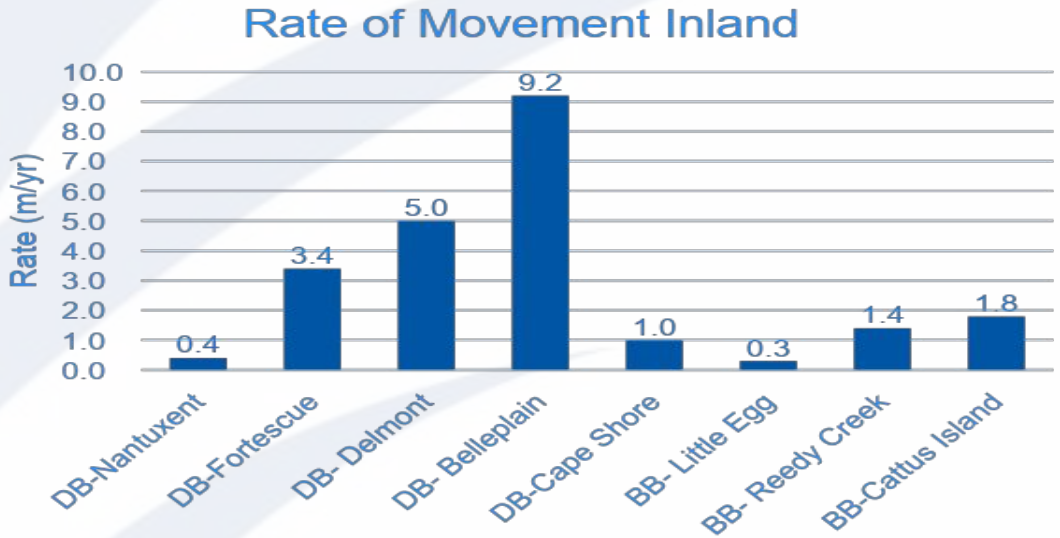


Reedy Creek



At what rate is the interface between salt marsh and marsh forest moving inland?





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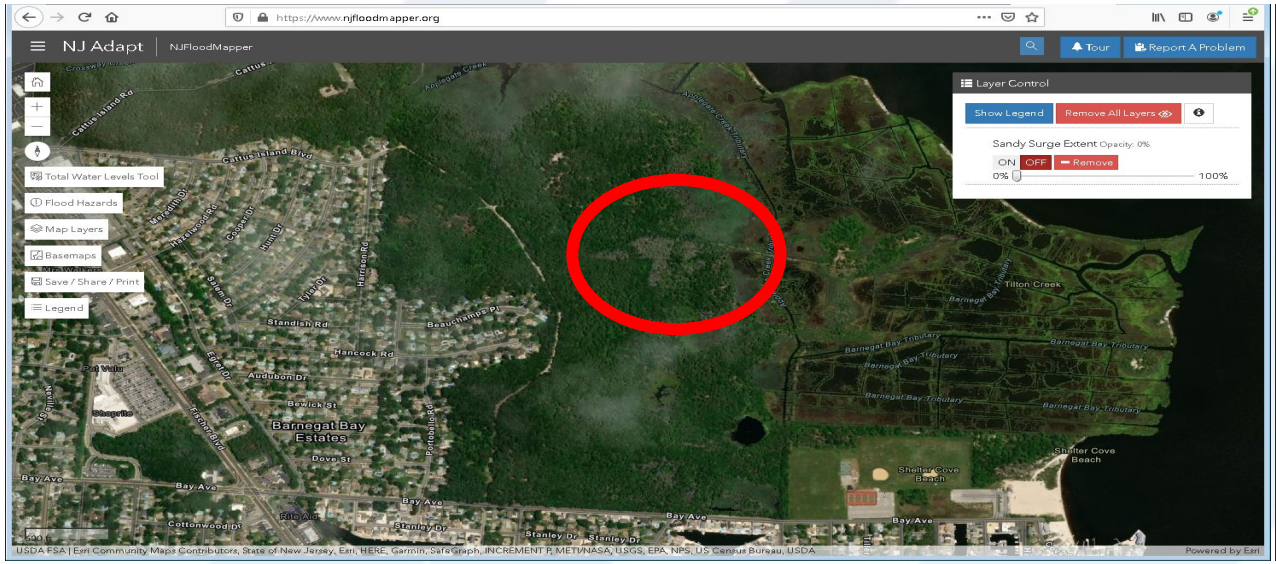
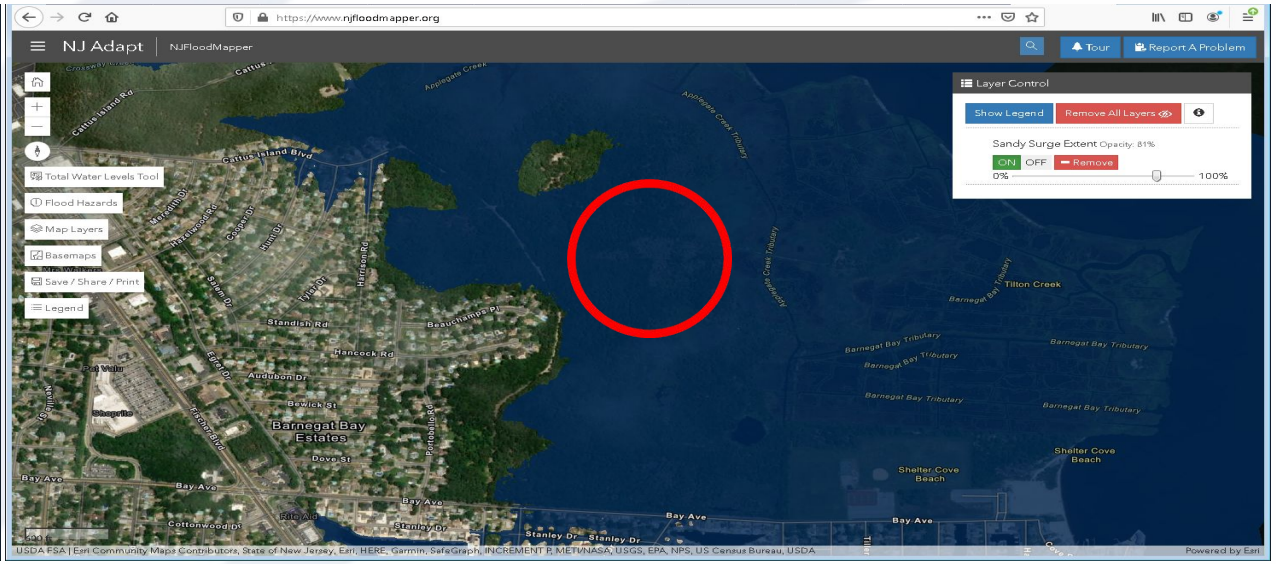
What's happening on the Marsh-Forest edge?



