Using Decision Tools to Design the Everglades Headwaters National Wildlife Refuge

Katie Poston: [0:05] Welcome from the US Fish and Wildlife Services National Conservation Training Center in Shepherdstown, West Virginia.

[0:11] My name is Katie Poston, and I would 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 "Using Decision Tools to Design the Everglades Headwaters National Wildlife Refuge."

[0:29] We're excited to have Stephanie Romañach with us today. To introduce our presenter today, we have Ryan Boyles, who is the Southeast Climate Adaptation Science Center's Deputy Director. Welcome, Ryan.

Ryan Boyles: [0:42] Thank you, Katie. Very pleased to introduce to you Dr. Stephanie Romañach. She's a Research Ecologist with USGS. She's based in Fort Lauderdale with the Wetland and Aquatic Research Center. She's done a lot of work in central and south Florida working with Everglades, Everglades restoration.

[1:00] She leads a fairly large research program working with decision makers on a lot of the complex problems that they're dealing with in terms of how restoration funding should be allocated. She's accommodation of field observations, ecological models to look at impacts and connect that back into decision making. That's one of the things.

[1:17] While this specific project that she's talking about was funded several years ago, it fits very well with the theme of this webinar series around the science that you can use. She brings decision analytics in and decision science in in combination with the ecological models and field observations that she collects.

[1:38] She's done a lot of work in Everglades in central and south Florida, but also has prior experience working in Africa around conservation issues there. Thank you to Stephanie for coming back to talk about something that she probably hasn't thought a lot about in the past year. I think the topic certainly still resonates with us today, especially the process that you went through to look at the reserve design for Everglades headwaters.

[2:03] With that, we'll turn it over to Stephanie, and say thanks to everyone for joining. Hope you get a lot out of this.

Stephanie Romañach: [2:09] Thank you, Ryan. Thank you, Katie. That is a nice setup to say that yes, this project was funded some time ago. It was completed in 2015, but we only published the work maybe a year or two ago. Year-and-a-half ago, maybe. It doesn't make it any less relevant.

[2:31] This was also one of my favorite projects to work on. It will be fun to talk about it again. My apology would be if you ask me a detail that I just can't recall, because the technical details -- it definitely has some problems.

[2:44] Like I said, it's just as relevant today, and the work by the Fish and Wildlife Service is ongoing. As Ryan and Katie said, I'm going to be talking about the work that Brad Stith, Fred Johnson, and I did to help the Fish and Wildlife Service with designing the new Everglades Headwaters National Wildlife Refuge.

[3:06] Designing a wildlife refuge is not too dissimilar to buying a house, in some ways, although that might seem odd to say. Yes, it is a little more computationally complex, but the process, in a way, is similar to buying a house or any other big decision that you make.

[3:27] I would guess that if you're buying a house, you don't just get on Zillow and put an offer on the first house that pops up on your search. You would probably think about things that you care about -- quality of life in general, but you'd probably be thinking about quality of the schools your kids would go to, or the layout of the house, or size of the house, or traffic patterns, or whatever it would be.

[3:50] You'd think about what you really want first, and then you'd find a house that matches those objectives that you have. If you're designing a wildlife refuge, chances are, just like if you went in Zillow and put an offer on the first house you found, if a refuge manager just puts an offer on whatever is the first parcel of land that comes up for sale in the area, chances are that that's not going to work out too well.

[4:18] The refuge manager will have to consider his or her objectives for the refuge when deciding which parcels of land to buy. I'll get back to all those details about details about objectives and that in a minute.

[4:30] I'm getting used to the slide-changer. I'll tell you a little bit about reserve design in general first, and about the refuge, and then we'll get into more details. I realize that we are talking about a refuge, and I'm calling this "reserve design," and that's because the field of study is generally called reserve design.

[4:52] It deals with identifying parcels of land that are in need of protection for whatever reason -- to protect particular wildlife species or populations or habitats of interest, ecosystem functions or whatever it might be. That's done in another sense just [laughs] like buying a house, where it's secured on an open market. You do your purchase. Some land can be put into easements.

[5:16] There are challenges. Usually, funding is not available upfront to buy all of the land necessary for an entire refuge or any other kind of protected area. What that means is that results in incremental implementation of that refuge or other kind of protected area.

[5:42] What that leads to is because we have to do this incrementally, it means these purchases are made over many years and in many cases, made over many decades. That subjects the area to changing condition.

[5:55] You might have properties that are lost to residential or commercial development. You don't know where you're going to have funding in 10 years from now in this case of Fish and Wildlife Service and what is congress is going to authorize. What are the funds can be in 10 years from now or even next year? We just don't know.

