SNEP Webinar 3 – Greenhouse Gas Mitigation & Adaptation: From Farms to Estuaries

Webinar Transcript

July 14th, 2022

Adam: Alright, so hi everyone. Thanks so much for joining us today and welcome to our webinar highlighting Greenhouse Gas Mitigation & Adaptation Strategies: From Farms to Estuaries. My name is Adam Reilly, and I'm the Communications Coordinator for the Southeast New England program, or SNEP here at EPA Region One and I'll be facilitating today's event, but before we begin, I just want to take a few moments to introduce you to our program.

This Southeast New England program is a geographic program at EPA founded in 2012 that encompasses three tribal nations in two States and aims to restore coastal watersheds throughout southeastern New England.

SNEP encourages a systemic watershed and ecosystem level approach to increase the effectiveness of the long-term regional restoration efforts and to increase the resilience of natural systems and the communities that inhabit them. By convening governmental and nongovernmental organizations to gather and provide their input on how best to address reasonable challenges, SNEP aims to provide a collaborative framework for the region to identify strategic restoration priorities, enable the testing and adoption of technical best practices, and build a broad regional capacity to adopt and implement innovative approaches. More information about the vision of our program can be found by referencing our strategic plan, which can be found on our website, www.epa.gov/SNEP. And this strategic plan lays out our vision for the region for the next 30 years.

Our program has two main pillars: the SNEP Watershed Implementation Grants Program, or SWIG, which facilitates SNEPs funding of on the ground implementation projects, and our SNEP network, which facilitates direct capacity building efforts throughout the region. We have two programs work in tandem to increase local capacity, collaboration and communication, and to ultimately promote sustained environmental restoration through the implementation of innovative solutions. Today you will be hearing presentations from four, today you will be hearing presentations from one of my colleagues at EPA, from two of our colleagues at USDA and a current PhD candidate at Northeastern University discussing challenges associated with greenhouse gas pollution and also ways that we can mitigate those challenges.

Today's discussion focuses on different types of greenhouse gases, but so to better prepare for this discussion, I wanted to briefly review how the potencies of these gases compared to the one we're most familiar with, which is carbon dioxide. All other greenhouse gas potencies are measured against carbon dioxide. And as you can see in this chart, our understanding of these potencies has fluctuated throughout the years, with the most recent IPCC report describing methane as 27.2 times more potent than CO_2 in a 100-year period and 273 times more potent.

And so, before we begin, if you haven't already, I'd like to remind everyone to please mute your microphones and turn off your cameras. This conversation will be recorded and made available on the SNEP website once it's transcribed and if you have a question during the discussion, please type your question in the chat box. Questions will be selected and read during the Q&A session following these presentations. Also, automatic closed captioning is available through the Microsoft Teams Options Panel, which can be found by selecting the three dots at the top of your screen.

So I'm just going to take a moment to pause and ask our first presenter Phil to start sharing your screen and I will introduce you. So our first presenter is Phil Colarusso. Phil is a Marine Biologist, National Estuary Program and protection section at EPA Region one and is a member of the EPA Research Dive Team and has over 30 years at EPA; Much of that time spent underwater contemplating the life of eelgrass, he's collected some valuable experiences on carbon sequestration, restoration, and the ecology of the species. So Phil once you're ready, you can take it away.

Phil: Can you see my screen?

Adam: We can, yes.

Phil: OK, so I'm going to talk about Regional Assessment of Carbon Resources from Maine to New York, this is actually…

Emily: Phil, would you mind sharing on your camera as well? I'm sorry to interrupt you, but would you mind just turning your camera on while you're speaking?

Phil: Sure.

Emily: And if you're not presenting, please turn your camera off.

Phil: OK. This is a work of many, many folks, but the three people who are probably most to blame are myself, Emily Shumchenia from NROC and Zamir Libohova, who is actually working for USDA in Nebraska of all places, but he's incredibly helpful in a lot of this work.

So blue carbon is, what is blue carbon and what isn't it? So blue carbon is associated with seagrass, salt marshes and mangroves within the tissues of those plants, but also more importantly than the sediments around them. It does not yet include, despite some people trying to promote these as blue carbon habitats, kelp, macroalgae, phytoplankton or even marine mammal carcasses falling to the deep ocean. The three habitats I mentioned all sequester the carbon, the ones on the right, and recycle the carbon. And so as of right now anyway, the traditional classification of blue carbon only encompasses those three on the left.

So I convened a group of experts throughout New England and New York. These people, none of who are in the actual picture, but these people work for a variety of Federal and State agencies, academic institutions and nonprofits, and they all either map these habitats or they are interested in collecting and have been collecting data in the carbon density associated with these habitats.

And so our work, we've divided our group up into two work groups, so a mapping work group and a settlement carbon work group based on people's area of expertise.

And for the habitat mapping, for salt marshes we started with the national wetlands inventory maps, but we found the really neat data set in the literature, Correll et al, which are investigators from UConn, had done some high-resolution mapping, primarily for avian research purposes, not for necessarily saltmarsh mapping purposes, but they had mapped from Maine down to the Mid-Atlantic at a 3-meter resolution, which is much higher resolution than the NWI maps, so we use that data set. And in both the NWI and the Correll et al data said there was small data gaps in the Massachusetts coverage and we supplemented some of that mapping data with the mapping data that Massachusetts DEP does for their wetlands and those gap areas, which is primarily around the New Bedford area. For eelgrass, each state collects their own, has their own mapping efforts, and we collected all of that data, the most current data from each state that we could find in the historical data, so we have data we can use for a trend analysis, which is one of our next steps.

For the soil carbon data, this is just a geographical depiction of where our samples are coming from and a variety of different sources so that you can see the USDA has been very gracious in providing a fair amount of soil data for us, even in the estuarine environment and a variety of academic studies and peer reviewed journal publications and EPA's National Wetlands Condition Assessment Program as well. But you can see we have a fairly good geographic coverage of our area of interest. The level of effort is not equal between the habitats, there's a lot more salt marsh data than there is eelgrass data but you have to work with what you have.

