

**TRANSCRIPT**

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**INTERVIEWER:** David Todd

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**David Todd** [00:00:02] Okay, well. Good afternoon.

**David Todd** [00:00:04] I am David Todd, and I have the privilege of being here with Dr. Bridgett vonHoldt.

**David Todd** [00:00:10] And with her permission, we plan on recording this interview for research and educational work on behalf of a non-profit group, the Conservation History Association of Texas, and for a book and a website for, Texas A&M University Press, and finally for an archive at the Briscoe Center for American History, which is at the University of Texas at Austin.

**David Todd** [00:00:34] And, I want to stress that she would have all rights to use the recording as she sees fit.

**David Todd** [00:00:40] And before we went any further, I wanted to make sure that sort of, you know, plan is okay with you.

**Bridgett vonHoldt** [00:00:47] Yes. Oh, good.

**David Todd** [00:00:48] Well, then, let's get started. It is Thursday, February 29th, 2024. Leap day. It's about 2:05 central time 3:05 Eastern Time.

**Bridgett vonHoldt** [00:01:02] My name, as I said, is David Todd. And I'm representing the Conservation History Association of Texas. And I'm in Austin, and we are conducting a remote interview with Dr. Bridgett vonHoldt, who lives and works out of the Princeton, New Jersey area.

**Bridgett vonHoldt** [00:01:19] Dr. VonHoldt attended Eckerd College in Pennsylvania, where she earned a B.S. in psychology. And then..

**Bridgett vonHoldt** [00:01:26] Sorry, Eckerd College. Florida.

**David Todd** [00:01:29] Florida?

**Bridgett vonHoldt** [00:01:30] Yes.

**David Todd** [00:01:31] My apologies. Thank you for correcting me.

**Bridgett vonHoldt** [00:01:34] Sorry. I didn't mean to interrupt you.

**David Todd** [00:01:36] No, no. Gosh. My mistake. Thank you. For finding the error in my ways.

**David Todd** [00:01:44] And then she received her M.S. in biology from New York University and finally her Ph.D. in population genetics and evolutionary genomics from UCLA.

**David Todd** [00:01:57] Dr. vonHoldt's Ph.D. dissertation is entitled, "Canid Population Genetics and Evolutionary Genetics", and she has gone on to do valuable research as an associate professor at Princeton University on the tangled genetics of red wolves, coyotes and ghost wolves, these canids that carry red wolf ghost alleles that have been recently discovered in southeast Texas and southwestern Louisiana.

**David Todd** [00:02:24] And, today we'll talk about Dr. Von Holdt's life and career, to date, and especially focus on what she can tell us about the diversity and conservation of red wolves and the genetically admixed coyotes.

**David Todd** [00:02:42] So, a little introduction, with some errors. Thank you for bearing with me, but I thought we might, start with just a question about your early years, your childhood, and whether there might have been people or events then that might have interested you in nature and animals and science.

**Bridgett vonHoldt** [00:03:03] Yeah. I think I start where a lot of people might say that their parents had an influence over these very early exposures that turned into, ultimately, obsessions. The parents play a role because my dad was in the U.S. Air Force. And as part of the military family life, we get to tour different places. So, we spent about five years in each location growing up. And then we'd pack up and hear about our dad's next assignment and move somewhere new.

**Bridgett vonHoldt** [00:03:42] So, when I, when we were, and so we (I speak in the plural because I'm an identical twin, and my sister and I are, joined at the soul and the hip and in every other aspect), so my sister and I, were about three years old. Yeah. And three years old, and my father got an assignment to Fort Walton Beach in the panhandle of Florida. It's on the Gulf of Mexico side. And being so young, we lived right across the street from some little shoreline marshes and the water.

**Bridgett vonHoldt** [00:04:28] It was really incredible that we could experience, go out and play for the afternoon, get in the muck and the just sort of shoreline grasses and the trees. And we were just, we were out there every day playing, seeing garter snakes and turtles and birds and fish. And all of that, I think, made an impression on me, thinking about the natural world and biology.

**Bridgett vonHoldt** [00:05:00] And I was always fascinated then with any animal, organism, that lives in the water. I just never fathomed how the world is so entirely different from living on land. And yet, you know, many of them are still breathing oxygen like marine mammals, but they move in such different space. And that always kind of stuck with me.

**Bridgett vonHoldt** [00:05:26] And, our parents, you know, took us to the normal, the local aquarium and we saw fish and touch tanks and any zoo or petting zoo. It was all about animals. And, my parents were really good at helping foster those experiences and exposure.

**Bridgett vonHoldt** [00:05:48] It continued to develop as my sister and I would want to then in high school volunteer in animal shelters, and it kind of took a turn for animal welfare and trying to provide what we could for animals that everyone, you know, people would discard and end up in these shelters and needing homes. So, there was a lot of compassion there that also, I believe our parents were really quite understanding of. We started adopting pets. We would have cats here and there. And we had our first dog, late elementary school, probably junior high-ish, around that time.

**Bridgett vonHoldt** [00:06:35] And it just continued. We wanted to have exposure to learn about animals, health and animals. And as we were going through high school, my dad had gotten then stationed in Stuttgart, Germany, which is kind of the southwestern part of Germany in the state of Baden-Wurrtemberg. And we went to an American high school. It was on the military base, and it was for all of the Department of Defense kids of the employees.

**Bridgett vonHoldt** [00:07:08] And it's a standard high school. And it was a small high school. I think we had something like 40 kids in my class. You know, coming in as junior high and graduating with about 40 kids. So, we got to know a lot of them, and the teachers knew us quite well.

**Bridgett vonHoldt** [00:07:30] My biology teacher was quite a major player in impacting my vision for what it could be like to be a biologist. Genetics wasn't really in the picture then - you know, high school biology, I don't know, I'm sure now there's a lot more genetics being taught, probably. But I remember just having to memorize a bunch of things, whether it's photosynthesis or cell cycles or taxonomy and organs and physiology.

**Bridgett vonHoldt** [00:08:07] And his name was Mr. Hanks, bob Hanks. And he, in his classroom, kept lots of animals and fish and plants and birds and just a huge, wonderful collection of kind of exotic things. So, my sister and I, being similar in our interests and always doing things together, started being those two students that would never leave the biology classroom. And we ended up either asking to help take care of things, or he just was like, "Hey, since you're going to be here, why don't you go feed the fish? Why don't you go help with the chinchillas or whatever, whatever it was he needed help with."

**Bridgett vonHoldt** [00:08:53] So, we became pretty permanent fixtures in the animal care role in his classroom. It was really wonderful. His chinchillas had some babies one year and we each got to take one home. And so, we had pet chinchillas for, I think, they live like 7 or 8 years. It was a really very supportive and encouraging environment.

**Bridgett vonHoldt** [00:09:21] And Mr. Hanks would always talk to his class as though each one of his students were going to be biologists and go to grad school. So, he would say things like, when you are at university, and you are going to have to, you know, know this or that. And it was, I'm sure he had a reason for doing that. But as a student, that was the first time I had ever heard someone say something like that, "when I was at university".

