Lyme Disease and Connected Landscapes, New York City

[Announcer] This program is presented by the Centers for Disease Control and Prevention.

[Sarah Gregory] Hi everyone, this is Sarah Gregory, and today I'm talking to Meredith VanAcker, who's calling in from New York City. She's a PhD candidate in the Department of Ecology, Evolution, and Environmental Biology at Columbia University. We'll be discussing her article about how city parks impact your chances of getting Lyme disease. Welcome, Meredith.

[Meredith VanAcker] Hi Sarah, thank you for having me to the show.

[Sarah Gregory] Could you start off by telling us a little bit more about what Lyme disease is?

[Meredith VanAcker] Lyme disease is an infectious vectorborne disease, and it's transmitted by hard ticks. The disease itself is caused by a bacteria, which is called *Borrelia burgdorferi*, and this is transmitted to humans from a bite of an infected tick. So, the symptoms of Lyme disease are typically fever, headache, fatigue, and sometimes the characteristic skin rash that can look like a bull's eye.

[Sarah Gregory] Let me just stop you right there. You said *sometimes* characteristic? I thought you always got the bull's eye rash with Lyme disease, no?

[Meredith VanAcker] No, it's about 70 percent will see a bull's eye rash.

[Sarah Gregory] Okay, go ahead.

[Meredith VanAcker] So, the disease was first discovered in Lyme, Connecticut, in the 70s. And it's since spread throughout the Northeast U.S. and parts of the Midwest, as well. So, the disease is maintained in the environment through what we call an enzootic cycle, meaning that it persists in an animal population, and then people become infected as incidental dead-end hosts by an infected tick.

[Sarah Gregory] So, how is Lyme disease infection different from any other tickborne disease?

[Meredith VanAcker] The infection prevalence of ticks with the pathogen that causes Lyme disease tends to be really high compared to other pathogens. So, for example, in the Northeast, about one in four black-legged ticks will carry *Borrelia burgdorferi*, the agent of Lyme disease, and this is reflected in the number of human cases of Lyme disease, compared to other tickborne diseases in the U.S.

[Sarah Gregory] So, what you're saying is if you get bitten by a tick with Lyme disease you're more likely to get it than if you get bitten by a tick that carries another disease. Is that what you're…right?

[Meredith VanAcker] Exactly, so if you're bitten by a black-legged tick you have about a 25 percent chance that that tick is infected. And other tickborne diseases are maintained in ticks at lower prevalences.

[Sarah Gregory] Is Lyme disease very common? Where is it found? I have a friend who got it in Scotland, which really surprised me. We tend to think of it as only being in the Northeast of the U.S.

[Meredith VanAcker] Tickborne diseases are the most common vectorborne illnesses in the U.S., but Lyme disease is really common, and it's distributed throughout Europe, so…as well as the United States. In the U.S. it affects over three hundred thousand people. And it's funny that you bring up Scotland, because my advisor, Dr. Maria Diuk-Wasser, and myself, are working on starting a collaboration with researchers in Scotland, as well as in Italy, to start looking at how the systems compare between the U.S. and Europe.

[Sarah Gregory] How is your study different from other Lyme disease studies? We've had a lot of articles on this topic in the EID journal.

[Meredith VanAcker] The main difference is that, historically, tickborne disease studies, specifically Lyme disease, have looked at the disease in rural and more natural landscapes, and so my study is the first to look at Lyme disease risk in cities, in New York City. On top of that, the study uses landscape ecology methods, and considers the effect of landscape connectivity on the movement of the host and their ticks and pathogens across the landscape. And this is kind of a new… I would say a new method merging two different fields to start thinking about what are the landscape drivers of disease spread.

[Sarah Gregory] Okay, so your study examines risk for Lyme disease in New York City parks, as you just said. Why would ticks be in city parks, and aren't they just usually found in the woods or the wilds?

[Meredith VanAcker] So, ticks are definitely found in the woods, especially *Ixodes scapularis*, the black-legged tick, which causes Lyme disease in the Northeast and Midwest. And New York City has done a wonderful job of maintaining high forest density in city parks. So, this is the main reason that ticks are able to survive in these city parks, is because they need moist forest environments to prevent drying out and dying. However, there's two other components that are required for the emergence of Lyme disease, and these are wildlife hosts that maintain the tick population, and then wildlife hosts that are reservoirs of the tickborne pathogen itself. So, in order for Lyme disease to emerge in cities, we need moist, forested habitats for the tick, but we also need hosts for the tick population persistence and the pathogen persistence.

[Sarah Gregory] And so, what are these hosts in New York City parks?

