# Well Traveled Bird Seeks Fun Loving Plant: Waterfowl Seeking Submerged Aquatic Vegetation

**John Ossanna**: Welcome from the US Fish and Wildlife Service's National Conservation Training Center here in Shepherdstown, West Virginia. My name is John Ossanna. I'd like to welcome you to our webinar series held in partnership with the US Geological Survey's National Climate Adaptation Science Center.

Today's webinar is titled, "Well Traveled Bird Seeks Fun Loving Plant: Waterfowl Seeking Submerged Aquatic Vegetation."

We're excited to have Kristin DeMarco, who's with Louisiana State University, with us today. Please join me in welcoming Shawn Carter, who is a senior scientist with the National Climate Adaptation Science Center who will be introducing our speaker today. Shawn?

**Shawn Carter**: Thanks, John. Welcome, everyone. It's our pleasure to have Kristin DeMarco give a presentation today. Kristin's a coastal ecologist that studies the effects of environmental conditions on aquatic communities.

She just defended her PhD dissertation from LSU in relation to spatial temporal processes that drive submerged aquatic vegetation distribution across the northern Gulf of Mexico.

Previously, Kristin's worked as a coastal resource scientist with Louisiana Coastal Protection Restoration Authority where she assisted with the development of the 2012 Louisiana Coastal Master Plan and helped create technical recommendations for incorporating sea level rise estimates in the restoration project planning and design.

Kristin has a master's in environmental management from Duke and also her bachelor's from the University of North Carolina at Asheville. Without further ado, please join me in welcoming Kristin today. Thank you.

**Kristin DeMarco**: Thanks for that, Shawn. Hey, everybody. Thanks for calling in. I'm going to talk a little bit today about waterfowl habitat and how submerged aquatic vegetation feeds into that in the northern Gulf of Mexico and get into some potential effects of climate change on those habitats.

The title, you guys will have to excuse me, was kitschy and cute. I couldn't help myself and I thought it was a little...I was a little unclear on the audience when I began this presentation, which you guys [laughs] may see as I go through. Bear with me.

Waterfowl are obviously very connected to water. They use a lot of different types of wetlands in their annual cycle. The figure that you guys can see is from USGS. It catalogs the wetland types across the United States. Everything that you see in green is going to be a wetland. Everything in blue is going to be a little bit more deep water.

Then you see some striped patterns, and that's going to be areas that have a high density of smaller, more isolated wetland.

Waterfowl throughout their annual cycle will use a lot of these different habitats as they migrate. They breed up north, a lot of them in the Prairie Pothole Region of the northern United States and Canada.

They breed up there, and they molt up there. Then, they'll do their fall migration. They'll cruise down the Atlantic Coast. They go and get some resources from the coastal wetlands down there. They end up a little bit further down south where I am in the coastal wetlands of the northern Gulf of Mexico.

This is where they spend a lot of time. They're not breeding. They're molting. Many of them, most of them, in fact, are undergoing pair formation. Then they do this whole thing again where they cruise back up north and either through the Central Mississippi Alluvial Valley or they go up on the West Coast.

Then they end up back up north and the whole process starts over again. Across these different wetland habitats, they're using different food resources at each of them depending on what they need. When they're up in the north, they need a lot of protein. They're eating a lot of fast-moving lipids.

As they move back down and they start their fall migration and they get into their wintering habitat, they're more interested in carbohydrates. What I'm going to focus on today is this northern Gulf of Mexico area where the birds are spending most of their time.

They're spending it in the winter, and they're eating a lot of carbohydrates in this area. I need to get a pointer going. Can anybody see that? Yeah, there we go. This is where I am. This red box is the whole area that we're interested in or that I'm going to be referring to today.

The wintering habitat in the northern Gulf of Mexico is home to 95 percent of the United States' gadwall mottled duck, 80 percent of green-winged teal, 80 percent of the redheads come through here. It's a really important migration habitat for blue-winged teal. It supports a ton of nekton, different sorts of fish and invertebrate species.