Without Sandy Surge layer



With Sandy Surge layer superimposed

Note red circle denotes Area of Interest.

Example of forest dieback near Cattus Point, Barnegat Bay New Jersey showing Atlantic white cedar dominated swamps undergoing both longer term gradual dieback with replacement by *Phragmites* and an extreme dieback event related to the SuperStorm Sandy surge

Coastal forest dieback precipitated by extreme storm events - Superstorm Sandy

USDA National Agricultural Inventory Photography (NAIP) True Color Imagery

2010 2013 2019

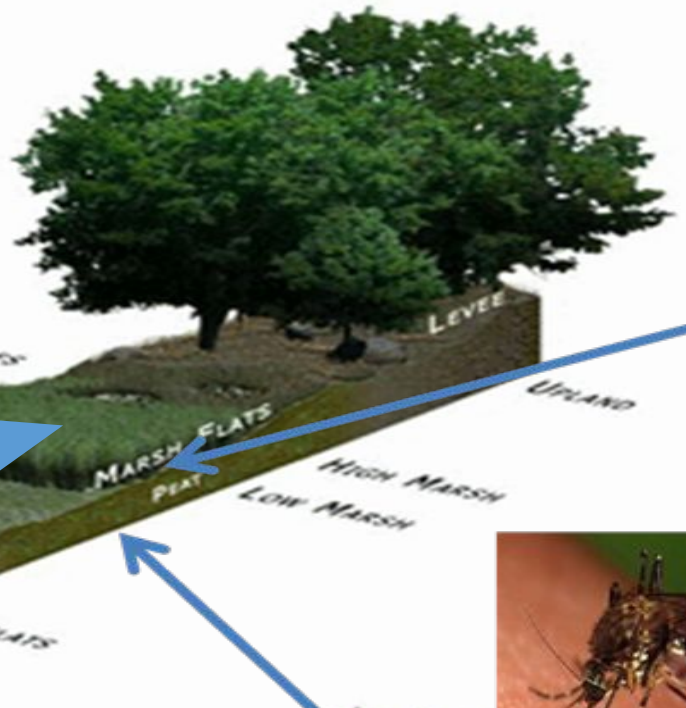
Sampling of swamp/marsh pools collected active larvae and eDNA evidence of *Aedes cantator* and *Culex salinarius*

How will a change in the coastal marsh landscape affect mosquito population ecology?

Aedes sollicitans, the salt marsh mosquito, epidemic vector of Eastern equine encephalitis (EEE)

Anopheles bradleyi, a vector of human malaria, *Plasmodium vivax*

Aedes cantator*, brown saltmarsh mosquito, *WNV and EEE vector



Graphic source: oceanservice.noaa.gov/education

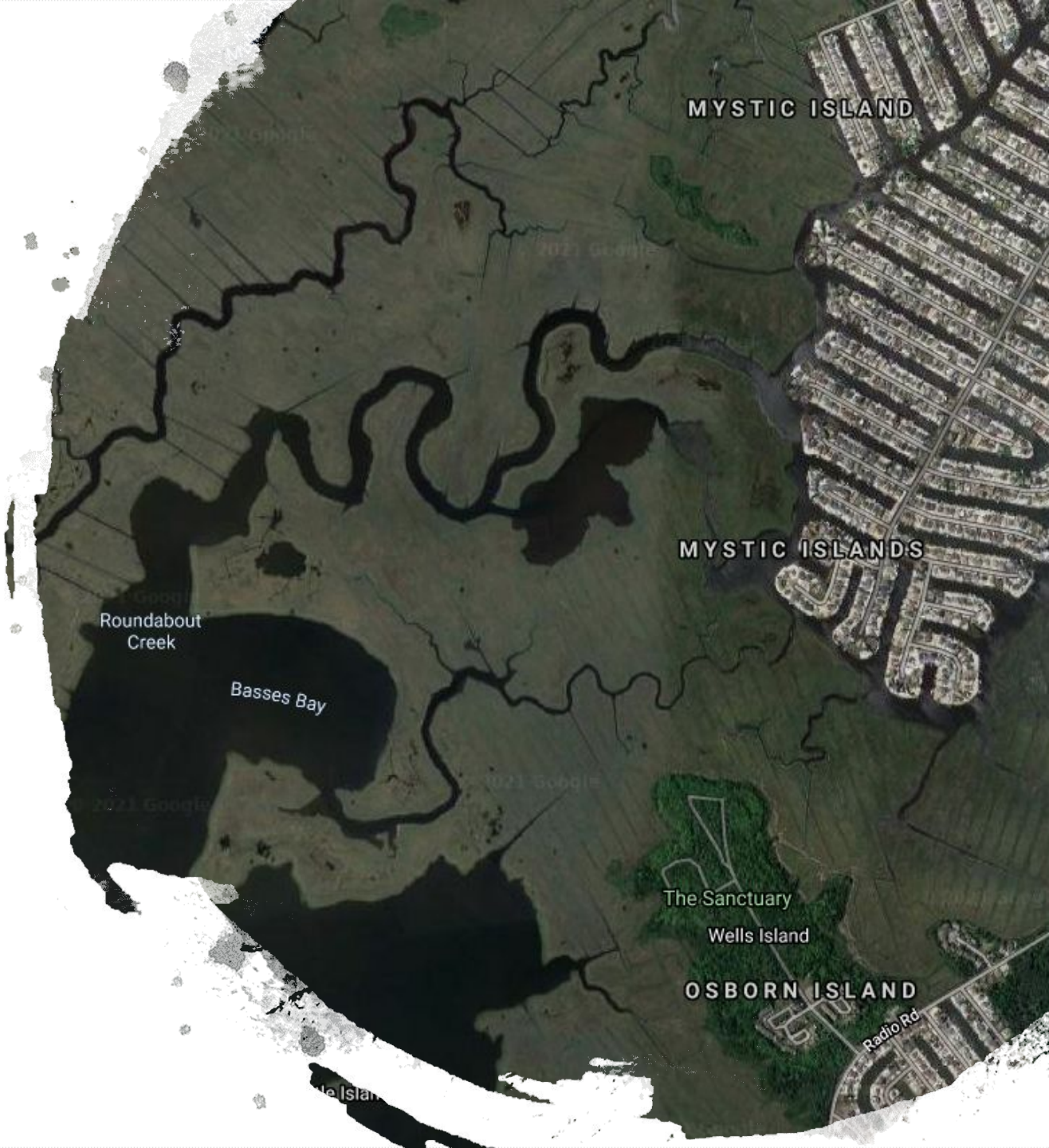
Culex salinarius, the unbanded salt marsh mosquito, WNV vector