**Bridgett vonHoldt** [00:09:53] So, I never really thought I wasn't going to go on in school, but I didn't know what it looked like. And I wasn't always, I didn't really have a surrounding of tons of adults in my life who were in academics. My parents both continued on in their education as adults well after they graduated from high school. My dad joined the military, so he went to vocational school first, and then, realized his vocation was probably not the healthiest. He was a mechanic and was concerned about chemical exposure after just a few

years. So, he joined the military, and he learned that he loved computers. So, he became a computer buff.

**Bridgett vonHoldt** [00:10:49] And my mom was a teacher and went, I remember in early teen years was continuing on in her Master's, you know, at night school and got a Master's degree in social work. And so, was doing that for most of my life. And only recently, probably in the past 20 years in my life, did she set aside all of her teaching and social work and went to school to become a vet tech and a wildlife rehabber. And she's really taken this animal welfare and compassion to a pretty extreme degree and has been bringing home. I mean, I wasn't living at home anymore, but my dad, my dad, had to deal with every animal that my mom just needed to care for. She felt compelled for every organism.

**Bridgett vonHoldt** [00:11:42] So, there's clearly some genetic strain here that my mom maybe unknowingly or very purposely cultivated in us, in my sister and I. And then, she was able to switch over her life focus from helping, you know, basically helping humans to focusing on helping animals and advocating for animals.

**David Todd** [00:12:07] Okay. That's great. There's some wonderful, I think, influences and leads and clues there about your life and your interest in animals and compassion for animals. It doesn't seem like this is an academic thing at all.

**Bridgett vonHoldt** [00:12:23] Well, so, I think you mentioned, one teacher, Mr. Hanks. Were there other teachers or classmates that you think were important to you in developing this interest?

**Bridgett vonHoldt** [00:12:39] Yeah, there are. There are, there are others. It isn't so much that these others had a very specific role in the biology sort of encouragement. But the fact ... I think it's hard to separate the fact that I had a small high school and I knew all the teachers. They knew us. The school was so small, but having essentially these teachers, students, very, very strong people that I could interact with at a friendly level. We talked about lots of things. My sister and I did after-school activities. We were on student council. We could be involved in the school structure.

**Bridgett vonHoldt** [00:13:36] And I remember my chemistry teacher, Mrs. Zekel, and my English teacher, Mrs. Zank, and my physics teacher, Mr. Rehwaldt. I still keep in touch with these people. And it's really wonderful. They were friends. They turned into really wonderful friends, I think, because we all were connected by being on this military base in Germany. And being able to get to know each other and follow up on where the students, after they graduated, where they went. So, they're all very supportive and clear in helping describe the value of learning and the value of education.

**Bridgett vonHoldt** [00:14:30] Of course, as I go through my own educational history, going to college was never a question. This was something that my parents had always set out for us to do, and it became very exciting to think that we were (my sister and I again went to college together) planning, like, what were we going to study and what are the things we get to learn and do?

**Bridgett vonHoldt** [00:14:58] I feel like that's now quite common. People, kids, are going to college all the time, sometimes not out of their own desires. And now I see that in my own classroom or my own students, that there are students who probably have no real interest in a college degree. And maybe their vision for life doesn't require that.

**Bridgett vonHoldt** [00:15:24] So,, when I set out for college and my parents really motivated us into doing that, it felt really special. But I never had guidance on what came after college. Was there more school? Was there a career? What does that look like? How do you get there?

**Bridgett vonHoldt** [00:15:49] So, when I was in college, again, I had several really wonderful professors. I keep in touch with them. I got a degree in psychology. I kind of turned from thinking about cognition and brain function into more of a very quantitative experience, designing studies, surveying whether or not the studies worked - building up a lot of statistical experience. But I still had no idea what was coming after college. And I had no plan.

**Bridgett vonHoldt** [00:16:34] One summer I was, I mean, every summer I think students are trying to find something to do in between their semesters. So, I was working at a national zoo, at the National Zoo in D.C., another very familiar stomping ground for me. I ended up in zoos quite regularly.

**Bridgett vonHoldt** [00:16:52] And I had this conversation with some of my team members. I was actually directing a program that had about 90 volunteers, so that was fun. But these volunteers were here just doing this, they're volunteering for their pastime. And it was really wonderful to talk to the volunteers who had totally other lives. And across talking to several of them, they gave me information and insights into how one could continue on in their education after that.

**Bridgett vonHoldt** [00:17:30] How to get into, you know, the programs that are available. Master's degree being a stepping stone that I was most likely changing my focus from having a bachelor's in psychology into something very biology-oriented. So having people tell me more about the feasibility and where money comes from and the expectations of students in graduate school. I never really, I never really got that anywhere else. It was a mystery for a really long time.

**Bridgett vonHoldt** [00:18:11] So then, the other influential people really boils down to my Ph.D. advisor. That was, you know, I purposely selected him as who I wanted to work with, and who I wanted to learn from. So, his name was Robert Wayne, and I ended up meeting him at a conference, and it was really kind of funny.

**Bridgett vonHoldt** [00:18:47] He was an invited speaker at a marine mammal conference. I had just taken myself to this marine mammal conference. It was during my Master's degree, because I always wanted something to do with the ocean, and marine mammals were species that I had seen and felt that I wanted to reduce the mystery around them. I wanted to learn more.

**Bridgett vonHoldt** [00:19:13] So, in the middle of my Master's program, I decided to sign up for, to register for a conference. I look back now and like I have no idea what pointed me in that direction, but it was the annual Marine Mammal Conference or whatnot that I think is annually held in San Diego. So, I got on a plane from New York City, went to San Diego, ended up at this conference for a couple days, learned about every type of dolphin and porpoise and whale and pinnipeds were in there.

**Bridgett vonHoldt** [00:19:47] And I had been alerted to the challenge of trying to enter into the marine mammal biology realm. And I still hold it to this day that it felt like if you weren't born into a family that already worked on marine mammals, you weren't going to get into it.

So, the networking was really important and I didn't really know anybody. I had just, I'd been working in a fish lab at NYU.

**Bridgett vonHoldt** [00:20:21] So, so I went to this conference. I had a really wonderful time listening and learning about all the talks and studies being conducted. And then, and then, Bob Wayne went up on stage and gave his presentation, and he started talking about scrub jays and Channel Island foxes. And he was the token terrestrial biologist in this whole thing. I mean, looking back now, I value everything the Bob Wayne knows and has studied and published on, and he's incredibly influential in the world of population genetics and wildlife studies and conservation.

**Bridgett vonHoldt** [00:21:06] So, there was clear, in hindsight, clear reason why, of course, he was an invited keynote speaker that was on something slightly different.

**Bridgett vonHoldt** [00:21:16] But I really liked his talk. It was oddly exciting and I tried to go meet him after the inter-session, where he was just hanging out some. Some people were flocked around him and busy. I was so young and timid. I just waited on the just the periphery. And I never went up and interrupted who he was talking to. But when I got back to NYU, I sent him an email. And he loved my email and he told me you should have interrupted me. Those were probably friends. I already know them. I talk to them all the time. I want to talk to new people. And it was very, it was very delightful and nice of him to say these things.