This is important, this habitat and the quality of this habitat is important for waterfowl in the winter because the winter is really energetically expensive. It's cold, so their metabolism has to work a little bit harder. They're undergoing pair formation, which especially for the male ducks is quite exhausting. They just have to follow the female around and hope it works out and they get food.

They're molting. There's just a lot of expensive stuff that's happening, so having high-quality habitat and a lot of food in this area is really critical to ensure their survival so that these bird species will actually make it so that they can eventually get to breeding.

What makes this high-quality habitat? What makes good wintering habitat in the northern Gulf of Mexico? There are these three things that they have to have. They have to have water, they have to have cover, and they have to have food.

There's a couple of different options for water body, depending on the species of bird that you are. If you're a diver, if you're a dabbler, you might be in a bay, you might be in a marsh. You might be in a lake.

For cover, a lot of dabbling species in particular like this idea of a hemi-marsh, where you have 1:1 ratio of open water to wetland vegetation. You can see here we've got some vegetation but we also have a lot of open water. It looks pretty shallow, and in a lot of cases down here in particular it is.

In these aquatic habitats in the northern Gulf of Mexico is where these waterfowl species are getting a lot of their food. There are a lot of insects that are hanging out on the plants. The dabblers are diving down, scooping it up, munching it off.

But more so in this season they're getting a lot of their resources from eating seeds, from eating roots and shoots, tubers from aquatic plants and a lot of these aquatic plants are going to be submerged aquatic vegetation.

They'll eat emergent plants as well, but this guy right here, these submerged plants that spend the entirety of their life cycle under the surface of the water with the exception of flowering are going to be where a lot of that carbohydrate nutrients are going to be -- they're going to get it from.

Really, when anybody's trying to calculate, "OK, how much habitat do I need?" When I say anybody, I'm talking mostly about waterfowl and coastal managers.

When these guys are trying to figure out how much habitat they need to support a target waterfowl population, they really need some estimates on what's going on with the SAV in this area, because the SAV is going to be really critical to this energy density component that is put into these calculations for habitat objectives.

Basically you figure out how much a given bird, a single bird or a group of birds needs to survive the winter. You figure out how much energy you have based on your food resources and then you can calculate how much habitat you need to support whatever population you guys are interested in.

Unfortunately, there are not a ton of studies in the northern Gulf of Mexico that quantify these values. There was a study that was done in 2003 by...He was an LSU guy, Christian Winslow.

He studied fresh marsh and he found this value of 240 kilograms per hectare for food resources in aquatic habitats in fresh marsh. This is seeds and submerged aquatic vegetation.

Based on other information, waterfowl managers, and I'm referring in large part to the Gulf Coast joint venture managers here, but who's kind of the baseline for everybody, what they go from.

They have just assumed that intermediate was about equal to fresh marsh in terms of food resources. Brackish was about 50 percent equal to fresh marsh, and saline marsh zones were about 10 percent equal.

The idea here is based on this theory that there's a giving-up threshold or a giving-up density where once the food density, the energy density goes below a certain threshold, the waterfowl -- they're going to move. They're going to bail. They're going to go to a different area. They're going to search out more food.

This theory, it's discussed and it's currently being more discussed by some other people, but as of right now it still holds.

That's what these guys are interested in. "How much food do I have in this area, or how much food do I need to have before the ducks are going to leave and I'm not going to be able to meet my habitat or my population goal?"

What we do know about SAV is that it's found in all different marsh zones across the northern Gulf of Mexico. We refer to these in these four major categories -- fresh marsh, intermediate marsh, brackish marsh, and saline marsh. Based on literature and studies, we know that it shows up in saline. It shows up in brackish. It shows up in intermediate, and it shows up in fresh.