So one of the big challenges is merging all of this data, especially from all these different sources. And you'd be surprised, something as simple as knowing where the cores are taken from and what vegetation type they are associated with, was in some cases a challenge because not everyone is collecting this data for the same reasons and so GPS coordinates may be very general, not very specific, people may not record the vegetation types of they're in a salt marsh, they may not say it's high marsh or low marsh, or it's salt marsh at all, they may just say it's, you know, vegetation, so we actually had to ditch a fair amount of data because we could not verify the exact vegetation type or the exact location. Most of the core links were only 30 centimeters, so about a foot, and some did go deeper, a few were shallower, but to maximize our data we cut everything off at 30 centimeters, acknowledging that that is an underestimate of, you know, the amount of carbon these habitats are actually storing. So, if you think about a salt marsh at low tide, there are feet and feet of peat, and so these this data only reflects that top 30 centimeters.

And everyone who's doing this is, of course, doing it for their own purposes, so they're subsampling those cores at different intervals for different reasons and so we had to do some analysis to look at whether that actually made a difference or not. And again, people are using slightly different analytical methods, so quite common is a loss on ignition. But people also use an elemental analyzer to measure the actual amount of carbon. And then, again, people are doing these for different reasons. So when you get percent carbon, you also need dry bulk density to be able to calculate the amount of carbon in your sample and not everyone was measuring dry bulk density so we had to develop a model correlation from the rest of our data set to fill in those some missing data points.

So I said most of the cores were 30 centimeters, subsamples were all over the place, so we what we did was we looked at averaging over that 30 centimeter horizon versus averaging over each of the sub samples and summing them and we got a very strong relationship as you can see, the other squares are upwards of, you know, high point nines, so we decided it was sufficient to just average over the entire horizon of the cores going forward.

We also, this is from data from my team where we split our samples and we looked at loss of ignition versus %C using the elemental analyzer and dry bulk density, and again got a very strong relationship so how you measure the carbon is important as to actually measuring it. We felt comfortable using either the more common methodologies.

And so for the missing data, we took all of our data and graphed bulk density versus percent organic carbon and got a pretty good fit. But you can see on either end of that curve, you know, there's a couple of points that are off so we came up with, this is all Zamir's work and came up with a couple of different ways to model those relationships to kind of rectify the variation and using the exponential model and a mixed model and the mixed model, they both have pretty good agreement in our squares and the .8, the mixed model tended to underpredict the bulk density a little bit so we end up using the exponential model to go to predict dry bulk density in the missing data set.

So we ended up looking at how do we assign carbon density values, you know, can we look at different vegetation classes so, you know, is there a difference between high marsh and low marsh? Is there difference in latitude as you go from New York to Maine? Is there difference in exposure? So if you're on the open coast versus an abatement. And we found that with the variation basically these are the only three classifications that were statistically significantly different based on our data was the was Neil Grass classification, a salt marsh which encompasses both high and low marsh and Phragmites and the Phragmites being, you know, estuarine or saline Phragmites, not, we're not talking about freshwater Phragmites.

And so we use the carbon density values and we bring them together with the habitat maps to create something we call blue carbon heat maps. These are color-coded maps that give you an indication of, you know, quantity of carbon in any geographic area.

And the way they're created is, and this is all Emily's work, the way they're created is we have these 30x30 meter grid cells that are stacked and if there's high marsh or eelgrass or Phragmites any of those grid cells, those totals are summed to give you a particular color.

And this is what the large-scale map looks like, the heat map, which is not very impressive from this scale, but when you zoom in, you know that's the great marsh in the North Shore, Massachusetts and Great Bay, New Hampshire, you can see the purple is all grass in Great Bay. These maps eventually will live on the Northeast Ocean data portal where the current habitat maps exist right now, and they'll be, you know, you can play with them, you can zoom into the area that you that you want and you can manipulate or you'll have some ability to manipulate these maps to some extent.

So we are, you know, summed the totals of all these habitats and Massachusetts by far is contributing the most habitat acreage in our geographic area and most of it is in the high marsh category or the salt marsh category, I should say, so just about half of the total habitat acreage is in Massachusetts itself and the other states contributing the balance. And so how does that convert to… Sorry to carbon stocks? And so this is in mega grams of carbon, you know over 7 million mega grams of carbon, and again, most of that is tied mostly in the marsh category and most of it's in Massachusetts, so what does that actually mean? What does that translate to?

So 7 million megagrams of carbon is about equivalent to 18 billion miles driven by an average car; it's the amount of energy use in one year for over 1.4 million homes, it could charge an incredible number of cell phones, it's the amount of energy generated by 2000 wind turbines running for a year, and this the amount of carbon sequestered in 8.6 millions of forest in a year, and it's equivalent to the amount of emissions from 8 billion pounds of coal so it's a substantial amount of carbon. All these numbers are generated from the EPA website that allows you to convert CO_2 or other greenhouse gases into, you know, these kind of fun facts. And again, I want to remind you this represents just the tip of the iceberg that these habitats hold, the top 30 centimeters, so the actual number you know is some multiple of this. And so we look at this as a resource that is important to sequester carbon going forward but it's also a potential source of carbon if these habitats are lost. Some of our data, some of our the data that I've done looking at carbon sequestration and eelgrass meadows shows that a lot of that carbon is decades to centuries old and it will stay in place as long as those habitat stay intact, but if they're lost, that carbon will be recycled into the system. And so, you know, these habitats potentially represent a significant source of greenhouse gases back to the environment if they're not conservative protected.

So some of the next steps with our analysis, we have the time series of eelgrass data, so we're gonna do a retrospective blue carbon mapping with historical habitat data. Just to see how much potential blue carbon has already been lost, capacity has been lost, just due to habitat loss through time. And we've been asked by our state partners to consider expanding into kelp and other macroalgae as part of this analysis and there's less available data on those habitats, but you know we will certainly consider that and pull together what we can. And then we also want to look at the co-benefits of these habitats, so they do a lot more than just sequester carbon, they're important for fisheries and coastal protection, primary production, et cetera. And so we don't wanna lose sight of those other important ecosystem values.

And so. There's contact information for Emily, Zamir and myself. Again, a lot of this will be on the Northeast Ocean Data portal if you wanna play with the data, there's a report that would be coming out very soon from EPA to go along with the mapping products on the data portal. And that is it.

Adam: Thank you so much. Phil, if you have any questions for Phil, please do type them in the chat and we will address those towards the end of the presentation. But next, I would like to welcome our next presenter and Brian, if you want to take a moment just to start sharing your slides while I introduce you. So our next presenter is Brian Donnelly. Brian is a fourth year PhD candidate in the Department of Marine and Environmental Science at Northeastern University, studying how coastal systems functions will change in the face of climate change on the microbial and biogeochemical levels. Brian's primary focus is on the multiple stressor impacts of nitrogen and carbon cycling in tidal systems. So with that, Brian, the floor is yours. And Brian it looks like your microphone is muted.

