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David Ceilley: Good morning. Thanks, Joel. Uh, this is a good follow up, I guess, because Jeff set me up pretty good talking about the exotics. Uh, been looking at fish community structure in southwest Florida for a number of years now, since the early 90's anyway, and, uh, there hasn't been a whole lot of work done over here, as I think Shawn Liston pointed out earlier, uh, in the conference. And, but we're starting to learn more and more as we go along. There are a number of exotics here. First of all I want to acknowledge a couple of, uh, of folks I worked with, Ian Bartoszek and Melinda Shuman, who spent an awful lot of time in the field with me, uh, collecting fish, facing alligators, moccasins, mosquitoes, poison ivy, you name it. And, uh, they had a lot to do with both of the studies I'm gonna talk about today.

Uh, there are some other people I need to acknowledge also. First of all, if I accomplish nothing else today I want to let you know about two very large studies that were done. They're both technical reports and it may be a couple of years before they come out in the literature, but one of 'em is the Fish and Wildlife Service, what's know as the refugia study. It was done, uh, over a period of time from 2001 through 2005 and it came out last year. A couple of people at the Fish and Wildlife Service that were, had a lot to do with that, Project Manager Dawn Jennings. When she moved on, then Cindy Schultz took over, and I worked with Marilyn Knight as well.

Um, another study that was funded more recently, it's the baseline assessment of Picayune Strand. And, of course, Anata Nath, and Clarence Tears funded some initial studies on that. Then when the accelerate program came in, Janet Starnes and Mike Dugar took over on that project. And we're gonna talk about just a small bit of that study, which is the fish study. And I should say also the refugia study, we looked at everything. We looked at wading birds, we looked at large mammals, we looked at, you name it, from top down. And so I'm just gonna be talking about the fish on that.

There's a number of other people, staff at the Division of Forestry, Fakahatchee Strand State Preserve, Florida Panther and 10,000 Islands National Wildlife Refuges, and even some folks over at Collier-Seminole State Park that helped with these studies. Uh, Steve Bortone and I, uh, originally designed the refugia study. Steve is off in northern Minnesota now, but Dr. Bob Schroeder flew the wading bird surveys for that study and Bob was out in the field with us quite a bit. And Bob's quite a character. He's a wonderful man. Bruce Boler had something to do with this stage, (inaudible), Joan Browder as well. Mike Berry, Mike Owen, Jeff Schmitt, Joshua Gates, Glenn Buckner, Kathy Whirley, Dave Addison and

my son, Connor also, and a wealth of interns both at FGC and the Conservancy. I just had to get that out. But if you want to know more about these studies; uh, I'm gonna go very quickly through these slides; but if you need to know more, you can contact me or somebody at the District or the Fish and Wildlife Service about these studies.

Uh, just to give you an idea, this is in our back yard. Now it's only about 20 miles away from here, Picayune Strand. It's interesting to point out that it's surrounded by preserve areas. The Belle Meade is part of the feasibility study, but this is the accelerate project, 55,000 acres. You got the Florida Panther Refuge up here, Fakahatchee Strand, 10,000 Islands and Collier-Seminole. We're gonna come back to that slide later.

Uh, this is a cross section, this is a typical cross section of what you might see, uh, in southwest Florida. We've got a mosaic of upland and wetland habitats. And the effects that canals have, they draw down the water table. And in Picayune Strand we have a number of cypress domes that the canals have effectively drained the cypress domes, that they don't contain any aquatic fauna anymore. And they actually still look like cypress domes, but they don't have any aquatic fauna, no fish, no invertebrates at all in at least the two-year study period that we looked at 'em.

Uh, for the refugia study, we'll start with that one. We looked at five different types of deep water, nearly permanent waters, in southwest Florida. And typically this is what they are: the canals that Jeff talked about earlier, we got plenty of those in our area as well. We have artificial ponds. These are borrow pit ponds that were built, or dug, to get fill dirt to build homes in, in Picayune Strand. We also have another remnant, uh, in Picayune Strand, these Willow ponds. Now these Willow ponds didn't used to be Willow ponds. After the road construction and the canals were put in, uh, there was a lot of logging activity as well. There was some catastrophic fires.

Anyway, these Willow ponds used to be cypress domes, and deep cypress domes and ponds. So that's a, it's a natural habitat, but it's still in a drained and fragmented state. Now over in Fakahatchee Strand we have the Tram Ditches, which are artificial but they're surrounded by natural native habitat and the hydrology of these systems is near normal. A lot of the trams were washed out, so you still have this sheet flow connection in Fakahatchee Strand. The Popash and Pond Apple Ponds are natural refugia in the system. They're fairly deep and they only dry out every few years, and when they do dry out they become gator holes.

Uh, fish studies. We tried a lot of different methods. I'm not gonna talk about all of 'em. But just to give you an idea, these are some of the methods we deployed to get a complete species list. We also used boat

shockers in the canals. We used visual. We used hook and line sampling, uh, which was quite effective, actually for Oscars. I'm gonna talk about Breeder Trap sampling. At each site in this refugia study we sampled them for three years on a monthly basis. We used breeder traps, eight of 'em at each site. We collected over 66,000 fish and we actually measured these fish as well. That's a whole other story. 12 families and 27 species were collected in these traps, and I know that they are, they have a bit of a bias to 'em because they're an activity trap, but they worked very well for this study.