Aedes taeniorhynchus, the black salt marsh mosquito, EEE vector

How does one survey salt marsh mosquitoes?

For over 100 years, control of salt marsh mosquitoes has been the primary focus of NJ mosquito control

- Proactive larval control: larvae don't bite
- Earlier (1900's), as well as recently (2000's), control included salt marsh modification – ditching and then OMWM
- Chemical insecticides were heavily used in the mid 20th century.
- Currently, across all coastal counties in NJ, salt marsh mosquitoes are controlled by application of biological larvicides, primarily *Bacillus thuringiensis israelensis (Bti)*



Traditionally, field monitoring relies on dip-netting of standing water looking for mosquito larvae.

Location of “hot-spots” is passed from superintendent to superintendent.

Many urban marshlands are dominated by *Phragmites (common reed)*

But how does one find the new ”hot-spots”?

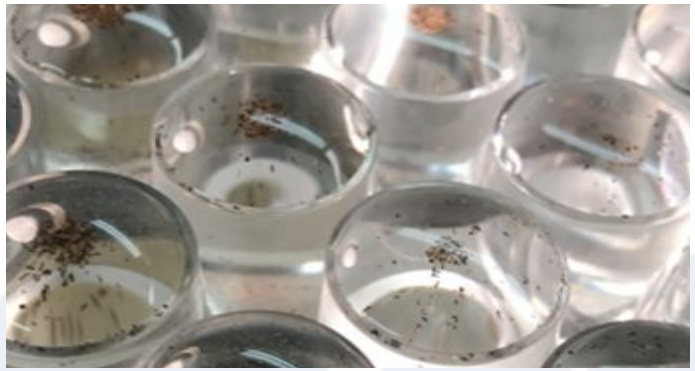
Can we develop sampling strategies that increase efficiency and effectiveness and are responsive to change?

- Four summers of field campaigns were undertaken to develop and test approaches to detect presence and monitor shifts in the distribution of different species of salt marsh mosquitoes

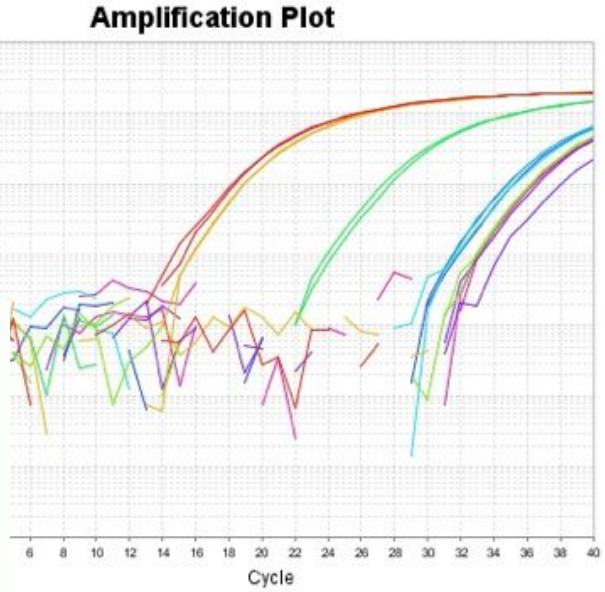
- Sampling sites were selected in coordination with 5 different county mosquito control agencies.

Initially, we combed the literature and consulted colleagues and mosquito control professionals

- Of note, in areas with effective mosquito control programs, the presence of live larvae of salt marsh mosquitoes is brief (!)
- We tried to use egg and later egg-shell sampling, which have been used in southern salt marshes



eDNA

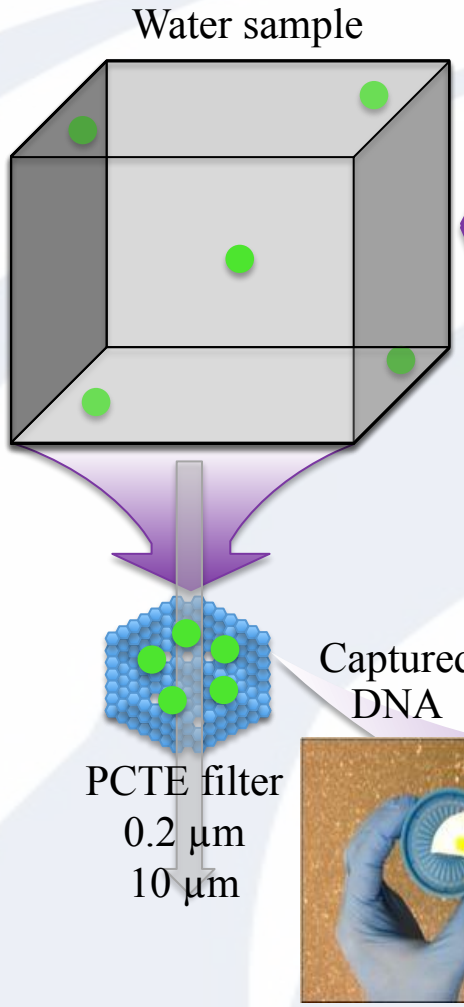


Aquatic eDNA Approach:

