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Beneficial Invertebrates in Our Soil – March 17, 2021

Good afternoon and welcome to today's webinar entitled beneficial invertebrates in our soil. My name is Jen Ryan and I am a Natural Resources Specialist with the East national technology support Center and I will be your host.

I want to take a moment to remind participants that the use of names during those tradenames during the webinars is for informational use only and does not constitute a guarantee of the product by the U.S. Department of agriculture, nor does it imply endorsement by the department of natural resources conservation service that are not named. With that, we will begin.

I'm pleased to turn the webinar over to Nancy Adamson. Nancy supports habitat restoration on farms and in communities as a partner biologist with the USDA natural resources conservation service in Greensboro, North Carolina. Nancy, you may now begin.

Thank you so much, Jen. Jennifer Hopwood provides resources and training for pollinator and beneficial insects habitat management and restoration and a variety of landscapes. She oversees a team of four USDA natural resource conservation service partner biologists and works closely with the NRCS. Jennifer has authored a number of publications and articles and is co-author of several books including farming with native beneficial insects, 100 plans to feed the bees and roadside vegetation manuals. Jennifer has a Masters degree in entomology from the University of Kansas along with work as a research specialist conducting an vertebrate field research and identification. She was an instructor and biology and environmental science at Iowa State University in the Des Moines area community college prior to joining this in 2009. The second speaker is Stephanie Frischie. Stephanie provides habitat expertise to farms in Canada, the U.S. and Latin America. She also works with the native seed industry and researchers to plan and develop seed supply of important plant species for restoration of insects habitat. Before joining, Stephanie conducted research on the potential of native cover crops and Spanish olive orchards. Sure -- her Master of science is from Northwestern University Chicago botanical Gardens conservation program. She holds a bachelor of science in international agronomy from Purdue University. Let me try to say that again. I'm just very excited to welcome Jennifer and Stephanie for this presentation and the accompanying, farming with soil life handbook. And jump right in, please.

Thank you, Nancy and Jen for the introduction and for getting us started. I'm Stephanie Frischie, agronomist and plant ecologist for joining me is Jennifer Jennifer Hopwood Senior conservation entomologist and we are both with the Society for invertebrate conservation. And as an overall outline of the presentation today, Jennifer and I will switch back and forth and we will first talk about some soil health basics. And then get into the profiles of soil animals and quickly go through some scouting and ways to observe these animals. We will talk about agricultural management practices in the NRCS programs that can support soil life and we will present a few case studies and wrap things up with a series of resources to provide more information and then as Jen said, we will have a question and answer session toward the end. And is a teaser, I know we are all on virtually connected here and we will pause two different times during the webinar just briefly to ask if you open ended questions that will have you put into the chat. So stay tuned for that as well please. For me at least, the more I learn and think about soil, it really is magnificent. From a perspective of human utility, there are several ways we think about soils. But generally we think of them as a medium or habitat for plant growth and wildlife. Soil also is really important in regulating and filtering water supply. It also is important in recycling storage of organic matter. And of course we are terrestrial animals and we build so much on soil so it is important for construction of our buildings and highways and other infrastructure. Also, there is another set of categories to describe the organized soil that can be physical with texture, or density. Also chemical and things like pH and exchange capacity and fertility. We will also talk about some of the biological characteristics and we might measure those thorough respiration or things like microbial diversity and abundance. And then things like color and age or soil orders are also used to categorize, classify and talk about soil. I think the concept of soil health brings each of these categories together in a special way. So we will talk a little bit about soil health basics. One definition of soil health is the continued capacity of the soil to function as a vital living ecosystem that sustains plants, animals and humans. I know one farmer that we worked with in the Midwest here has said that he recognizes healthy soil and he has been able to decrease the external input while still maintaining good and stable crop yield.

And the NRCS health division has developed this really nice diagram here. The right-hand side, those two quadrants are really about protecting the soil. So that is minimizing through things like no-till or reduced tillage and maximizing soil cover and that could be through cover cropping or leaving crop residue in place. And the left-hand side looks more at feeding the life in the soil through two main ideas. One is to maximize continuous living roots. And again, cover copying or relay cropping is important. Or a good way to achieve that. And then maximizing biodiversity. Again, in terms of plants and the animals that are on the land above the ground that has a big effect to maximize and feed the life underground in the soil. And this takes us to the focus for today's webinar. That soil is full of life. From the tiniest microbes like bacteria to the fungi and produced and increasing in size to meso invertebrates and of course land plants and vertebrate animals. There are so many things moving in soil. In fact, it has been estimated that 1 teaspoon of soil contains more individual living organisms than there are people in the world. This is bacteria. More than a billion bacteria. Many nematodes and a lot of fungal filament and other small critters. To cover briefly, I want to talk about bacteria and fungi. So bacteria are all single cell and they are the most abundant soil organisms. As I said before, it can contain up to 1 billion individual bacteria. And they really feed on carbon. They contribute to decomposition and they are eaten by some micro- and meso fauna. And they also do some chemical magic in the way they are able to transform elements like atmospheric nitrogen into forms that are available to plants. The fungi are also very abundant in the soil and are really key to decomposing plan residue and also regulating pathogens. I think most importantly, from the human perspective, is how they multiply the capacity of roots to absorb water, nutrients and also increase the plant's ability to tolerate drought. They also play a role just being understood more recently through research in building soil structure and aggregate stability. The reason I wanted to share this image quickly is the way that it illustrates the flow of energy through some of these groups in the soil. So in the green triangle are the organic residue. Not showing living plants and their roots which are also really important but this is just looking at the organic residue of plants that have been shut off or dead animals. And then if you look at the rust colored circles around the bacterial groups, you can see they are feeding on those organic residues. But they kind of just dead end and then they will cycle back into organic residue. Whereas if we look at this from where fungi are in here, decomposing and breaking down the organic residue and incorporating them into the tissue, which then go on to feed this, in the middle row of the blue rectangles there which are a lot of meso fauna which are fed upon by these larger macro invertebrates. So that is just one example of how fungi and bacteria have different roles within the soil ecological community. And with that, I'm going to switch things over here to Jennifer to get us started talking about all of these small but larger soil animals.