[6:15] Just like with any real estate transaction, what's the probability of a successful purchase or successful land transaction? As we know, there are a lot of environmental change. We have no idea what a particular price might look like, depending on management or nature or other factors. Things could change. Whatever we think might make a good refuge, now that might be quite different in 10 years from now.

[6:47] Everglades. Just getting into the study area a little bit. If you have worked in the Everglades or you're familiar with the Everglades at all, chances are you have seen this figure a million times or something like it. If you look over at the left panel, this is what the Everglades...

[7:04] When I say Everglades, Everglades National Park is down here. This is the greater Everglades. This is typically when we're in the Everglade, this is what we're talking about when we say the Everglades.

[7:15] This figure is what the Everglades look like in the 1800. We had this area was the headwaters of the Everglades. I'll show you that more closely. That basically form this really nice ship flow that moved fast over the landscape.

[7:34] Then, humans came in and started all of these mines here. People started digging, so they were draining this ecosystem. These lines are levees and canals and other features that basically move water away for flood control or in this case, agriculture or whatever human purposes were. The system looks very different today than it did in the 1800s.

[7:59] The idea is that we would like with restoration, which will take many decades. We would like water to come from this headwaters and move south through the ecosystem once again.

[8:16] Why is this area important? This is the area that we're going to be focusing in on and this is the headwaters of the Everglades. It's important because in terms of the Fish and Wildlife Service desiring to have a refuge in this location, the headwaters of the Everglades, this can help to restore the wetlands and uplands in this region.

[8:42] Some of which are degraded from human activity. There's a lot of restoration going on in that area. If they already in particular can protect a number of federally listed threatened and endangered species, 38 specifically in 161 state-listed species.

[8:57] It also connects habitats, which you'll see in a map that will show you the refuge study area. Connect them to other protected areas in the region. Some are state parks or military lands in better under one protection or another. Another idea was that this would be a potential refuge for many species from impacts of climate change.

[9:24] Zooming in a little bit, maybe I can reorient you. Here was Lake Okeechobee. This was the Kissimmee River coming down. This is the headwaters of the Everglades. Here's the edge of Lake Okeechobee here to reorient you here. This is the Everglades headwaters.

[9:43] In black is bounding the study area, which is a 1.8 million acre area. The reserve will not be continuous. What this means is the Fish and Wildlife Service can select parcels of land from within this study area.

[10:02] There are two constraints. One is that they can buy up to 50,000 acres outright and then they can put easements on another 100,000 acres. It'll be a 150,000-acre refuge when it's done. The good news is that there are willing sellers. This was not the case at the start.

[10:22] There was a little bit of a turbulent start along the lines of the government coming in to take over people's property. That has subsided. There are willing sellers now, so that's not a problem. Some of the desired outcomes for the Fish and Wildlife Service in the conservation-partnership area, and again that's where the easements can be, are to basically keep working lands working.

[10:52] Allow ranching activities to persist in private ownership, again if they're reflecting the goals of the refuge, which are things like wildlife-viewing, hunting, and fishing. Then for the conservation focal area, which is where the lands will be purchased, some of the desired outcomes there are to have habitats for the threatened and endangered species.

[11:19] Inland, to keep common species common. They have an emphasis on migratory birds, listed species, and wetlands in particular. The Fish and Wildlife Service had thought through what were their priorities. These were some of their top priorities, which were for land acquisition. That was to have landscape connectivity or corridors through the habitats in the region.

[11:46] Again, habitats for threatened and endangered species. Restoration of wetlands and water quality was very important. You can hear that in the name of the Everglades Headwaters. They wanted opportunities for wildlife-dependent recreation and educational opportunities. Some of the species of particular interest are the panther.

[12:14] You've probably heard about the Florida grasshopper sparrow. I know at one point it was considered the most endangered bird in North America. Things have not gotten any better for it. Unless another species has gotten worse, this one was considered to be the most endangered in North America.

[12:30] There are a number of other birds, mammals, and some habitats in need of protection -- Florida dry prairie, scrub habitat, and sandhill. The Fish and Wildlife Service was looking at land-protection options in order. The ideal would be if others would protect the land so that they wouldn't have to buy it or use the resources in those particular areas. The second option would be easements.

[13:04] Then the third, then they would go to a fee title or buying land outright. The focus there would really be for things like if they wanted to build boardwalks or whatever other visitor-use-type areas that really wouldn't be as suitable to land with an easement. Just a little bit about cost. It's not cheap to design [laughs] and to take over a refuge.