We know that the distribution of SAV has spatial and temporal variation that is affected by salinity regimes, water levels, temperature, precipitation, geology, and various sorts of human activities. Out of these different sorts of environmental drivers that can impact SAV distribution, a lot of them are going to be changed, altered. Variability might be affected by climate change.

Salinity regimes, water level, temperature, and precipitation are the heavy hitters here. We know that these areas are going to be affected. We know this coastal landscape is going to be affected by accelerated sea-level rise. Most of the models predict a minimum of a half a meter up to a meter and a half.

We're very unsure about what the submerged aquatic vegetation response to sea-level rise is going to be. What we do know is that, in this area, everything that you guys can see in red on this figure is zero to five feet above sea level. This is in 2008. This is from a 2008 data set, so who knows what it looks like now?

Orbit imagery data and our elevation data in Louisiana is not super, but we do know that this area is very low-lying. Even if we do only get a half of meter of sea-level rise, it's still going to change the landscape considerably. What that could mean for these different marsh zones is that we could see a shift, a landward migration of saline habitat and fresh.

Everything could essentially move up. What we could also see is we could just see land loss. This is a climate-change scenario projected out to 2060 from the CPRA, Louisiana Coastal Protection Restoration Authority 2012 Master Plan. That's assuming about a half a meter of sea-level rise. Everything that you see in red is basically going to be converted to open water under this scenario.

Instead of these marsh zones moving up, they could just convert to open water, which for submerged aquatic veg, that might just be more habitat. We just don't know at this point because, again, we don't have a lot of quantifiable data on that. Everything that's over here in pink we identified as potential submerged aquatic vegetation habitat.

These are shallow, in general under two-meter waters. These are interior coastal ponds. Especially the interior coastal ponds are really important because they do support a lot of SAV. They also support a lot of waterfowl. It's a really important habitat for those guys as well.

Again, looking at these different marsh zones, what some models are predicting -- this is the sea-level affecting marsh model that was ran for the entire Gulf of Mexico -- in some cases up to a 60 percent decrease in fresh and tidal-fresh marsh that would include intermediate, fresh marsh, and almost a 40 percent decrease in interior fresh marsh.

These really critical interior habitats, the intermediate and fresh marsh, could be completely lost in the event of sea-level rise, or they could migrate. Again, we need some quantifiable data to figure out how that's going to affect waterfowl.

What's the actual habitat quality of marsh zones for waterfowl? This fresh study that I mentioned earlier was all done in interior coastal ponds. 240 kilograms of food per hectare, but we really don't have any data on the rest of these marsh zones.

What my project did is we went across the northern Gulf of Mexico. We divided it up spatially into regions. Over here, this is the Texas Mid-Coast region. These are all based on Gulf Coast Joint Venture Initiative areas, which are based on waterfowl and ecological data.

Anyway, this is the Texas Mid-Coast. This is the Chenier Plain, all this area over here. This is the Mississippi River Coastal Wetlands. Then this is Coastal Mississippi and Alabama. I'll refer to these regions a few times coming up. We randomly generated individual sites across the coast.

What we did was we sampled about 384 sites during the growing season, so every summer for three years. We collected a whole bunch of data. We got species data, presence data, percent cover, depth, salinity, turbidity, temperature. We compared SAV presence and cover by region, by marsh zone, and by year to try to figure out if there were some patterns that we can pull out.

Just very generally what we found, mean percent cover was 16 percent coast-wide for all three years. Over this time period any differences that we found, any significant differences, were all spatial. There was no temporal difference in SAV presence or cover. Now, if you guys remember, 2013 through 2015 there were no big storms either.

Certainly, if there had been a storm, we probably would have had a temporal change. If the scale had been a little different or if we'd been looking at one species instead of an assemblage, it might have been different. Over here, the figure on the right is percent SAV presence. The figure on the lower left is percent SAV cover so cover, presence. I'm going to talk about presence first.