**Bridgett vonHoldt** [00:22:07] And we had an email exchange where he ended up, because I had been coming up to the end of my Master's and wasn't sure what was next, and was basically looking for research jobs where I could get some more experience. And he hired me over email. "Come on over, Bridgett, you can do some genetic work in my lab".

**Bridgett vonHoldt** [00:22:28] And he had this whole project without someone to work on it that was genetic, collecting a genetic data set for Yellowstone gray wolves. Since at that time, they had just been released and reintroduced into Yellowstone National Park. That happened in 1995, and I had been reaching out and talked to Bob Wayne at around the 2000, and, I don't know, I guess it was 2004. So I started working in his lab in 2004, that summer.

**Bridgett vonHoldt** [00:23:06] So, the wolves had been on the landscape for ten years, and there was a lot of need to learn about the genetics. And Bob just, I guess he was delighted at what I had been doing, which was some fish genetics. And he set up a start date. I was going to graduate, you know, in May, and I showed up in June. And, I've known him ever since.

**Bridgett vonHoldt** [00:23:34] Sadly, he passed away a year ago and I miss him every day. But I've had: you know what, what is that? It's 2024. I've had about 19 years of knowing him and I would do it all over again. But he is absolutely the only, I'd love to say the only reason I'm here today. He gave me all of the experiences and guidance and feedback and just the time, the time to sit and talk with me and introduce me to people and really help build me up.

**David Todd** [00:24:21] It's wonderful to have these kind of mentors and supporters, guides. You're a lucky one.

**David Todd** [00:24:27] Well, so, for some folks, aside from their parents and these key teachers and mentors, they may also have been big readers or they've perhaps enjoyed seeing TV shows or movies that also influenced them in their interest in the outdoors and wildlife and science. Is that the case with you?

**Bridgett vonHoldt** [00:24:56] Not so much. I remember back in the '80s, there was this show, I think, called "Wild America". It was just a very, like, well, from what I remember as a kid, a fairly charismatic narrator. And it was just, it's almost like, I mean, nothing close to David Attenborough and wildlife. Incredible footage and exposure, but these sort of after-school TV shows that would give you a glimpse into, "Oh, here's the life of a grizzly bear", or "Here's the habitat of a bald eagle", or something, something that I wasn't living in or next to, and it would just be a really brief exposure to species from around the world.

**Bridgett vonHoldt** [00:25:56] But nothing, nothing more than that. It wasn't, I wasn't reading about something. I really do think having that Gulf of Mexico in my backyard for a handful of years. Really being able to voice to our parents, taking us to any sort of animal interaction. Something that really stuck with me.

**David Todd** [00:26:30] Okay.

**Bridgett vonHoldt** [00:26:31] Yeah.

**David Todd** [00:26:31] Well, I think you mentioned that you were introduced to wolves when you were in your early days with Bob Wayne and this effort to do some genetic research on the Yellowstone gray wolves, I guess they are.

**Bridgett vonHoldt** [00:26:52] Yeah.

**David Todd** [00:26:53] And I was wondering if you could sort of switch a little bit and talk about the red wolf, which I think has been a real target of some of your thinking and research, and maybe start by just telling us, if you could, introduce us to maybe the life history and ecological role for red wolves, so we can understand a little bit about that.

**Bridgett vonHoldt** [00:27:19] Yeah. So, the red wolf has always seemingly been a challenge to understand. And I got this immediately from Bob Wayne when I started working on gray wolves. And then we were expanding to think about other, essentially other North American canids. And red wolf was probably the bane of his existence, and he had wonderfully passed it on to me because this was a very, it continues to be a critically endangered species. And there's so much confusing knowledge and data around a red wolf.

**Bridgett vonHoldt** [00:28:08] Just to basically start with, it seems to be, well, for namesake, it's a wolf that lives, or has historically also been found, on the eastern part of the United States. The historic range, which has mostly been gleaned from museum specimens and historical documents, extends from the southern tip of Texas, up along the Gulf Coast states to the, some people will argue, up to the southern part of the Great Lakes, and all the way up through perhaps New England.

**Bridgett vonHoldt** [00:28:55] There has always been a challenge around knowing that for sure, because the red wolf and the coyote and the gray wolf and the eastern wolf, all species that live in North America, kind of look like each other, in terms of their skeleton remains and the morphology of those remains.

**Bridgett vonHoldt** [00:29:23] So, Ron Nowak, and his focus on morphology and really trying to understand when you pick up a piece of bone, whether it's a skull or a tooth or whatever, trying to really make sense, that if it's been called a red wolf, is that indeed a red wolf?

**Bridgett vonHoldt** [00:29:51] This is because that red wolf has lots of intermediate traits about it when you compare it to a coyote or a gray wolf.

**Bridgett vonHoldt** [00:30:03] And the name of it, being a wolf, it does imply that the red wolf has very wolf-like behavior. It lives in family groups or it lives in a pack, a social group. There can be unrelated animals in a pack. They usually are there to assist in resource acquisition. So more individuals in a pack, greater than one individual, means that you can possibly acquire larger prey. It might mean you have a better chance, as a group, to defend territory, especially if that territory has high-quality resources, or just maybe any resource at all.

**Bridgett vonHoldt** [00:30:48] It often might have a really wonderful benefit for disease recovery. We know in Yellowstone that mange can really impact some individuals, and as they become sick, really sick, if they can't provide for themselves, the pack mates have been observed to help, care for, bring food. Just being in a group will provide warmth and shelter for an individual that is not doing well.

**Bridgett vonHoldt** [00:31:20] So there's a lot of benefit to living in a pack. And red wolves do live in packs.

**Bridgett vonHoldt** [00:31:25] Coyotes don't often live in packs, but they can. This is a very canine-specific behavioral trait, but coyotes seem to be far more plastic and adjust to the needs around them.

**Bridgett vonHoldt** [00:31:42] So, by purely behavior alone, the red wolf appears to be more wolf-like in nature, but it's smaller than gray wolf. It lives or, you know, had historically lived in a part of the country that gray wolves were not entirely clear if they lived there or not. Is the red wolf an actual relative of a gray wolf? Or are they more closely related than the red wolf is to something else?

**Bridgett vonHoldt** [00:32:09] Because of all of these intermediate aspects, that the red wolf is small, so it resembles a coyote more, but it acts like a wolf because it lives in packs. It's bigger than a coyote. It's eating things that are maybe a little more wolf-like. The vocalizations of red wolves are distinct and different from coyotes and gray wolves. It.

**Bridgett vonHoldt** [00:32:35] It's highly suspect to show enough traits that are unique, that it is indeed its own species, but not knowing where that species originated. Is it more closely related to a gray wolf, or is it more closely related to a coyote, has always been a challenge.

**Bridgett vonHoldt** [00:32:55] With another hypothesis that some people have put forth is that a red wolf is actually just the product of a coyote and a gray wolf mating, and those hybrid offspring grow up and kind of essentially mate with other hybrid offspring that you end up with what's called a hybrid species origin.