[13:39] If we look at the conservation focal area, which is where the land is going to be bought outright, the estimated cost is about $4,000 per acre. For the 50,000 acres that they can buy minus some expected donations, it's just under 200 million.

[13:56] If we look at the easements, that's estimated to be at about 2,000 per acre times the hundred thousand. That's another two million. Just for the land is just under $400 million, plus some operations costs, both one-time and annual costs.

[14:15] Just to buy the land necessary for the refuge is about 398 million. You can see why I was saying that we usually don't have that kind of money all at once to just say, "OK, here's the best design for the refuge. We're going to buy all these lands." It's just not going to happen.

[14:35] The Fish and Wildlife Service did all of the hard work for us. It can be really challenging to really get at objectives, and then quantifying them is another challenge, but the Fish and Wildlife Service did this quite nicely.

[14:55] They were very clear on exactly how many acres of each habitat they wanted -- for example, 34,000 acres of wetland for particular species of interest, 13,000 acres of dry prairie. We had their objectives to work with while we were working on this refuge design.

[15:20] We ended up choosing to work with Marxan with Zones. Basically what it allowed us to do...It goes a little bit beyond Marxan to help us find an optimal reserve design. What we considered as zones were easement and fee titles. We were able to allocate land in those two categories to help us meet the overall habitat objective.

[15:57] Marxan was originally designed in the marine world, in Australia. I think it was University of Queensland. It's been widely used all over the world on land -- terrestrial uses as well as marine, at this point. It's been in use for quite some time. It's a pretty strong program.

[16:15] We used that because for me, I can't do trade-offs of calculating 50,000 parcels in my head, so we had to find some way to do it, and Marxan with Zones was a great way for us to be able to do that. We were also able to look at the target habitat within a parcel, so not just the whole parcel, but making sure that we were able to get the habitat within a parcel while we did these analyses.

[16:44] We also looked at two urbanization scenarios, and those urbanization scenarios went out to 2060. I'll talk a little bit more about those later. What Marxan does is it allows us to have a static solution to the problem. This assumes we have that 400 million today, and we don't. I'll talk about that a little bit later, but this was the best we could do for this case.

[17:15] There are a number of other methods that allow us to look a little bit more dynamically, but not for 50,000 parcels. That method did not exist.

[17:26] I'll just show you the inputs that we used, which is pretty simple and straightforward. These were the five inputs we used, which were the parcel boundaries and cost, habitat...I don't know if you remember if I said, this was funded in 2012. That's where the numbers...You'll see these years of these data layers come from that time period.

[17:52] We did the work from 2012 to 2015. The parcel boundaries, the costs, and the cost we used was just value -- the land cover, existing protected areas.

[18:05] I think I forgot to point this out to you on the map -- areas not considered. The Fish and Wildlife Service...There were particular parcels of land that they knew they would not buy or put easements on, and so those they had designated as areas not considered. We factored that in to make sure we weren't selecting parcels in that area.

[18:26] Then, of course, we used the focal area boundary where we could buy land, and then we can't buy land outside of that, and so easements on the partnership area.

[18:35] This is where we ended up. We had four counties, and to start, we had 200,000 parcels. We removed those in the areas not considered, removed those that are already protected, and we ended up with 51,000, almost 52,000 parcels to consider in the reserve design.

[19:02] The two urbanization layers that we used have a lot of the same assumptions, but there are some differences. There was one layer developed by a group called Geodesign, for anyone who's worked with Mike Flaxman. He used to be at MIT. He's done a lot of work for the Fish and Wildlife Service in the past.

[19:29] He did a layer for us, and it used a 70-year median growth rate. He incorporated some local county regulations, and he develops an attractiveness index to look at where residential development might be occurring in the future.

[19:52] We also used a University of Florida urbanization layer. It had a lot of the same assumptions. It also used distance from existing development -- development based on projected population growth, and major roads that are planned.

[20:12] We ended up with nine scenarios. We basically had a current, assuming-no-further-urbanization scenario, the Geodesign scenario, and the University of Florida scenario, and then we had three land allocation scenarios. If we had 10 percent of land in the fee zones and 90 percent in easement, 33 percent in the fee zone, 67 in the easement, and then 50-50 split.

[20:39] We also looked at connectivity. We explored a range of values for the boundary length modifier, or the boundary cost matrix. It really had no influence, which suggested that our design was as compact and efficient as it could be.

