NEHA
Colorado's Ticked Pink Campaign

Hello and welcome to the presentation Colorado's Ticked Pink Campaign instituting a statewide passive surveillance program for ticks. To ask questions about this presentation, join the presenter in a chat hour in the networking lounge.

I would now like to introduce our presenter, Leah Colton, Medical Entomology and Zoonoses Epidemiologist with the Colorado Department of Public Health and Environment.

Hello and good day everyone. I'm Leah Colton, and I work at the Colorado State Health Department. I am the Medical Entomologist at the State Health Department, and I'm also a Zoonoses Epidemiologist, which means I assist in the investigation of human cases of diseases such as plague, tularemia, and tick-borne illnesses.

Today I wanted to share with you my experience putting together a statewide passive surveillance program for medically-important ticks in Colorado. During this presentation I will cover Colorado's medically-important ticks, including a bit about their biology and life history. I'll review the tick-borne diseases of important that we have in the state. I'll discuss the strategy and goals of this surveillance effort. And some important limitations of the data collected. Then I'll present our preliminary findings. These are preliminary because I still have a number of submitted samples to identify. Finally I'll talk a little about some additional considerations I have in examining these tick submissions, including ticks introduced into Colorado from out of state and whether climate change might result in the distribution expansion of novel tick species into the state.

There are several species of medically-important ticks in Colorado. The most important of these are the hard tick Dermacentor species, specifically Dermacentor andersoni, the Rocky Mountain wood tick, and Dermacentor variabilis, the American dog tick. These ticks are our most prevalent human-biting ticks and are vectors of a number of tick-borne illnesses. The figure in the bottom left-hand corner of the slide depicts adult female and male Rocky Mountain wood ticks.

Next we have the brown dog tick, Rhipicephalus sanguineus. Public Health in Colorado has received a number of anecdotal reports on the presence and distribution of this tick in the state, but how widespread it is, is unknown. Our desire to understand where it may be in the state arises from the fact that in the early 2000s, this tick was discovered to act as a vector of Rocky Mountain Spotted Fever in Arizona.

Finally, we also have medically-important ornithodoros species ticks, which are soft ticks which normally feed on rodents and birds. These ticks are vectors of tick-borne relapsing fever. I mention these ticks because they are important vectors in our state, but I had no expectation of collecting them as part of our surveillance effort, and indeed we did not. The figure in the bottom right-hand corner of the slide is a soft tick ornithodoros species.

I will now briefly review these tick vectors.

The Rocky Mountain wood tick is a large tick compared to the Lone Star tick or the Eastern Deer tick, which many people may be more familiar with. The larva and nymphs feed on small rodents, while adult Rocky Mountain wood ticks feed primarily on larger mammals. The adults are the human biting stage of this tick and are responsible for transmitting disease agents to humans.

The Rocky Mountain wood tick transmits Colorado tick fever virus, tularemia, and Rocky Mountain spotted fever. In addition, it's bite can lead to a condition called tick paralysis.

In looking at this distribution map, we see that the Rocky Mountain wood tick is found in the western United States, specifically in the Rocky Mountain states. Its distribution is restricted to elevations of about 4,000 to 10,500 feet.

This figure shows the lifecycle of a three-host hard tick such as the Rocky Mountain wood tick. As we can see in number one, in the top left-hand corner of the slide, engorged the adult female ticks leave their host and lay their eggs in a sheltered area on the ground. One female can lay several thousand eggs.

As we continue through number two, three and four of this lifecycle depiction, we can see that a blood meal is required at each life stage for the tick to molt and progress to the next stage. Larva feed on small mammals, such as mice and chipmunks. Nymphs feed on somewhat larger hosts such as rabbits and squirrels.

Most ticks acquire disease agents as larva and nymphs from feeding on these smaller mammal hosts, which can be infected with Colorado tick fever virus, tularemia, or Rocky Mountain spotted fever. The disease agent remains in the body of the tick as it molts from one life stage to another. Some of these disease agents can be passed on from a female to her young.

Finally, we see here that adult ticks prefer larger mammals, and mating of males and females occurs on these hosts.

It may take up to two or more years for a tick to complete its lifecycle, depending on host availability, so it's easy to understand how ticks can contribute to a disease agent's persistence in an area.

Here we have the American dog tick, Dermacentor variabilis, another large Dermacentor species tick. In most of the United States it is the primary tick vector of Rocky Mountain spotted fever. Interestingly though Colorado is a Rocky Mountain state, we have very little Rocky Mountain spotted fever cases here.