Emily: You're still muted, Brian. You're muted. You know, OK.

Brian: Sorry, it wasn't letting me screen share and also get back to Teams. So, can you all see my screen?

Emily: Not yet.

Adam: Yeah, not yet.

Brian: OK.

Adam: Yeah, it might be easier to kind of exit out and then like exit out of screen share and then enter back in.

Brian: Yeah. Oh, here we go. Hold on, now you should be able to see them.

Emily: Not yet.

Brian: Sorry for being late too, I was having a day.

Adam: No, no worries at all.

Brian: OK.

Adam: Brian, we'll give it one more try.

Emily: If we need to I can share the slides.

Adam: Yeah, why not.

Brian: Yeah. Let me do the faster way to do it, it's giving me issues.

Adam: Yeah. OK, let's just go, we can go ahead and do that.

Emily: Can you all see this?

Adam: We can, yeah, if you just kind of can go full screen.

Emily: Yeah, yeah, I will, I'm just doing that.

Adam: Beautiful. All right. Thank you everyone for your patience. Brian, it's all you.

Brian: Awesome. Thank you so much and sorry for being a little bit late, had some sampling and some Wi-Fi issues, but as Adam mentioned, I'm a PhD student in Gen Bowens lab at Northeastern, and today I'm going to talk about Multiple Stressor Impacts on Microbial Community Structure and Biogeochemical Cycling in Tidal Freshwater Wetlands.

Can advance slide. So still touched on them briefly, but we know that these tidal freshwater systems have a wide variety of ecosystem services, they provide a wider habitat for a wide array of flora and fauna at multiple life stages, they can act as storm surge protection, as they're basically a giant coastal sponge that can absorb a lot of water, and they can also help attenuate the waves that are coming from these storms that may be coming from offshore. I'm also getting a little bit of feedback, I don't know if someone has their microphone on. But the two that I'm going to talk about today are the fact that they can store carbon for long periods of time, so they have very high primary productivity rates, which means that the plants in these systems pull carbon dioxide out of the atmosphere, use it for photosynthesis and store it in their biomass, or expel some of that into their root systems as well. And then that, combined with the sediment systems being very anaerobic, meaning that there's no oxygen there, allows for them to store that carbon that they're pulling in through photosynthesis for really long period of time because they don't have the electron acceptors that they need to break down that carbon at high rates. They're also really good at removing and recycling nutrients before they reach the coast, so as humans have altered the landscape for centuries now, we've been adding more nutrients in our runoff to these systems and when those nutrients reach the coast, they can have potential deleterious effects. The limiting factor of growth, and so when we add a bunch of nitrogen, whether that's from fertilizers on our lawns or in agriculture, that often runs off into these systems and provides LG with the necessary nutrients that they need to grow, creating large algae blooms, which eventually die away. The microbes in the water then break down all of that algal biomass, depleting all of the oxygen in the water, creating a dead zone where life cannot exist. However, these tidal Freshwater Systems Act as a last line of defense for those nutrients and can pull in those nutrients and either remove them or recycle them from the system before they reach the coast and have create all of these problems.

We can go to the next slide. As we know, sea level rise and climate variability are real things that are going to be happening in the future, and they're threatening these potential services. Sorry, you can click once. So saltwater intrusion can cause shifts and biogeochemical cycling so that nutrient cycling and carbon storage, and can also alter the microbial community structure by altering the amount of nutrients that are there and different electronic sectors that they can use to perform all of these important ecosystem services. You can click again. As we know, temperature stimulates all of these different decomposition and metabolic processes so by increasing sea surface temperatures we would be stimulating these carbon breakdown processes that are going to put that carbon back into the atmosphere instead of locking them. In these systems that store them for long periods of time. Next bullet. And it's also been hypothesized that these dominant nutrient removal processes are potentially hammered by salt addition which would come with that sea level rise.

Next slide. However, a lot of these studies just look at these different environmental changes in isolation. So this study here shows that with increased salinity in the porewater denitrification rates drop off. But as we know, with climate change and sea level rise, these stressors aren't going to happen in isolation, they're going to be coming together in tandem. So at sea level rise, we would expect not only salt your water to creep further up into an estuary into a historically freshwater region, but that water is also going to be warmer, so it's important to look at both of these stressors together.

Next slide. So the nitrogen cycle is a really complex cycle happening in these systems, but for the purpose of this talk, we're just going to focus on this simplified version, which looks at the fate of nitrate in our systems. So nitrate is in a lot of fertilizers, this is washing off into systems, into coastal systems, but these title freshwater wetlands are really good at removing and recycling it. They can remove this nitrogen, this nitrate, by performing a pathway called denitrification which you can see here on the left-hand side where nitrate is then reduced into N2 gas through a multi-step reduction. Each of these steps are mediated by a microbial enzyme. However, each of these microbial enzymes have varying sensitivities to environmental change, specifically nosZ, the enzyme responsible for transforming nitrous oxide into NQ gas is particularly sensitive to environmental change. And if you just click once, we get a plot. So here in this slot here you can see that NO production increased with decreased pH, so the environmental pH changed and we saw more N2O production which could be a sign of this nausea gene being inhibited by decreased pH. It's expected to also be sensitive to a lot of other stressors including salinity, so if we increase salinity in these systems, which will happen with sea level rise, we could potentially inhibit that last step of denitrification producing nitrous oxide instead of N2. And as Adam mentioned before, nitrous oxide is a really potent greenhouse gas with the warming potential that of almost 300 times that of sea level rise or CO2, and so one molecule of N2O does the warming that 300 molecules of CO2 does. Another important step here that could happen with that nitrate is DNA or dissimilatory nitrate reduction to ammonium, where they transform that nitrate into ammonium, which is then more readily assimilated into plant biomass, so that represents more of a retaining of nitrogen in the system as opposed to denitrification, which would be a removal pathway.

Next slide. So the objectives of the study are to investigate the shifts in dominant nitrate reducing pathways to potentially determine future nitrous oxide source potential of tidal freshwater wetlands. So with title freshwater wetlands, they mainly perform that denitrification stuff, allowing for that N2O to be transformed into N2 before being admitted. However, this could potentially change and have Microsoft side be the final product of that making these wetlands more of a source of N2O instead of a sync.