We have developed and optimized specific assays for:

Aedes sollicitans
Aedes taeniorhyncus
Aedes cantator
Culex salinarius

in the rRNA ITS 1 & 2



PCTE = Polycarbonate track etch membrane

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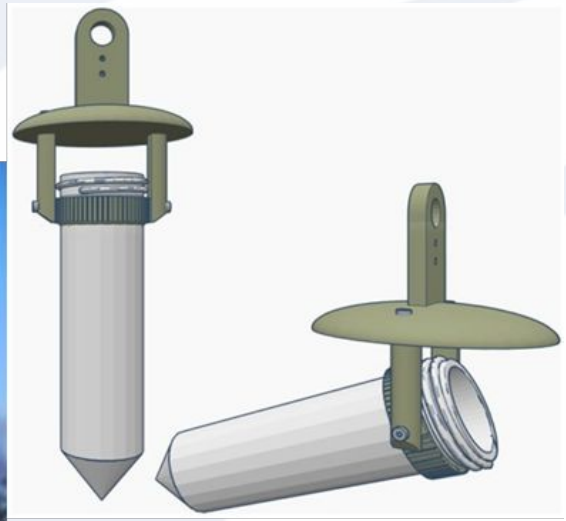
2020 field season was targeted to test the operational efficiency of the aquatic DNA monitoring approach via drone-based sampling of marsh pools

-Collected pairs of samples: by hand and drone

-Brought back to CVB lab that day for filtering and subsequent qPCR analysis



https://dronebelow.com/2019/05/29/dowse-a-drone-water-sampling-system/

50 ml collection vial

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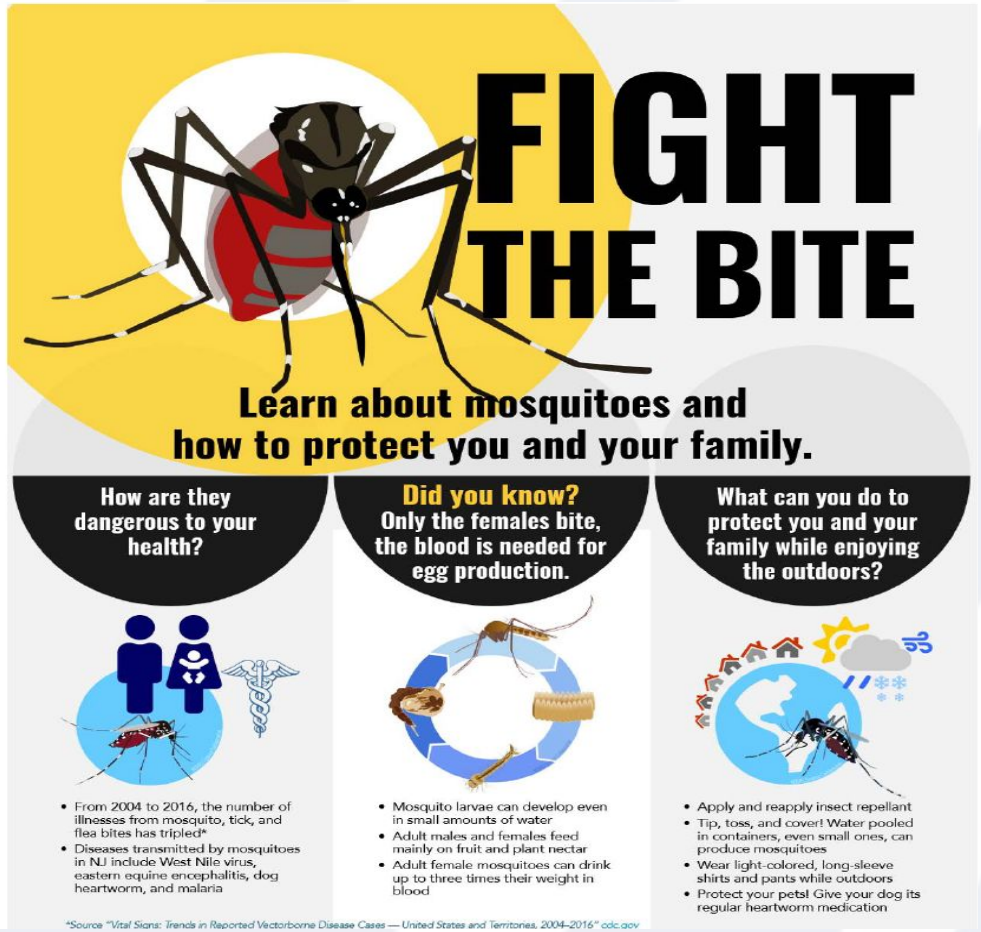
Drone-based sampling system developed and piloted by Greg Williams of Hudson County Department of Health.