This map shows the distribution area of the American dog tick as we currently understand it. This tick lives in wooded, shrubby and long grass areas but can also live in residential areas. For example, properties with shrubs, weeds, tall grass, clutter and debris can attract rodents which can in turn support tick populations. In looking at this distribution map, you should note that no part of Colorado is indicated to have this tick. Our surveillance findings have definitely challenged our understanding of this tick species's distribution.

Here again we see an abbreviated tick life cycle. The American dog tick, like the Rocky Mountain wood tick, is a three host tick, targeting smaller mammals as a larva and nymph and larger mammals as an adult. Although it is normally found on dogs, this tick will readily attack larger animals such as cattle, horses and people.

Rhipicephalus sanguineus, the brown dog tick, is shown here. The photo on the left shows a male tick seeking out a host, a behavior called questing. It is common for ticks to climb vegetation such as grasses and shrubs when questing. When a host brushes by the vegetation, the tick will grab onto the host then crawl around until it finds a suitable feeding site. Adult hard ticks can remain attached to feed as long as a week or more, especially the females.

The brown dog tick can be found throughout the United States from coast to coast. This figure shows the brown dog tick life cycle, another three-host tick. Here we see dogs one through three representing the tick's blood meal host at each life stage. The brown dog tick is capable of completing its life cycle in the domestic or peri-domestic environment, which is one of the reasons it is recognized as a serious pest species. Brown dog ticks have been found to infest dog kennels and residential homes in very high numbers.

I'm going to devote a few slides now to provide an overview to Colorado's tick-borne diseases. Arguably Colorado's most prevalent tick-borne disease is a viral illness caused by Colorado tick fever virus. This disease was reportable in our state in the 1990s at which time several hundred cases a year were commonly reported. Since it's generally a self-limiting disease, it was removed from our list of notifiable diseases, but we added it back onto the list in 2014 to allow us to examine how urbanization and changing recreational behaviors of people might have impacted the disease burden.

Important tick-borne bacterial diseases include tularemia, Rocky Mountain spotted fever, and other spotted fevers and tick-borne relapsing fever. Of these, tick-borne relapsing fever is transmitted to humans by Ornithodoros species soft ticks, and I mention them because it's a Colorado tick-borne disease. However, no soft ticks were collected during our surveillance effort, and I will not additionally discuss soft ticks or tick-borne relapsing fever during this presentation.

This slide shows the ecology of Colorado tick fever virus. This tick-transmitted virus circulates in mammal populations at elevations between 4,000 and 10,000 feet, which is the elevation distribution of the Rocky Mountain wood tick, the tick vector of the virus. If you look in the center bottom, this figure shows that the virus is circulating in small mammal populations, specifically squirrels, chipmunks and mice. It's important to understand that these reservoir species do not typically become ill at all.

Different life stages of the tick, larva or nymph, can feed on these small mammals and acquire the virus. The Colorado tick fever virus is also passed from one stage of the tick life cycle to the next, as we see in number two, from larva to nymph to adult.

For number three we see that people are infected with Colorado tick fever virus when they are working or playing outdoors and are exposed to ticks.

Number four reminds us that other animals such as elk, marmots and deer can also be infected with Colorado tick fever virus, but it's unlikely that they play an important role in passing the virus to other ticks.

Tularemia is our most important tick-borne bacterial disease. Tularemia circulates in small mammal populations such as rabbits and rodents where transmission is primarily driven amongst these hosts by species-specific ticks such as the rabbit tick. The bacteria can also survive and persist in the environment, for example in soil or water. The infection spills over into humans when they are bitten by an infected tick that has fed on an infected animal, either as a larva or nymph. People cal also acquire this bacterial infection from direct contact with infected animals or from contact with contaminated soil or water.

The inclusion of mosquito into the tularemia aquatic cycle is based on literature coming out of Scandinavia in Europe.

Rocky Mountain and other spotted fevers are a group of acute febrile illnesses caused by bacteria in the family Rickettsiaceae. This, of course, is a disease that's transmitted to humans via tick bite. Our vectors for this disease are the Rocky Mountain wood tick and the American dog tick. And we have an extremely low incidence of Rocky Mountain spotted fever in our state, so cases are actually very rare in Colorado. And most cases that we see are actually acquired out of state, for example in Missouri or Arkansas.

Following a tick bite, an acute febrile illness will begin and a rash will appear two to five days following illness onset. Again, this is the most severe of Colorado's tick-borne diseases, and since we do, indeed, have this, albeit at low incidence, healthcare providers always consider this and should empirically treat even though, indeed, it may be the much more common Colorado tick fever virus.