You can go to the next slide. So how do we test this? So we found a beautiful title freshwater wetland up in the upper reaches of the North River and the historically freshwater region you can see in this photo here, there’s incredible plant diversity and it looks like a really healthy marsh and very little salt gets up this far in the systems.

So we can go to the next slide. And we were able to test this hypothesis by using something called the flow through reactor. So this is just a basic diagram of a flow through reactor, so what we have is a reservoir of water that is then pumped very, very slowly through these reactors from the bottom out through the top. And so we can measure pretty much anything that we want from the reservoir water and then also the water that's coming out of the reactor, taking the difference between those concentrations and dividing that by the residence time, so how long the water remains in the reactor to be able to establish a rate over time of which something is either produced or consumed. And Emily, if you just wanna, sorry I have bullet points that pop up if you want to just put them all up there and that should be the last one there. So we took sediment cores from that site, brought them back to the lab and packed them into flow through reactors. And then we changed the temperature and salinity based on what treatment we wanted. So the ambient temperature of water at this site during time of collection was 25 degrees C, so that represented our control. And anything in the orange box here we elevated the temperature up five degrees to 30 degrees C, which would represent the potential warming that may occur in this region over the next 100 years. And then anything to the right of the red dotted line received brackish water instead of their normal freshwater, which was a salinity of 10 parts per thousand. So this gave us basically four treatments of a control which was 25 degrees C and freshwater and increased temperature, which is 30 degrees C and freshwater, an increase salinity treatment, which received the same temperature water as the control but received brackish, and then finally a multiple stressor treatment which had that brackish water and increased temperature. We flowed the water very, very slowly to allow for the nitrate that we added in here to be used up so we spiked the reservoir water with isotopically heavier nitrate so that way we can track it through the system using mass spectrometry.

And we can go to the next slide. Which I think is, so yeah, so you can click through, there's a couple bullets. So we were able to establish these rates of both denitrification and N_2O production and DNA across eight time points over 45 days establishing rates, I kind of mentioned earlier, so I think we're going to jump straight into some results.

And so just looking at this here, just to orient you a little bit, all of these plots will have the different rates on the Y-axis going up and then time point, which is in weeks on the X-axis. So just looking here at the first five time points, we can see that the control, this is also looking at denitrification, the control plots are in pink and the increased salinity ones are in this light blue, and you can see that while they may not be significantly different from each other, there's definitely a drop off of denitrification in the increased salinity treatment for these first five time points. And click again. However, when we add in these increased temperature in purple in the multiple stressor in red, we can see in time points 2, 3, and 4 that we had increased rates of denitrification, which is what we would expect to see as we saw as it's well known that increased temperature stimulates these different rates. However, it is surprising to see that in the multiple stressor treatment that we also saw increased denitrification rates whereas the salty sites. the salty treatment we saw decreases, I would expect to probably see less denitrification in those, but this could just mean that temperature has more of a hold on denitrification rates here. And then if we want to click again. And then looking at the last three time points, all of our treatments had nonsignificant differences in their denitrification rates, which could mean that these microbes have already adjusted to the treatment that we gave them by that time. And so that salt addition didn't necessarily show the same effect throughout.

Next slide. This is now looking at nitrous oxide production and the big screaming red box kind of orient you to the point here that in the increased salinity treatment across all time points had higher rates of N2O production which could potentially mean that that last step of denitrification is being inhibited so that enzyme production of NOSc could be inhibited, which we kind of saw in those first five time points on the last plot of that drop off of denitrification, now we're kind of seeing that nitrate is going towards end two production instead. However, we didn't necessarily see this in the multiple stressor treatment so this could mean that salinity is really the main driver and two production. One other thing to note here. If you look at the scale of the Y-axis, it's a lot smaller than the denitrification rate access, however, these systems are known to be nitrous oxide sinks, so any little bit of this nitrous oxide coming out of the system means that they're becoming more of a source, and it's very potent in the atmosphere so while as it's not as concentrated, it still could do some warming. Next side.

Adam: Brian, we have about a minute left.

Brian: OK, I'll blow through this really quickly. So DNRA, we see that in the multiple stressor treatment we saw increased rates of DNRA and this is most likely due to that salt addition. Salty water has a lot of sulfate, sulfate has been shown to inhibit denitrification which would allow for DNRA to use that nitrate DNRA is not necessarily as competitive for that nitrate and ambient conditions so by adding that sulfate, we're potentially inhibiting denitrification and allowing for a DNRA to spike.

Next slide. So in conclusion, salinity was the main driver in inhibiting denitrification. Salinity also drove up nitrous oxide production so the saltwater intrusion could potentially change these systems from a sync of in N2O to a source and then the multiple stressors treatment increased rates of DNRA probably because of sulfide.

One more slide. Next steps. We want to evaluate how these changes in nitrogen cycling affect decomposition rates so that carbon does this change in nitrogen cycling affect how much carbon is being decomposed and how quickly? We want to look at the actual microbial communities that are there to see how they're shifting and how this underlies all of these biogeochemical cycles. We can skip through the last two. That's a little bit further, few more acknowledgements. Sorry for running overtime, but thank you very much for having me.

Adam: Excellent. Thank you so much, Brian. And if you do have questions for Brian, please do type them into the chat so that we can address them towards the end. Next, I would like to welcome our next presenter and Elizabeth, if you wouldn't mind sharing your slides while I introduce you. Our next presenter is Elizabeth Marks. Elizabeth served as the biologist for the United States Department of Agriculture, Natural Resources Conservation Service, or USDA, and NRCS in the Hudson Valley, which is in New York, specializes in helping farmers and land owners, excuse me, farmers and land owners understand how the climate is changing and what they can do to adapt. She received her bachelor's degree in biology from Mount Holyoke College. Elizabeth, thanks so much for joining us and the floor is yours.

Elizabeth: Hi, everybody. Thank you so much, this is such a great webinar. You've heard the surf portion of the webinar, now it's time for the turf portion and I'm gonna be talking about Climate Smart Agriculture in Massachusetts and Rhode Island.

So just to start with a definition of what climate smart agriculture and forestry is, it's really agriculture that sustainably increases productivity, resilience, which is adaptation and reduces or removes greenhouse gases, so the mitigation. It also has some other terms, but really we're looking at these win wins where you can have farm be more resilient to these climate changes as well as to help mitigate what is causing climate change.