Thank you very much, Stephanie. All right. This illustration is a way to think about and a way to visualize all of the abundance and curbs within the soil life. Stephanie mentioned how much life you can find in a teaspoon. This is a way to visualize how much life you can find in a square meter. It is not to scale. But you can see the most abundant organisms are at the bottom of the platform. The bacteria and the fungi. And then the mites. And the smallest organisms are the most abundant. And as this increases, any given space. I think the diagram Stephanie just showed you really helps to illustrate how many members of soil life are dependent on one another. And so it really needs creatures big and small. As Stephanie already highlighted, soil contains diversity of life which is really amazing to me that the animals found in the soil represent nearly 25% of all the species that we know of today. All the species on the planet. 25% of those are animals found in the soil. 99% of those are invertebrates or animals without backbones. These soil animals can play a number of different roles in the soil. There are decomposers that break down plant material and animal material into smaller pieces that bacteria and fungi can use a little more easily. The more that materials broken down, the more niches there are for bacteria and more pores for bacteria to occupy. And after plant matter goes through the gut of a larva fly, the bacterial population can increase up to five times. Insects and animals that burrow in the soil help to mix nutrients and minerals between the different layers of soil which influences soilfertility. This also helps to carry air and water to deeper layers in the soil. And these channels created by the animals help plant roots which like to travel throughout. There are also a lot of different roles within the food webs in addition to decomposition. There are herbivores, animals that feed on fungi and bacteria. Predators that feed on other animals and some that are important pollinators. There is a lot of life happening underground. Because much of it is happening at this site, we are hoping today to showcase some of the soil organisms which are valuable to soil health, particularly in agricultural systems. I'm going to start with the smallest organisms first. Starting with protozoa, these creatures are less than 1 millimeter and are best viewed with a compound microscope. This is a group that used to be considered animals but are now in the very own kingdom. Protozoan's are single celled organisms and they are mobile. Different groups of protozoan's move in different ways. And so the amoeba has the cytoplasm extensions that they extend to help them move and then move in similar ways but have a shell. The silly eight amoeba use the cilia to move and the flagella use a weblike organism that propels them around. They primarily feed on bacteria.