More videos: https://youtu.be/whoJipYNvtU https://youtu.be/lW7CNhuzq-c?t=244

Education & Outreach – Kaitlin Gannon



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Activity 2: "Muddy Genes"

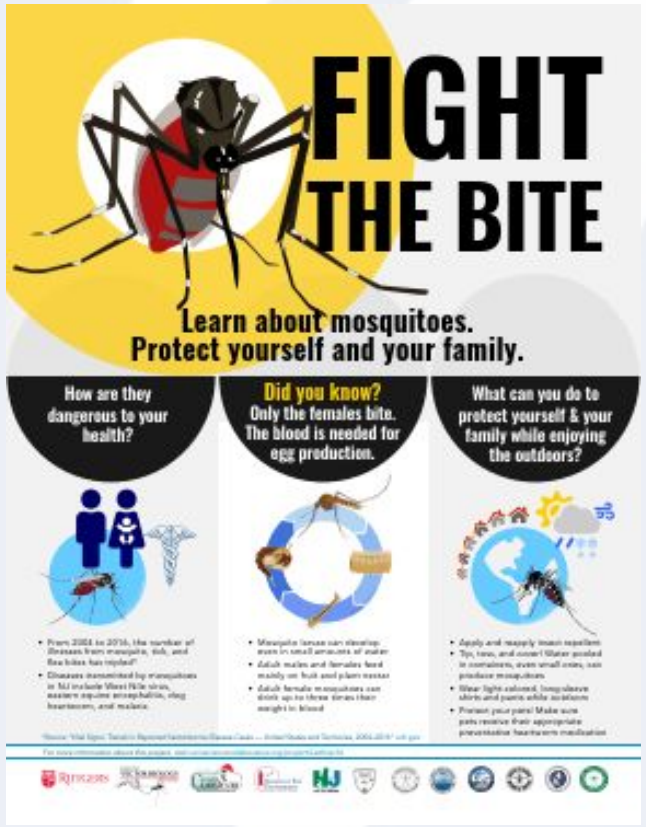
Grade: 6th grade and up
Topic: Environmental DNA (eDNA) to study habitats and biodiversity
Lesson Description: Students will understand one way environmental DNA can be used to study an ecosystem.
NGSS Standards: MS-LS1-1, MS-LS2-1, MS-LS2-2, MS-LS2-4, HS-LS1-1, HS-LS2-6, HS-LS4-2, HS-LS4-5
Learning Objective: Students will be simulating how scientists obtain and analyze environmental DNA (eDNA) and how this information can be used to make informed decisions about species management.

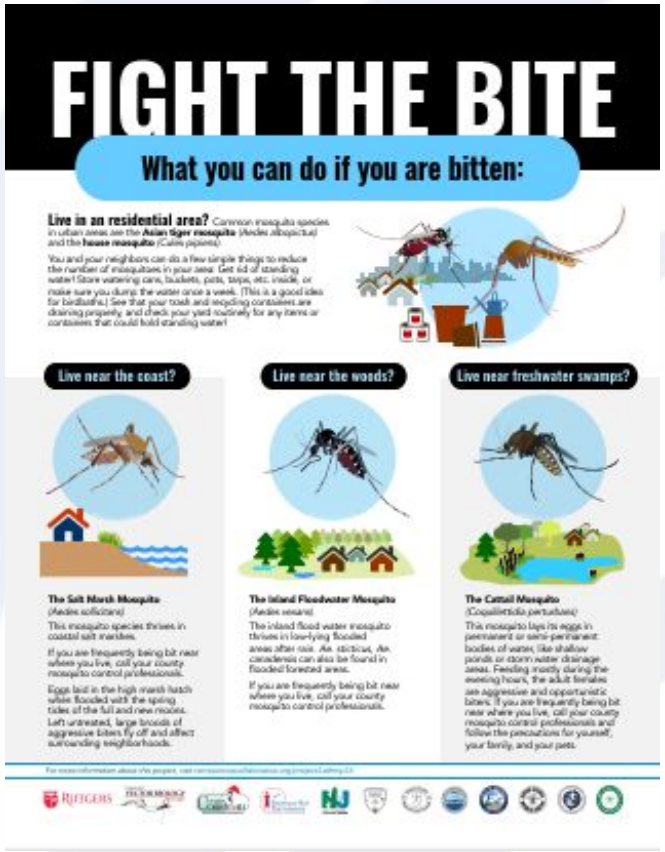
Materials:

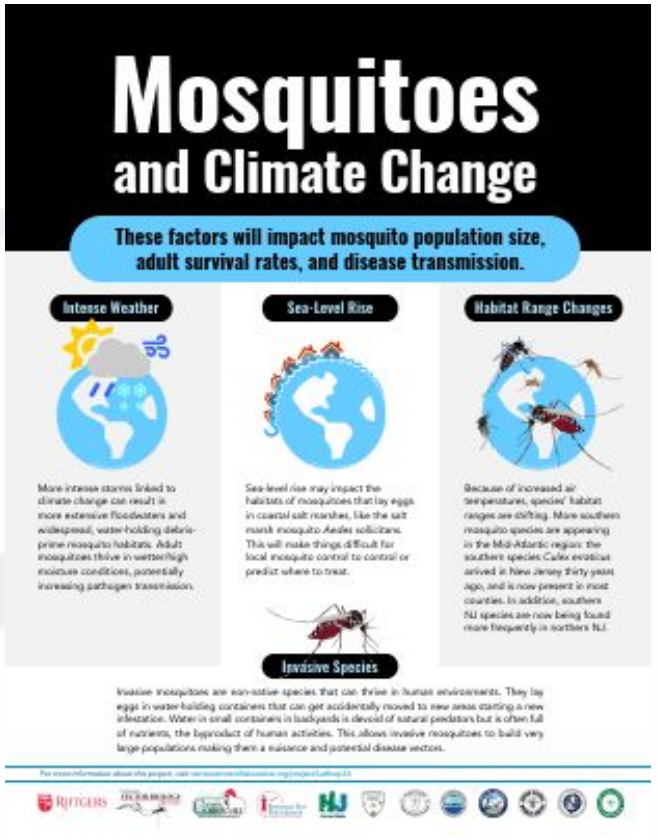
- 3 buckets (paper bags, or other deep containers)
- Multicolor beads
- 36 six-inch-long pieces of pipe cleaner in three different colors (12 in each color)
- eDNA probe worksheet