So I work for the Natural Resources Conservation Service and essentially we've been doing this since the Dust Bowl, helping farmers and forest donors adapt to climate changes in climate. So I think one of the things that is helpful to understand how to adapt is to understand how the climate is changing. So in this next portion of the talk, I'm pulling information from the 4th National Climate Assessment. We are working on a 5th National Climate Assessment and hopefully that will come out soon.

So overall, the global temperatures have risen about 2.1 degrees Fahrenheit since 1880, but you can see that not everywhere is warming at the same rate and some places have even cooled a little bit.

So if we look at the United States and, you know, you can zoom in on Massachusetts and Rhode Island again, we've got portions of the US are warming or cooling at much different rates. The northeast is warming quite a bit because the Gulf of Maine is one of the fastest warming oceans in the world whereas if you look at the Southeast, they've actually experienced a little bit of cooling over the last 125 years.

Not only are portions of the world not warming at the same rate, but the seasons are also warming at different rates. And if we look at winter warming, the Northeast has experienced quite a bit of warming just since 1970. So in Rhode Island, Massachusetts, you're looking at three to four, almost five degree warming since 1970. And for those of you on the call who have grown up in that area, you've experienced this, right? You've seen how maybe when you were a kid, I've certainly seen this in New York as a kid, you know, really consistent winters with a lot of snowfall to maybe we get snow, maybe we get a lot of rain.

The other big change that's happening is rainfall, so here's a look at rainfall patterns in the United States. You can see the Northeast and Midwest we've really seen a big increase in precipitation, while some of the drier areas are becoming much more dry.

And if we break that down by season, you can see that we've got changes in our rainfalls in the seasons. And I don't know if anybody can see like what jumps out, but what jumps out to me is if you look at that fall precipitation, we're getting a lot more precipitation in fall, maybe not so much in spring, which is when we really need it, we need that spring and we need that good consistent summer precipitation.

So if we look specifically at Massachusetts and Rhode Island, we'll get into that, but the information from this next section came from NOAA State Climate summaries. These are excellent four to five page fact sheets that are summarizing. How the climate is changing and the trends for each specific state. So if you're not from Massachusetts or Rhode Island on this call, I urge you to look this up and maybe somebody might wanna put that link in the chat.

So if we look at Massachusetts, Massachusetts is warming a little bit at a higher rate, more so than the world on average. So average temperatures have increased almost 3 degrees Fahrenheit and you've got warmer winters, so maybe in the past you have had frozen soils and a blanket of snow over the winter; Now these winters are going to be more rainy, you'll have more freeze thaw which is really a big issue when it comes to bare soil over the winter time. So if you've got bare soil over the winter, no cover crops, that's going to be a much bigger issue. Average rainfall has increased 17% since 1895 and extreme rain events over 2 inches has increased almost 100% since 1950. And those rainfalls over 2 inches, that's pretty difficult for farmers to handle. You know what you want is nice, gentle rain evenly throughout the growing season, but when you get these sudden big bursts of rainfall that can be quite damaging to crops.

So you can just see some of the increases in that rainfall and the most recent 10 years have been the wettest on record.

And these are the number of extreme precipitation events. The bottom is how it compares to the United States as a whole and the top is just Massachusetts.

So for those of you in Rhode Island, I don't wanna say congratulations, but you are number one as the fastest warming state in the continental US. So average temperatures have increased over 3 degrees since 1900. Average rainfall is increased about 13% since 1895 and extreme rain events has increased 50% over 1950.

There's some of the precipitation data for Rhode Island.

Alright, so now that I've depressed you, I wanna give you some solutions and this is why I'm so optimistic about climate smart agriculture and forestry in the US, because there's such win-win strategies that not only help a farmer or producer be more resilient, but can also mitigate some of these issues, some of the climate change things are being caused by increased greenhouse gases. So we're really looking at improving soil health, increasing organic matter, improving soil structure, keeping soils covered and keeping plants growing throughout the year.

Soil organic matter is going to be the number one tool in a producer’s toolbox to be resilient to all these changes, this increased rainfall, the increased intensity of rainfall because it's going to allow increased infiltration and help the soil retain moisture. We want that water to go into the soil and stay there because even though we're seeing an increase in rainfall, we're also seeing an increase in drought; How can that be? Well, because our rainfall is coming in larger storms. Last year in New York, we got quite a bit of rainfall and I have a picture of a parking lot where the water was up at the level of the tops of the cars, and at that point in July we were at average rainfall. So even though we had this huge storm where we got 7 inches in less than 24 hours, because we were in drought up to then our average rainfall, we were just at average at that point. So increasing a solar organic matter reduces erosion and has all sorts of really amazing benefits including holding nutrients.

So the solution is to increase organic matter and we want that organic matter in the soil because it's taking it out of the atmosphere. And how do we do that? By increasing roots. Roots are a great way to put organic matter into soil, it's what makes United States great because we have those plains, you know, the whole plains where all the Prairie grasses were sequestering that carbon and now we farm those areas. You can also top dress with organic matter and then you wanna keep that carbon in there by reducing tillage.

I thought this was a great study that I came across, that it soil organic matter really helps protect against drought.

So this increased rainfall, it's going to make areas with compacted soils a lot more difficult to farm, so ways to mitigate that. Compaction so that all this rainfall can go into the soil rather than sit on top of it, is a variety of no-till or reduced-till strategies and bonus. The no-till will help preserve the carbon. So in this picture you can see a cloud of soil that has been untilled on the left tilled on the right. And you can see just by the color how much more organic matter is in that untilled soil. And if you were a microorganism or a worm, you're gonna wanna live in that left-handed soil versus the right, which looks just like a brick, even though these are the exact same soil types. That's how much organic matter and no till can affect the soil.

Here's a great photo of reduced till, multiple till and no-till soils and water and what happens to them. You can see that they hold together because of the biological organisms, the glue that is secreted by them.

And by reducing our no-till, you can maintain those pathways created by roots and living organisms. So the photo on the left is actually a rubber mold of Nightcrawler channels from a crop fields. And the photo on the right just shows some dye that has gone into the soil and where those preferential pathways are.

