No-TillFarmer.com

How Beneficial Insects, Pollinators Can Boost No-Till Resilience

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Manage 'Good' Insects Like Your Farm Depends On It

No-till practices and diverse cover-crop mixes are like a beacon to beneficial insect communities that pollinate crops, munch on weed seeds and kill yield-robbing crop pests — all to your benefit.

For every yield-robbing pest no-tillers know of in a field, there are 1,700 insect species that are beneficial or neutral to their farm.

On every farm, insects form the basis of complex food webs and provide services to farmers. Insects feed wildlife. Others like dung beetles return nutrients to the soil, and still more regulate herbivores or shape the dispersion and density of plant communities.

Jonathan Lundgren, CEO of Blue Dasher Farm in Brookings, S.D., says farmer decisions about managing pests shouldn't come at the expense of "friendlies" in cropland, since they save farmers billions of dollars each year by killing crop pests, eating weed seeds and pollinating crops.

LOOK DEEPER. For every yield-robbing crop pest that no-tillers can name, there are more than 1,700 insects that are beneficial or neutral to farms, says USDA researcher Jonathan Lundgren.

"We can't live without them," says Lundgrena, a former USDA researcher in South Dakota. "And you can use these insects as tools."

Welcome the Predators

One major role that beneficial insect communities play is as predators of harmful crop pests, such as corn rootworms and aphids.

In the "South Dakota Corn Insect Survey" project completed in 2010 and 2011, USDA and South Dakota State University researchers searched through 53 different fields across eastern South Dakota where non-Bt corn was growing and found more than 91 species of insects in untreated fields. A few were harmful crop pests, but 93% of species were not and 87% of the insects weren't even herbivores.

"These were just insects found in the crop canopy," Lundgren says. Some 7% were primary pests, although they weren't present at economically damaging levels, and 13% had some impact on corn. The researchers found about 4½ predators per plant in 2010 and 5.3 predators per plant in 2011 — which equates to 137,000-161,000 predators per acre in the corn canopy.

More predators were found in the soil. In one cornfield alone, researchers found 63 predator species in soil cores, 86 predator species on the soil surface and 85 predator species in pitfall traps.

"What are they doing out there? A lot of them are predators and they're giving you free services that are hard to put an economic value on,"

Lundgren says. "Killing these insects costs you money."

Lundgren says farm machinery and chemicals are the primary ways beneficial insects are killed, through trauma or elimination of vegetation from the landscape other than crops. This has an impact on environmental diversity of insect communities that manages pests in crops.

Lundgren notes that a lot of key pests in agriculture — such as corn rootworms and weed seeds — have life stages that are associated with the soil. Although millions of dollars of research has been directed at eradicating corn rootworms, for example, Lundgren believes resurgence is likely given this pest's history.

"The primary response has been to throw insecticides, simplified crop rotations, Bt traits or seed treatments at them. But history teaches us this pest always figures out a way around what we're throwing at it," Lundgren says.

ROOTWORM KILLER. A harvestman (Phalangium opilio), is one of the more important predators of corn rootworm larvae. USDA researcher Jonathan Lundgren has found predators with sucking mouthparts like harvestmen, spiders and mites eat more rootworms than any of the other predators he's tested.

He notes that immature rootworms often experience 95-99% mortality in the soil, but there has been very little "consistent and directed" research focusing on what organisms (diseases and predators) kill rootworms.

"Almost all the eggs die in soil, but it doesn't take many larvae to hurt the corn plant. Yet we don't know what's causing all that mortality. Predators kill a lot of these rootworms, and we've got the data to show it," Lundgren says.

A few years ago, Lundgren's group conducted research on the predators affecting corn rootworms, analyzing the stomachs of thousands of predators for corn rootworm DNA. To do this, researchers had to figure out when rootworm eggs and larvae were present in the soil, and which predators bumped into them during those periods of the growing season.

At test sites in Brookings and Pierre, S.D., they found 11-19% of the predators tested positive for the DNA, and dozens of predator species tested positive.

While this may not seem like much predation, he notes that as soon as the organism eats the pest it begins to digest the DNA, so the DNA is only detectable for a few hours. And also consider, he says, there are millions or even billions of predators that can be found in one acre of farmland.

"So 11% of billions of predators that ate rootworms in the last few hours before being collected means there is a lot of predation going on," he says.

Lundgren also notes there is a seasonal asynchrony of predators within the insect community. For example, as the life stage of rootworms changes in a given field, the predator community also changes. And only some predators will eat a target pest.

"These predators will manage our insect pests and weed seeds — when we allow them to," Lundgren says. "But there isn't just a single smoking gun. It's a whole community and it's very dynamic. There are even changes in activity cycles in a 24-hour period, because some only walk around in a 3-hour period at the end of the day."

Cover Crops Key

When it comes to building diverse insect communities that can assist in managing yield-robbing pests in farm fields, no-till systems are necessary, "but it's not enough," Lundgren says.

