Sadie Witkowski: Hi! I'm Sadie Witkowski

Ian Martin: And I'm Ian Martin

SW: And you're listening to Carry the Two, a podcast from the Institute for Mathematical and Statistical Innovation

IM: Aka- IMSI! This is usually the podcast where Sadie and I talk about how math and statistics impact the world around us.

SW: "Usually," because today we're doing something a bit unique today!

Tiffany Christian: Hey everyone!

SW: While we're in between our more in-depth seasons, we wanted to bring you something a little different. So for this run between our main seasons, we have a special guest joining us.

IM: Let's do introductions!

TC: I'm Tiffany Christian. I'm a rising fourth year PhD student at Northwestern University in their statistics department and I'm knitting my very first sweater.

SW: Is this your first knitting project? Or your first sweater?

TC: My first sweater! I think the last project I completed was a tiny knitted chicken.

IM: I also just started my first sweater! And by 'just' I do mean about 8 months ago. And I am about 1.5 inches in…

TC: At this rate, I'll be finished with my PhD before you finish your sweater!

[LAUGHS]

IM: That's so kind of you, thank you so much.

SW: Ok, but to get back on topic, Tiffany is joining us as our Statistician-in-Residence to help us tackle statistics in the world of environmental and climate science.

IM: We're so glad to have you here Tiffany.

SW: Especially with today's topic that I understand you have some direct experience with: remote sensing of wetlands.

TC: Well, the specific paper I want to talk about isn't my project, but I do have experience with similar research. Today we're going to talk about the importance of wetlands like the marshes around Louisiana, and how those wetlands are being affected by climate change.

IM: When I think of conservation and climate change, I'm usually thinking about planting trees to reforest areas.

SW: Or like around Chicago, there's a lot of work to restore the prairies but I don't know as much about wetlands.

TC: Wetlands are actually super important to the world. Many cities, including Chicago, were built on top of wetlands. Wetlands perform a number of important ecosystem services like water purification, stormwater retention, and they provide habitat for a diversity of plants and animals.

But, climate change is affecting how well wetlands can perform these services. For example, we know that climate change is making storms worse. What does that mean when these ecosystems are hit by harder and harder storms?

IM: So as usual there are a lot of things to consider.

SW: Let's start with how climate change impacts wetland ecosystems specifically.

TC: Sure. So climate change is warming the oceans, including areas like the Gulf coast, which can make hurricanes and tropical storms more intense. These intense storms can cause all sorts of damage. Like uprooting trees and native plants, destroying plankton and algae populations necessary for many aquatic food webs, and causing saltwater intrusion into freshwater areas.

SW: Yeah, it kind of makes me think of Hurricane Katrina. We usually talk about the human toll, with displacement and lives lost. But New Orleans is right on the edge of wetlands that probably had their own damages to contend with.

TC: Yeah, those wetlands were deeply affected by Hurricane Katrina and are still recovering today. Turns out, wetlands need to be restored and protected after a major event.

IM: Ok but how do we even know that wetlands have been damaged? Like, this feels similar to our invasive species episode. How do we keep track of these broad swathes of land and monitor sensitive ecosystems?

TC: There are two approaches that researchers can use. The first is that they can go out to the site and collect measurements in the field.

But for hard to access sites or sites that are very large, they can use another method, called remote sensing. Remote sensing is just a way to gather information about what's happening at a place from far away.

We can take information about something without being physically in contact with it. Satellite images, aerial photos, even telescopes are all examples of remote sensing.

SW: Like using satellites to understand the urban heat island effect in our episode about Angel Hsu's work. Using the satellite images like that to get temperature was a form of remote sensing.

TC: yup! Although what **we** really want to know is how the wetlands are changing over time.

IM: Oooo, time for a timelapse video?

TC: That's the basic idea!