[Meredith VanAcker] So, the hosts that maintain the tick population in New York City are white-tailed deer and white-footed mice. And the hosts that maintain the pathogen in the wild are a whole suite of different small mammals, including the white-footed mouse and birds.

[Sarah Gregory] You used "circuit theory models" to determine how park landscapes keep their connectivity. Would you explain this to us?

[Meredith VanAcker] Sure. Circuit theory models were adopted from the field of electrical engineering and they were pioneered and developed by an ecologist, Brad McRae. And the model basically represents patches of habitat as nodes in an electrical circuit board, and it represents the movement of animals or plants as the current flow between these nodes or habitat patches. For example, we can have an animal population in the nodes that would flow across

multiple pathways between these nodes. So, as the flow moves between nodes, it can encounter higher resistance in some areas. So, for example, if the flow came across a landscape like New York City with high density buildings or highways, then it would have higher resistance flowing over that surface. Whereas the flow would more preferentially move through better habitats with lower resistance. Say, for example, forested corridors between urban parks. So, in my study, I used the New York City parks as these nodes of habitat, and the developed urban landscapes between the parks, they were given different levels of resistance. And so, the levels of resistance came from expert opinion on the movement and behavior of white-tailed deer. So, the outcome of the model showed what pathways between urban parks are deer more able to navigate in New York City, and this is important for the Lyme disease system because adult black-legged ticks will climb on top of a deer as their final host, the male and female will mate on top of the deer, and then the female drops off and lays eggs in the leaf litter. And so, we really think about the importance of deer in establishing new tick populations in these parks because they can carry such a high density of adult ticks that could eventually lead to new established populations in urban parks.

[Sarah Gregory] So, you found that the pathways that led to the most tick increase, or populations, were these wooded pathways as opposed to just city streets or something.

[Meredith VanAcker] Exactly. So, the more forested the area around the parks, and the more connected the parks were, the higher the density of infected ticks.

[Sarah Gregory] And what was the aim of your study? How…and also how were the ticks collected?

[Meredith VanAcker] So, the study was looking to understand the effects of the urban landscape on the risk of Lyme disease for New Yorkers. I was interested in getting a broad view of what parks and what boroughs are highest risk for the New York population. So, the ticks were collected using corduroy drag cloth, which is pretty typical for tick studies. So, these cloths are dragged along transects, and they are trying to collect questing ticks, so these are ticks that are looking for hosts. And so, every twenty meters, as we're dragging the cloth along a transect, we turn over the cloth and check for ticks, ID the species, count the number of ticks, and then we collect them in ethanol to bring them back to the lab for testing. And so, we did the transect drag along trails in city parks that people were likely to use, and then we also did dragging in the forests themselves.

[Sarah Gregory] So, you…it sounds like you were personally one of the ones that went dragging for these ticks? If so, how did you protect yourself from getting infected?

[Meredith VanAcker] Yeah, so I was the one looking for ticks for the study, and I'm always concerned about getting infected with a tickborne disease. So, I take extra precaution to protect myself. All of my field clothes are treated with permethrin. I wear high rubber boots, and tuck my pants into my socks inside the boots. My hair is always pinned back, and I wear a hat. I use DEET pretty regularly. And after a day of fieldwork, I do a routine tick check and those are some of the steps that I take to protect myself.

[Sarah Gregory] Okay, so how long did this all take?

[Meredith VanAcker] The study took about a month for the nymphal tick collection at the park sites, because we were focusing just on the nymphs, which are often used as an indicator of

Lyme disease risk for humans. But the tick testing, the modeling, and the statistical analysis took about a year. So, there's definite differences that I have learned recently about doing fieldwork in cities compared to some more natural landscapes, and traffic has a huge effect on the timing of fieldwork. So, right now we're doing a big study on Staten Island, and one thing that we are always considering is the time that it'll take getting just between sites because we're in such an urban landscape, which I didn't have to previously consider when I was working in more rural, remote areas.

[Sarah Gregory] How do ticks move from one location to another or spread?

[Meredith VanAcker] So, ticks hitch rides on the host while they're feeding. And to me this is one of the most interesting parts of tick ecology. If a tick is feeding on a mouse, then we can expect it to travel much less than if a tick is feeding on a deer, which tend to travel longer distances. And so, this is really where there's an integration of the movement behavior of the host, and the tick ecology and spread of the vector. So, when we think about how new tick populations get established, we're often considering what hosts are most likely to have really high tick burdens. And as I mentioned earlier, these tend to be the white-tailed deer during the adult life stage of the tick.

[Sarah Gregory] What were the results of your study? What factors were most important for determining Lyme disease risk?