[20:54] Just so you're aware, and we should have said this at the start, but I'm not going to show you through a map of our final design. I'll show you plenty of other results, but I'm not going to show you that, just because of the sensitivities of land acquisition. You won't see a final map, but you'll see some other grasping tables and maps of other parts that went into the design.

[21:21] This -- I just had to put up here the calibration, because I thought it was quite crazy. As Ryan mentioned at the introduction, I run a team, ecological modeling team. Marxan was new to me. That's why Fred and I brought in Brad Stith, who's worked quite a bit with Marxan. I'd just never seen a hundred trillion iterations per repetition [laughs] before. I thought that was pretty neat. I just thought I'd bring that up. It was a little crazy.

[21:49] I will jump into some of the results, and I'll first show you the urbanization results. Let's see. This is the study area, again. The gray are the areas that are existing protected areas. These polygons in the dark outline are areas where purchases can be made, and then the rest of this area is where the easements can be made.

[22:19] Green is showing you habitat that is projected to not become urbanized by 2060. This orange is showing the habitat that the University of Florida model is showing to be urbanized. The purple is where the Geodesign layer is showing to be urbanized, and then red is where they both are showing.

[22:47] There's most agreement between the two models up here in the northeast, and we used two because we just wanted a broader look. Like I said, they do have a lot of the same assumptions, but they have differences. We just wanted to be able to see, what are these different approaches? What might they be telling us about where we might want to focus attention or not?

[23:11] That's another conversation and something I'll bring up later. The good news is that the majority of habitats you can see a lot of green. The majority of them are not forecast to be developed by 2060, so there'll be a lot to choose from.

[23:25] We did see greater habitat loss with the Geodesign model, the purple compared to the orange -- the 31 percent habitat loss overall with the Geodesign model compared to 20 percent for the University of Florida model. This scrub and sandhill, these xeric habitats, had the largest projected losses -- from 40 to 60 percent, which is quite big.

[24:00] Let me orient you on this figure a little bit. There's a lot of information here. Here on the y axis, you see area in hectares, and here are the habitats we considered. What this is showing you is, in the fee zones, if we look at just the area where we might make purchases, if we wanted 50 percent of the refuge to be in the fee area, versus 33 percent or 10 percent, and this is showing you 100 percent, just for reference.

[24:38] Really, this should be a bar across the top to show you this is the target -- that's what we're aiming for -- but because that target is different for each habitat type, it's just represented here as another bar, but that way you can see what we were shooting for.

[24:54] These show the future scenarios. In this case, current urbanization versus the University of Florida versus the GeoAdaptive. Really, the bottom line here is that we were able to design a refuge that met the Fish and Wildlife Service objectives for all of the habitat types in all of the scenarios, except for xeric. This is the one that we had the most trouble with.

[25:24] I'll show you an image here to give you an idea. This is, in our modeling world, on the left, and on the right is a satellite image just to show you. You can see all these tiny little blue parcels. This is what we had to work with for xeric.

[25:45] There was a point where we met with the Fish and Wildlife Service to talk about the outputs as we were partway through the process and refining what we were doing to help. We had made the decision that we weren't going to consider any parcels that were under 100 acres. What that meant was, all of these little parcels that have xeric habitat couldn't be considered.

[26:15] That's something that, as the Fish and Wildlife Service is moving forward with the refuge design that they'll need to think about -- whether that 100,000-acre cutoff is across the board a good idea. For a lot of reasons, it is -- I mean, this would be a really difficult habitat to manage -- but just to show you the struggle that we were having with that xeric habitat.

[26:40] Most of the area where the xeric habitat is is already heavily urbanized, so it just makes it a real challenge. This is similar to the other figure that I showed you -- same setup, so trying to get 50 percent of dry prairie in the easement zone, versus 67 percent, versus 90. This is just in the easement zone. Again, we really only struggled to get the right amount of xeric habitat.

[27:10] Just to show you a little bit about cost, this is kind of obvious. Well, let me tell you what you're looking at [laughs] before I tell you how obvious it is. Here's the cost on the y axis. This set of columns is showing the scenario where we would buy outright 10 percent of the land, and then have easements on 90 percent.

[27:35] Then we move up to a 33/67 split, and then 50/50. The more land that we're buying outright, so 10 percent versus 33 versus 50 -- as that amount we buy goes up, it's going to cost more money compared to an easement, and then shows us with the current urbanization, so if no further urbanization versus the UF model versus the GeoAdaptive model.

[28:03] We always had a higher cost with the habitat that was projected to be left as available with using the GeoAdaptive model. We'd have to do a lot more digging into those models and understand all of the assumptions that go into the model and those projections to see why it's coming up that way.

