This is a (Very!) rough draft. The first part is primarily taken from “Silent Earth” by Dave Goulson and the second part is primarily taken from “Attracting Beneficial Bugs to your Garden” by Jessica Walliser.

It offers a condensed problem/solution dynamic to what is currently happening with the bugs that inhabit our land.

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The Bugs appocalypse

The decline of insect populations is a concerning phenomenon. The disappearance of insects precedes a domino effect, leading to the decline of fish, mammals, birds, and amphibians, followed by the extinction of flowering plants and fungi. However, a surge of recent studies highlights significant drops in the abundance and diversity of insect species across the globe. Astonishingly, their numbers are dwindling at alarming rates at various research sites—some places report a 50% decrease, others up to 75%, and one study in the seemingly serene countryside of Denmark notes a catastrophic decline of 97%. This accumulating evidence forces us to confront the grave implications of their loss for the first time in our history.

Insects have been entwined in a complex relationship with nearly every facet of the terrestrial ecosystem for millions of years, forming an underrecognized cornerstone of human civilization. They enhance our food supply, serve as a primary food source for many other living beings, decompose waste, control pests, and, importantly, enrich the soil—a mere 15-centimeter (6-inch) layer enveloping the Earth that supports all human life.

"Every time you lose a species, you're severing links within this network. The more links you cut, the less functional this 'internet' becomes, until it fails to operate." The absence of pollinators leads to plant extinction, forcing birds and other creatures to adapt or perish.

The alarm over the decline of insects has been sounded intermittently over the years, though not with the urgency it demands today. As early as 1936, Edith Patch, the first female president of the Entomological Society of America, criticized the increasing use of insecticides on crops in a speech. "Certainly, the benefits insects offer to humanity have been underemphasized," she stated, highlighting our reliance on them for food, clothing, industry, and recreation. She presciently warned, "If mankind's goal is the widespread eradication of harmful insects, eventually, we will develop the means to achieve it."

In the decades that followed, humanity did not intentionally set out to decimate insect populations, just as it did not choose to flood its coastal cities or exacerbate wildfires through climate change. Yet, these have been the consequences. The destruction of natural habitats, the application of harmful chemicals, and the increasing temperatures of our planet have collectively forged a hostile environment for many insects, jeopardizing everything we depend on them for. We are inadvertently crafting a world that poses a threat not just to insects, but to humans as well.

Quantitiy of insects:

"We've got 50,000 people studying one type of monkey and just one person looking into 50,000 types of flies." For each fly species identified by its unique genitalia, countless more remain on the desks of overwhelmed taxonomists. In 2016, Canadian scientists were astonished by DNA analysis results from over 1 million insect specimens, revealing around 94,000 insect species in Canada alone—nearly double the previously estimated number. If Canada houses 1% of the world's insects, the global count could be around 10 million species.

It's evident we inhabit an invertebrate-dominated world. Only 5% of all known animal species possess a backbone. Our planet teems not with humans, sheep, or even rats, but predominantly with beetles—350,000 species and counting. Our knowledge of insect populations hardly suggests scarcity. The Smithsonian Institution estimates the global insect population at 10 quintillion (10 followed by 18 zeros). A single locust swarm can comprise 1 billion individuals, while the southern part of England sees an annual migration of 3.5 trillion flying insects, collectively weighing as much as 20,000 flying reindeer.

Gathering the world's termites into a giant ball would create a biomass exceeding that of all birds on Earth. Before the surge in human population and size due to industrialized modernity, the total weight of the world's ants likely surpassed that of humans. "Today's human population is adrift in a sea of insects," remarked scientists from Iowa State University in 2009. By sheer numbers and biomass, insects are the most successful animals on Earth.

Removing vast numbers of insects from the environment disrupts the entire web of life, including humanity. The ecosystem's collapse can spiral further—around 10% of insects are parasites, often of other insects. Without caterpillars for certain wasps to use as hosts, or if some flies can't hijack and decapitate ants, these species too face danger. This troubling scenario is becoming clearer as scientists piece together the puzzle of insect life.