So the next thing I'm going to talk about, and feel free to interrupt me if I'm going over time, is increased soil temperatures. So there's a number of problems with an increased soil temperature, but as this photo shows, producers and land managers have a really great way to influence soil temperature. So I did a little experiment on my farm. I have a soil thermometer in my soil health bucket and you can get it I think at kitchen stores, but it's not anything special, it's about 10 bucks. And so I did a little experiment at my farm where I took the temperature; It was a hot, sunny day in June. The ambient temperature was 93 degrees. And then I went to different various parts of my farm to see where the soil temperature was at one inch. So I have some pasture in a place where there was tall grass. It was 83 degrees, so 10 degrees less, and this was at one inch depth. I had some mulched veggie beds, that was 90 degrees, so that had some straw mulch, overgrazed pasture that was less than one inch in height, that was 108 degrees, so that's 15 degrees warmer than the ambient temperature and then 115 degrees in bare soil, I had some bare soil in my garden. I had an area where I was putting on black plastic that was 128 degrees, so you can see how that what you're covering the soil with is gonna have a huge impact on temperature.

And just to go back and why is temperature so important? It’s because that's influencing the soil evaporation rate, so the hotter the soil, the more water is lost and it also effects how the plant grows and the biological activity.

So some solutions covered soil, cover crops, they're going to buffer that temperature, they're going to add organic matter.

Winter cover crops, I think, are gonna be even more important in Massachusetts and Rhode Island. Having that bear soil over the winter is gonna be really problematic, you know, since it's no longer frozen and covered in snow.

Just an illustration of how important that those cover crops are. If you're growing corn, you might only be capturing solar energy for four or five months out of the year, four months. But if you add cover crops to either end of that, then you're able to collect more energy and then store that energy in the form of carbon into the soil.

So I will end my presentation just by saying again, I'm really optimistic when it comes to agriculture and climate change because we've got so many great win-win tools and when I work with farmers, I work with them all across the country and some of them don't believe in climate change. And I say, you know what, the great news is, you don't have to believe in it, here are some things that you can do on your farm to make you resilient to weather. So even if climate change is all a big hoax, there's a lot of great things you can do to in agriculture to boost profitability and boost productivity on the farm.

So that is my contact information if anybody wants to get a hold of me and just say thank you.

Adam: Excellent. Thank you so much, Elizabeth. And just as a reminder, if you have questions for Elizabeth about her presentation, if you haven't already, please do drop those questions in the chat and we will address some shortly. I would now like to introduce our final presenter who is David Hollinger. And Dave, if you wouldn't mind just putting up your slides while I introduce you.

David: Alright.

Adam: Dave is a Plant Physiologist for the US Forest Service and Director of the USDA Northeast Climate Hub. His research has focused on understanding how climate change impacts CO_2 and CH_4, methane exchange in forest ecosystems. So David, the floor is yours.

David: Alright, thanks Adam. And can you hear me OK?

Emily: Yes, we can. Yes, we can.

David: OK, terrific. And so we'll, we'll continue the the turf part of the presentation and Elizabeth, thanks for, you know, your great sort of story about adaptation and CO_2 benefits within agriculture. I'm gonna talk a little bit more about greenhouse gas emissions and kind of ways of controlling those. But I will say the problem is not pumpkins and the answer has nothing to do with pumpkins, but I like pumpkins.

So just a quick kind of sort-of definition of terms, what we just heard about from Elizabeth was mostly climate adaptation so those are practices that increase the resilience to climate extremes and climate change, such as cover crops and keeping the soil covered, these sorts of things. And climate mitigation; those are the practices that that reduce greenhouse gas emissions from agriculture or they actually are practices that help store carbon dioxide from the air into the soil. Within the USDA, these climate mitigation practices are considered climate smart practices, and I'll talk a little bit more about that as well.

So an important difference between adaptation and mitigation is that adaptation directly benefits the farmer. You're increasing the resilience to drought, to excess rain, perhaps to insects, and in some cases you, the farmers may be doing things to take advantage of some of these changes; planning longer season varieties or further to the South, even double cropping. Within terms of mitigation, the whole point of mitigation is really that it benefits the planet and we just have to keep in mind that there may not be any direct financial benefit to the farmer. But you know, farming is a business and it's sometimes difficult to get, you know, producers to do something that doesn't have a direct financial benefit. So the question is, how do we benefit both?

One of the key ways we just heard about are to talk about practices and utilize practices that have co-benefits. We heard about the practices that help produce soil, healthy soils, which increase organic matter and store carbon in the soil so co-benefits are really cheap. There are also in place, in use in some places, federal or state incentives. And these are often programs that come through the Farm Bill Conservation Programs, such as through NRCS. And there are presently a number of conservation practices for maintaining healthy soils or clean water or other aspects that the government will pay farmers or cost share with farmers. In the case of Massachusetts, they have an interesting program to support agrivoltaics and it's, I would say, a very generous program for supporting solar cells on farms. There's also state and private voluntary carbon markets which I'm not going to have time to talk about today. And another option is to see if consumer demand can be increased for climate friendly products and you can think here about sort of organic designations; Many people choose organic food perhaps sometime in the future, they'll be able to choose climate friendly food.

So within the whole agricultural sector, the EPA reports that about 10% of US greenhouse gas emissions come from agriculture. The two biggest sort of sources or the two biggest gases are methane and nitrous oxide, we've heard about nitrous oxide from Brian earlier on. Within agriculture, though, it's interesting that carbon dioxide is not generally looked upon as a significant or agriculture, is not looked upon as a significant source of CO2 emissions, instead it's actually seen as a part of a climate solution. So within agriculture, about 10% of the total emissions are associated with manure ponds or manure lagoons. So this is important and relevant to the Northeast, where dairy farming is the sort of number one farm commodity and you get these sort of anaerobic sort of Lagoons with manure and without that oxygen some of the some of the material there gets converted into methane, which then escapes into the atmosphere. A larger source is in fact the cows themselves, and one of the you know, the stomachs within the within cows. It's also an environment with low oxygen and methane is also produced there and as cows sort of chew their cud and the material comes back and forth they emit a lot of methane that way. But by far the largest source of sort of greenhouse gases are all converted to a CO2 equivalent or fertilizer application, and other soil processes releasing nitrous oxide. And we kind of heard some good details from Brian about the nitrogen cycle and denitrification earlier on.