There was a significant interaction between marsh zone and region. You see that we have some of these regions that have much higher presence than the other regions. Mainly, the Mississippi River Coastal Wetlands had about equal presence in fresh, intermediate, and brackish marsh.

The Texas Mid-Coast Region in the dark had very, very high presence in fresh and then much lowered presence in intermediate, brackish, and saline.

What we also have is we have a pretty significant difference in cover between fresh and saline. Fresh we have higher cover. Saline we have lower cover.

You can tell that when you look at the Texas Mid-Coast and the Coastal Mississippi-Alabama, these areas have much higher cover in the saline-marsh type than Mississippi River or the Chenier Plain. We see some very significant regional differences that are also affected by marsh zone. You just have to trust me a little bit. These are taxonomic species codes. It moves from fresh up to saline.

The fresher species are down here. The saline are down here. This is the Texas Mid-Coast. This is the Chenier Plain. This is the Mississippi River, Coastal Mississippi-Alabama. Down here, we have fresh, intermediate, brackish, and saline. This is just a qualitative analysis. I want to describe some of the marsh types to you guys.

What we have over here, this is all of our fresh marsh. Everything that you see in blue, fresh. You notice right away that a lot of it is concentrated in the Chenier Plain and the Mississippi River Coastal Wetlands area.

What we have in this fresh marsh is we have a lot of different species. We also have a lot of hydrilla. That's this guy right there, hydrilla. We have a lot of coontails, the Ceratophyllum demersum. That's that guy right there and that guy right there. Really, really in a high-percent cover in the Mississippi River Coastal Wetlands and in the Chenier Plain.

We see that we don't have that over here in the Texas Mid-Coast. We don't have that in Coastal Mississippi-Alabama. In fact, in Coastal Mississippi-Alabama, we mostly just have Ruppia maritima or wigeon grass, which shows up. What we start to see is that there are some differences in species assemblages across regions.

One of the environmental variables that we did pull out in fresh marsh was that fresh marsh was significantly deeper than all of the other marsh types, and significantly deeper on the Mississippi River Coastal Wetlands area than the other areas. Fresh was always deeper. The Mississippi River was real deep.

We lumped intermediate and brackish together. This is all of the intermediate. You see a lot of intermediate marsh in the Chenier Plain. These are the intermediate species assemblages. We see an increase in species assemblages for the most part, with the exception of Coastal Mississippi-Alabama.

This is the brackish. One of the things I want to point out is you'll notice Texas Mid-Coast. There was almost nothing to pick from in terms of what was defined as being brackish marsh by the data set that we used, which we used and write 2014, if you all are familiar with that. If you want to talk about it more, I can tell you.

The species types that we had in this intermediate brackish, we had a lot of Ruppia, a lot of wigeon grass. We had a lot of milfoil. It's Eurasian milfoil or Myriophyllum spicatum. We had a lot of Najas guadalupensis.

What we notice is that we would have these similar numbers of species assemblages. The habitats looked pretty different. All of these habitats supported Ruppia maritima. This is Texas Mid-Coast. This is Chenier Plain. This is Louisiana. This is Alabama.

This is really, really deep, deep pond with Ruppia. It was probably about two meters. This was a little bit more stubby-like lawn. You see some species will show up everywhere. I'll just point there.

Moving on to saline marsh, you can't see it very well because it's saline. It's all on the fringe. What we immediately notice is that saline marsh, we drop down in the number of species that we have.

However, we have some seagrasses that show up. Halodule wrightii or shoal grass shows up in the Texas Mid-Coast and in Alabama. We have turtle grass show up in Coastal Mississippi-Alabama. We even know the species assemblage goes down.

We don't see any of those invasives that we saw in some of the other areas. Saline marsh looked really different, depending on where you were. Saline marsh, Texas Mid-Coast, Chenier Plain, Louisiana, and in Alabama.