Outreach materials for end users

- Infographic development
  - For in-person and digital outreach





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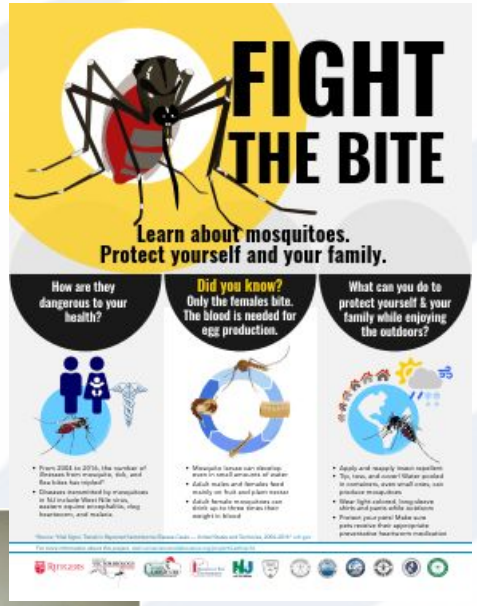
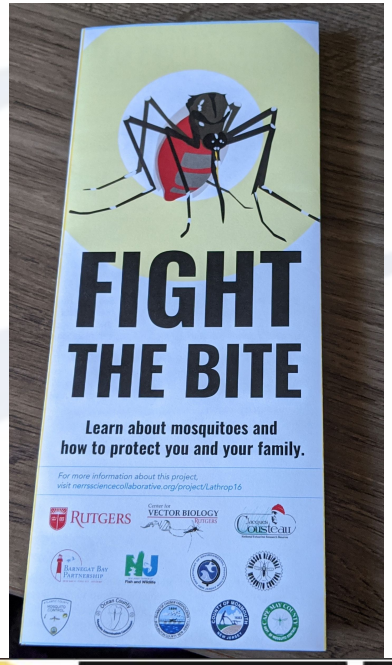
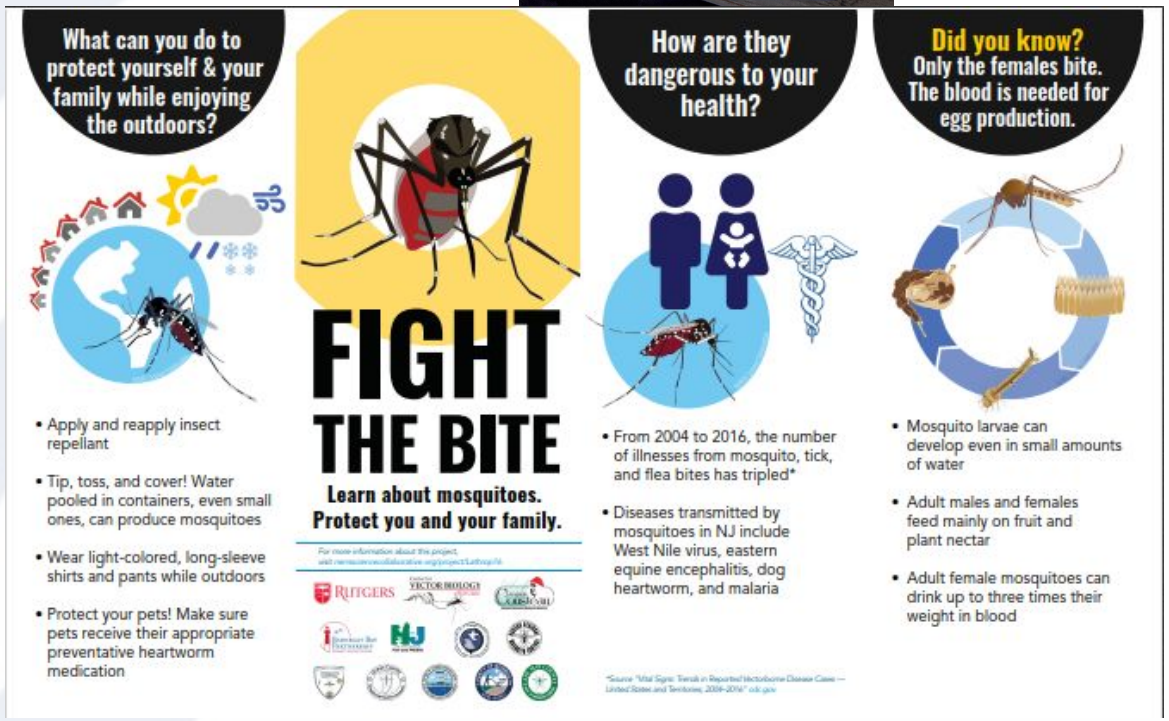

FIGHT
THE BITE
Learn about mosquitoes.
Protect yourself and your family.
How are they dangerous to your health?
Did you know?
Only the females bite. The blood is needed for egg production.
What can you do to protect yourself & your family while enjoying the outdoors?