We can take a series of pictures at one site over time and that gets us a sense of its history. Satellite images can essentially take photos and convert them into numerical information. We then treat these pictures as a snapshot in time, and we can take the numerical information from these images to make a time series. We're basically playing a statistically rigorous game of connect-the-dots.

Think of events like trees growing new leaves in the spring or dropping their leaves in the fall. Those events can be affected by many outside forces, so we want to use imaging to see how they change over time..

SW: Sure, maybe one year there's a terrible drought and the tree doesn't grow new leaves until late in the spring.

TC: Exactly. This is why we study the timing of *when* changes in an ecosystem occur year after year. We can use the changes in the timing we detect as an indicator of something affecting the ecosystem.

IM: So if we see a shift in the ecological clock where things aren't happening at the time we expect, that's a sign of a shift in the system that might indicate a problem.

SW: That makes sense. But so far, we've covered a bit of the science in how we can watch wetlands over time and see if they're degrading or improving or staying the same. But, and I hate to do this, we *are* a statistics and mathematics podcast. So where's the math?

TC: Well let's go back to the wetlands of Louisiana. Scientists have used imaging to detect changes in wetland health after Hurricane Katrina. Yu Mo, a scientist at University of Maryland, used something called NDVI.

IM: NDVI don't know what that is!

[Laughs]

TC: NDVI actually stands for Normalized Difference Vegetation Index. It's just a proxy for 'greenness' that scientists used to assess the wetland productivity during a few years, a normal year, drought year, and the year of Hurricane Katrina.

SW: What do we mean by productivity in this case?

TC: Productivity means how much biomass is produced by the plants. Usually the biomass of plants is all about the photosynthesizing parts, like the leaves. That's the part that we see growing over the course of the season.

Think about your standard deciduous tree in Chicago.

SW: That's basically your maple or oak or something. Just not an evergreen like a pine tree.

TC: Right. In the winter, the tree isn't very green because it has no leaves. But as spring comes, the tree uses energy stored in its roots and becomes a little bit greener as it starts to leaf out.

SW: Leaf out? Oh, that's what those little leaf buds are doing.

TC: So continuing the analogy, in summer the tree is even more productive and reaches its peak greeness for the season. The sun is shining, it's photosynthesizing, and the leaves get bigger to soak up all that sunlight. Then as fall approaches, the tree needs to prepare for winter. So starts to lose its greeness, **literally** as the leaves lose their chlorophyll and fall off the tree.

And that's the usual cycle, year after year.

IM: Ok, so that's the timing across one year.

TC: Right. If we continue the tree example, if the tree loses its leaves at the same time every year, and regrows them at the same time every year, we might be able to conclude that the tree's environment is stable.

SW: But what if there's a hurricane?

TC: That year might look normal with everything chugging along, until there's an abrupt drop in NDVI. The Normalized Difference Vegetation Index drops because water flooding the site is obscuring the vegetation. Or because the storm caused actual physical damage by stripping the leaves.

SW: So like hurricane Katrina flooded the wetlands and all that greenery was covered with water. That would have given us a sudden dip in the NDVI.

TC: Yea, or something like a pest outbreak could also cause a decrease in NDVI over time. If a bunch of caterpillars are munching on our leaves, greenness will also decrease. It might be a more gradual drop, since it takes time for the bugs' damage to register in a satellite image.

SW: Are there examples of NDVI in the other direction?

TC: Sure. So if an invasive vine, like Kudzu starts to climb our tree. Then what we are seeing from space isn't just the tree's leaves, but also the leaves of the Kudzu vine. We might see a higher summer peak in NDVI, because we're seeing both the kudzu's

leaves and the tree's leaves. Kudzu also has a longer growing season than our tree, so the NDVI will increase earlier in the spring, and stay greener later in the fall.

SW: Woah, so to have a green signal for longer than expected could also be telling us something about an invasive species like kudzu. That's so cool!

IM: So I know you weren't involved with the Louisiana research post-Katrina, but I want to hear what some of the findings were from that work?