**Bridgett vonHoldt** [00:33:25] So, the ecology, the where red wolf lives, the what it's eating, how it's behaving on the landscape, its ecological function, is indeed distinct, and it plays a very particular role. If a red wolf is on a landscape, with great enough numbers, then they seem to out-compete coyote and basically reach an equilibrium very similar to what we see in Yellowstone, that the gray wolves on the landscape really are the dominant carnivore, and coyotes are generally going to be essentially, their population numbers and their prevalence on the landscape will usually be controlled by the presence of a gray wolf.



**Bridgett vonHoldt** [00:34:16] If you remove a gray wolf, or if you remove ... a red wolf, then the coyote will become the dominant canid on the landscape. It may not fill all the roles that a red wolf or a gray wolf can. But it gives us more of that insight into ecological competition and how they partition themselves both in time and space, when wolves and coyotes are present in the same landscape.

**Bridgett vonHoldt** [00:34:43] So, we do see that with red wolves. Given enough red wolves in the vicinity, a red wolf will mate with a red wolf and stay with red wolves.

**Bridgett vonHoldt** [00:34:53] But, also, from years of study and research, people know that if a red wolf loses their mate or they're quite young and they are surrounded by coyotes, red wolves and coyotes will indeed produce offspring that are fertile and viable.

**Bridgett vonHoldt** [00:35:16] Gray wolves can do the same thing. Eastern wolves can do the same thing. ...There's no reproductive barrier, not really, between the canids.

**Bridgett vonHoldt** [00:35:25] There are some differences in when mating season will happen. So, there does have to be this sort of late bloomer in one end, and an early bloomer in the other end, for the timings to match.

**Bridgett vonHoldt** [00:35:40] But given a lot of their flexibility around phenology and climate change and the pressure to reproduce, wolves and coyotes and dogs are all able to produce fertile offspring. So, this really challenges like what we know and how we define red wolves.

**David Todd** [00:36:04] That's really interesting. It seems very fluid and an intermediate sort of situation where things are shifting and it's hard to, I guess, partition species.

**Bridgett vonHoldt** [00:36:16] Yes.

**Bridgett vonHoldt** [00:36:20] So, one of the things I think you mentioned, which drew my attention is that the red wolf was critically endangered, and I was wondering if you could tell us why that's so.

**Bridgett vonHoldt** [00:36:34] Yes. Oh, I'm sure there's lots of other sort of regional tidbits of knowledge, that will go into really describing when and why the red wolf went into decline. I usually start this story, briefly, in the mid-1600s, when it became very popular for states to use bounty programs for getting off the ground predator elimination program. A lot of this was built around valuing, essentially valuing people and their livelihoods and their livestock, and wanting to reduce the competition with predators and also reducing the fear that we are living in the same space as predators.

**Bridgett vonHoldt** [00:37:34] So, states and governments would offer financial bounties for, you know, whatever evidence that you have killed predators. And predators were bears, lions and canids - coyotes and wolves. And essentially you could count on, annually, starting in the late 1600s up through 1800s, state by state would come on board and start offering their own predator elimination program, bounty reward system.

**Bridgett vonHoldt** [00:38:08] And this made it incredibly incentivized for anyone to go and trap, hunt, poison anything that was a predator.

**Bridgett vonHoldt** [00:38:21] In the Southeast, ... any time, essentially, bounties were submitted and newspapers would start reporting on who's got, you know, how many animals do they get bounties from? How big are these animals? Just like any other trophy prize kind of display of, I don't know, I don't even know what it's a display of. Who got the biggest coyote or the biggest wolf? Or this is the last wolf in the region, maybe in like, northeastern Louisiana. People are like, "Yeah, there's only a few left, who is going to get them?"

**Bridgett vonHoldt** [00:39:03] And I mean, that kind of mirrors our community, at least the communities I interact with, for coyote hunting. Coyotes ... usually require a very skillful hunter and trapper because coyotes have ... the sly ability to detect and avoid, and it usually takes, usually it's a very skilled event to trap coyotes. Now they're killing them with a gun might be kind of different.

**Bridgett vonHoldt** [00:39:33] But, so this was a bounty program and the red wolves were, I mean, there's inherently, it seems, some difference between a wolf that's persecuted and a coyote that's persecuted. We know, even now, every year there's easily ... half a million coyotes killed in the United States. And every year, though, there's roughly 5 million coyotes in the nation. So, the bounty program isn't doing anything for population control. In fact, I'm sure there's some studies out there that show coyotes can actually have some reproductive response. If you kill heavily, heavily control the population in an area by killing coyotes, they might produce 1 or 2 more pups than normal to try to, as this response to population loss.

**Bridgett vonHoldt** [00:40:33] Wolves don't seem to be able, or aren't doing that same response, but it doesn't mean that they aren't able to persist in their own ways. They are far more, I think, sensitive to such persecution efforts. And we see that by their numbers going down quickly. And even nowadays, having gray wolves being the target of hunting and trapping in the Rocky Mountains: there's goals to try to reduce populations by 90%.

**Bridgett vonHoldt** [00:41:09] And even though we probably won't see all the gray wolves killed through hunting and trapping, there could be some incredible damage done to populations through this statewide state-sanctioned effort.

**Bridgett vonHoldt** [00:41:25] So red wolves being a group-living social organism, and being heavily hunted and trapped in the 1600s, 1700s, 1800s, and also showing most likely a specialization for the southeastern part of the US, it could very well be that this is a coastal prairie-adapted wolf, that once those populations are being decimated, region-by-region, county-by-county, and everyone's on board doing this, red wolf numbers decline really fast.

**Bridgett vonHoldt** [00:42:11] If you're hunting in January, February, you're killing pregnant females. That's one big way to ensure that the population doesn't grow in the next generation.

**Bridgett vonHoldt** [00:42:22] So as these wolves were declining in number, that also has an ecological impact. The fewer wolves on the landscape, essentially the fewer ecological competitors are keeping coyotes at bay. So red wolf numbers decline leads to coyotes able to expand, come and inhabit new territories that are recently vacated because wolves were shot and trapped and poisoned.

**Bridgett vonHoldt** [00:42:57] They can respond, it seems, through hunting pressure a little bit better than a wolf can.

**Bridgett vonHoldt** [00:43:05] But then also part of that decline, the concern about the decline, came from knowing that red wolves, who were still somehow persisting despite this elimination program, could also start mating with coyotes because what choices do they have at one point, if all of their neighboring red wolves, which could have been potential mates, had been poisoned, shot and killed?

**Bridgett vonHoldt** [00:43:34] And breeding season rolls around in February. And then there's a coyote. And nothing else passes your door for days on end. The reproduction, the cross-breeding between a red wolf and a coyote will at least ensure red wolf genes get into the next generation.

**Bridgett vonHoldt** [00:43:55] But what we don't know is, those offspring: are they living with mom? And if mom is a red wolf, then they also very likely face gunshot mortalities and trapping mortalities. But, if their mom is a coyote and they're out in the landscape, being a little less impacted in the immediate future, then the red wolf genes and those coyote/red wolf pups gets to persist longer.