Tick paralysis is a condition that results from inoculation of a toxin from tick salivary glands during a blood meal. The condition is unascending paralysis. A tick bite, usually it's a female who will remain attached for quite a long time, again a week or more. Symptom onset can begin within two to seven days. Once the tick is removed, recovery is quite quick. There have been some rare cases where the ticks were not removed quickly enough because it wasn't recognized that that was what was going on, and there could be a fatality. We really most commonly have tick paralysis occurring in dogs in our state. It's not a reportable condition. I know in the past we've had some cases in humans, but it's not a reportable condition so I don't know what the current status of the occurrence of this condition is in our population.

I started by job at the State Health Department in June of 2013, and I quickly realized that Colorado has no public health historical records of tick species in the state from sampling activities. I found some

research studies that documented the presence of some different tick species, but there really was a dearth of statewide surveillance information. Seasonality of host seeking, presence of different ticks, what kind of biting pressure there might be on humans or domestic animals. So, of course, as a Medical Entomologist, I'm extremely interested in potentially doing some surveillance, but the problem is and always will be, we have extremely limited resources for surveillance.

So what's a Medical Entomologist to do? Well there's always the option of some kind of passive surveillance. And some way of looking around at what's going on and taking advantage of opportunities to sample. I know that it's not uncommon for researchers or public health to actually piggyback on other activities that are going on. For example, ectoparasite collection from hunter-killed deer or moose is something that can happen. Road kill can actually be sampled for ectoparasites. This is also a mechanism for people, public health research to acquire blood and tissue samples as well.

Another option when thinking about passive surveillance and where the opportunities might lie is to recruit interested parties and provide a service, perhaps, in exchange for samples.

So we have a very active veterinary community here in the state. We have a lot of people with dogs. So my idea was that we should request that veterinarians send in ticks collected from dogs. Ticks biting dogs are the same species and life stage as are anticipated to bite people, so if I can think of a way to reach out to the veterinarians in the state and ask them if they would be so kind as to send in ticks from dogs, I'll have a way to kind of opportunistically sample across the state.

In the spring of 2015, I had a Master's of Public Health student doing her practicum with me. Jillian and I worked together to craft a message to solicit tick samples from all the veterinarians in the state. A brainstorming session led to the following tagline for a solicitation postcard which was sent out to thousands of licenses veterinarians in the state. As you can see this is quite striking, and our message was that we'd be tickled pink if you sent us your ticks. We got a lot of good feedback from veterinarians. They really liked the postcard, they liked the presentation of the solicitation, so we really felt we had achieved our goal of reaching out.

The goals of this passive surveillance, this opportunistic passive surveillance, were pretty modest, I would say. We wanted to identify species of host-seeking ticks in the state, learn something about their distribution, learn something about the seasonality of their host seeking, and potentially identify risk activities and areas for public health messaging.

One of the things that we were really able to do that's been helpful is to confirm to county public health offices that indeed there are ticks in your area, that they are getting on people, they are getting on dogs specifically. And this was really helpful to them.

So one of the questions I've been asked and that deserves a little bit of discussion perhaps is why not request ticks from humans, especially if we look in the northeast or in the east we see that there are some extremely robust surveillance programs where university-associated groups usually can accept ticks from humans. So why not request ticks from humans here?

Well first of all because I wasn't hearing that humans were being bitten that often. Second because people tend to want the tick tested if you ask them to submit it to the Health Department. From a public health perspective, there is no advantage to testing a tick here in Colorado when it's collected using this kind of surveillance methodology. We recommend that people who are bitten by a tick monitor themselves for a fever or other signs of a tick-borne illness. If they become ill, they should consult with their healthcare provider to see if testing or treatment is indicated. Whether or not we test a tick for disease agents, and whether or not those tests are positive or negative, doesn't change that recommendation.

There's going to be some kind of a time lag between the time that they discover and send it to us and there's some other issues as well. So we didn't want to request ticks from humans. We really didn't want to have to answer that question, can you test this, over and over again.

So that begs the question, why not test the ticks for disease agents? So we don't test ticks because we just don't have the resources to do that. That's in terms of funds for testing and laboratory personnel time. But let's say that we did have those resources. In this particular situation, I would still not recommend testing ticks collected and submitted using this surveillance method. We have no quality control over the sample. We don't know how it's been stored, how long the tick's been dead, and therefore can we trust the test results. I've also seen that the location where the tick was acquired is often imprecise or missing on the submission forms. So there is no derived public health benefit from testing these ticks.