[28:27] Again, this is why we use two, just to get a little bit of a broader look at a couple of possibilities of how things might play out in the future. In terms of the design, here again, we have area on the y axis. The limit for the reserve -- if you'll remember, it was 50,000 acres in the fee simple and 100,000 acres in easement. That is 60,000 hectares, which is up here.

[29:02] You can see that in every way that we configured it, we were able to get the reserve to be smaller than what the refuge was aiming for.

[29:12] That's good news, because we're able to meet the habitat targets that they have in a smaller area, which means that you spend less money on it. That could be a really good thing if it we're able to meet those objectives for the species and habitats and recreational and all those other objectives that they have. We were able to do that in every scenario.

[29:33] Again, this is the splits of 10 percent fee, 90 percent easements under the current conditions, what's projected with GeoAdaptive and the University of Florida projections, and so no matter how you slice it, we were able to meet the habitat objectives well below the limit that the Fish and Wildlife Service had authorized.

[29:56] This is something I want to show you just because I like it. This is selection frequency that comes out of the Marxan output.

[30:09] One way that I like to look at this is as a measure of irreplaceability. When there are parcels that are coming up over and over again, in every design, every scenario coming up, all

the time, these darker parcels, that probably tells you something -- that these should be high-priority areas when they do come available for purchase.

[30:34] That's a really nice output we got. That was something that the Fish and Wildlife Service really liked as well.

[30:40] I mentioned that our approach was a static one. We did this design assuming that we have $400 million today and we don't. Fred Johnson, one of my collaborators ended up bringing in a postdoc while we were doing this work, who was a mathematician. His name is Matthew Bono and he was tasked with figuring out a dynamic approach.

[31:11] Just for entertainment value, I should have put some of his equations up. You can look at the paper and see for yourself, but it's quite something. I could usually follow him through 75 percent of what he was saying and then he would loss me. It's pretty intense. He was able to pull this off even with the amount of parcels that were looking at.

[31:34] This paper was published last year in PLOS One if anyone's interested. You can look it up.

[31:44] We know that parcels are subjected to all these threats that we talked about earlier like urban development, habitat degradation, climate change. He was able to come up with a way that accounts for the conversion rate of these habitats through time. It's done on an annual time period, so it gets that that dynamic aspect that I was talking about.

[32:05] You can see this trade-off of buying parcels that have high ecological value. Yet, the highways threatened parcels, threatened to change accounting for the conversion from one of these factors. It's really neat that he was able to do that.

[32:27] It took a while for him to develop this. He finished it after the project had ended. Even if he had finished it during the lifespan of the project, we still would have needed that information to go into. We would need the information on even if it's expert opinion or best judgment on probabilities of those changes of habitat degradation and climate change. Those conversion rates.

[32:56] That would have taken more time in another step. I'd be interested to know if this method has been used since Matthew was able to put it out in the literature. I don't know. It'd be really neat.

[33:12] Just to summarize some of the takeaways for us in working with the Fish and Wildlife Service on the things that were really valuable. Again, we were able to get those designs well below the limit that they have authorized.

[33:35] We were also able to get the cost down. Compared to the 400 million that was estimated, our maximum cost was 138 million. I will note again that we are using just value. There are problems with that type of database where someone can record the value of their several hundred acre ranch a dollar to sell to their cousin or whatever it might be.

[34:07] The values might not be great, but this was all we could find in the records. If we had more accurate values for the land than for the parcels, that would help us to know are we really getting closer to this 400 million or how much closer would we be getting to that?

[34:30] Again, I mentioned the selection frequency which the Fish and Wildlife Service really liked in thinking about how to prioritize land as it's coming available. As I said they're going to have to think about what to do for the xeric habitats where they're smaller in urbanized areas, how do you manage that? Can you burn those habitats with all those houses? There's so much to think about for that xeric, meeting the xeric targets that they have.

[35:06] Really, the question of whether to avoid land that's projected to be urbanized or not. You could argue that you should jump in and protect the land that should be urbanized or avoid that conflict and go for the land that have that high quality target habitat that isn't as likely to be surrounded by condos and roads and strip malls and whatever else it might be.

[35:35] I think that's an interesting debate in their definitely strong views on both sides of that. That's it. That's it for me.

Katie: [35:43] I just want to say a big thank you to our presenter Stephanie today. Thank you all for tuning in. So much, Stephanie. Thank you, Ryan.

Stephanie: [35:51] Thank you.

Katie: [35:53] Thank you.

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