TC: The paper I mentioned investigated how we can model changes in the NDVI across the growing season in different kinds of wetlands. Remember, wetlands aren't all the same, so they compared images of freshwater marshes, intermediate marshes, brackish marshes, and saline marshes.

SW: Oh yeah. And as a quick reminder, brackish is a mix of salty ocean water and freshwater.

TC: Right. So, they plotted NDVI for each of these wetland types over time. And they did this for three different years: 1999's drought year, 2005's hurricane Katrina, and 2007's "normal" year.

Basically, they wanted to do two things. First, find the best statistical model to explain the relationship of NDVI across years. Second, see how different climatic conditions affected the growing seasons.

SW: Ok, let's start with the statistical modeling.

TC: If you remember our other episode on urban heat islands, It's the same technique! They used regression and found in a normal year for all wetland types, that the best model was a Normal, or Gaussian, model.

SW: And the second finding on climatic conditions?

TC: The researchers found that the growing season curves differed between marsh types. Saline marshes had the longest growing season but were the least green according to NDVI. And freshwater marshes had the shortest, but greenest growing seasons.

They also found that in the drought year, saline marshes were the most affected with a 2 month delay in their peak growing season. Unsurprisingly, Hurricane Katrina also cut the growing season in half for all marsh types.

SW: It's so cool that we can use satellite images to see how growing seasons are changed by these big climate events! Thankfully, if I recall correctly, hurricane season is almost over for the year. I think it officially runs from June 1 through November 30th. That gives us a few months to prepare before the next onslaught of storms.

IM: Although I feel like the breaks between these storms get shorter and shorter each year. Yet another effect of climate change that we have to contend with.

TC: And that's why it's so important to maintain the health of these wetlands. A healthy mangrove stand or sawgrass marsh acts as a buffer against these big storms. But if the wetlands aren't healthy or protected, they can't do that function.

SW: And based on this work, we know that we have to actually track the health of these wetlands in order to make sure we have a good measure for what's happening.

IM: And we have to use math (or, I guess statistics) to get that measure that changes over time.

TC: Yup!

IM: So this seems like another way that we can use math to determine what areas need more attention so we can use our resources more effectively.

SW: And then when hurricane season comes around again, we hurri-CAN expand on this research with additional researchers.

IM: Oh Sadie, I know you hurri-can do better than that.

[LAUGHS]

[Music Plays]

[AD BREAK]

SW: As always, don't forget to check out our show notes in the podcast description for more about this research on monitoring wetlands.

IM: And if you like the podcast, subscribe to the show and give us a review on apple podcast or spotify or wherever you listen.

TC: By rating and reviewing the show, you really help spread the word about Carry the Two so that other listeners can discover the podcast.

SW: And for more on the math research being shared at IMSI, be sure to check us out online at our homepage: IMSI dot institute. Our fall programming has centered on climate change and sustainability. In fact, next week we have a workshop titled Remote Sensing for Climate Analysis! If the talks look interesting, you can register for free and attend via zoom.

IM: But back to social media… We're also on twitter at IMSI underscore institute, as well as instagram at IMSI dot institute!

TC: How do you spell that again?

SW: That's IMSI, spelled I M S I.

TC: And what are your mathy questions? Maybe you have an idea for a story on how mathematics and statistics connect with the world around us.

IM: Send us an email with your idea!

SW: You can send your feedback, ideas, and more to sadiewit AT IMSI dot institute. That's S A D I E W I T at I M S I dot institute.

IM: We'd also like to thank our audio engineer, Tyler Damme for his production on the show.

TC: And music is from Blue Dot Sessions.

SW: Lastly, Carry the Two is made possible by the Institute for Mathematical and Statistical Innovation, located on the gorgeous campus of the University of Chicago. We are supported by the National Science Foundation and the University of Chicago.

Until next time!

IM/TC: Bye!