If I can systematic surveillance and go out and look at a population in a specific area at a specific time, then I'd be interested in testing the ticks because then I can extrapolate to population prevalence of the disease agent in the population. But based on this surveillance method, I'm not interested in doing that.

So what are the limitations of opportunistic sampling? I'll just kind of sum them up.

First of all, it's not systematic. We cannot infer anything about the population. I can say, for example, well, we clearly have, you know, some Rocky Mountain wood ticks in this area, but it's very nonspecific.

I have presence data only. So if you're not sort of systematically sampling across the landscape, you know where individual or small numbers of ticks are coming from, but you really don't know too much about is it here or not here, or is it over there only. So it's presence data only and for what that's worth.

The sampling is life stage specific and we are missing data regarding seasonality.

Now having sort of summed up that surveillance project, and our limitations, pros and cons, we do have some interesting preliminary findings. So I've identified over 500 ticks so far. We've received submissions from 27 of the 64 Colorado counties, or 42% of counties. The vast majority of ticks, as expected, were adults. Only 48, or about nine percent, of submitted ticks were immature, and these were nymphs. Forty-four of those were spinose ear ticks, so not a medically-important tick in the state. Two of the immature were brown dog ticks, one was an Ixodes species, and one was an American dog tick.

So I had four different Dermacentor species submitted. These were Dermacentor hunteri, American dog tick, the winter tick, Dermacentor albipictus, and the Rocky Mountain wood tick. Dermacentor hunteri is an interesting finding because this tick is usually found on big horn sheep. I received three males and one female, all collected from dogs in mountain counties. My assumption would be that the dogs were taken by their owners into areas where big horn sheep are present.

The American dog tick. The American dog tick was the most common tick submitted. I received submissions from 18 counties in Colorado. Most came from eastern plains counties. Two samples came from Denver metro-area counties. And one sample came from a Western Slope county. Recall the limitations of the surveillance method, however. In order to really understand whether we have established populations of this tick in these different areas, the best thing to do would be to go out and sample in the spring, for example. In other words, conduct some active systematic surveillance. Clearly, however, this tick is present in our state, definitely throughout the eastern portion.

We see here the winter tick. I received a handful of those ticks. This is not a medically-important tick in terms of human health, but this is a tick that actually has a very negative impact on wildlife health, specifically moose. This tick can parasitize moose in extremely high numbers, as we can see here in this figure. And really have a deleterious effect on their health. This photograph and a picture of this male Dermacentor albipictus comes from the Humane Extension office.

The Rocky Mountain wood tick was submitted from 21 counties. They were, as expected, mostly mountain counties. Recall that we have an elevation restriction on the distribution of this tick. I do have some submissions that reported the location where the tick was acquired as what I kind of consider to be an improbable area, and that is just an issue with the submitter obtaining the correct information about the samples. They really do have a pretty strong restriction on their elevation so I wouldn't, for example, expect to see them out on the eastern plains. That kind of highlights issues with the submission paperwork where we sort of tried to solicit where the tick was likely acquired and received, really, a wide variety of responses to that. Sometimes, you know, it would say, in the back yard yesterday, when the tick that was recovered was clearly greatly engorged and had probably been on the animal for a week, for example.

The brown dog tick was collected from 14 counties in Colorado. These were in the Front Range, southwest and south central Colorado. Some of these counties were rural, some were from urban and suburban areas.

I got, I think it was three, submissions of Ixodes species. An Ixodes species from Wyoming, it was likely spinipalpus, was submitted. Ixodes spinipalpus here in Colorado is a tick that is found really predominantly on small wild mammals such as rodents.

I had a very interesting single Haemaphysalis species tick that was submitted. This is likely Haemaphysalis laporipalustris. This tick, it was really interesting to actually receive this tick from a dog because this is one of those fairly species-specific ticks or ticks that have a high fidelity for a particular host. And they're generally found on lagomorphs like cottontail rabbit, jack tailed jackrabbit or snowshoe hare. And this was recovered, like I said, from a dog. It's interesting to see this because we've had, in the last two years, quite a large epidemic of tularemia in our state, so it was interesting to see that apparently tick numbers were high enough that they were even incidentally questing and seeking on dogs.

So this creature that you see here is not an alien, but this is Otobius megnini, the spinose ear tick. And as I said, the 44 of 48 immatures received in our samples were this tick. This is an interesting tick. It lives out its life in actually the ears of ruminants. The ones I received, over 30 of them – I think 30 or 33 – came out of the ears of a kitten out on the eastern plains. And the other ones came from dog, cat, and then horse, I believe. So these ticks live in the ear. They feed and molt and develop. Once they've molted to an adult, they actually leave the host and go out on the ground and finish out their life.