Eliminating tillage serves an important function in preserving soil biology and reducing the destruction of insects and their habitats. To illustrate the importance of this, Lundgren notes an experiment several years ago where researchers tried to infest a field at the Dakota Lakes Research Farm in South Dakota with corn rootworm eggs, at a rate of 1,000 per row foot.

Almost none of them survived, he says, purportedly due to the long-term no-tilled environment and thriving insect community.

"Just like with no-till, the benefits of insect communities accrue over

time," he says. "After tillage, things will come back, but it's usually in response to pests going crazy. And the community won't be as good, or as stable, as one built up over the years."

No-till crop residue is also important because it brings in insects that serve as beneficial food for desirable predators.

But seeding cover crops can bring a major boost for beneficial insect communities, Lundgren says. He pointed to a 3-year study that found a winter cover crop (slender wheatgrass) increased the number of predators so dramatically that there were few corn rootworms left in fields to eat the roots of corn seedlings when they sprouted.

"Cover crops link the growing seasons, so that you have vegetation and habitat for predator communities," he says. "Predators are there in spring when the pests arrive, and cover crops also provide habitat for alternative foods like fungi, pollen and vegetation. Covers feed the predators and sustain them much more than bare soil."

Studies in 2010 and 2011 in South Dakota cornfields showed a significantly higher presence of predator insects in fields with cover crops when compared to bare soil. He's also noted through research that predation of rootworm larvae is strongly correlated with reduced root damage ratings in corn.

Lundgren says cover crops interact with predators and make them more effective in two ways: More predators live in cover-cropped fields, and covers also change corn roots structurally.

"What we think is happening is the cover crops change corn roots, which is forcing the older rootworm larvae out of the corn roots," he says. "When they move out of the root, the predator communities that cover crops promote are waiting for them. As predation increases, root damage diminishes."

So which cover-crop species are best for predators of rootworm larvae or killing other crop pests?

"We don't have an answer to that yet," Lundgren says. "Until more directed research is conducted, I advise that some vegetative diversity is better than none, and more diversity is better than less. And the predator community is more diverse with diverse cover crops. Cover-crop cocktails can increase the number of predator functions performed if you have more species in them."

Weed Seed Buffet

The predation effect with beneficial insects also holds true with weed seeds — which is key with herbicide resistance, a major concern in the U.S. with glyphosate losing its effectiveness on many farms.

Previous research shows up to 162,000 weed seeds can be found per square meter of a farm field. And insects actually shape when and where weeds happen in farmland, Lundgren says.

"If we change our cropping systems, reduce soil disturbance, reduce pesticide use to when it's needed or when a problem exists, and add cover crops and diverse rotations, those can be used to mimic aspects of natural systems..."

— Jonathan Lundgren

"Insects eat weed seeds. Approximately 10% of seeds that fall onto the ground are eaten per day, and these seeds determine what future weed communities look like in a field," he says.

There are hundreds of species of ground beetles, crickets, ants and other insects that eat weed seeds at a rapid rate, and many of them are almost the same exact community that deals with corn rootworm larvae, he says. And for predators, the seeds typically are a better source of calories, protein, lipids and carbohydrates than prey.

"You can look inside stomachs of seed predators and see which ones are eating the focal seed," he says. "We mark seeds with a protein that doesn't

occur in the environment, disseminate the seeds into a habitat, and then collect insects and remove their stomachs. Using a biochemistry assay, we can see which predator has eaten a particular weed seed."

USDA researchers have been testing this method with dandelions, which can be a major pest in no-till fields. A granivore community that is well described in Europe — but unknown in the U.S. — eats dandelion weed seeds.

Some 1,800 specimens from 65 taxa were analyzed recently in the U.S. and researchers found 22% of them ate dandelion seeds. The usual suspects were carabid beetles (up to 34% positive), ants (12% positive) and crickets (47% positive). But they also found isopods, millipedes, caterpillars and weevils ate the seeds, too.

A key term here is "trophic interaction" — how much a particular food that insects gravitate to and eat. The top 5 most frequent consumers of weed seeds are millipedes, small crickets, isopods, field crickets and carabid beetles.

HARD WORKER. Carabid beetles, or predatory ground beetles, are one of the top consumers of weed seeds. They also have a large appetite for corn rootworms, with different species hunting them specifically during the day or night. The beetles typically thrive in environments where cover crops or non-invasive perennial margins are present.

But not all species have an equal effect on all weeds. Lundgren's studies of field crickets (Gryllus pennsylvanicus) showed that they prefer crabgrass seed to foxtail, lambsquarters, pigweed, alfalfa, morningglory or velvetleaf seed. In contrast, the carabid beetle, Harpalus pensylvanicus prefer to eat lambsquarters and pigweed seeds than the other weed species.

These interactions are often based on seed nutrition, defense, size and structure.