**Bridgett vonHoldt** [00:44:32] So, the wolf numbers by, I think it's the mid-1900s, Ron Nowak and other biologists had become very concerned that red wolf numbers were pretty low, so much so that seeing one was now almost a very exciting moment. They were considered very definitely close to their extinction in the wild, not only because red wolf numbers were on the decline, but because then those few red wolves that were left were probably mating with coyotes.

**Bridgett vonHoldt** [00:45:15] The term has been used, "hybrid swarm" or "genetic dilution" or "genetic replacement". And there was a newspaper article at around that time, 1960s, I think, talking about, "Are we just losing all of the red wolf genes? They're being swamped out by coyote genes because coyotes and red wolves are mating with each other, and those offspring are just a diluted form of a red wolf."

**Bridgett vonHoldt** [00:45:56] I know I haven't even talked about habitat loss, but I think it seems pretty intuitive on how that plays a role in this picture too. As more and more people are traveling across the region trying to find the place to expand, buy up land where they could convert either prairie or forest into agriculture or farming land. And this is still a major issue, you know, going on in the last century that most of the contiguous landscape that canids would live on has been converted or it's protected.

**Bridgett vonHoldt** [00:46:45] And habitats are changing in composition, especially as climate change occurs: that they're losing it or they're having to deal with a tremendous amount of urbanization.

**Bridgett vonHoldt** [00:47:02] So, wolves don't seem to be okay with urban environments like coyotes are. You know, coyotes can be found in the middle of Los Angeles, in the middle of New York City and Chicago and Denver and Atlanta. But we don't really see wolves there.

**Bridgett vonHoldt** [00:47:24] So, somehow coyotes have a little bit of an edge on, I mean, even just a little bit on all these different challenges. And wolves seem to be far more sensitive to that, and it would probably take a lot longer for them to become resilient in terms of being able to deal with a large portion of their population being killed. And coyotes can do it fast.

**David Todd** [00:47:59] So, I think you've talked about some of these problems that face the red wolf, whether it was habitat loss or conversion, and then you've got this - you know, hybrid swarm / genetic replacement / genetic swamping - lots of different terms for that. And I think that given your expertise in the genetic field, I think it might be good to just focus on this issue of the interbreeding between red wolves and coyotes. And I think that, when we've discussed this before, you've tried to be clear about some of the vocabulary that really is good to use here. And so, I was hoping that you could talk a little bit about the differences in hybridization and maybe a more accurate term of admixtures. And you know how this plays into our understanding of the evolution of this new ghost wolf. Could you help us understand this?

**Bridgett vonHoldt** [00:48:59] Yes, absolutely. There are a few concepts here that are, I think, fairly complicated and deep in terms of their interconnectedness.

**Bridgett vonHoldt** [00:49:15] The first one is, let's start with the species concept. And this means there are ways in which biologists, or anyone for that matter, thinks about how they define a species. A lot of people rely upon the very first, and almost the most simplistic, definition of what makes a species, and that's called the "biological species concept". And that simply, for lack of better words, just says that if two organisms can reproduce with each other, they must belong to the same species.

**Bridgett vonHoldt** [00:49:58] So, you can't really take, a porcupine and a cow: they won't have offspring. Then they must belong to different species.

**Bridgett vonHoldt** [00:50:10] But there are some inherent aspects of that definition. And that can work for the most part. I mean, we can pick out a lot of different things that we know would never reproduce, for lots of different reasons. But they've also not been able to reproduce with each other - porcupine and a cow - for millions and millions of years.

**Bridgett vonHoldt** [00:50:34] When we get into the problematic area is when there are species or lineages, groups of organisms, that are more closely related to each other, and more recently related to each other.

**Bridgett vonHoldt** [00:50:51] So, probably at the disgust of some of my colleagues, I don't really talk about species concepts so much, because I don't entirely think it's relevant yet, when it comes to red wolves and ghost wolves and coyotes.

**Bridgett vonHoldt** [00:51:13] And just to explain myself briefly, the conservation part of my brain and soul takes precedent ... over a species concept. I would much rather have a red wolf or ghost wolf persist, hopefully under protection for as long as it needs, until we understand exactly how we define species for very complicated groups of organisms.

**Bridgett vonHoldt** [00:51:47] So, I don't care if it's a wolf. I don't care if it's a coyote. I don't care if it's something new.

**Bridgett vonHoldt** [00:51:51] I do know that it is distinct from these other things.

**Bridgett vonHoldt** [00:51:56] And, for the moment, we don't know the answer for the species concepts that are best applied in this very challenging set of complicated relationships.

**Bridgett vonHoldt** [00:52:09] So, I like putting that on hold for quite a while until we get more data.

**Bridgett vonHoldt** [00:52:14] For the coyote, red wolf, and ghost wolf, I also think that genetic exchange is very important to be clear about the language and the definitions. The term that everybody seems to be very comfortable with in using is the word "hybrid", or the act of interbreeding, which is "hybridization".

**Bridgett vonHoldt** [00:52:39] And, the connotation by most people when they use this word is probably negative. And it usually conjures up an idea of contamination. And this comes from that hybrid swarm idea for the red wolf: that we needed to be concerned that the red wolf DNA was going to be lost because it's going to be diluted out with coyotes. And thereby, you know, we lose red wolf DNA because it's just going to be carried in an animal that's a coyote and not a red wolf anymore. And there's value and merit to that concern. I'm not saying that that's a ridiculous concern.

**Bridgett vonHoldt** [00:53:30] But it is hard to talk about that and incorporate a different, a diverse set of values that people hold when they use the word hybrid. If it's not a dog or a cat or cattle, something that's domesticated, we create hybrid or mixed breeds all the time, and those indeed are hybrids to start with.

**Bridgett vonHoldt** [00:53:57] We view wildlife and hybridization very differently.

**Bridgett vonHoldt** [00:54:02] So, the definition of hybrid that I would encourage everyone to really use is that only when, you know, a pedigreed relationship of breeding animals, breeding individuals and you use the word hybrid and be clear that you indeed know that there are specific breeding events between organisms of different types.

**Bridgett vonHoldt** [00:54:31] Hybridization doesn't have to happen between just two different species. The original definition is that you need to be able to identify each parental type. They could be two different subspecies that have different ecologies, are found in different landscapes, have different plumage or different fur structure or different diets. You just need to have a collection of traits that can be clearly defining each parental type. And those two types, when they reproduce, can be a hybrid event: they produce then a hybrid offspring. And that's essentially where I stop using the word hybrid is after that first generation.

**Bridgett vonHoldt** [00:55:15] Using the word hybrid usually means it's a first-generation offspring of two different groups, two different types, or two different species.

**Bridgett vonHoldt** [00:55:25] What happens next to those hybrids, those first-generation hybrid offspring, will now dictate what we call their offspring. If that hybrid offspring reproduces with one of the parental types, that's a back-cross. And we call it a back-crossed offspring. If it reproduces with the other parental type, that's a different back-cross.