One of the other things that we needed to look at was seed biomass, because we want to know what the birds are able to eat. We also found that there was no temporal effect by the scale. We also found a significant difference by region in marsh zones.

What you can see here is that Mississippi River Coastal Wetlands, really high seed biomass in the intermediate. Texas Mid-Coast, really high and fresh. Then everything starts to go down from there. You have these hot spots, depending on where you are.

This is all food. This is seeds that are considered to be waterfowl food. These are just submerged aquatic vegetation seeds. If you look over here at Texas Mid-Coast, this is two-and-a-half grams per meter squared. The SAV seed is a little bit under one gram per meter squared. Not all of this food was necessarily SAV seeds.

What we had in the fresh zone of the Chenier Plain, we had a lot of Cyperaceae seeds. In the fresh zone of Texas Mid-Coast, we had a lot of Schoenoplectus seeds and a lot of Nymphaea species, so a lot of lilies, things like that.

In the fresh zone of the Texas Mid-Coast, we had a lot of Stuckenia pectinata, which is a sago pondweed. Really, really good wildlife food. Potamogeton species in Mississippi River. Ruppia maritima contributing really almost entirely to this big food biomass in the Chenier Plain area.

The other cool thing that we looked at was that increasing submerged water vegetation cover was correlated with increasing food seed biomass. That's not just SAV seeds. We know that you're in a SAV bed. All of these SAV seeds are being deposited on site. There are some little Ruppia seeds right there, if you can't see them.

What we're also seeing is that the SAV beds are trapping other seeds, not just anything. It's trapping a lot of different things. It's trapping a lot of food. If you're a bird, there's a lot of stuff to eat if you're in an SAV bed.

We knew that there are some key drivers for SAV, based on the study and literature. What we see is we primarily saw a big effect of salinity, based on marsh zone. We know that light is a big deal from our research, because of some depth stuff that we found. Other people have found light is just very, very important for submerged plants.

Exposure also seemed to be pretty important. Depending on what was going on with wave, what was going on with wind-driven wave, where you're going to find SAV is relevant to that.

What we wanted to do is we wanted to take all of these individual sites. We wanted to say, "OK, can we take this information that we learned and predict SAV distribution across unsampled areas?"

That's what you really need to know if you're trying to predict how these habitats are going to be affected by climate change. Understanding these drivers of presence can tell us a lot about SAV and a lot about waterfowl habitat, and how it might change in response to changing climate.

Enter the species distribution model. Species distribution model takes a current data, so observational data, what we collected in the study I just detailed. It relates it to environmental characteristics. These are also called "niche model." That's why you'll see the word "niche" here a lot.

Basically, it's one condition. Say, that's salinity. Then you have another condition. You say that that's exposure. You find all of your presence data. You are able to quantify the likelihood, the probability that that species or that assemblage of species that share similar niche requirements, that have similar environmental requirements. You figure out the probability that it will live there.

We did this for a distribution of SAV assemblages, so all SAV species together. We only did this in Louisiana because Louisiana, we have access to this great continuously recorded hydrographic data from the Coastwide Reference Monitoring Station.

We collected all of these hydrographic data -- salinity mean, salinity standard deviation, water level mean, standard deviation, and temperature -- to derive our species distribution model and attached it to our observational data.

This is an example of what the salinity layer looks like. We took all of the hydrographic data. We interpolated it across the surface of coastal Louisiana. This is just an example from winter 2013 to 2014. Using that salinity data, we calculated a seasonal mean and seasonal variability.

We also wanted to come up with a proxy for light. As I mentioned earlier, Louisiana has terrible bathymetry data. We used turbidity as a proxy for light. This has been shown to work very well in other areas.

Basically, what you do is you use band three from your landsat imagery. That correlates really well with turbidity in other areas, particularly in muddy base and deltas. Now we have a spatially contiguous layer for turbidity across the coast.

We generated an exposure index. The exposure index is fairly simple at this point. It's being worked on right now. The exposure index is just a measure of sets across an open water body.