It's difficult to say what species of insects are best at controlling the seed bank, but it's best for no-tillers to create an environment where many different insect species can exist, Lundgren says. Seed predation alone probably isn't enough to eliminate herbicide applications, but combining beneficial insects with diverse cover crops and crop rotations could possibly accomplish such a goal.

"We don't always understand how these species interact, but we need to get out of the way and let them do their jobs, rather than trying to manage them all the time," Lundgren says.

Pollinators Crucial

While much industry attention is devoted to helping farmers eradicate insect pests deemed harmful to U.S. crops, it's easily forgotten that many insects play a crucial role in pollinating crops.

Long-horned bees (genus Melissodes) thrive in cropland, and numerous other species of butterflies and small flies can have a direct impact on the pollination of soybeans, sunflowers, canola and other crops that flower. One testament to the diversity of pollinators in any given field was illustrated in a project undertaken at the USDA-ARS research fields in Brookings, S.D.

USDA researchers in South Dakota and Minnesota used pan traps to collect pollinators from several plots in a single study year. During the season, they collected 2,170 syrphid flies, bees, wasps and butterflies totaling some 114 species.

Lundgren says there are two problems currently facing pollinators, especially in the Dakotas: A lack of food resources and diversity, and risks posed by pest management practices.

In order to stabilize or increase the amount of pollinators, no-tillers should take a hard look at insecticide use on their farm and determine if it's needed.

"Prophylactic use of insecticides as an 'insurance policy' often does more harm than good for the farmer, and unnecessarily costs them money," Lundgren says. "Farmers should know whether they have a pest problem before they use products like insecticidal seed treatments or foliar applications.

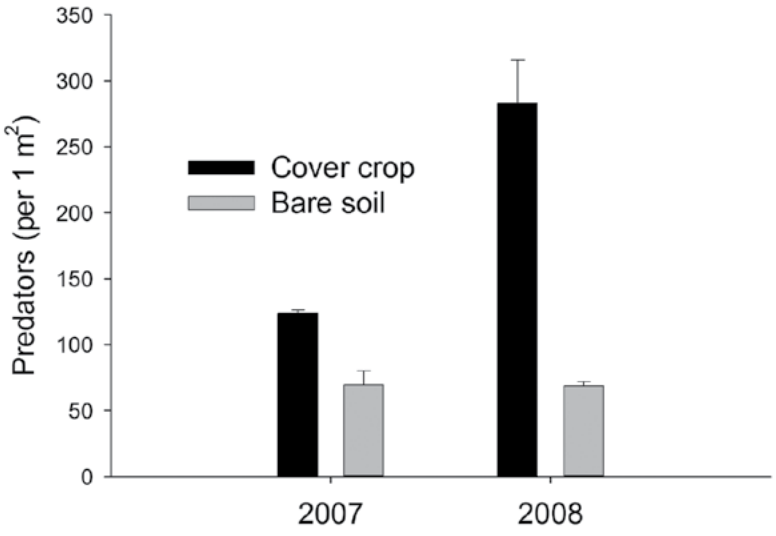

Figure 1. Seasonal mean predator densities (SEM) measured in hand-collected quadrats in corn fields planted with cover crops or left with bare soil.

Source: USDA-ARS

COVERS WORK. Research in South Dakota cornfields by USDA researcher Jonathan Lundgren found that significantly more predators exist in fields where cover crops are present, compared to fields with just bare soils.

"It is a bad business decision to kill off all the insects in your fields."

In South Dakota and Minnesota, researchers are trying to accommodate pollinators by studying the feasibility of adding flowering oilseed crops to rotations, such as sunflowers, spring canola, echium, flax, spring camelina, calendula, crambe or cuphea.

"Part of the goal of this work is to figure out what species work agronomically, and what species work as a pollinator conservation tool," Lundgren says.

"The nice thing about these crops is that bees love them, and you can select crops that flower at different times of the year so there are floral resources for the bees. And you can do that while taking the crops off," Lundgren says.

Oils from these seeds are used for cosmetics, food and biofuels. Some of them have markets already, and some are just developing, he says.

Lundgren says the benefits of oilseed crops can have a spillover effect into adjacent corn or soybean crops as well. For example, some lady beetles consuming aphids or nectar in the oilseed crops could move into soybean crops and eat crop pests.

"And there are some documented yield bumps in soybeans due to pollinators living next door," he says.

Big Tent Approach

No-tillers often gauge the health of their soils by counting the number of earthworms in a shovelful of soil, perhaps comparing that to when they began no-tilling years earlier.

In the case of insect communities, no-tillers may be tempted to ask what specific species of insects they should try to attract, or how they can benchmark the quality of their farm's insect community.

That's not an easy task, Lundgren says, because food webs in the crop canopy, soil surface and underground are too complex and numerous.

"If you manage for diversity, all of the jobs in the food web will be taken care of..."

"We've been trying to identify some indicator species, but it's not been a simple thing," he says. "But if you look at how pests interact in a natural environment like a pasture or prairie, you can understand why you seldom see pests in those areas.