**Bridgett vonHoldt** [00:55:52] In the plant world and Drosophila world, we can have model organisms that we rear in lab and we can create lots of different crosses. A second-generation cross is when you cross explicitly two first-generation hybrids. Mendel had lots of traits that he identified in pea plants and created very specific crosses.

**Bridgett vonHoldt** [00:56:15] So, once we go through, after that first generation, it's not so much, for my world, important to know what label of this sort of degree of hybrid mating and back-crossing. That label becomes messy and very difficult.

**Bridgett vonHoldt** [00:56:33] We use the word, "admixture", as a way to describe that the product of this hybrid breeding, or just the breeding between two different groups, means that the offspring will have a mixture of genes and ancestry from each of the parental types. So, the collection of traits, whether it's DNA and chromosomes or other features, are now mixed. And we want to use those kinds of compositions to understand more deeply the history of interbreeding.

**Bridgett vonHoldt** [00:57:15] In the case of coyote and red wolves, we know that their genetic exchange happened in the 1970s, and probably leading up to that, as the red wolf population was on the decline. So, more and more red wolves likely found a mate that was a coyote, had a first-generation litter of hybrids.

**Bridgett vonHoldt** [00:57:43] And what did those pups grow up to do? Probabilistically, they grew up to breed with coyote, because red wolves were few and far between. But, if they were living with mom, and mom is a red wolf, there's a chance that they also were able to mate with another red wolf.

**Bridgett vonHoldt** [00:58:03] So, we've got all sorts of opportunities there, and we can't just label an organism. We can't label all the organisms of those products as a hybrid. They're all admixed at a different level, from a different time, and to a different degree. So, the admixture means that we can start investigating the ancestry composition of each animal. And just like every person is different from another person (maybe strike from the record an identical twin like myself). Even though my sister and I are different.

**Bridgett vonHoldt** [00:58:43] Every individual, even from the same litter, could carry differences in their genetic composition. From the same litter, some animals might have even a smidgen more red wolf DNA than their brother or sister, and that's just because inheritance could be random, could be influenced by something, could be biased.

**Bridgett vonHoldt** [00:59:11] Humans have admixture in our genomes. We have signatures of Neanderthal DNA that reside in our own genome. We've learned a bit, I think, about whether or not it's beneficial to have that.

**Bridgett vonHoldt** [00:59:25] The same is true for these red wolf and coyote instances.

**Bridgett vonHoldt** [00:59:33] So, now this, I think, leads me up to what is a ghost wolf. And I really like this because it relies upon that history: red wolves were declining rapidly and were declared extinct in the wild by 1980, which technically means you could never go to the landscape and see a wild red wolf. The last bit of them, 14 of them, had been brought into captivity to establish their captive breeding program to help save the species.

**Bridgett vonHoldt** [01:00:14] There's lots of stories and anecdotes and documents that tell me that this was a very complicated time from 1970 to 1980, when the government was trying to save the red wolf by grabbing the last ones from the wild, essentially causing the red wolf to be extinct in the wild.

**Bridgett vonHoldt** [01:00:39] But also not really keeping every red wolf that they caught. They caught several. I think the number is on the order of 40 of them. I mean, they caught several hundred canids in an attempt to find the last wild red wolves. And they were evaluated individually for several features and characteristics, and those that showed the most red-wolfy set of traits were the ones deemed, "This is a red wolf. Let's figure out if it, over the next generation or two, produce puppies that also look red wolf like".

**Bridgett vonHoldt** [01:01:19] So, that's how they narrowed it down from those 40 animals, give or take, to the 14 that ended up being declared the founders of the red wolf program, the captive breeding program.

**Bridgett vonHoldt** [01:01:31] There are stories and documents that indicate some animals that were deemed a red wolf were released back again into the Louisiana or Texas landscape. This is the geographic area where the last red wolves were seen. Hence, this is where the government went to try to find the last wild red wolves.

**Bridgett vonHoldt** [01:01:57] So, this means that red wolf DNA actually probably persisted in animals after the government went and captured what they needed. Declared, federally declared, the animal, the species, extinct in the wild in 1980.

**Bridgett vonHoldt** [01:02:18] And yet, some years later. In 1990, there was another document that declared, "Yes, we know that there are some red wolves. They're probably red wolves. Without handling them, you know, with our own two hands, the government said, "Yeah, it looks like you probably have red wolves on your private property. But I think, for lack of better words, the resources weren't there to go out and do a full study or to capture them. So, those animals which were suspected to be red wolves were acknowledged and left to be on their own, on this private land.

**Bridgett vonHoldt** [01:03:04] So, that tells me that there are probably lots of bits of DNA of red wolf that's floating out on the landscape, that does not seem to be represented in the captive breeding population of red wolves.

**Bridgett vonHoldt** [01:03:23] If you grab any random 14 animals from a species, you are unlikely to capture their full catalog of genetic variation. They captured enough. They had enough genetic variation to start this program. But not all of it. Not all of it was representative of the species.

**Bridgett vonHoldt** [01:03:45] But yet today, this is how, this is the only way we define the red wolf. All of the DNA that descends from the 14 founders.

**Bridgett vonHoldt** [01:03:55] So, when I start looking at DNA across coyotes in Texas and Louisiana, I've been able to find DNA that doesn't look like coyote, and it doesn't look like dog or gray wolf or eastern wolf, and it doesn't look like the red wolf DNA from the captive breeding program.

**David Todd** [01:04:23] Bridgett, while we're here, why don't you explain how it is that you got pulled into this whole debate?

**Bridgett vonHoldt** [01:04:30] Yeah.

**David Todd** [01:04:32] And then how you used these tools of genetic analysis to try to untangle what you are seeing in, I guess, the southeast Texas and Galveston area.

**Bridgett vonHoldt** [01:04:43] That's good.

**David Todd** [01:04:44] That might help us to understand a little context.

**Bridgett vonHoldt** [01:04:47] Yes. Okay. So, we're going to follow that comment about the Fish and Wildlife acknowledging in 1990 that there were indeed some very interesting large canids in Louisiana that were highly suspected to be red wolves. But, for some reason, the government couldn't follow up on it, or didn't follow up on it.

**Bridgett vonHoldt** [01:05:16] And this is not unusual for people in that region, the Gulf Coast, to have sightings of canids that look very different from a coyote. They're either very large, they're very blocky. Coyotes are pretty narrow and have kind of little, pinpointed faces and usually are a little smaller, and have a very kind of different appearance about them.

**Bridgett vonHoldt** [01:05:46] Even in my career, I get people sending me pictures or emails saying that they've experienced a sighting that they think is equivalent to "I saw an extinct species" - the ivory billed woodpecker - or something that people have this, this local legend that their grandfather saw something. So, these are not unusual stories for even me to just get in my email inbox.

**Bridgett vonHoldt** [01:06:17] But these stories nonetheless exist for decades in the Texas, Louisiana, Mississippi, Florida part of the world, in particular, with respect to a red wolf. And most of them don't have a lot of data or evidence to follow up on to confirm these sightings.