Doing so, they release nitrogen in the form that plans can easily use. So a great deal of the nitrogen found in plants is the result of the work of protozoan's. Protozoan's live in water film within soil. And the next two groups also live in water films. These are best viewed with microscopes. The road for -- ROTIFER, you can see in the top picture, they have crowns and little hairs. They use those to whirled around and create a vortex and that helps them to draw in the food they will consume. Tardigrades are also known as water bears. They superficially do resemble little bears with their steady legs and their claws. Both of these groups feed on bacteria and protozoan's, fungi, plants and algae. And other interesting thing about these two groups is they can enter a state of suspended animation when the water film dries up. So it allows them to go into this resting Phase and they can be particularly long-lasting in these states. Not just months or years but up to a decade or more which is pretty resilient. Nematodesare among the most numerous animals on the planet. They are really ubiquitous. Either and segmented transparent worms. Tapered at both ends. And these animals feed on all sorts of different plants and animals. And have mouthparts specialized for their particular food source. This nematode here has adapted to consume bacteria. The nematode in the middle has piercing mouthparts that allow it to feed on plant roots and this nematode on the right is a predator and hunts other nematodes and protozoan's and so forth. Nematodes too can enter a state of suspended animation and can be incredibly long-lasting, up to many, many years and potentially millions of years. Some folks were able to reanimate nematodes from glacial deposits incredibly. The next group of worms are the pot worms. And these are small segmented worms. They live in the upper soil layers and they feed on bacteria and they consume decaying matter. They do soil structure on a small scale. They burrow and mix minerals and organic matter. They are quite a bit smaller in size but have similar roles as earthworms. Although earthworms are much more similar to these worms but quite a bit larger, I'm sure everyone is familiar with these. They have a segmented body. One thing to note about earthworms that pot worms don't have as they have a structure located closer to their head which houses the reproductive structures. If you have ever wondered which end of the earth warm is the head, just look for that smooth band. Earthworms burrow within the soil and that burrowing action can improve the soilporosity and improve water infiltration. And as they consume leaf water and soil itself, they transform nutrients to make it more available to plants. They can be very beneficial in some studies. However, some earthworms can up to be a detriment to another settings. In the United States, about a third of the earth warm fauna is actually introduced species. There are native species found along the Pacific coast and in eastern states. But a huge swath of the country is without earthworms. So there have been a lot of opportunities for these species to move in. In many cases, there are many species that are ubiquitous. More recently, there have been introduced species. The Asian jumping worm which is a group of about 17 species that have really spread quite quickly. And have been problematic in some habitats. And increasing erosion through the action. Reducing habitat for other soil animals. We will be looking at the losses of nitrogen. It is important to remember that in some studies, earthworms can be very beneficial. And others, they are not the superstars of soil health. So from here on out, I will be speaking about groups of soil animals that are arthropods. Arthropods are invertebrates with an exoskeleton, a hardened skeleton on the outside and segmented bodies and jointed appendages. Because the skeleton is on the outside of the body, as they grow, they have to shed it occasionally and different groups of arthropods go through different transformations in order to develop. And those with incomplete metamorphosis have young that look very similar to the adults and have a very similar suit food source and are found in a similar habitat. This includes groups like mice, spiders and insects like bugs and grasshoppers. On the other hand, we have groups that have more complete metamorphosis and for those groups, they have lifestages that look very different from one another. This includes groups like beetles, flies, ants. They have a larva stage that looks very different from the adults. And in many cases, there is a different food source or different habitat. This is Justin backgrounds. We start to talk about the groups that have larva or eat different things, just so you have that familiarity. Moving into the first group of arthropods, these are the mites. These are among the most diverse animals in the soil and are frequently very abundant. They have eight legs. They have pear shaped dark bodies. They are super decomposers at the soil surface and within soil leaders and -- layers and even the deep soil as well. They are essential to breaking down organic matter into smaller pieces that the bacteria can readily use. There is also a subset of soil mites that are predatory and feed on smaller soil and one thing about mites, since they do move through soil leaders, as they move, they help to disperse fungi and bacteria. And one quick interesting thing about how many mites disperse themselves, you can often see them hitching a ride on larger arthropods. Particularly they like to load up on beetles and they may look like parasites. But they are hanging on and will drop off at another location to find a new place to live.

The next group are spring tales. These, like mites, you can see without a microscope. You can see them with your naked eye. Do you can also view them easy under the microscope. They are pretty tiny. They get their name from the way that they propel themselves around. They really just do spring on the ground. They have a mechanism that you can see here on this picture with a structure called a FURCULA that propels

them around. The springtail is quite globular and others have a more elongated body. Is easiest to see them within the leaf litter where sometimes you can disturb this or overturn a log. They are found in deeper soil layers too. Those that do exist in the deep soil and have a reduced spring and have usually lost their eyes. This is a group that breaks down plant material and fungi. And it also can influence the bacterial through predation. Moving into the largerarthropods, millipedes are a group with a really elongated body. Their name of course tells you that they have many legs. Millipedes means thousands. On each segment of their body, they have two pairs of legs. It really does look like they have many feet. They have chewing mouthparts and they mainly feet on decaying plant material. And their bacteria is very important and plant decomposition. They fragment up to about 15% of fall leaves. One thing to note about millipedes is they can be really long-lived. Some of these other groups have lifecycles that are rather quick. But millipedes can live up to be 11 years old and invest in a lot of care and their young. Similar to millipedes, centipedes have that elongated segmented body. They are more flattened and they do only have one pair of legs per segment. Most notably, centipedes are not decomposers. They are predators. They have legs that are modified as pinchers and they will inject venom into their prey. And they are really excellent hunters. They are mostly nocturnal. They will eat large soil animals. Not just earthworms and arthropods but small mammals and small reptiles. Unlike millipedes, this group also provides some care to their young. And cities spiders for that matter. Spiders are pretty easily recognizable. They have two body regions. They have eight legs and they have multiple eyes. And there are a number of spiders involved in soil life. The ones that we can see most easily are the hunting spiders, the ones that actively seek out PREY and these include jumping spiders, wolf spiders and ground spiders. But there are many other species that have webs either on the surface of the soil where they will dig a tunnel into a tube and then trap or ambush prey, lay and wait for the prey to visit their web. Spiders also reproduce slowly. That means they can be very susceptible to changes in habitat. They really benefit from permanent habitat on farms for example. Places where they can have refuge from insecticides. Spiders can contribute to the control of crop pests as well. I think we will take a short break and we are ready for the chat box. We want to hear from you -- have you thought about this before in your work today? And if so, tell us how. We would love to hear about it.

Just a reminder. If you have specific questions, you can put that in the Q&A panel. What we are looking for here is really just your own thoughts or observations. Thank you.