"If we change our cropping systems, reduce soil disturbance, reduce pesticide use to when it's needed, or when a problem exists, and add cover crops and diverse rotations, those can be used to mimic aspects of natural systems.

"If you manage for diversity, all of the jobs in the food web will be taken care of."

Enlist Pollinators, Predator Insects to Help Fight Pests in No-Tilled Crops

'Extending the bloom' with buffer zones, cover crops and native prairie grass strips helps nurture the symbiotic relationship between insects, soils and flowering plants.

In an age of surface-applied insecticides and seed treatments, the importance of beneficial insects and natural pollinators to a thriving agricultural ecosystem can easily be overlooked.

After all, the most essential staple food crops on the planet, like corn, soybeans, wheat, rice and sorghum, are self-pollinating. And the role of insects in pest management typically doesn't get a lot of attention, says Eric Mader, even though less than 2% of all insect species are true crop pests.

SCENTED STRIPS. In Montana, large producers of various small grains, including wheat, are using Xerces-designed seed mixes to create beneficial insect habitats.

"We've seen a staggering conversion of CRP land and grazing lands to commodity crop production in the wake of the renewable fuel standards and as a response to the ever-present demand for cheap livestock feed," says the co-director of the Pollinator Conservation Program at Xerces Society.

"What has resulted in the past decade is really the largest conversion of permanent perennial grassland back to crop production since just before the Dust Bowl."

Nature's statistics on insect abundance and diversity in soils are pretty remarkable, Mader says. In most temperate climates, for example, a native prairie or native forest system can reveal several thousand insects in 1 cubic yard of intact native soil. And, in many cases, these insects can live for years.

Bees and Butterflies

Despite an abundance of some insects in native soils, two pollinator insects that have been in notable decline are honeybees and monarch butterflies.

Over the past 50 years or so, there's been a roughly 50% decline of honeybee populations in the U.S., Mader estimates. The reasons for the decline range from parasite and disease issues, to increasing pesticide loads, a loss of flowering plants from the landscape, to an aging demographic of beekeepers.

Wild-bee populations are in significant trouble as well, which is evi-

Regional Pollinator Information from Xerces

Xerces Society's core programs focus on habitat conservation and restoration, species conservation, protecting pollinators, contributing to watershed health and reducing harm to invertebrates from pesticide use. Founded in 1971, the organization takes its name from the now extinct Xerces Blue butterfly *(Glaucopsyche xerces)*, the first butterfly known to go extinct in North America as a result of human activities.

The organization produces many conservation-oriented resources and many are available for free online at www.xerces.org.

In its Pollinator Resource Center there are links to videos, presentations and webinars, pollinator program reports, studies and technical articles. There are also recommended pollinator plant lists, conservation planting guides and lists of native pollinator seed companies broken out by geographic region throughout North America.

denced by declines in bumblebee species. North America has 46 species of wild bumblebees that are native to the continent and of those, roughly 25% of them are directly at risk of extinction, Mader says.

Similar, more dramatic declines of formerly common insects, like monarch butterflies, are continuing to occur. "In just the past 20 years or so we've seen an 85-90% decline in the number of monarch butterflies breeding in the central United States, he says.

Providing Habitat

To help stem these trends of decline, Mader advocates the concept of "extending the bloom." This can be as simple adding a flowering cover crop to a mix or planting a diverse assortment of early- and late-blooming native flowering plants into prairie strips or grass waterways.

"No-tillers that are already familiar with cover crop cocktail mixes know the benefits of extending the bloom during that cover crop period.

"We are also seeing more interest in rotating crops like flax, buckwheat and sunflower that are taking hold in some parts of the Midwest and the Great Plains," he says. "These crops provide benefits to the insect community that corn and soybeans alone won't provide."

Mader notes that partridge peas — a warm-season, Midwestern native prairie plant — are beginning to gain some interest among farmers due to the plant's large biomass and nitrogen-fixing characteristics. With growth habits and physical similarities to vetch, it could be an idea for someone looking for a warm-season rotation, he says.

From a pollinator standpoint, another interesting characteristic about partridge peas is that it has extra-floral nectar that is secreted from its leaf petals, as well as its flowers.

"A variety of flowering cover crops, such as mustards, buckwheat, phacelia, vetch and clover, act as the primary drivers that accelerate beneficial insect populations, whether that's bees or predatory insects," he says.

Mader recommends that no-tillers look beyond their traditional seed providers to find those companies that cater to CRP and conservation easement plantings, as they're likely to specialize in native prairie species.

No-Till's Difference

Many farmers are looking for ways to help conserve bee populations, Mader says. With wild bees, easily 70-75% of those species nest in the ground. Naturally, any cultivation destroys not only the nesting habitat but negates future bee development as well.

"Ground beetles are the cheetahs or lions of the soil surface..."

Beneficial wasps have been studied by the USDA's Agricultural Research Service (ARS) in the Southeast, says Mader. By integrating flowering cover crops like buckwheat around soybeans, where stink bugs tend to be a more common pest, multi-year studies show higher rates of stinkbug egg parasitism by beneficial wasps due to the flowering covers.