Just to give you an idea of the number of species that we collected from these different, what we call biotopes. Artificial ponds had 20. Canals had 21. Popash Ponds had 21 also, different species though. The Tram Ditches had 19 and the Willow ponds 15. Now that's what we collected just with the breeder traps. Actually the species list is a little bit larger. It's hard to catch a tarpon or a snook in a breeder trap, but they're out there.

Uh, just to show you how daunting it is; sometimes when you have these big community data sets; we've got, this is just overall abundance from the refugia study sorted by biotope. Now remember, this is three years of data, five different biotopes, and we had replicates, four replicates in each of those groups, so just the total numbers; now, typically, uh, you know, biologists look at these data sets and they can do the basic stuff. Well, let's look at percent composition. Let's look at, you know, your basic diversity metrics, like the Shannon-Wiener species richness, percent composition within and between sites, really basic stuff.

But I'm interested in looking at the whole community. What's going on with the whole community? And I took, uh, I took, I went looking for some tools to analyze the data and looking for multivariate tools, and there's a guy named Bob Clark who teaches a class on primer, which is a really robust program, a multivariate program. And it was funny, at one of the training sessions; Bob's quite a character; uh, he said to me you know, biologists that I work with, they're, they remind me of drunks leaning on a lamppost. They're really looking for support more than illumination. He meant that as a compliment, I think, because he worked with some brilliant people. But what he said was really true. A lot of times we know what we're trying to say but we're just hoping to prove it somehow with some statistical tools. In my case I actually was looking for some illumination too. But I found a tool that, a multivariate tool that is based on Bray-Curtis Similarity because I'm interested in the whole community structure. Uh, we use cluster analysis similarity profile tests, which is a global significance test. SIMPER is a similarity percentage test which tells you how much each individual species contributes to the difference between sites.

Another global significance test is a pair-wise test called ANOSIM. And, uh, we have another one called; uh, multidimensional scaling is an ordination technique which I'm gonna show you a little bit. And for environmental variables I use principal components analysis.

This is a basic cluster diagram of the refugia data and everything is presented here, but it's difficult to interpret. There's a new version that helps me illuminate what was going on here, and it's Version 6. It has this global significance test. And what you see here is we have three different, significantly different groupings at the 95% confidence level. And what I'm showing you here with the labeling that you can do, it shows that the artificial ponds and the canals here are grouping very nicely together. In other words, this fish community is not significantly different within that group, but as a group is different from this group, the Willow ponds, and is different than this group, the Fakahatchee sites. So in other words, we have three distinct fish communities: one that's characteristic of canals and borrow pit ponds; one that's, uh, characteristic of the Willow ponds, and that happens to be the livebearers. The livebearers in the Willow ponds are kind of a remnant, I think, because they, uh, they get in there, they, uh; the lepomis and the sunfish have been pretty much extirpated, at least during the dry down. In the Popash sites and the Tram Ditch sites we have a whole different community that's typically native small fishes.

This is just a, uh, representation of a global significance test and it shows you here; these are 999 random permutations and this is our observed data. This is a cluster diagram here and this shows you we cannot achieve that output or that result with these 999 random permutations; therefore, there is a significant difference.

MDS plots. I like to use those 'cause I'm kind of a visual guy anyway. And this is just another way of looking at the same data. Bray-Curtis similarity. We've got the Picayune sites overlaid on these 75% similarity. So we've got this group here, the Fakahatchee sites, Tram Ditches and Popash ponds, the canal sites over here and the Willow ponds here. Three distinctly different communities.

The fishes; like I said earlier, native fishes in the natural sites of the Popash ponds and Tram Ditches. We do have exotics in there. We have the Brown hoplo. We have Black acara. We have Oscars. But you don't get the tilapia and the mayan cichlid. Here we got the bluefin killifish, sailfin molly, marsh killi fish, least killi fish and the Warmouth.

As Jeff mentioned, the disturbed habitats of canals and the artificial ponds, they have more of an exotic dominated community. The mayan cichlid and the tilapia are probably the most abundant fish. And as Picayune Strand restoration went forward these fish were isolated in some of these pools

and you could really see the biomass. We also have some large, like I said, there's tarpon. We have large mouth bass. We have gar and other big fish, but the exotics clearly dominate.

Uh, what makes the different refugia different other than their structure? Water chemistry is much different. And what I want to show you here real quickly is that; these are vectors in a principal components analysis. Temperature is typically higher in the artificial ponds and canals and dissolved oxygen is typically higher in those habitats. And typically where things are cooler, we have a lower DO in Fakahatchee Strand. And a lot of these fish; one of the points I want to make is a lot of these fish, native fish, are adapted to extremely low DO and often times we found hypoxic conditions, of dissolved oxygen less than 1 mg per liter.