[Meredith VanAcker] The main findings are that not all New York City parks have equal risk of encountering infected black-legged ticks, and this is really important for the public to know, in terms of the risk of the parks that they visit. And so, we found a range of nymphal infection prevalence with *Borrelia burgdorferi*, the agent of Lyme disease, from eight percent of the population in parks being infected to up to forty percent. And we found that, outside of Staten Island, there are few areas in New York City with established tick populations. So, there are…and I want to specify that these are black-legged tick populations, but you can encounter other tick species in New York City parks; however, the study was just looking at black-legged tick populations. And so, we do have a park, Pelham Bay, which is in the Bronx, that has established high densities of black-legged ticks and the majority of the rest of Lyme disease risk is really on Staten Island.

[Sarah Gregory] So, big Central Park in the middle of Manhattan, that's not a risk?

[Meredith VanAcker] No, during my survey I found one tick there, and that was likely a tick that fell off of a bird.

[Sarah Gregory] Hmm, why would that be? Why would Central Park, such a big area, not have very many ticks?

[Meredith VanAcker] So, this comes back to what I had mentioned earlier, that you can have an area that has great habitat for ticks, and potentially even the reservoir hosts that carry the pathogen, but if you don't have the large deer hosts that are required for the tick population life cycle, then you'll likely not have established tick populations at that site. This would be the result of deer not being able to navigate through the urban landscape to live within Central Park.

[Sarah Gregory] I guess I find that surprising because Central Park itself is so huge, and, I mean, there's ticks all, sorry, there's deer all over Atlanta, and I always wonder how they survive, they seem to be in such urban settings. So, hmm, interesting.

[Meredith VanAcker] Yeah, I think that's one of…it actually reflects the finding of the study really well, where you can have these large areas that may be great for ticks and all of their hosts, but if they're not connected to other parks that have the host population, and the hosts aren't able to move between parks, then you may not see tick populations there. So, I'm not very familiar with the Atlanta landscape, but perhaps it's more connected than some of the more isolated parks that we have here in Manhattan.

[Sarah Gregory] Well, what were the results of your study? What factors were most important for determining Lyme disease risk?

[Meredith VanAcker] In the parks with established tick populations, roughly one in four black-legged ticks are infected by the bacteria that causes Lyme disease. And our modeling showed that highly forested parks, with vegetation around the park periphery, and parks that were very connected to other parks were more likely to have high densities of infected ticks.

[Sarah Gregory] We've heard a lot recently about the benefits of having green spaces in cities. Some cities, as I was just saying, like Atlanta, are making efforts to connect green spaces and parks through walking paths. Does this mean cities should reconsider connecting green spaces to each other?

[Meredith VanAcker] That's a great question. I don't think that it means that urban parks shouldn't be more connected, because there's major benefits of doing this for the natural systems that urban green spaces support. However, I do really think that there's a need to understand the ecology of ticks in cities. And in the U.S., this is kind of a new landscape for ticks. And so, there's a need to understand the ecology of ticks and their association with urban-adapted wildlife hosts in order to mitigate the potential risks of connecting specific parks. A strength of using methods like circuit-theory modeling is that you can identify which corridors are most important for maintaining, say for example, deer movement between parks. And so, this can be directly used by park managers to understand whether improving connectivity and habitat for deer in or near these high-density areas may lead to higher tickborne disease risk in cities.

[Sarah Gregory] And what would they do if they discovered it did?

[Meredith VanAcker] If city park managers were considering connecting parks and realized that the populations of species and vectors between these parks may cause higher risk for tickborne disease emergence, they could reconsider connecting that landscape. Also, reducing habitat for specific species that are important players in the tickborne disease system could be an option.

[Sarah Gregory] What about just spraying?

[Meredith VanAcker] So, spraying can definitely help. Right now there are a few different intervention methods that New York City is trying out to reduce tickborne disease risk. One of them is reducing the deer population on Staten Island. They have also started to consider using bait boxes for rodents, as well as spraying acaricides in the habitat. So, all three of those options are definitely being considered here.

[Sarah Gregory] Well, so what can listeners do to protect themselves against Lyme disease?

[Meredith VanAcker] So, listeners should use insect repellent regularly when they know that they're going out into tick-infested areas, and specifically, insect repellent with DEET, if they feel comfortable with that. I would recommend buying permethrin-treated clothing or treat your own clothes that you know that you would regularly wear out in the woods. After going into tick environments, check yourself thoroughly for ticks and remove any attached ticks as quickly as possible using fine-tipped tweezers and pulling directly out from the skin. We also recommend showering within two hours of spending time in tick environments. I would recommend listeners to reduce tick habitat in their backyard. And this is a very important but often missed area of risk for exposure to ticks. And our lab, alongside a lab at the University of Wisconsin, has developed an app. It's called the Tick App. And it can be found and downloaded at TheTickApp.org. So, this is part of a tick exposure study, where people can learn about preventative measures that they can take to reduce tickborne disease risk. And it provides education on tick identification and how to reduce tick habitat in and surrounding your house.