One insect group that certainly thrives in undisturbed ground is ants. While ants typically aren't going to capture the fascination of most farmers, they're among the hardest working soil engineers, Mader says.

The tunneling action of ants has been well documented. As they excavate tunnels they also move subsoil particles through the soil profile, much like earthworms do. The tunneling also acts to incorporate tons of organic matter into the soil.

Beneficial Beetles

An insect group that provides perhaps the most direct impact on corn-and-soybean profitability are common ground beetles, which live their entire lives either in or on the soil.

"Ground beetles are the cheetahs or lions of the soil surface, as they can live for years and are incredible predators of pests like slugs," Mader says.

"These are running hunters on soil surfaces. They're known to consume more than their own body weight in prey on a given day, often killing more prey insects than they can eat."

One more unsung group of ground beetles are seed-feeding ground beetles. They exhibit a very strong preference for feeding on seeds of many plants considered as agronomic weeds, with lambsquarters topping the list.

Depending upon the species, a single, seed-feeding ground beetle can feed on dozens to hundreds of seeds over a 48-hour period, Mader says. Aggregated over large populations of ground beetles on an acre of cropland, their impact can be significant.

LATE BLOOMERS. Early- and late-blooming flowering plants in cover crops mixes not only enhance the nutrients and biomass available to future crops, but also "extend the bloom" for numerous pollinators.

A smaller group of beneficial beetles are dung beetles, which perform the grimy-but-important job of integrating and disposing of animal waste, Mader says. "There are three different categories. We call them the rollers, the tunnelers and the dwellers, depending on what they do with the dung."

Rollers tend to spool dung into small, marble shaped balls, roll them across the soil with their back legs and drop them into excavated underground storage pantries. The dwellers, as the name suggests, live right in that dung patty and eat it. The tunnelers move into the dung patty and then tunnel down, letting the dung fall down into their pantries.

"They're really interesting animals, although increasingly rare, and yet their role in methane reduction is well documented," he says. "They can eliminate E. coli from pasture systems, when their populations are high enough. It has been documented."

Treat the Problem

Mader cautions no-tillers about becoming too reliant on systemic pesticide groups, such as the growingly popular neonicotinoids in seed treatments and foliar sprays.

The insecticides are spreading out into larger environment because they're mobile in water, he says, and they can last for multiple years in the soil.

"Over-reliance on these is contrary to the fundamental principal of an integrated pest management program, which tells us we should only use insecticides when there's a documented pest outbreak. We shouldn't be using pesticides prophylactically," he says.

Penn State University has called attention to the issue of slug outbreaks that are occurring in the wake of seed treatments, he notes. As slugs are mollusks, they're not affected by these insecticides. But their major predators, the ground beetles, are very susceptible.

"There's now mounting evidence that these seed treatments are poisoning the predator populations in fields and causing slug outbreaks in soybeans where historically it has never really been an issue," Mader says.

Encouraging Beneficial Insects for Better Soil Health and Higher Profits

Fifty-seven billion dollars.

That's the annual monetary value a 2006 economic study published in BioScience attributed to just four services performed by wild insects in the United States – pest control, pollination, dung burial and wildlife nutrition.

How can agricultural producers increase their share of the value provided by insects and protect them as an economically important natural resource?

The answer lies in regenerative agricultural practices.

PHOTO COURTESY OF USDA-NRCS SOUTH DAKOTA.

IN BALANCE. Bryan Jorgensen of Ideal, SD, uses the five principles of soil health to promote balanced insect communities at Jorgensen Land & Cattle near Ideal, SD.

Types of Beneficials

"There's certainly a lot of beneficial insects," Agricultural Research Service Research Entomologist Louis Hesler said. "There're predators out there, so they provide natural biological control of pest insects. There are pollinators. There are what we call the recyclers or the detritivores."

Hesler said recyclers also include micro-insects that live in the soil and other invertebrates like earthworms and beneficial nematodes. They help to break down and recycle material in the soil.

All of these insects – the predators, the pollinators, and the recyclers – provide crucial services on farms and ranches. Some of the most important insects on the farm, however, might be considered pests, but they also provide the basis of the food pyramid for the entire insect community.

"In terms of abundance, springtails, mites, thrips, and aphids are probably some of the most important invertebrates. They are like plankton in the sea," said Jonathan Lundgren, agroecologist, producer, Ecdysis Foundation director, and owner of Blue Dasher Farm near Estelline, SD. "These things – mites and (springtails) in the soil – are foundational to everything else. It's like the base of the pyramid."

That abundance and diversity of insect life is what will lead to better outcomes for producers, Lundgren said. "It's about the number of species and the life on your farm," he explained. "It's diversity. Predators, pollinators,

granivores that eat weed seed, herbivores that help to regulate weeds – all of these things are really important."

Why are they Important?