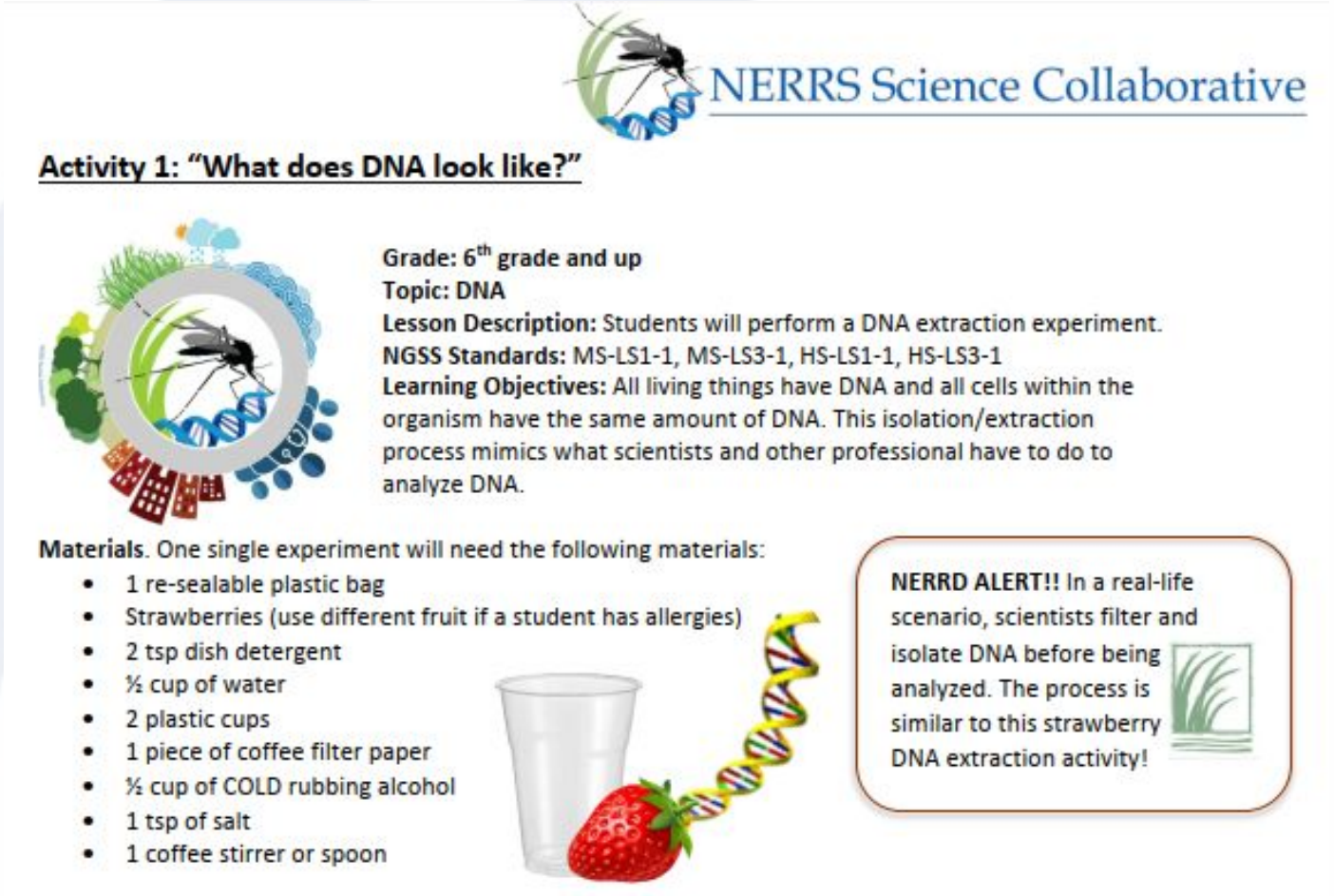

FIGHT
THE BITE
Learn about mosquitoes and how to protect you and your family.
For more information about this project, visit nerrsciencecollaborative.org/project/Lathrop16
RUTGERS


FIGHT
THE BITE
Learn about mosquitoes.
Protect yourself and your family.
FIGHT THE BITE
What you can do if you are bitten:
Mosquitoes
and Climate Change


What can you do to protect yourself & your family while enjoying the outdoors?
• Apply and reapply insect repellant
• Tip, toss, and cover! Water pooled in containers, even small ones, can produce mosquitoes
• Wear light-colored, long-sleeve shirts and pants while outdoors
• Protect your pets! Make sure pets receive their appropriate preventative heartworm medication
FIGHT
THE BITE
Learn about mosquitoes.
Protect you and your family.
How are they dangerous to your health?
• From 2004 to 2016, the number of illnesses from mosquito, tick, and flea bites has tripled*
• Diseases transmitted by mosquitoes in NJ include West Nile virus, eastern equine encephalitis, dog heartworm, and malaria
Did you know?
Only the females bite. The blood is needed for egg production.
• Mosquito larvae can develop even in small amounts of water
• Adult males and females feed mainly on fruit and plant nectar
• Adult female mosquitoes can drink up to three times their weight in blood

Education modules for teachers

- Provide new lessons for educators related to the project
- eDNA focus
- Background info, NGSS
- Grades 6th and up



NERRS Science Collaborative

Activity 1: "What does DNA look like?"

Grade: 6th grade and up
Topic: DNA
Lesson Description: Students will perform a DNA extraction experiment.
NGSS Standards: MS-LS1-1, MS-LS3-1, HS-LS1-1, HS-LS3-1
Learning Objectives: All living things have DNA and all cells within the organism have the same amount of DNA. This isolation/extraction process mimics what scientists and other professional have to do to analyze DNA.

Materials. One single experiment will need the following materials:

- 1 re-sealable plastic bag
- Strawberries (use different fruit if a student has allergies)
- 2 tsp dish detergent
- ½ cup of water
- 2 plastic cups
- 1 piece of coffee filter paper
- ½ cup of COLD rubbing alcohol
- 1 tsp of salt
- 1 coffee stirrer or spoon

NERRD ALERT!! In a real-life scenario, scientists filter and isolate DNA before being analyzed. The process is similar to this strawberry DNA extraction activity!

“Muddy Genes”

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NERRS Science Collaborative

Activity 2: “Muddy Genes”

Grade: 6th grade and up
Topic: Environmental DNA (eDNA) to study habitats and biodiversity
Lesson Description: Students will understand one way environmental DNA can be used to study an ecosystem.
NGSS Standards: MS-LS1-1, MS-LS2-1, MS-LS2-2, MS-LS2-4, HS-LS1-1, HS-LS2-6, HS-LS4-2, HS-LS4-5
Learning Objective: Students will be simulating how scientists obtain and analyze environmental DNA (eDNA) and how this information can be used to make informed decisions about species management.