So in terms of out-of-state-introduced ticks, we received Lone Star tick, American dog tick, and Ixodes species. Of greatest concern to me in terms of being an introduced tick into the state is the Lone Star tick. We received 12 Lone Star ticks from out of state coming in on dogs whose owners had traveled out of state. The majority of these were female. And some of them had actually laid their eggs in the containers that they were submitted in. And I had a couple of containers, for example prescription pill bottles, that were just simply swarming with thousands of larva.

This is an aggressive human-biting tick. It bites people at all life stages. And it's a vector of Ehrlichiosis, Heartland Virus, Southern Tick Associated Rash Illness, and Tularemia.

So I seem to have a decent number of these ticks being introduced into Colorado on dogs. They are definitely a public health concern. I know that this tick is not currently here in the state because the conditions here are not conducive to its survival and persistence, but again, that kind of begs the question as to whether or not when we think about climate change, whether or not that might change here in Colorado. So one of the things I did upon seeing this information was go ahead and look in the literature to see if there were any models that looked at how the Lone Star tick's distribution might change with respect to climate change.

Now whenever I look at a model, a climate model or any kind of model really, I sort of have to remind myself that, you know, to take it all with a grain of salt because models depend on their underlying assumptions. So the things that you think are important that you've identified as being important are those parameters and conditions, measurements of the environment that you put into the model. So, for

example, temperature, relative humidity, vegetation. And when you're selecting these characteristics or things to put into the model, you need to account for the life history traits of the organisms whose distributions are being forecast.

These models are very complex usually because they do try to look at the best evidence that's out there and, again, forecast that.

They are often tested against the historical record which kind of sort of is a way of ground truthing a model. And when you look at the results of a model, it's important to understand that what you're seeing is probably some kind of predicted distribution across the landscape where it appears we know what's happening in an area but there's usually issues with the resolution.

So with all these things in mind making me fairly skeptical about what a model would look like and what it would tell me, I found this really great article that was published by Springer, et al. in 2015 that actually looked at some forecasting with climate change for the Lone Star tick distribution. So this took, as of 2015, what was known for Lone Star tick populations in the United States, and you can see here in the figure that black is our established populations, gray are where populations or ticks have been reported from, and those areas in white have no records.

Now there's nothing west of what you see in here, and it's not because I've cut this off. This is what was presented in the article, so I did not cut this off. You just can see right here as far west as it goes.

So this group that published this paper did a very interesting thing, and what they did was they produced five models, each kind of looking at slightly different array of parameters that are important in determining the distribution of this tick. And produced five different models. And then what they kind of did here was that they have layered them on top of one another. So here you see on the left the report's established tick populations and then where they were reported. And then if you look on the right, you can see that this is a kind of the prediction or the forecast of the distribution under climate change. And I believe it was 50 to 80 years out. The number of optimized models predicting suitability is seen there in the legend. So the darkest black area is where all five of the evaluated models agreed that under the climate change scenario, that tick would be present. So I actually rested a little more easily after seeing this because it really looks like, at least according to this model, that this tick is really not going to be moving west.

So, again, the darkest areas are where all five of the models agree. And we see that here. And nothing in Colorado.

So to summarize, how do we move forward from here? Well, we want to finish – or that would be me, of course – I want to finish identifying the submitted ticks because I've actually continued to get them through the fall and the winter and even here in the spring, so I have, you know, probably a good 40 more samples or so still to look at. I've thought about maybe doing some outreach to veterinarians in areas from which no submissions have been sent. And that's kind of a two-fold goal because first of all, you know, find out are you not submitting because there are none or are you not submitting because, you know, you're not interested in submitting, or you don't think it's important, or whatever. So it's good to maybe find that out.

Possibly do some active surveillance in some areas. Students are always super helpful with those activities.

And also one of the things I'm going to think about a little bit more as this project moves forward and we look a little bit more about what the distribution of the brown dog tick and the American dog tick are in Colorado, is whether over time this could lead to an increase in the Rocky Mountain spotted fever incidence. And if we think so, or we're concerned about that, how we might react in terms of public health.

So that's the end of my presentation. Thanks, everyone, for your attention.

Thank you, Leah, and thank you, everyone, for attending today's presentation, Colorado's Tickled Pink Campaign Instituting a Statewide Passive Surveillance Program for Ticks. On behalf of the National Environmental Health Association and our presenter, thank you for joining us today.