It is really great to see all of these answers coming in. Nematodes especially. Hopefully everyone is able to see all of these responses as well. I love that comment. Yes, they make the world go round which is so true. And some questions about the groups coming up. Hang tight. If I don't address them, you can add them in the question and answer box. Yes. That is really important. And this is a great comment. Farmers will be better soil managers seeing the soil as living. Thank you. Keep adding to those comments. And I love to include my kids. They like to count earthworms and look for insects in the garden. Thank you. Great comments everybody. We really appreciate it. I think we can put that aside and we will keep going on some of these groups and then there will be a chance again later. We would really like to here from you -- -- hear from you and get your input on things later on. I am now going to move into talking about soil insects. And I think what is mind blowing about all the groups we talked about so far are that, of all the soil animals out there, 80% are insects. We have a huge diversity that we haven't covered. There are many groups of insects that live in the soil or that have a portion of their life dependent upon the soil. There are so many that I'm not going to do them justice. For example, all the pictures of insects that you see, I'm just going to gloss right over those and focus on highlighting those that have the most important -- in particular to agriculture. It doesn't mean these animals are not important. I'm just highlighting the ones that have the most important due to our time. And for time constraints, I'm going to just group a bunch of families of flies altogether. There are many families of flies that are breaking down decaying plant matter as fly larva. This includes groups like praying flies found here. They are quite important and they include dance flies. Non-biting images, mock flies, March flies. This is the larva stage. This is the adult. And then snipe flies. These are some of the families of flies involved in plant decomposition. There is quite a lot out there. The next group, you might be more familiar with. These are flower flies. And these are often found on flowers where they consume nectar or sometimes pollen. And they are the most important non- be pollinators of crops. The adults have pollution that mimics user WASP. A way to tell the difference between a fly and a wasp is flies have one pair of wings and the other groups have two pairs. The adults are pollinators and the larva are really dependent upon the soil, the larva are decomposers of the plant material. They can also be predatory in the soil or be auditory on plants. Here in the picture, this is a larva that is attacking in a bid -- APID. So functional roles in agricultural systems that can contribute to crop pest control or pollination and play a role in soil health. Is group, because of their connection to flowers, they really need some form of flower plant habitat in order to persist in the agricultural landscapes. Moving into another group that contributes to crop pest control, these are soldier beetles. It is predatory. And these feet in the soil layer. And sometimes on

plants. They have jazz and -- JAWS -- and they are found on flowers. Also do some hunting. Many drink nectar or consume pollen. Soldier beetles superficially resemble the next group which are fireflies which also have leatherwing covers. Fireflies have luminescent organs. They use those to grow. The larva also have luminescent segments in the larva are predators. They are excellent hunters and will search for earthworms in burrows or tracks logs by following their slime trail. Another important group of predatory beetles in the soil are ground beetles. And you will see adults and the larva of ground beetles are excellent predators. You can see the JAWS. They have an important role in controlling crop pests, big and small. Grasshoppers, beetles, slugs and snails, flies. Caterpillars and so much more. Some of these beetles also will each decaying plant material and some will consume weeds. It is an important group. These beetles overwinter need well-drained soil to survive the winter. This is another group that really benefits from having a permanent habitat which is really necessary if you are looking to promote this. They really need that habitat. This group of beetles has very similar needs as ground beetles. They respond to similar conservation measures. Their lifestyles are very similar. Both the larva and adults are predatory. They will look for leaf litter. Rove beetles have short wing covers and they are short and speedy runners. Sometimes they will lift up the tip of the tail when they are running. One thing interesting about the group is they do hunt deeper in the soil so those species that are better diggers often have even more reduced wing covers than what you see pictured here. These next groups of beetles feed onCARRION. We have these beetles here. And some of these with the red markings are BERRY beetles. And because these Carrion beetles, are such a hot commodity, they find a way to utilize it as fast as they can. They are exceptional at locating Carrion. And they can be one hour away, 2 miles away and find the Carrion. Carrion beetles lay eggs on Carrion wherever it lies and usually have faster development. Just as the name might suggest, they bury and dig a hole under the carcass and let it sink down into the hole and covered up. And that gives them more exclusive access and hides it from competitors. Just one quick side note, these little mites that you see clinging on to that Carrion beetle are mites that are hitching a ride. To go back really quickly, one important thing about the decomposition of Carrion, these beetles are important because Carrion is so nutrient rich that it can significantly increase soil fertility and it has influences on the plant community. The next group, these decomposers are dung beetles. They have scalloped legs which help them in their digging. You can see they have this antenna and a more oval body than some of the others we have been looking at. The larva look just like the shape of the C and they are found in DUNG. They are very good at locating don't cap -- DUNG. They have similar strategies for securing it. Laying eggs directly into it and quickly, they may dig a tunnel underneath the dung and then remove chunks of dung and bring it to their nest. Or they will put the dung into a ball like you see in this picture and then roll that back to a nest nearby and then rear their young on the Carrion -- dung. They are efficient at removing the dung. And this is critical for improving the plants. It is also critical for reducing the habitat for parasites of life. There are a number of flies that develop in dung. So dung beetles are removing that quickly and it can reduce the habitat for those parasites. Similarly on farms, the dung beetle removal of dung reduces the spread of pathogens like E. coli E. coli because it is the same dung feeding flies that can transmit E. coli. So removing it quickly can remove the spreaders. For pathogens on farms and these are worth more than $380 million a year for estimates. Which is pretty incredible. But they also are important in moving soil and they help to disperse seeds which are present in the dung. One other quick thing about dung beetles are that the chemicals that are used -- for example, insecticides used to treat cattle or livestock parasites can sometimes be harmful to dung beetles. Some can find its way into the dung which can be toxic the next few groups are also related with the ANTS, bees and wasps. These have a constrictedwaist. There are lobes that separate them. Most readily at a glance, you can distinguish them with the wings. The ANTS are the most significant groups in the soil. One study in Massachusetts found that they move about 30 tons of soil per acre. They integrate the soil and aerate it and so forth. Part of the reason they are excavating moving soil so much is that they create these extensive and complex colonies underground. They nest and they have a truly social colony with individuals within the colony that have specific roles such as soldiers or the Queen. And they also maintain overlapping generations and work cooperatively. So these extensive nests that you see pictured here, this nest can be quite deep. 6 feet or more. And so this hopefully helps you to visualize just how much soil they can move when they are just going about their daily life of living and creating their nests. In addition to the role of moving soil and helping.