So about a year ago, USDA delivered a report, this 90 day progress report on the left there that listed a number of climate smart practices and discussed ways to sort of help farmers and other landowners sort of get into them. This is sort of a summary of the practices within that document. These are also practices that the USDA is listed as climate smart within their recent program to help support climate smart commodities.

One thing, one other important factor I guess just before I continue, Brian mentioned that nitrous oxide is sort of 300 times more powerful than an equal amount of carbon dioxide in the atmosphere. Methane is 86 times more powerful than CO2, so both nitrous oxide and methane, if you will, swing above their weight. But another really important point about methane is it has a very short atmospheric lifetime; it's only about 12 years. It gets destroyed by sort of natural processes within the atmosphere. And that means if the methane emissions are reduced, the amount of the gas and the atmosphere can drop quite quickly and so we can see an unusually quick sort of impact on the climate system if we reduce methane emissions. So there's a lot of reasons to focus on methane and at least in the short term.

So reducing methane from manure, there are sort of solid solutions for that. It mostly has to do with covering the manure with a sort of plastic. 86 times the amount of greenhouse warming to back to CO2, so it reduces that that warming enormously, that warming impact. Another sort of more elaborate process that again begins with the covering of these lagoon pits or ponds is actually burning it in a digester and generating sort of renewable electricity. Cornell University is a great program, a lot of information about covering and flaring. Funding is available from NRCS if you if, you know, are a farmer or know a farmer to cost sharing to help do this and methane sort of covering and flaring does have important co-benefits. Often one of the important most important is odor control; farmers want to be good neighbors and covering up your manure helps do that and also covering of course keeps water out, which is also can help improve water quality and prevent it from getting lost, escaping.

Reducing methane from ruminants. This ones a little, this is tougher because this is in instead of a centralized sort of project, you know, this manure pond or lagoon, you're talking about every single animal for animals that are in pasture, it's a more difficult thing to do but there's been a tremendous amount of work and these are sort of three areas which have been shown to sort of measurably and reliably reduce methane production from cows and other ruminants. One is just changing what you feed them; if you increase the digestibility of the feed, it reduces a methane. There are a number of additives, 3-NOP is a interferes with the methane production from some of the bacteria in the rumen and it is licensed for use in Brazil but not yet in in the US. It just, adding fats and oils such as sunflowers oil and/or seaweed also can help reduce the methane, but for me I think some of the most exciting sort of news on this is that breeding of animals and the rumen microbiome, so that kind of bacteria and fungal flora in the rumen and can actually significantly reduce methane. There's work in in England where they're seeing 10 or 11% of reductions in methane production per generation, so after just a very few generations you can see quite significant decrease in methane production. So use currently of all of these things is very low because you don't necessarily see any benefit in milk production and certainly these things tend to add cost, but the potential is moderate and perhaps it's maybe even more than moderate, but there is this problem of you know pasture grazed animals.

And finally, I just go over nitrous oxide emissions again. The nitrogen cycle is well understood and for a long time within the farm world talked about the four R’s of nutrient management. It's easier said than done sometimes because sometimes doing it at the right time when the plants are actively growing can be difficult just due to machinery constraints or other things like that so many times fertilizers applied in the fall for a spring crop. But following all of these can really help. Additives can also help actually. Again, Brian mentioned you know some of the sort of enzymes that were active in converting nitrogen from one form to another. Some of these additives such as N-Serve or AGROTAIN can actually interfere with the enzymes that convert nitrogen from one form to another and serve bloxy change from ammonium to nitrate for example. And AGROTAIN is a is a urease inhibitor. At this point, though, additive use is pretty small. I found one study in Minnesota where maybe 20% farmers use ammonias inhibitors and less than 10% use urease inhibitors. And there are benefits to this, because if you don't use these or if you apply nitrogen in the wrong time, that nitrogen is gonna run off, it's going to cost you more than your yield is gonna suffer and by applying either the four Rs or some of these additives, you can you can definitely generate some code benefits as well.

Lastly, I'll just go over real quickly the potential role of storing carbon on land, so that's now agriculture being part of the solution here. At the top you can see, and this is from the IPPC AR6 report that came out just a couple months ago, that if we're going to sort of solve the greenhouse gas and solve climate change, this is what it's gonna take. So like Elizabeth, I'm also very optimistic; gonna take the big increases in wind energy and solar energy, but also in order to do what all of these sorts of things are needed and agriculture can store a tremendous amount of carbon as can forestry and forests and other ecosystems. So just talk real for a moment about carbon sequestration in agriculture, and I will admit that there are a number of issues including, you know, how long that carbon stays there, whether there are other climate impacts from these changes, you know how, how you actually credit the carbon storage and whatnot; we'll save those for another time.

And what I want to do is I wanna go back to two particular practices cover crops and no-till because both of these store carbon in the soils about can be sort of a few tenths of a ton of carbon per hectare per year. And there are tremendous co-benefits. I mean, Elizabeth already talked about the value how using cover crops or no-till kind of increases the resilience of your farm to heavy rainfall or even drought in in many cases. In the case of no-till there's an added benefit too, because basically no-till you don't till the residue back into the soil you leave it there. So that means fewer tractor passes, so less fossil fuels burned right from the start. So no-till is now actually the dominant cropping system in the US more than the half of the acreage crop acreage in the US is no-till. Cover crops are a little bit different. Their use is highest in the central Atlantic and in Maryland and Delaware, and it seems the further you get away from that, that region the less and nationwide only maybe less than 5% of properly and is covered with crops, so far more I guess potential in cover crops. Probably the big difference is that in cover crops, you know, you have to basically purchase the cover crop seeds, there was a cost to utilizing cover crops. In Maryland and in Delaware, where the use is highest, those crops are subsidized, those costs are subsidized by state programs, so it really shows, it's a good example of how incentives can work in a practice that has adaptation benefits and clearly also stores carbon within the soil.

So really, climate smart farming, it's ready to play a role. The USDA is ready for it to have a role, play a role. I think we're gonna hear lots more about this in the coming months. Again, this is just a summary of some of these practices which I didn't have a chance to get into, but I'll finish up there and just thank you for your time and make sure you can visit the climate hubs when you have a chance. So thanks, thanks very much, Adam.