[Sarah Gregory] So, Meredith, tell us about your program, your PhD program and what it's like on a day-to-day basis. What are you doing?

[Meredith VanAcker] So, every day is really different. I'm entering into my fourth year, and so, I just advanced to candidacy and I am no longer doing any teaching or taking courses, so it's very much focused on the research. I'm leading a big research project on Staten Island, and this is based on the results of this paper, really. Being that Staten Island has such an issue with tick populations, I focused a lot of my dissertation on the Staten Island landscape. So, right now I'm managing fieldwork that's happening on Staten Island, where we're doing small mammal collection. We're actually collaring mice to look at mice movement. We are…we have camera traps set up in city parks, and we also drag for ticks within the parks. So, this is to get an idea of, again, the Lyme disease risk within the parks, as well as the spread of ticks between parks. There's also a second study in the lab that's taking place on Staten Island that focuses on the human elements of Lyme disease and so, that group is doing household surveys and dragging for ticks in people's backyards and having people participate in the Tick App. So, right now, I'm focused on fieldwork, and in the fall I tend to focus more on lab work, so testing of ticks and doing some genetics studies of ticks.

[Sarah Gregory] Oh, sounds like you're doing a lot of things that will be extremely beneficial to this tick problem. This is a small question, but you said "collaring mice." What does a mice collar look like?

[Meredith VanAcker] So, we have a really small battery and transmitter, and a very fine, flexible antenna that kind of falls along the backside of the mouse. And then the data is picked up every fifteen seconds by these nodes that are placed within the forests. All of that data is then sent to a base station where we can download the locations of the mice. And the whole study will cover the area of the grid that we trap the mice, so we'll get a better understanding of how mice are moving and picking up ticks in the landscape.

[Sarah Gregory] Wow. That's amazing.

[Meredith VanAcker] It's been challenging to troubleshoot, so far. But we have almost twenty collars out right now and we're picking up signals from the mice, so we're really excited about this project.

[Sarah Gregory] Mice are such avid chewers, I'm just kind of—really surprised they don't chew it off each other.

[Meredith VanAcker] Yeah, so we have one antenna that has been chewed and we're trying to work with the company to troubleshoot a more protective layer but the rest of the collars actually are in really good shape.

[Sarah Gregory] So, outside of all of the work that you've been doing as part of your program, do you spend a lot of time outdoors yourself, just for fun?

[Meredith VanAcker] I do. I love hiking, I like rock climbing, and I try and spend as much of my free time outside. And New York City is actually an amazing city to have access to some of these natural areas for hiking. There's a ton of mountains that are just within an hour to two hours from the city and, as I mentioned before, the park system here is pretty phenomenal, in terms of how much forest cover and trails the city provides to people. So, I grew up in Michigan hiking and camping a lot with my family, and I think this has really had an influence in my interest in ecology and my hobbies that I enjoy doing as well.

[Sarah Gregory] Well, I was going to ask you that. So, how did you get interested in tick tracking?

[Meredith VanAcker] So, before starting my PhD, I was looking at parasites in frogs, actually, in suburban ponds in the Northeast. And that really piqued my interest in the field of disease ecology, because before starting my Masters, where I looked at amphibian disease, I was very much focused on wildlife conservation and conservation biology. And when I started thinking about what aspects of disease I was most interested in, it was really land use change and how landscape can affect the interaction between pathogen, host, and people. And so, what better place to study that than in New York City? The Lyme disease system specifically is really interesting because there are so many wildlife hosts that are important for the emergence of the disease. And I'm also very interested in animal movement, and so how animals move within an urban landscape and alongside their own movement, they're also moving their vectors and pathogens, and so, these are really the questions that got me interested in urban Lyme disease in New York.

[Sarah Gregory] What is your PhD going to be? What's the thesis or project title?

[Meredith VanAcker] So, this is a thesis PhD, and right now, it may change, but right now the title is "The Ecological Drivers of Urban Tickborne Disease Emergence."

[Sarah Gregory] Well thank you much for joining us today, Meredith, this was really interesting.

[Meredith VanAcker] Thank you so much for having me.

[Sarah Gregory] And thank you, listeners, for joining me also. You can read the June 2019 article, Enhancement of Risk for Lyme Disease by Landscape Connectivity, New York, New York, USA, online at cdc.gov/eid.

I'm Sarah Gregory for *Emerging Infectious Diseases*.

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