Soil, they are also -- some species are predators. Some feed on plant material in the soil. Some species also help move for food dispersal. Next are ground nesting bees. About 70-80% of native species of bees in the United States nest underground. These can be shallow. A few centimeters in the more compacted soil to a few feet or a meter or more and well-drained soil. They too can be expensive. Unlike the ANT, most these will live solitary lifestyles. They feed their young pollen and nectar. They make -- the females make many

trips between flowers. This is one of the features that make them absolutely critical pollinators for wildflower plans and many crop plants as well. So these wild ground nesting bees will nest here. This is a sunflower field. Over here these are squash bees. And the squash bees nest typically beneath squash plants. In part because their lifestyle goal is tied to squash flowers. And then we have ground nesting wasps. Very similar to bees, they are solitary. They build underground nests in the soil. They are good diggers. They do provision nests differently rather than provide young with nectar or pollen. They provide them with other arthropods. So the females hunt the PREY and they collect grasshoppers or crickets or stink bugs and take them back to the nest to feed their young. The other adults drink nectar and can play a role in wild plant pollination occasionally. These are a group that does play a role in controlling crop tests. Because they are able to keep some pests like caterpillars in check and because they have a wide range of prey also that they can attack. Quickly, wasps do resemble bees and quite a number of ways. They typically don't have as much hair on their body. They often have spikes on their legs which help them of course to hang on to prey. So we have heard about many different groups of soil animals. There are a few soil animals that eat living plant material. These animals typically feed on roots in the soil. To spotlight a couple of groups, there are weevil grubs, click beetle larva and there are a few groups of moths that have caterpillars that feed on roots in the soil. Some of these species can feed to an extent that they cause economic damage on crops or ornamental plants. But it is important to remember that in a balanced system, they are other predators out there that we have covered today that can help keep these herbivores in check. So hopefully we have given you a quick snapshot of the life happening under our feet at all times. These animals really have a huge influence on our life as well. The nutrient cycle they do is really critical like breaking down plant and animal matter transforming complex compounds into simple compounds plants can use an alternating soil structure. That work is really important because it enhances plant productivity. Obviously very critical for supporting our life through the production of crops and generating materials in so many ways. A couple of other roles that these little animals play, their work in incorporating organic matter into the soil can help sequester more carbon contributing to regulation of the climate. And mentioned that they keep each other and check. They also keep other organisms in check, the population of other organisms in check. There are bees, wasps and beetles that can contribute to pollination. And then a lot of these animals are a food source for larger animals, for vertebrates in particular. So the soil system really is the foundation in so many ways. And with that, I will turn it back to Stephanie.

Thank you, Jennifer, for the great overview of so many wonderful soil animals. We are at about five or six minutes until the top of the hour. We probably have 15 minutes of presentations to go. We will also then stick around for more questions and answers. If you have to jump off, we understand. But if you can stick around, please do. With all the positive things and functions that soil animals do in the course of living their lives, supporting those animals and supporting soil health go hand in hand. This is a simplified table to summarize the effect that some egg management practices have on soil life. And so if we look at tillage, this is in the green area. With less tillage, there is more soil life. With more tillage, there is less soil life. Likewise with synthetic or inorganic fertilizers. If we are using more of the organic-based ones, there is more soil life and more fertilizers are applied, and inorganic form, that is contributing less to soil life. Pesticides, lower use of pesticides enhancing more soil life and with greater diversity above ground, plants and other animals like livestock, there is also more soil life. Taking in a little deeper, some of the ways tillage impacts soil and organisms is through drying out. There is space in there. the body does a lot of damage to the breakage that is so important for connecting plans and feeding the food webs. Also causing the destruction of tunnels, burrows or nesting sites and many of these invertebrates and even vertebrate animals. Inorganic fertilizers cause spikes in nutrient availability and that can be followed by spikes in the population of certain organisms and excess nutrients are either locked to water or leaching or groundwater or runoff or to the atmosphere. And where they cause other contamination, often it is an economic lost -- lost off-site. Pesticides which include insecticides, fungicides, herbicides or even my decides or even the parasite treatments Jennifer mentioned with livestock, those of course lead to both direct and indirect negative effects on the soil and ecological communities. They are either through a mode of action or killing, non-specifically. Whether it is a poster beneficial insects, many of these are not specific enough to discriminate and they can disrupt the digestive lining of many of these animals which either makes him sick or can kill them as well. And infect them. And we want to touch on the topic of scouting. It is an easy DIY option. And a way to begin looking at soil and vertebrates. We did the chat a little while ago and many of you talked about how you like to look in your soil. And see what some of these animals are. There is a set of instructions here shown in the right panel. You can search for soil scouting and find where the link is for that to download. In a nutshell, you choose the site or the habitat that you want to monitor. It is shown here in these panels. This is something I did late last summer near where I live in West Central Indiana. So the top one is a cornfield. It uses reduced tillage and there are cover crops in that field. The middle panel shows