"The number of insect species on your farm correlates directly with how much profit you generate. We've got the data," Lundgren said. "The more bugs, the more water infiltration, the more soil carbon and organic matter, the more plant diversity – that's at the base of the whole thing – but it scales with just about every positive regenerative outcome that you can think of. Soil genesis happens because of bugs. Most soil is insect poop or invertebrate poop. If you want to raise organic carbon, the organic matter in your soil, thank a bug."

This idea of increasing insect life to benefit agricultural operations is paying off for producer Bryan Jorgensen, partner and chief agronomy operations officer at Jorgensen Land & Cattle near Ideal, SD. His operation has about 900 Angus cows and markets 4,000 Angus bulls every year through a multiplication system. He also farms 12,000 acres, growing corn, milo, soybeans, spring wheat, winter wheat, oats, alfalfa, forage sorghum, and cover crops.

For the most part, he relies on Mother Nature and regenerative ag practices to handle his insect problems.

"In nature there tends to be a balance of predators and prey," Jorgensen said. "We try

PHOTO COURTESY OF MIKE CATANGUI.

LUNCHTIME. A lady beetle larva stalks aphids on a soybean leaf.

PHOTO COURTESY OF USDA-ARS, SCOTT BAUER.

SOIL BUILDER. The mustached mud bee is an important beneficial insect that lives in the soil.

and promote a balanced system throughout by the use of cover crops, diverse rotations, livestock integration. All the five principles of soil health are going to promote a much more balanced insect community."

It seems to be working because his operation seldomly applies insecticides.

"The only instance that we may now use insecticide – and it happens maybe once out of four or five years – is a little bit of insecticide on our alfalfa crop. If we acquire an infestation of alfalfa weevils, we're kind of at the mercy of having to spray for those," Jorgensen said. "In any other crop we grow, we do not use any soil-applied or surface-applied insecticide."

Jorgensen credits his six-year crop rotation for this reduction in insect pest problems.

"The corn rootworm, of course, is a pretty a devastating critter across the Corn Belt," he said. "We don't see that here primarily because our rotation is so long. We don't have a monoculture type system where you have just corn and beans. Some of those insects have learned that pattern, learned how to lay eggs in the season before so that they're there when the corn germinates. So, we avoid a lot of those types of infestations of insects purely because of the long rotation that we have."

In addition to reducing pest insects, Jorgensen's rotation promotes pollinator health with flowering plants in his diverse cover crop mixes.

Jorgensen Land & Cattle Crop Rotation Sequence

Option	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
1	Winter wheat/Cover	Corn	Milo	Oats	Winter Wheat/Cover	Corn
2	Winter wheat/Cover	Corn	Corn	Soybean	Spring Wheat	Winter Wheat
3	Winter Wheat	Winter Wheat/Cover	Corn	Milo	Triticale/Pea	Winter Wheat
4	Winter Wheat	Winter Wheat/Cover	Corn	Milo	Triticale/Pea/Alfalfa	Alfalfa/Grass...
5	Winter Wheat	Winter Wheat/Cover	Corn	Forage Sorghum	Oats	Winter Wheat
6	Winter wheat/Cover	Corn	Milo	Soybean	Winter Wheat/Cover	Corn
7	Alfalfa Out	Winter Wheat	Winter Wheat/Cover	Corn	Forage Sorghum	Oats

IMAGE COURTESY OF BRYAN JORGENSEN.

DIVERSE ROTATION. Bryan Jorgensen credits this diverse six-year rotation for helping to control pest insects and promote pollinator health. His operation only applies insecticide once every four to five years in the event of an alfalfa weevil infestation.

"We happen to have several bee companies around this part of the world that raise bees for honey. We have a pretty rich environment for them, and they tend to like to place a lot their hives in pretty close proximity or on our property because of the numerous flowering plants that we have in the cover crops," he said. "It's not just bees. We're getting all kinds. We're getting some butterflies, getting some moths, some beneficial ones, in fact."

Protecting Diversity

One way to help ensure a diverse and balanced insect community on your operation is to limit tillage.

"Tillage is a disturbance," Hesler said. "It disrupts where insects overwinter, or a disk or plow can directly kill insects. It's a disturbance that has direct and indirect impacts on those beneficial insect populations in the soil."

Hesler also said producers wishing to increase their beneficial insect populations should avoid fencerow-to-fencerow planting. "You're leaving these islands or pockets out there of undisturbed land along the fencerows," he said. "Leaving that is a refuge habitat for these insects to overwinter, to have a place where they can go to avoid some of the disturbance."

Hesler agreed with Jorgensen that avoiding unwarranted pesticide applications is the best approach. He said producers should limit "calendar sprays" or prophylactic use of pesticides, whether they be seed treatments or foliar sprays. "In the overwhelming majority of cases, they really need to rely on their scouting or their crop consultants to come out and scout their fields to know whether they have a particular pest and whether it's there at economically damaging levels," he said.