If you had a really big open water body, you have a really high exposure value. We weren't able to account for orientation or dominant wind or wind power at this point in time. It was just a place to get started. Using these data, we used a bunch of different environmental variables, the different seasonal variability and mean. It was a binomial logistic model.

What it pulled out was that mean winter salinity, reflectance, and exposure were the most important things and the only things that you necessarily had to have to calculate submerged aquatic vegetation presence or the probability of submerged aquatic vegetation presence across Louisiana.

High probability presence, warmer colors. Low, cooler colors. This is hard to see on your figure. This is buffed. I don't know if any of you guys are Louisianans. That area is absolutely full of SAV. It looks a little bit like the salinity map. You can see how the likelihood of SAV goes down as you get out toward the coast.

That makes a lot of sense, both because of the salinity type but also because of the exposure out there. There's just not a lot of plants that can grow out there.

Our model was significant. It had a correct classification rate of 75 percent. It was correct 75 percent of the time. If you guys look over here, the error, the red stuff is going to be where the model was incorrect. What we have is where the model predicted presence and it was absent in the field, or where the model predicted absence and it was present in the field.

Just a couple of zoom-ins. This is an area in Southwest Louisiana that we had a pretty high error rate. That area is bizarre. There's a lot of crazy stuff that happens out there in terms of management, in terms of water level. Nobody really knows what's going on.

This other area, you see a lot of error at the border between saline and brackish marsh zones. There's something going on there as well.

What this told us was you can use a couple of key conditions to predict SAV occurrence in coastal Louisiana. You can do it pretty well. You can get a 75 percent correct classification rate.

What that told us is that salinity is important, but it's not our whole story. Also, this whole thing is using seasonal salinity, salinity changes, and seasonal turbidity to predict presence in the summer season.

This is South Louisiana. We wanted to see if there was any benefit to sampling at a finer resolution and finer scale.

We took a smaller area, Barataria Bay, which is this area that's west of the Mississippi River. We sampled every six to eight weeks in 2015. We collected the same data that we collected in the big data set -- presence, absence, turbidity, depth, temperature.

They were more meaningful though because we collected them every six to eight weeks instead of just once during a growing season. We collected information on SAV and on FAV, which is Floating Aquatic Vegetation. We evaluated the effective of marsh zone season and the influence of FAV cover on SAV cover.

Again, what we found, this is the mean salinity over the season. This goes from early spring all the way to late winter. Salinity makes sense. The purple is saline. The green is brackish. Light blue is intermediate. Dark blue is fresh. Salinity all makes sense.

There was a significant effect of marsh zone and season on depth. You see, again, fresh marsh zones were deeper. In coastal Louisiana, we have these cold fronts that come in, and they decrease the water level pretty significantly. We were able to pick that up in our data.

Temperature, we see that temperature totally makes sense, temperature across season. We also see cooler temperatures in the fresh marsh zone. Again, that's probably because it was deep. Then there was no effect of marsh zone or season on turbidity. Turbidity, there was nothing interesting going on there.

Like the big data set at this scale, all the drivers of SAV were spatial. There was no affected season when you looked at all of these different marsh zones. What we saw is this is SAV presence. We saw equal presence in fresh, intermediate, and brackish marsh zones. Decreased presence in saline.

This is percent cover. We saw equal percent cover in fresh and intermediate, a little bit lower in brackish and saline. This is for SAV. Looking at FAV, we found that FAV only occurred in the fresh marsh zones.

If you look up here, we've got fresh, intermediate, brackish, and saline. You don't see any brackish or saline on here. We had plenty of aquatic vegetation only occurring in the fresh marsh zones, to a very, very small degree in intermediate.

There was a significant effect of season on SAV. What we wanted to do is I wanted to look at just submerged aquatic vegetation in fresh marsh. There was a significant effect of season in floating aquatic vegetation on submerged aquatic vegetation in fresh marsh.