the cool season perennial grass roadside. The bottom panel is a more diversepasture and that has a lot of perennials, both wildflowers and grasses. Many of them are a native species. And so to create a pitfall, you get a plastic container does this is one of those drink cups. You dig a hole that fits the cup size and you put the cup in the hole and you fill in the loose soil around the side to the top of the cup is level with the soil surface. And then leave it overnight or for 24 hours or so. I left mine drying. I didn't want to kill these organisms. But you can put water with just soap in there to keep them from drying out her from jumping out if you are not able to come back and check it within 12-24 hours. There wasn't a lot in these. But in the cornfield, I had many ants and springtails and on the roadside, some crickets. And there were more of them and the perennial habitat. And not a fully scientific method of catching these but an easy way to start making these observations wherever you are.

Next a high-level overview of some of the soil animal resource concerns. And different programs that can be used to address those. So one is habitat loss or degradation with the objective of improving habitat for beneficial soil organisms. And another resource concern is terrestrial habitat for wildlife and invertebrates with an objective to improve the quantity and quality of habitats to meet requirements of identified terrestrial wildlife or invertebrate species. When we get to the actual resources section, I will provide a link for this. We have a new publication that includes a table and this table summarizes about 35 different NRCS practices that support soil organisms. It is a snapshot at that. For the sake of time, because many of you are familiar with these, we won't go into detail. Suffice to say, there are many NRCS practices that can support soil life. One of those is Robidoux -- residue and tillage management or reduced tillage 345 and another is no-till 329 and also there is CSP enhancement to increase soil health and soil organic matter content. Conservation cover 327 is to establish and maintain permanent vegetative cover and one of the objectives for that is specifically improving soil health. There are many benefits that come from 327 which includes reducing ground and surface water quality degradation and also enhancing wildlife pollinator and beneficial insects habitat. Wildlife habitat planting 420 is another way to improve soil life or enhance it. Not every state has adopted 420. Many still use 327 which is a conservation cover. For states that do offer 420, it is really straightforward to use and it can be used for things like fetal banks which are usually linear plantings of grasses that are great habitat for many predatory beetles species that Jennifer talked about. And it can also be used to create pollinator habitat for beneficial insects habitat.

Cover cropping 340 allows you to build aboveground biodiversity and also keep the soil covered and maximized the continuous roots which are several of the principles for building soil health. There is also practiced 386 which is fueled border which includes a diverse mix of native or other low cost non-native but non- invasive plant species that are established at the edge or around the perimeter of the field. It is also important that this habitat is protected from potential drift. Borders can be really important for some of the macro fauna like the Beatles that we talked about as well. And then 595 and this CSP enhancement aimed to eliminate the use of chemical treatments to control pests and increase the presence of dung beetles. It can be used in different ways to reduce pesticide use at least at the national level. The practice targets reducing the impact of livestock parasite treatments in dung and the impact of that on dung Beatles. Here is another summary slide. Trying to give people an idea of all the different practices thatmeet various resource concerns. Not only for soil health but certainly the building soil health and supporting soil life. Next, we are going to talk about a few different farms and case studies. And give you an idea of how they are supporting soil life. So this farm in Cannon Falls, Minnesota is a 30-acre total farm of diverse vegetable crops. It is certified organic and they also produce native plants for sale and their market is through CFA and wholesale. They use traditional tillage methods and also reduced tillage to find something that works well with their diversity and scale. On the left, you can see cover crop mulch in place and the cash crop was planted later. And they have strong mulch down the row centers to keep the soil covered. On the right is a photo showing interceded cover crops. It is annual ryegrass clover and this was planted before the crop was harvested. This helps them to reduced tillage and the fruit is cleaner with less soil on it. And it is easier to harvest and get in there after rainfall. A lot of the practices and habitats are just gorgeous to look at as well. In addition to the native plant field borders, they also use clover borders and flowering cover crops such as buckwheat. These two photos here show a couple of different examples of these native plant field borders. Also in Minnesota, here is an example of a Latino farming cooperative. They are using a variety of flowering cover crops. These photos show different mixes they child recently and looking at ways they can increase their aboveground diversity. And what they are hoping to learn from these trials is how these different combinations grow and if they present any problems and what they see as far as changes in pollinators or beneficial impact on the farm as well.