**Bridgett vonHoldt** [01:06:41] And I think it was in 2016, I got an email (again, nothing unusual for me to get emails like this), but I got an email with this amazing picture from a man in Galveston, Texas. His name is Ron Wooten. And he had this amazing image of a canid, a coyote, sleeping on the Galveston Island runway, the airport runway, taking a nap in the sun. And it looked, it looked like a red wolf.

**Bridgett vonHoldt** [01:07:20] I'm not supposed to say those things. I, I know the DNA and the outward phenotype, I know those don't always match. And the way something looks for a canid can be very misleading. But I saw this picture: "Well. It kind of looks different". I told Ron, "Yep. I would love to help out".

**Bridgett vonHoldt** [01:07:46] He was very curious. He lives on the island. He had some interactions with these canids. He really thinks and really thought they were different, and was reaching out to researchers. And I think he reached a number of researchers, but no one really had a plan of attack for how to address and investigate if these were actually very different coyotes. And then so I got the email from Ron and I said, "Yes, I would love to do something. I just need some tissue sample or blood sample, like some biological material from an animal".

**Bridgett vonHoldt** [01:08:26] I did not know at the time that there had been an active community effort to kind of keep tabs on these animals, and he easily, quickly, sent me some roadkill, which I now know in hindsight, the Galveston Island Police Department and their, their Animal Control section had a very active non-lethal coyote management program. So,



when there was a roadkill, it was very easy for th Galveston Island Animal Control to go collect it. I'm sure Ron had been talking to them for a while.

**Bridgett vonHoldt** [01:09:04] So, I managed to receive two pieces of two different carcasses that were road, vehicle collisions from Galveston Island, and I could sequence them. This was the first time I got any evidence, tangible evidence, from someone to help answer their question of what it is.

**Bridgett vonHoldt** [01:09:24] And this is now that connection back to thinking about how ghost wolves and red wolves in Galveston Island connect. That in sequencing these two animals from Galveston Island ... since Ron's question was really, "What is this? Can I get a species identity for that animal?" I said "Sure. Let's, let's work our way through all the possibilities of what this animal could be."

**Bridgett vonHoldt** [01:09:57] It could be dog. It could be any type of wolf that we know in North America. It could be any type of coyote. And we know that there are several different types of coyotes living across our country.

**Bridgett vonHoldt** [01:10:09] So, and this happens to be what my research is. I have thousands of North American canine samples. And by sequencing these two from Galveston, I stepped through and compared it to every other known species or distinct population to try to understand what it was. And for the most part, it's a coyote. I think of those two samples, they came back like a 70% coyote genetic ancestry - 70 something, maybe 73%. And then the last 25% came back as red wolf.

**Bridgett vonHoldt** [01:10:58] And this red wolf catalog I was comparing it to is a bunch of genomic sequencing data from captively bred red wolves. All descend from 14 animals that went into captivity by 1977. So, our only genetic definition of a red wolf is that: stems from the 14 founders. But that is indeed the federal definition of a red wolf.

**Bridgett vonHoldt** [01:11:31] So, when I when my student at the time (she's graduated), she did this analysis, showed it to me and I didn't, honestly, I was like, "You have to triple-check this. Because, if this is the case, this is going to be something. This is going to be a challenge."

**Bridgett vonHoldt** [01:11:56] So, we triple-checked everything and that's where we published: that indeed, these animals, the coyotes on Galveston Island, are carrying upwards of 30% of red wolf identified DNA.

**Bridgett vonHoldt** [01:12:10] Now, that's not a ghost thing. We can identify what it is. It has a name. It's the red wolf DNA living in these coyotes.

**Bridgett vonHoldt** [01:12:21] So, the ghost part comes in because we started exploring a little bit more. What essentially I'm faced with is I go through every bit of DNA from these Galveston Island animals, and I can put them into buckets with names on it. And that's what we did. 70% of that data could be put into the coyote bin. And 30%, roughly, could be put into a red wolf bin.

**Bridgett vonHoldt** [01:12:51] But the straggling few little pieces. And I know I've given you things that add up to 100%. So just imagine it's like 68% this and 25% that. So, I'm dealing with, like 3% of everything else that, that I can go through the whole gamut of options and it doesn't fit into any of those things. So, I have to put it into a bucket that's called unknown. And

I know which DNA sequences cannot be named with a species name. So, we've called them "unknown", but more sort of popularly branded, we're calling that "ghost DNA".

**Bridgett vonHoldt** [01:13:30] And the hypothesis to explain that, is back in that history of the red wolf decline, as the red wolves are undergoing rapid loss, hybridization and breeding with the local coyotes, they are passing their genes on, red wolves are, into the local coyotes.

**Bridgett vonHoldt** [01:13:58] So, when the government comes through and tries to capture the last wild red wolves, they're not capturing, they're not keeping a coyote that might be a hybrid or an admixed version of a red wolf and a coyote. They're only going to capture, their only interest is in, those animals that look to be 100% the idea, the vision, of a red wolf.

**Bridgett vonHoldt** [01:14:27] So, everything else was kind of left there. I've heard stories that of the 400 whatever canids that were captured, there are stories that they destroyed them all. And then there are other stories that they didn't destroy them all.

**Bridgett vonHoldt** [01:14:41] So, under the, I'm sure, the guise of what government wants us to know and not know, I'm sure that they didn't capture every wild red wolf. And I'm sure that they didn't destroy every canid that also carried red wolf DNA in it.

**Bridgett vonHoldt** [01:15:02] So, what they plucked out of the wild was essentially 14 animals and their representative DNA, and then the rest of that red wolf DNA persisted. It still lived on the landscape. It did not get transferred into a captive breeding program.

**Bridgett vonHoldt** [01:15:21] But, based on the government, that species is extinct in the wild. So the name "ghost wolf" and "ghost genetics" tries to connect us with the idea that the wild red wolf is extinct. Look it up on a web page. It's extinct. But yet their DNA almost certainly persisted in the wild beyond those 14 animals that founded the red wolf breeding program in captivity.

**Bridgett vonHoldt** [01:15:56] And those bits of DNA either circulated around in red wolves that were never captured. And those red wolves more than certainly reproduce with local coyotes. And maybe there is no true red wolf out there now on the landscape. Maybe. Maybe it is. I don't know where it would be hiding. Well, I have some ideas.

**Bridgett vonHoldt** [01:16:19] But, what we do know is that a lot of that ancestral DNA that never made it into the breeding program is indeed not extinct. And it's coming back to the surface in a totally different form. And I think that's why the "ghost" name is very suitable: that we're looking at kind of this disembodied version of a red wolf. Bits and pieces of a red wolf are surviving in coyotes.

**Bridgett vonHoldt** [01:16:50] And we could go out and have like a thought experiment to put all the puzzle pieces back together and know what that red wolf genetically looks like, that cannot be identified in the captive program. All of that DNA - not every bit of it made it into the captive breeding program.

**Bridgett vonHoldt** [01:17:13] So, a ghost wolf - it may not be a coyote and may not be a red wolf, but it seems to be somewhere in between. And this is where the taxonomy, the species concept, doesn't really bother me yet, because it's probably helpful that these ghost wolves are considered coyotes by the government. They're a coyote. They have no legal protection.