This red is SAV. Over time this blue is FAV. Over time you can see that as FAV increases, SAV starts to decrease. Then as FAV starts to decrease, SAV starts to increase. This makes sense. If you guys work in these areas, it's intuitive but it hasn't been quantified before.

It was cool to find that it's spatially specific to this one area. Again, it makes sense. We see that these cold temperatures are probably essential for maintaining SAV in this fresh marsh habitat. This is temperature. This is season.

This is in the winter. We see all the vegetation is dead. There's no floating aquatic vegetation that's alive on the surface of the water. Temperatures are low.

This is the early spring. Everything's starting to green up nicely. You can't see it from this photograph, but there's SAV starting to pop up. We probably had about 30, 40 percent cover at this point in time.

We start to get into the summer. You see this massive increase in floating aquatic vegetation. This is all hyacinth. It was about a meter high. At that point, all of the SAV under the surface of the water is completely dead.

Increasing invasive FAV cover significantly decreases SAV cover. It makes sense, but there was a clear temperature pattern that was associated with it. The main point that I want to make is that habitat-supporting SAV are affected by multiple effects of climate change.

Sea level rise, for sure. These low-lying areas, these are going to change the distribution of open water, marsh zones, things like that. With these changing flood risks, that's going to change exposure values and how much the individual plant is affected by waves, winds, and things like that.

We're also dealing with temperature increases, and temperature increases may also affect species assemblages. Precipitation changes will absolutely affect species assemblages.

We also have us, running around down here putting in marsh restoration projects, putting in terraces, putting in fresh water diversions, putting in sediment diversions. All of these efforts are going to have an impact on the habitat, on the environmental variables that determine whether or not you have SAV or you don't.

Which, in turn, can create differing types of waterfowl habitat. Waterfowl are great. They're super mobile. They can move to adapt. These are two examples of sites that we visited. This is Grand Bay, Mississippi. This is San Antonio Bay, Texas.

If a project goes up, or an area floods, or it's not optimal habitat, the bird can move. It will do that, but habitat configuration is also important to waterfowl. You need certain habitats to be within a certain distance of one another, particularly the bird that springs to mind is redheads. Redheads have to have fresh water. They need fresh water within eight kilometers of seagrass beds.

This is an example of Mississippi. What's happened here is we have this road here that's hydrologically cut off the area. You don't get this nice transition into fresh marsh anymore. You just have seagrass, nothing, and then you get some fresh stuff up in here.

In Texas, they're undergoing this big drought right now. They have these beautiful seagrass beds in here, and then virtually no fresh water to deal with. Natural and anthropogenic changes, they can decrease habitat quality, especially when you think of it in a larger scale.

The main point that I want to get across from this seminar is that there are multiple characteristics that determine habitat quality. It's not just the salinity regime, it's landscape configuration. It's species assemblages. It's the combined effects of these environmental variables in estuaries, the proximity to humans.

The takeaway from that is while fresh marsh may support the highest SAV cover and seed biomass, these areas might not always be the highest quality habitat, depending on where you are.

If you remember, the Mississippi River coastal wetlands area, we have these deep ponds that were just absolutely loaded with hydrilla. Then you go over to the Texas marine coast, and you'd have these somewhat shallower fresh ponds that were full of Stuckenia pectinata, which is a much more desirable waterfowl species.

We also have to consider these other macro-climatic drivers affecting these aquatic habitats. These increasing temperatures and increasing sea level rise, as they impact fresh marsh, they may significantly increase the importance of intermediate brackish habitat, especially if we see this increase in invasive floating aquatic vegetation species limiting emergent aquatic vegetation's ability to thrive.

That's going to do it for me. This project was funded by the Department of the Interior and the USGS South Central Climate Center with support from the Gulf Coast Joint Ventures and the various LLCs that you see listed on here.