Adam: Thanks so much, David, and thank you to all of our presenters, Elizabeth Marks, Brian Donnelly, Phil Colarusso and so now at this point, I would like to invite everyone who has not yet typed their questions or has a question for any of our presenters to please type your questions in the chat box now. And please also remember to make sure that you include who your question is directed for. I'm looking up in the chat now and I think we have, there's one question that I'll read. This is actually from Phil. This is a question for from Phil to Brian. Phil says that he was under the impression that adding salt water to these marshes could decrease methane emissions, but your data suggests that nitrous oxide is increased. Do we know what the balance between these two processes would be in that greenhouse gas impacts?

Brian: That's a really good question. So that most likely would happen. The thing is, when you add salt water to these systems, you're going to stimulate a lot of sulfate reduction because there's just so much sulfate in salt water. So they have a lot of, that's the important electron acceptor. So that's what we see a lot of the decomposition in salt marshes is a lot of that's from, I mean, that's decomposition in general, but sulfate reduction, so you would probably be exchanging the methane emissions for more CO_2 emissions, which as we talked about is less potent in the atmosphere but you'd probably be seeing a lot of replacing of both into a production and methane emissions for CO_2 and it could happen a lot more than the others. So I'm not sure exactly what the balance of the two are, but methane production in freshwater systems is definitely something that needs to be looked into, and it has been looked into a lot. I haven't necessarily focused on that in my work, but there's a lot of stuff out there about that.

Adam: Awesome, thank you, Brian. Next up I think is a question that I believe is directed towards Elizabeth. And the question is, do you know why overgrazed pastures would be hotter than the ambient temperature? And this seems to be a two-part, and then also what kinds of work are you doing with foresters? This person was curious to know how you're applying this knowledge of climate and agriculture to forest management.

Elizabeth: Yeah, so I answered the question in the chat, but I'll just say real briefly, a lot of it has to do with the soil being dark. And so it's just gonna absorb, dark surface is gonna absorb a lot more heat than a lighter surface. So like even if you have crop residue on a field that's gonna keep the soil temperature a lot cooler than the bare soil because the crop residue is a lighter and the soil is darker. With the tall grass that is shading, so like cover crops, even plants, so as corn gets taller it's going to shade the soil and cool it. So that's why spring and early summer droughts are much more damaging because they're often not shaded by the plants. So that's what makes up the temperature difference, but it's really that all sounds logical. there's a lot of smart people on this webinar and it's like, oh yeah, that's logical, but until you actually see it, you're just shocked at how much that affects things and you think about like all of the farms that use black plastic as mulch, I don't think that's gonna be feasible; I don't think it's feasible now, but especially in the future. For forestry I just put in, you know, one of the things I'm encouraging foresters to do is to leave slash on the ground. A lot of foresters kind of like to have it cleaned up, so the forest looks neat, but it definitely helps with a variety of things. Dave, did you wanna add anything about climate smart forestry?

Dave: No, I mean it's, you know the issues are a little broader, but that's OK. It's certainly one of the problems is dealing with what would have happened anyway. So forests are an important part of the carbon cycle now and are already taking up a lot of carbon, but if we're gonna use them as a natural climate solution, then the question would be getting more out of them. And so that, you know, what do you do that that gets more out of what they're already doing and that sometimes, you know, some of the issues that are kinda those that wanna get into the carbon markets have to have to face.

Adam: That's helpful. Thank you, Elizabeth and David. The next question I have is directed for Phil. Phil, do you know if shellfish like oysters play a significant role in blue carbon or the carbon cycle?

Phil: I don't know the answer to that question, but Susie and Kathy and myself have a proposal in it, which Adam is also part of. We'll be exploring that exact question, looking at how oysters may positively or negatively affect your eelgrass ecosystem services, including carbon sequestration, but also looking at greenhouse gas exchange, looking at nitrous oxide and methane, either emissions or absorption by all of those habitats. So maybe that will be a webinar in the future.

Adam: I would love to feature it and again I would just like to update. So thank you, Phil. And again, I just like to remind everyone, if you do have questions now is the time. I don't see any new ones, but actually I will take the chance to ask question of David. I know you didn't get the chance to touch on voluntary carbon markets in your talk today, but I was curious, especially where as you said that the number of farmers that are taking advantage of potentially capping their manure fields as fairly low, if there was any appetite or discussion in working with farmers to quantify how much methane they've prevented from being released through manure capping and then to benefit from any relevant carbon offset credits that come from that?

David: Yeah, that's a really good question and when you, you know, cover a manure lagoon or a, you know, a pit and then, you know flare to use it, you, you can precisely measure the amount of methane that you have, so it can be a really good candidate for that. I know things are moving really quickly in this area and especially in New York because New York is really, you know, amongst the New England states, or the Northeast anyway, has the, they're really, really pushing hard on this whole mitigation. I don't know the details of all of their programs because they're changing and perhaps other folks do here too, but I think, you know, we're likely to see that you know very much more in the future.

Adam: Thank you. And actually David, there's one more question for you. Does seaweed as cattle feed hold much potential in reducing methane and can we farm these algaes?

Elizabeth: Yeah, sure I can answer that. Yeah, I think it has huge potential. Yeah, definitely. So I was just responding to Ben and the chat. Yes, I do. And Phil I think the comment you made about wildfires and slash out west, I agree. I think and this is kind of what the challenge of climate change is because the climate is changing differently in different parts of the country, we're going to need different strategies for different parts of the country. So leaving slash may not be a good strategy, I don't know. But in the Northeast where we have from a much better moisture regime leaving slash which is gonna break down quickly is not really much of an issue for wildfires.

Adam: Thanks so much, Elizabeth and David. I am not seeing any additional questions in the chat, so I'm happy to end a little bit early. I would just like to give a big shout out again to each of our speakers, Phil Colarusso, VPA Elizabeth Marks and David Hollinger of USDA and Brian Donnelly of Northeastern University. I do also just want to remind everyone that our meeting, our webinar today was recorded and it will be transcribed/closed captioned and posted to the SNEP website, which is www.epa.gov/SNEP. And again, if you do think of any additional questions for myself or any of our speakers, please feel free to e-mail our program with your question and we'll make sure that our speakers, you know, get that question. And finally, if you haven't already, please do consider registering for our newsletter, whether you'll be kept up to date about any future events that SNEP hosts as well as we got a bunch of good stuff in the newsletter, one just went out, so I'm sure you don't want to miss it, so please do consider registering. Otherwise, please have a great rest of your day and an excellent weekend this week. So thanks again for attending.

Elizabeth: Thanks Adam.

Adam: Absolutely, thank you.