Here is an example from Casey Bailey's farm in Fort Benton, Montana. This can be difficult to capture in a single image because rotation happens over time and you can't get one picture showing it. In this case, the position in the system Casey uses as shown has the proper crop rotation in a series of bands on the 8000-acre

farm. You can see using this type of rotation that is shown there on the box, it has really helped them to diversify the cropping system and break test cycles and enable the transition to certified organic. They fully transitioned in 2017 and I know Casey was just amazed on how he has been able to flash a lot of those fertilizer bills mainly using alfalfa as a cover and then they also have pay and that is another source of income. And then pictured here is Rick Clark with his family that farms in west central Indiana. They are organic with no tillage. They did not get their overnight. You can see this long and beautiful list of where they are in that journey. As Rick will say, it has been a journey of learning and they have been on the journey for more than a decade now. What started it for them was I think about 12 years ago, they had planted some cover crops in an area where they were trying to help recover from soil erosion and further protect it along the waterway and then following the growing season was a really dry year. Part of the soybean field had been where the cover crops were and part of the soybean field had been their business as usual. And where the cover crop had been, those Wiens did so much better than the part of the field at the cover crop had not been in place. And that was really a lightbulb moment for Rick. Now they have this six crop system. The crops are corn, soybeans, wheat, alfalfa, TEA. There is one I cannot remember at the moment. And then cattle. They also have integrated livestock into the rotation. Cap diversity as well as skill in planting green which is planting the cash crop into the living cover crop and terminating the cover crop and then therefore keeping a continuous living route which keeps animals alive and well. Now to talk about other resources. There is only so much we can introduce and talk about in a one hour webinar. These are more detailed publications if you want to read further. A lot of them have really nice photos as well. The first two are available as free PDFs for download. The third is a lovely book written for the general public and gardeners. It provides -- is a very accessible approach with a lot of technical information and illustrations and photos as well. The beautiful diagram we showed near the beginning of the webinar with the mushroom and the illustration of all the animals underground, that is by Jim Nardi from this book. We really thank him for letting us use those illustrations. And finally I want to present the Canva society as a resource. We are a nonprofit organization science based that works in education, outreach, applied research, policy and restoration to protect vertebrates and in their habitats. We have a strong relationship with NRCS. Throughout the country, we have staff in nearly 15 different states and 10 of those are in partner biologist roles in the NRCS offices and they support the planning and implementation of these practices that can help support this life. And we work in pollinating and promoting agricultural biodiversity. Also protecting and in -- recovering endangered species. We work with aquatic invertebrate conservation. We have a fantastic team that helps provide recommendations and you risk assessments for pesticide. And we are doing work in urban conservation, community science as well as policy and advocacy for all of these important invertebrates. We have an amazing array of publications on plans, pollinators, other insects and also creating habitat for these and they are available on our website as a pre-PDF to download from our publications library. To highlight a few, we have a brochure on cover cropping for pollinators and beneficial insects, farming for pest management and the handbook for planning beneficial insects and how to manage your farm or land with them in mind. I showed the squeal -- soil scouting one before. And we have scouting guides and how to look for and count beneficial insects.

Stephanie, this is Jen. You are breaking up. Your audio is breaking up. It may just be a poor cell phone connection. I'm sorry. Should I repeat anything?

Just a little bit of the last slide.

Okay.

The -- I showed the soil scouting guide earlier in the webinar. We also have these flowers scouting for beneficial insects. And then I'm excited to share this publication of farming with soil life. It is available as a PDF at the link shown here. You also can do a web search. It is 136 pages long with 266 images and essentially the webinar today is a distillation of this handbook. Further into 2021, Jennifer and I will be delivering a series of more in-depth online short courses about these soil invertebrates. Also you can reach us with other questions or to follow-up at soils@canva.org. Finally, I want to say thank youto all of our donors and society members to make our work possible. We are a donor supported nonprofit conservation organization. We thank all of our members on the call today and we invite anyone who is not a member to visit our membership page and join us.

Specifically for today, I want to thank Northeast SARE and organic Valley. And also say thank you to Nancy Adamson, Karen and Dana, Jay Callow, Eric Lee Mader, Sara Foltz Jordan Jen Ryan, Mazon and Rick Clark for their contributions to today's webinar. And I will end with a final thought from the 1938 USDA Yearbook of agriculture. It says, essentially, all life depends on the soil. There can be no life without soil and no soil without life. They have evolved together. We promised one more open poll question. Again, Jen has put the chat up there. And the question this time is to ask you to think about and share what particular practices you have implemented or seen implemented to support soil life. We talked about some

of these quickly. But we would really like to hear what you are doing or what is happening around you. I'm certainly seeing a lot of no-till and another really great thing about soil organisms and these practices that support soil health, that you can adapt them for your garden or your yard, a very small area. And to farms on tens or hundreds of acres or farms at the scale of thousands of acres. All kinds of great things coming in here. So delay cleanup of the flower bed. That is worth mentioning. Especially this time of the year when so many of us are ready for spring to be here and when we can be out working in gardens. And we want to clean up the plant residue from the previous year. As much as we can, it is recommended to keep that in place until temperatures are consistently around 50 degrees Fahrenheit and warm enough where insects can become active again. Because they are either overwintering, nesting or protected by a lot of the leaf residue or systems and things. Jennifer, I guess we can both come on the audio here now and transition into the Q&A part of the webinar. And asked Nancy to join us again also and moderate.