Materials:

- 3 buckets (paper bags, or other deep containers)
- Multicolor beads
- 36 six-inch-long pieces of pipe cleaner in three different colors (12 in each color)
- eDNA probe worksheet

Snowy egret (*Egretta thula*)

Image from www.allaboutbirds.org

eDNA probe

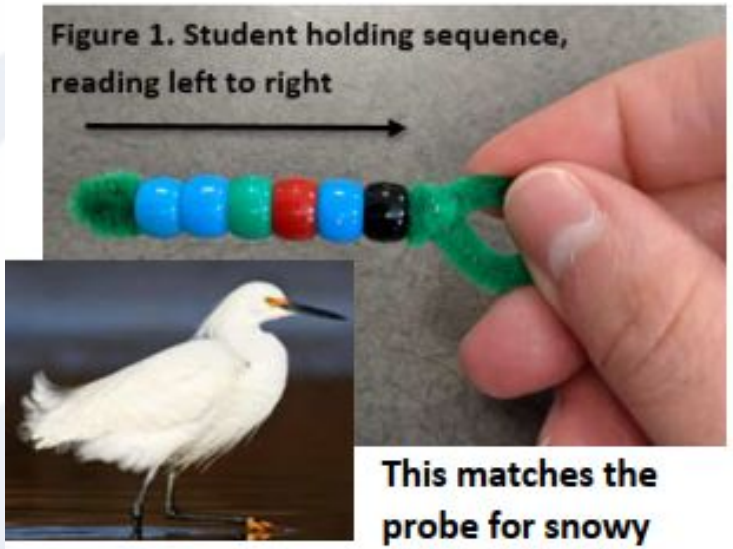
Clapper rail (*Rallus crepitans*)

Image from baynature.org

eDNA probe

Salt marsh mosquito (*Aedes sollicitans*)

eDNA probe



This matches the probe for snowy egret.

Questions & Answers

Funding provided by the NERRS Science Collaborative Program with further support from the New Jersey Agricultural Experiment Station

Q&A

Q: For the SLAMM modeling, how many different data elements were run and approximately how long did it need to process?

- **A:** We were working with SLAMM model results produced by NOAA, and integrating them together. We worked with three different SLR scenarios using a 4-mm per year accretion rate to identify locations of future change. Looking at the upland areas, we did some of our own spatial modeling to see which areas could retreat inland impeded versus unimpeded. The mapping results were also integrated in the NJ Flood Mapper web tool.

Q: Since *Phragmites* tends to have a flatter marsh surface than *Spartina*, I would expect there would be fewer/smaller puddles for mosquitoes to breed in. Have you found that to be the case - less eDNA in *Phragmites* patches?

- **A:** We have not looked at it in such a qualitative or quantitative way. We wouldn't assume that the size of the pool would be related to the likelihood that females would lay eggs there. It's not necessarily the size of the puddle; it's more likely to be associated with how long the water has been there and other microbiome factors.

Q: Was color of aerials used to differentiate between *alterniflora* and *S patens*/*D spicata* zones of marsh?

- **A:** The NEIP data comes in a true color and a false color. The newer versions include a near-infrared band as well. It's about a 1-meter scale in terms of resolution, normally collected leaf-on in August or early September.

Q: What do you think has been the biggest impact of the outreach and education materials?

- **A:** These products are fairly new, but we're hoping that it can change perspective of mosquitoes in and around your home, and help people think about these changes moving forward.

  Another helpful aspect of these brochures is that they're very informative while using a very minimal amount of space, and that they can be distributed digitally. People are often not aware of vector control agencies, and can contact their agencies to learn more with help from these resources. These resources provide readily available infographic materials for agencies and end users who may want to engage in outreach.

Q&A

Do you see this research having implications for other types of salt marshes, like those in the South, that you mentioned are structured differently?

- **A:** It's a coastwide phenomenon in terms of marshes. Each marsh has its characteristic vegetation types and is changing differently, but we'd also expect to see changes in mosquito populations as well. The overall framework, we believe, is adaptable to other locations. These four mosquito species we mentioned are common up and down the Eastern seaboard.

Q: Does an increase in mosquito populations co-occur with other climate change events like harmful algal blooms or *Vibrio* increases?

- **A:** We know that mosquitoes are temperature- and water-dependent. In general insects, if the conditions are warmer, will develop faster and produce larger populations. There have also been species of mosquitoes moving north as average temperatures continue to increase in those regions. Saltwater mosquito species have been decreasing, partially from good mosquito control, but also partially because of flooded environments due to construction or other changes.

Q: How are mosquito control professionals likely to make use of the methodology and tools developed through this project?

- **A:** It's tricky because this analysis involves a molecular lab, which many mosquito control programs don't have; but we do have similar testing done by the Department of Health. Essentially mosquito control programs can do the sampling and submit water samples for processing.

  We've had good conversations with mosquito programs that are intrigued about methods for finding these new locations where mosquitoes of interest are coming from, and there's interest in integrating some of these methods to make it easier to collect samples.

Q: Where do you see the work headed next?

- **A:** We're going to continue refining the models on how the marshes may change so we can better understand that aspect from the remote-sensing side. As we develop a better understanding of where mosquitoes are breeding, we can refine those models even more.

  From a molecular perspective, we'd like to get a better understanding of DNA longevity. From some lab experiments, we've seen that saltwater helps to preserve DNA, but temperature destroys DNA, particularly when there are a lot of bacteria present.

  The interplay among marsh restoration goals, combating climate change, and mosquito control/public health is constantly changing, and will likely continue to change as we move forward. How we handle those relationships will be of critical importance in determining success in the region.

  The K-12 materials are new, and we'd love to get some feedback from teachers and get a sense for how they might like to use them.

EXTRA SLIDES

NERRS Science Collaborative

How long can eDNA last in marsh pools?

- can the eDNA tool be used to determine whether a location is (or has been used) as a breeding site in the recent past? Over the breeding season?
- During Summer of 2020, Dina conducted a lab study with mosquitoes reared in lab and water sampled periodically over time.
- 2019 field data may also inform this question (i.e., we followed specific pools over time, so may be determine how long a pool maintained a signal after a hatch event.

What areas/locations should be targeted?

- The future modeling and marsh-upland edge mapping suggests that the marsh-upland transition zone is and will continue to be a hotspot for change.
- Mosquito commissions expressed interest identifying what species are using this area now or might start using this area in the future.

More in-depth comparison of ground vs. drone eDNA water sampling

- A proof-of-concept test at selected locations to address questions related to time/cost efficiency, with-in site effectiveness (pool edge vs. pool middle sampling or windward vs. leeward edges of pools).