**Bridgett vonHoldt** [01:17:42] But they're carrying endangered DNA. And I think that's really important. It's really important when we understand that the captive red wolf program has a finite amount of genetic resources. The population is limited in genetic diversity. They have limited options for avoiding inbreeding. And no new genetic diversity can come into that captive population, at least not yet.

**Bridgett vonHoldt** [01:18:22] These ghost wolves carry something that could potentially rescue a species, not only the captive breeding program, because it could bring in new red wolf DNA that the program never saw before.

**Bridgett vonHoldt** [01:18:43] But what's more interesting is that these animals are doing this on their own and in a wild landscape. These ghost wolves have been surviving for 50 years, even under states, Texas and Louisiana, that have coyote hunting.

**Bridgett vonHoldt** [01:19:01] But what we suspect has played a critical role in this red wolf DNA that's surviving, are two different habitats, Galveston Island being one of them, that has a non-lethal management program. And in the other places, more on the Louisiana side of things, very low human density and very low gunshot mortality. That people are not playing a very big role at all in killing these animals. So, perhaps these ghost wolves are able to self-maintain populations in these pockets where they have uninhabited land, or they're in land where they're not being killed by people, such as the case for Galveston.

**Bridgett vonHoldt** [01:19:58] Cars will hit them every now and then, but it's nothing near the level of that predator control that the red wolf was experiencing in the 1900s up through the mid-century, when they were declared extinct.

**David Todd** [01:20:17] This is fascinating. What a dilemma. What a quandary.

**David Todd** [01:20:21] I know.

**David Todd** [01:20:21] So, I see that we have just a few minutes remaining. And so, I'm curious if you could tell us a little bit about what your analysis has meant to you, and what some reaction you've had both from the public, and from the regulatory bodies, that, you know, this falls within their bailiwick.

**Bridgett vonHoldt** [01:20:50] Yes. The general community response has been, I think, the same, whether you talk about coyotes or gray wolves or red wolves. People love them or they love to hate them. Or everyone's hot and cold on this, or they're hot in one direction or very hot in the other direction.

**Bridgett vonHoldt** [01:21:11] The community in Galveston has been incredible. I, when I first visited Galveston, they, people told me about their special coyotes, and that they really valued them. And I know it's a subset of the community. It's not every person who lives on Galveston. But, the community has, they're using their voice and declaring that these are fancy and special animals, and they have them there, and you can see them every day. You can just drive out to a beach. You can see them on the beach.

**Bridgett vonHoldt** [01:21:52] If these end up being red wolves, then this is the easiest place to just go and see them. But they need habitat and they need to be considered in a co-existence model. Being a non-lethal control program on the island, Galveston Island, I think they're already leaps and bounds ahead of some other communities.

**Bridgett vonHoldt** [01:22:20] It's the habitat protection and preservation that concern me at the moment. So, it's wonderful to have Galveston on board, generally speaking, that the community is vocal about their support for ghost wolves.

**Bridgett vonHoldt** [01:22:35] The Fish and Wildlife Service is also intrigued by this, and I sit on some of the discussions, some of them. I'm on the Red Wolf Recovery Plan to help devise the future and the objectives for red wolves. And, believe you me, at every moment I can interject about ghost wolves, I do. And I think that, overall, this would be an incredible innovation to include ghost wolves for the conservation and long-term persistence of red wolves. But it would mean a very bold move by a government body which does not like to take bold moves and who seem to be very cautious on how they are perceived by communities.

**Bridgett vonHoldt** [01:23:34] And I don't blame them. They've had a really hard time in the red wolf program. Communities were supportive, and then they weren't. And the moment a community turns on you, it's, it seems tragic.

**Bridgett vonHoldt** [01:23:47] But I do think they are a collection of very poised and intelligent people. And we talk about ghost wolves a lot. It, to the bureaucratic process, means that if anything gets to be done for red wolves that incorporates ghost wolves, it's going to take years, years of discussion, years of planning, years of red tape, and then finally years of actually implementing. And I do think that.

**Bridgett vonHoldt** [01:24:13] But, I'm very hopeful and optimistic that that is the direction that they are slowly moving in. But the only fear is that it's going to be too slow perhaps: not because ghost wolves might disappear. They seem to be doing their thing in the, you know, back country of uninhabited Texas and Louisiana. And there might be more.

**Bridgett vonHoldt** [01:24:38] But the fear that red wolves in the captive breeding program are going to need something sooner than later is, is certainly a real fear. And ghost wolves could really help instill some genetic health and some new vibrant energy into the genomes of the captive population.

**Bridgett vonHoldt** [01:25:00] So, I'm hopeful. We talk about it a lot, but there's very determined and cautious moves by the Fish and Wildlife Service. But we have discussions with states, at the state level, at the federal level.

**David Todd** [01:25:19] Okay.

**Bridgett vonHoldt** [01:25:20] Yeah.

**David Todd** [01:25:21] Well, Dr. vonHoldt, I see we're about an hour and a half into this, and I know you need to run, but, let me ask just one last open question. Is there anything you'd like to add, about red wolves, coyotes, ghost wolves, these alleles that are floating around?

**Bridgett vonHoldt** [01:25:48] I think it's just my passion to help people think outside of the box when it comes to labels, especially species labels, and to value biodiversity at a level that maybe isn't so immediately clear. The biodiversity of these ghost wolves is that they have an incredible, unique mixture of traits and features and DNA. And kind of going back to that

comment, I said earlier, if we were to get rid of most of the wolves that people love to hate, then we're going to just have coyotes.

**Bridgett vonHoldt** [01:26:40] And A), that'd be very sad. And B), that would leave us in an even bigger mess ecologically than what we're already in.

**Bridgett vonHoldt** [01:26:49] So, that biodiversity needs to be considered when we think about habitats, ecosystems and communities of species. And the ghost wolf is an incredible, it plays an incredible service to the environment that is different from a coyote. It might be what a red wolf is doing or would have done, should it have lived long enough on the landscape.

**Bridgett vonHoldt** [01:27:22] I think that that's, I think that's what I would want to say.

**David Todd** [01:27:30] Okay. Well, fair enough.

**David Todd** [01:27:33] This has been fascinating: a little bit of history and then also some speculation about where this might go. So, I think we will all need to stay tuned. I look forward to hearing more about your work.

**Bridgett vonHoldt** [01:27:45] Yeah.

**David Todd** [01:27:46] Thank you for taking time today to talk about what you've been doing and thinking. And, I really appreciate it.

**Bridgett vonHoldt** [01:27:52] Thank you for inviting me. And I still also want to say, if you have follow-up questions or want to talk more, I'd love to.

**David Todd** [01:28:00] Thank you. That's very generous.

**Bridgett vonHoldt** [01:28:02] Thank you for what you do, David.

**David Todd** [01:28:04] Oh, well, it's a pleasure. Thank you so much for your time. I'll stop the recording now.

**Bridgett vonHoldt** [01:28:09] Okay.