Thank you so much, Jennifer and Stephanie. That was just wonderful. And he can see some comments about how much everybody loved it. One of the first questions is from Dale Parrish. About 50 years ago, it was postulated that the total biomass was greater than all others on the planet. Is that views still supported? Can you guys hear me?

In terms of biomass, I'm not sure. I know we talked about abundance or individuals. Jennifer, are you able to respond to that?

I'm not but I look forward to digging into that and looking for an answer.

Ron Gamble had a question at the beginning. And I don't know if you answered it. But he asked,(indiscernible) not really in the soil. As far as I know they are in the soil.

Nancy, you can answer that one. Go ahead.

I just did a quick Google search. And there are a lot of articles. It is a type of fungi. And let's move on to William. Jennifer, when you were talking about mites, you said they were important even in deep soil. How deep is deep soil?

That is a really excellent question. Off the top of my head, I don't remember how deep they get but it is certainly a few feet down. How about if I look through my materials and respond to this with a more specific answer. If you want to send an e-mail to the soils website which is soils@canva.org. And I can definitely respond to that. I don't remember off the top of my head. But I appreciate the question.

I'm not sure how to pronounce Steve's name but he asks about resilience to pesticides and of course it is a big topic. Is adjusting to the farming with soil life handbook?

It is. There is a good amount of information about how different groups respond to different types of pesticides so that might be a good place to start. It is not a short answer.

Right. Great. And I wanted to remind everyone that in the handouts today, there is a copy of farming with soil life and there is a link to these links today. So you can get it either way. Calvin Essex is asking that if a prescribed prescribed burn is applied in the winter months, describe the impact on soil organisms. Will recovery occur quickly or take the entire growing season?

That is a good question. Fire certainly can impact invertebrates, whether they are in some of the residue being burned or the standing stones or in the soil. But it is a pretty good insulator. Depending on the intensity and how hot the fire gets and the duration, how long the heat is there, that really affects how deep these soil animals are killed. And I think which ones, some are more mobile than others. Another good recommendation -- just as you would be mindful of insects and that residue, you don't want to burn the whole area all at once. But instead divided up in any given time you are burning, leave at least half or more unburned and then from year to year, rotate the section that is burned. So you always have a refuge where some animals will not be negatively impacted by the fire and those can we colonize in areas that may have lost animals because of the fire.

Most of the NRCS practices encourage you to include grasses and your plantings and those help carry the fire more quickly across the landscape. So I hope you don't mind me jumping in there. And another question. How is soil invertebrate composition affected by soil health? I think you answered that. It came up earlier. That again is probably answered in detail.

That is a good place to go.

I'm sorry to be rushing. We are trying to finish by 3:30 when the recording will end. So it is asked, what can I do to my Sandy land to make it more welcome to invertebrates to nurse the soil?

I would say wherever you are, there are native plants or crop plants it would be adapted to your soil and climate. That is probably the best recommendation I would give, would be to use those plans that will work well there and let them do their thing. They will be building the associated soil organisms. They also will be adding organic matter to the soil. So rather than trying to get things to grow that might require a lot of irrigation, I would recommend finding crops or other plans that would more naturally do well in the soil and climate type. Again, the website or the planner, you can find which plants might be the right ones.

Janet, how do Carrion beetles find food from 2 miles? Small?

They use their antenna and they are just excellent. So they can detect the smell from quite a distance.

And can tumble bugs --

That is the common name for the type of dung beetles that role dung back to the nests.

Great. Let's see. When rolling over logs, it seems if you find ants, you don't find much of anything else.

Ants have a variety of strategies for protecting their colony or their preferred food source. Sometimes they can be a little territorial. Especially if they are predatory.

And car rolled to -- shared a couple of websites. I'm replying to everybody. One is about how the microorganisms in stomachs can affect autismin the introduction and the other is about soil and food webs. Kevin Brown asked, so do ground bees have to have -- ground or is soil health detrimental? I think human is the groundcover over soiled detrimental?

Ground bees can match -- can nest in small patches. It doesn't have to be a huge expensive area. The difference is that there are different preferences. So with what we looked at with the bees nesting in the sunflower field, the reason that was so attractive with so many nests in one place is because it was exposed. But no. The bees are capable of nesting in rather dense visitation as well.

You prevented us -- presented us with life from the bottom of the food web. Can you show us how large mammals or birds influence this web?

Good question. Definitely involved in mixing soil too. And they eat a lot of the critters we talked about today as well. They definitely play a role as well. We do have a little more about vertebrate soil life in the guide if you want to go there for more.

Just like the question with burning, that add nutrients to the soil and so did the mammals and birds. And that can support soil life.

How might you describe grazing photosynthesis management with soil habitat?

Can you read that again?

How might you describe grazing photosynthesis management to build soil organism habitat?

I'm not familiar with that strategy.

It is almost 3:30 now. Jen, can we go past 3:30 with questions or should be close things down at 3:30?

We can go a few more minutes but we will lose the captioner at 3:30.

Okay, great. Let's see. Kevin asks, do you have recommendations for sources related to forest soils? But I don't know if that is covered in your manual handbook.

[Event Concluded]