Producers should consider avoiding insecticide seed coatings, especially if they have no history of problems with early season pests, Hesler said. "Various studies have shown that it's hard to realize a consistent benefit to these seed treatments in terms of economics in corn and soybeans in the Upper Midwest," he said. "In a lot of instances, the seed treatments don't provide enough benefit to justify their cost, and we know they're having some type of negative aspects off-site that's very difficult to quantify economically."

The negative effects of insecticidal seed coatings can include harm to

pollinators and other beneficial insects, harm to aquatic life, and harm to wildlife.

"Studies have shown there can be sublethal effects sometimes on beneficial insects, especially pollinators – sublethal meaning it doesn't kill them outright but causes some disfunction or disorientation," Hesler said.

Those insecticides are also ending up in streams and waterways where they affect aquatic insects and perhaps animals like fish and birds that feed on those insects, he said.

"We did a study recently – two studies, one on pheasants and one on white-tailed deer – and we ended up seeing very similar results where neonicotinoids were adversely affecting even these vertebrate animals that they were supposed to have no adverse effects on whatsoever," Lundgren said.

PHOTO COURTESY OF BRYAN JORGENSEN

CYCLING NUTRIENTS. Dung beetles are important nutrient cycling insects

It may be difficult for producers to source untreated seeds that have the latest genetics, but Hesler said they should speak to their seed dealers to request uncoated seeds.

Lundgren said that while uncoated seeds may not be at the local co-op, there are a growing number of South Dakota seed companies that are selling untreated seeds. "Sometimes you have to order them a little bit early, especially for corn, but that isn't even true anymore," he said.

Transition Slowly

For producers who want to try a regenerative approach to pest control, Jorgensen has some important advice.

"I would recommend that they move out of (their system) slowly because, most likely, unless they have adopted the principles of soil health – if they haven't yet – then it's going to be a little bit risky to move out of the insecticide or fungicide realm quickly," he said. "We have to rebuild what we destroyed. We have to allow nature to rebalance itself by way of the five principles of soil health. If it were somebody pretty heavily dependent on nutrients and insecticides and fungicides in order to grow a crop, then I would recommend they slowly implement some of those principles before they get too gung-ho about dropping out those components because they'd probably set themselves up for pretty much a disaster. It's not something they can do or implement overnight unless they have at least four of those soil health principles in place."

"Just through the five principles of soil health," Jorgensen said, "you're going to create a better environment for the insect communities."

Interseeding Diverse Cover Crops Builds Beneficial Insect Populations

Entomologist Mike Bredeson shares insights on how no-tillers can increase insect diversity by interseeding cover crops into cash crops.

WHEN IT COMES to interseeding cover crops, growers should think about designing their agricultural ecosystems — including insects, microorganisms, bacteria and fungi — to make them function to the best of their ability, according to Mike Bredeson, a Grove City, Minn.-based entomologist with the Ecdysis Foundation. Speaking at the National No-Tillage Conference earlier this year in St. Louis, Mo., Bredeson shared insights on interseeding cover crops to increase beneficial insect populations.

HERBIVORES IGNORED THE CORN. Mike Bredeson's research found 516 insect species living in corn fields. Rather than eating the corn plants though, Bredeson found that the herbivores were more interested in eating the cover crops.

Crop, Insect Diversity Are Critical

Bredeson says that Mother Nature is the greatest architect, creating diversity and structure and that the immense level of diversity equates to a highly functional system.

"For example, prairies really hold onto their soils through that diversity," Bredeson says. "They infiltrate and purify water. They harbor incredible amounts and diversities of biological organisms, microbes. The diversity held within a prairie results in this abundant, stable and diverse community of invertebrates — of insects."

There are a couple of factors that Bredeson says play into a vibrant insect community. The primary top-down factor involves predator insects consuming herbivorous insects and keeping the pest population in check. Predators limit pests by directly consuming them. By simply being present, having predators in your system can reduce the feeding and reproductive efficiency of a pest population.

There are also bottom-up, plant mediated factors that help plants prevent pest outbreaks, such as plant-induced chemical reactions that help the plant resist a pest or reduce the efficiency of pests doing any sort of feeding.

"In a monoculture system, we're not providing the right habitat and resources for these top-down predators to consume and check that pest

population," Bredeson says. "In addition, in such a simplified system, the bottom-up plant mediated factors are also absent. Without top-down and bottom-up factors to keep a population at a manageable level, what happens? We get the occasional pest explosion, an herbivore explosion."

Bredeson says the most innovative farmers are diversifying their farming ecosystems by varying crop rotation, adding pollinator strips, utilizing cover crops, growing multi-species mixes and integrating livestock.

HUNDREDS OF SPECIES. Mike Bredeson's research evaluated the insect community when corn was at various growth stages and anthesis. Sampling revealed more than twice as many insects on the soil surface in the interseeded fields compared to corn monoculture fields — including everything from spiders and centipedes to beetles and flies.