I'm still hosted at the LSU Ag Center, so I always have to thank them for putting up with me. I appreciate you all for calling in on this hot summer day. That's all I got. I'll take questions.

**John**: Thank you, Kristin. As she mentioned, she'll be taking questions. If you have any, feel free to throw them into the chat box.

First question is from Lindsay Viezey. "What was the most surprising finding of this research?"

**Kristin**: It was the difference between fresh marsh, depending on where you were. We've always been under the assumption or, at least, I was as a bird person and as a wetland person that these fresh marsh habitats are so high quality. They're going to be the most desirable thing.

In a lot of areas, it's not. You go in there, and you're like, "This is not anywhere a duck is going to want to be. This is not anywhere I want to be." [laughs] It's these super isolated ponds that are incredibly, incredibly deep. They're just loaded with a lot of invasive species.

Then you go to a fresh marsh zone in a different area, and it's perfect. A lot of that is regulated by salinity. Again, there are all these multiple factors. Depth is important. That was the thing, that a fresh marsh in the Mississippi River coastal wetlands versus fresh marsh in the Texas Mid-Coast.

In my mind, they're not comparable in terms of anything. They're totally different. As ecologists, we're always struggling to try to classify things, especially spatially to make things easier on ourselves. That was the thing that really stuck out for me is that they're super different. They should be treated as such.

**John**: Thank you. We have a question from Norman Johns. "Did your species sample include Vallisneria Americana, the only one population known in Texas?"

**Kristin**: You're right, Johns. There was not a lot of Vallisneria in Texas. Most of the Vallisneria was in the intermediate zones of the Mississippi River. I know you told me how to do this, John, but I didn't write it down. Most of the Vallisneria was in the intermediate zone.

**John**: Kristin, you can click on that box next to the right-hand arrow.

**Kristin**: This guy? Oh, the draw? That's what it was. I'm where I want to be anyway. Can you guys see it?

**John**: The arrow?

**Kristin**: There we go.

**John**: You can see the arrow.

**Kristin**: This is Vallisneria. This is Texas Mid-Coast. We had a little hit of Vallisneria over there. This is the Chenier Plain, a little hit of Vallisneria over there. This is the Mississippi River coastal wetlands, and we had Vallisneria across fresh intermediate and fresh marsh zones over here.

We were able to pick some up in Texas. I'm trying to remember where on earth that was. I could probably find out, but we were able to find it. It was very sparse in Texas, to say the least.

**John**: Thank you. I saw someone typing. I'll see if they want to follow through with that. While we're waiting to see if anyone else has any more questions, I would like to say thank you, again, to Kristin.

I'd like to thank our partners at USGS and all of you who participated. Thank you for attending today. Let's see. It doesn't look like we have any other questions coming through the chat box. On that note, there we go.

**Kristin**: Hi, Ken.

**John**: There we go. I saw somebody typing.

"Nice talk, Kristin. How does the increase in black mangrove factor into food availability in brackish salt marshes?"

**Kristin**: That is going to be the next hot topic is what do we do about mangroves, particularly here in Louisiana? Everybody's excited about mangroves because they provide that additional shoreline protection.

Again, mangroves in these brackish habitats, it's going to shade out any possibility for SAV. Right now, it's a non-issue because the SAV is so patchy. In our brackish habitats, we don't get these nice meadows, like we would get in saline marsh types

Having some mangroves show up, they actually might provide a little bit into that landscape that would create more protected coves where SAV could show up. I honestly don't know what's going to happen with that now.

We had a bunch of mangroves in Louisiana, and they all got killed this winter. They were all murdered. No, ducks do not consume Avicennia propagule. It would be nice if they did because they're these huge, big, fat seeds. No, they don't eat them.

**John**: That sounds like a good question to end on. I see Norman typing away. I just want to see real quick if there's a question. I just want to thank you. Excellent. Thank you both. Thank you everyone for your questions. Thank you, Kristin, for the presentation.

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