I want to talk a little bit about the baseline assessment. Uh, again, we used breeder traps for this. This was a method that was adopted by the PDT for baseline monitoring of fishes. And when we did the fish sampling we also collected macro-invertebrates and we did some amphibian sampling. Again, we used breeder traps, 10 traps with one hour soak time at 43 sites, 32 impacted and 11 referenced sites. Habitats include cypress, cypress graminoid, wet prairies, hydric pine and marshes, both; excuse me, both fresh and salt water marshes. Uh, we visited these sites three times a year during the rainy season and, uh, those were the times we were out there, August through February basically. Uh, now at least 11 sites were completely dry. As I mentioned earlier, the cypress sites were completely dry during the whole study period, 2005 to 2007. Or if they had water it was only for a day or two after a rain event and then the drainage, uh, dried them out.

Getting back to this figure again, I just want to point out that you've got four large canals that bisect Picayune Strand. They all come down here and drain out the Faka Union Canal. These are the actual sites that we sampled here. SG indicates Southern Golden Gate. Florida Panther, we had three sets, had three sites on the transect here to get cypress, wet prairie and hydric pine. The same thing down here, reference sites in Fakahatchee. And we have three sites down here in 10,000 Islands and this is our reference site that gets natural sheet flow through this system, and these pretty much have interrupted fresh water flow. These are more brackish, because the flow is cut off by a canal system here.

This is a much smaller data base, but we've collected over 6,000 fish; uh, 25 species and nine families.

This is all the sites that had water. It's kind of difficult to interpret, but you see in the red here? These are not significantly different from each other in each group. But you have four significantly different groups of fish. And

you'll notice that this group includes all of the referenced sites except for this one. This is a hydric pine site on the Florida Panther Refuge that didn't get very wet.

Uh, it's important to point out that you've got 12 or 13 sites that don't show up on here because they didn't have any fish and you can't do an ordination on them. It would skew everything if we put them on there. They would show up as outliers and everything else would bunch very closely together. So I looked at just cypress and, uh, cypress graminoid and wet prairies because in a typical natural situation they're connected hydrologically. Water sloshes back and forth and the sheet flow is really important to fish. Otherwise they can't get to a spot.

And so looking just at cypress, cypress graminoid in those that had water, you'll notice that very; there's not that many impacted sites that even had water, but look at the difference and similarity. They separate out at about 40, well not even 40%. So these sites here, look where the break is. The important thing is where this break is here. And you see this break here as well. Uh, they're more dissimilar than similar, which is unusual. Uh, I might come back to that, but at 52% similarity, we see at least three groups, looking at just the cypress.

Now you'll see this is an overlay of the reference sites. It captures all those reference sites. And you'll look at, we've got some green impacted sites in there. But guess what? Those are the ones that are very far south in Picayune Strand and they have a more natural hydroperiod and they actually do have a fish community that's not too far off of the reference sites. In fact, I can tell you that this, there's a (inaudible) pine site, that's no longer impacted. That's next to prairie canal that's already been filled in. So this actually is a post-restoration, uh, signature of what happens to the fish communities post-restoration. This is no longer baseline here. So this, these sites right here have been hydrologically restored by the filling in of prairie canal, and look what's happened. They're moving in toward those reference sites. And that's what we would expect to see. That has implications for restoration. It has implications for performance measures.

Um, real quickly I'm gonna go through this. I just wanted to show you one of the tools that I use as a similarity percentage test and this, I've got two fish here that showed up only in the reference sites. That's the *Lepomis gulosus*, the warmouth, and the Everglades pygmy sunfish. You see, this is the, uh, actually the fourth root abundance here. It didn't show up in the impacted sites. So those two fish may be good indicators. Thank you, Joel. Uh, they may be good indicators of both disturbance if they drop out of the system or if they start to show back up.

This is just a bubble plot overlay to show you what, uh, their abundance is on the ordination. Again, this is the same multidimensional scaling ordination. It's just a visual tool that I use to look at where these fish are and where they aren't. And all this was in the report. We've actually done the bubble plot overlays for all the species that we collected.

In conclusion I wanted to make the point that all aquatic refugia are not created equal. Borrow pit ponds, retention ponds, canals have the same fish community for all intents and purposes and they do not function very well for wading birds. They just don't have the access, they don't have the literal zone access to forage. Uh, we've identified landscape level negative impacts with Picayune Strand baseline monitoring. Uh, we've looked at, you know, the effects of roads on fish communities, the lack of sheet flow, and we've identified the impacts of hydroperiod. So even though these wet prairies and cypress systems, they look like there's plant communities there, they don't have the fish community. And so we're gonna use fish as an indicator of restoration success in Picayune Strand, hopefully.

We tested and developed some rapid and cost effective fish sampling techniques. I've seen a lot of fish sampling techniques, uh, presented during this conference and over the years, and there's a, we've got a long way to go in trying to quantify densities I think. But, uh, the breeder traps are pretty good activity traps for catch per unit effort comparison between sites.

We also identified, like I implicated earlier, that; I think we identified restoration targets for fish communities. We know what the natural communities are through the refugia study and through the baseline assessment of the reference sites. We know what the target is and we just need to come up with how similar do we want these restoration sites to be to those reference areas. Uh, and with that I'll open up to any questions. I think we have a minute or so left. Thank you.