Building Predator Populations

Through his doctoral research as well as studies he's conducted at the Ecdysis Foundation, Bredeson has learned that an effective method of controlling pest outbreaks is through interseeding cover crops.

There are a few different ways to approach interseeding, according to Bredeson. Interseeding can be done simultaneously when planting cash crops, and then harvesting both crops at the same time, separating them later, or in a relay cropping system.

"By interseeding cover crops, we can provide alternative sources of food and build up a persistent population of top-down beneficial predators," he says. "Even if that predator is disabled, the pest population spends more time and energy trying to avoid being eaten. That results in less time feeding and reproducing. It's really amazing. When you take it times millions and billions of organisms on your farm, it can make a huge difference."

When we interseed cover crops we can also help reestablish the bottom-up forces to help resist a pest population.

"When you have a mixed cropping system, the signals a pest receives are confused," Bredeson says. "It's much more difficult for the pest to find exactly where it needs to go, and it burns up a lot more energy in the meantime."

"When we diversify the corn agro-ecosystem with interseeding cover crops, we see predator activity more than double," Bredeson says.

Interseeding vs. Monoculture

During work on his doctorate, Bredeson did a trial with three farms. Half of the fields were interseeded with cereal rye, field peas, flax, hairy vetch, lentils, mung beans and oats, while the other half were planted to a corn monoculture. The interseeded cover crops took off, creating a different habitat in which insects could thrive.

Bredeson's research evaluated the insect community when corn was at the V4 and V8 stages and when the corn was at anthesis, sampling nearly 1,100 corn plants and gathering nearly 300 insect samples from the soil surface. There were more than twice as many insects on the soil surface in the interseeded fields compared to corn monoculture fields.

"The number of species that we found in interseeded fields far exceeded the number of species that we found in corn monocultures," Bredeson says. "We're adding this extra plant diversity. It's equating to a more robust community of insects — more than 20 additional species on average per plot when we interseeded cover crops."

There were more of all types of insects, including herbivores. But the herbivores were not making their way to the corn plants — instead, they were more interested in the cover crops.

"For an entomologist, this couldn't be any better news," Bredeson says. "We're attracting herbivores that want nothing to do with the corn plant at all. As for predatory insects, having alternate prey will encourage them to stick around and build a long-term population."

Under the Soil Surface

The insect community below the soil surface was also more diverse within the interseeded fields, with more different types of species.

"There's no better way to figure out what's going on below the soil surface than to take soil cores," Bredeson says. "We found 516 species of invertebrates residing on the corn plants, soil surface and below the soil surface. To me, that's absolutely remarkable.

"When we interseed cover crops during the middle of the season, we had 18,000 animals per square meter of soil," Bredeson says. "I wear a size 12 shoe. Every step that I took in an interseeded field in the middle of the season, I stepped on 604 animals," Bredeson says. "That should get us really excited because we're all talking soil health."

"By interseeding cover crops, we can provide alternative sources of food and build up a persistent population of top-down beneficial predators..."

There were also more detritivores in the interseeded acres — 18,000 per square meter. Detritovores are animals that eat detritus, or dead things. Detritovores are difficult for entomologists to study due to their tiny size. However, these small creatures make up most of the living animals below the soil surface. Detritovores eat bacteria, fungi, dead plant matter and more.

Detritovores get the credit for changing the physical properties of soil by ingesting plant matter and leaving micro soil aggregates in their wake. This unique group of animals is critical for nutrient recycling in the soil.

Bredeson's research showed that adding cover crops resulted in the same yield and corn density. One field even had higher corn density. The soil in the interseeded fields was more shaded and stayed cooler.

"I think the cooler soil is a large part of what's driving the change in that insect community," Bredeson says. "We saw a great deal more diversity in the insect community. This led to a significant change in the function of the predator community."

Another benefit of interseeding cover crops is providing more plants for pollinators to collect more pollen and nectar.

"The whole idea is to recruit and maintain a persistent and stable predator population," Bredeson says.

Neonicotinoid Research

Insecticides, particularly neonicotinoids, are a common way to deal with pest populations. Neonicotinoids work by disrupting normal nerve function in insects, affecting their regular behavior. More than 79% of seed corn planted in the U.S. is treated with neonicotinoid, but only 2-20% of the pesticide actually enters a plant.

Bredeson's research has showed neonicotinoids going from the treated seed corn into the interseeded cover crop.

"What many people don't know is that when you treat the plant with a neonicotinoid, it can metabolize within the plant tissue into a whole different type of neonicotinoid," Bredeson explains. "When we sampled the cover crop plant tissue, we found around 10 times the concentration of the chemical that we actually put on the corn seeds."

The implications are that seed treatments don't stay where they're put, and growers have to look for breakdown products as well.

"When interseeding cover crops, choosing to use a seed treatment is risking that beneficial insect population that you're working so hard to establish," Bredeson says. "When neonicotinoids get into surface and ground waters, it can have huge implications for the natural resources that we depend on."