A significant warning was issued in 2014 with a research compilation indicating that a third of invertebrate species assessed by the International Union for Conservation of Nature (IUCN) are declining, with a 45% global decrease over the past four decades—nearly twice the decline rate of vertebrates. The majority of Orthoptera (including locusts, grasshoppers, and crickets) and Coleoptera (beetles) species are in decline. "Such animal declines will cascade onto ecosystem functioning and human well-being," warned the study, highlighting this crisis within the ongoing sixth mass extinction—nature's unprecedented annihilation since the dinosaurs, driven by industrial human activity.

This extinction event features notable species like tigers, rhinos, elephants, and polar bears. The plight of these "charismatic megafauna" dominates media and conservation efforts, often seen as pivotal to biodiversity preservation. This "institutional vertebratism," as entomologist Simon Leather describes, mirrors George Orwell's "Animal Farm" notion that "all animals are equal, but some animals are more equal than others." We empathize with certain species while neglecting others, particularly insects.

"Many people actively fear, dislike, or are disgusted by insects," he observes. "This sentiment is often instilled by parents, peers, and even teachers." Media portrayal of insects contributes to this fear. Our ignorance of what we were losing stems from a lack of care or awareness of the stakes. Neglect and ignorance have long been intertwined.

Public awareness of the insect crisis has gradually increased, traceable to the publication on October 18, 2017, by PLOS One of a study titled "More Than 75 Percent Decline over 27 Years in Total Flying Insect Biomass in Protected Areas." This long-term investigation across 63 German nature reserves revealed a 76% decrease in flying insect biomass since 1989, worsening in summer with an 82% decline. Protected areas, despite their conservation efforts, showed significant losses, hinting at the impact of surrounding agricultural practices like pesticide use and loss of wildflowers. This raised a critical question: if insects are vanishing even in protected German areas, where can they be safe?

Many insect species have vanished unnoticed. These "Centinelan extinctions," named after a biodiversity-rich area in Ecuador, highlight the challenge of grasping the insect crisis's full scale. A study titled "Scientists' Warning to Humanity on Insect Extinctions" suggests that 5 to 10% of insect species have disappeared since the onset of mass industrialization, equating to 250,000 to 500,000 species lost—a significant blow within a brief geological period.

We are pushing ecosystems beyond recovery, leading to critical insect extinctions and the loss of irreplaceable services to humanity. Urgent action is needed.

On different ecosystems/farmers effect

For those who resist the expansion of urban areas, the shift in agricultural practices is stark and disheartening. The last two decades have seen a consistent decline in insect populations across farmlands, leading to the disappearance of entire insect families. The advance of modern agriculture has been particularly harsh on rove beetles and solitary bees, which struggle to survive not only in cultivated fields but also in their margins.

In the UK, initiatives to compensate farmers for creating wild grassland strips alongside their fields have been implemented, yet these efforts often fail to establish true wildlife corridors, benefiting common, mobile species over the rare, sedentary ones. Despite this, the aim to eradicate bees and butterflies was never the intention of farmers, fostering hope that a balance can be achieved between agricultural productivity and biodiversity conservation.

The transformation of landscapes in regions like Poitou, Champagne, and Beauce, where hedgerows and natural ponds have been replaced by vast, flat expanses optimized for machinery and maize cultivation, has left naturalists disheartened. "It's visually appealing, yet ecologically barren," observes Fontaine, noting the widespread desertification of the French countryside—a trend mirrored across Western nations due to uniform industrial farming practices.

Entomologist Jett Pettis, formerly with the US government, paints a grim picture for any insect attempting to traverse these altered landscapes, likening their journey to that of early settlers moving westward. Today, the prairies that once teemed with diverse wildlife and resources are now dominated by monocultures of corn and soybeans, offering little sustenance or refuge for migrating insects.

The consolidation of farmland in the US highlights a broader trend towards fewer, larger operations—a shift away from the country's agrarian roots, despite a population that is eleven times larger than during the Civil War. With a significant portion of cropland under the control of a small fraction of farms, the landscape is increasingly characterized by sprawling suburbs and highways, designed with little consideration for insect habitats. The exclusion of native wildflowers and the prioritization of aesthetic, manicured environments over ecological functionality are practices that Pettis criticizes fiercely. He warns that neglecting the needs of insect populations in favor of clean farming could have unforeseen repercussions.

The profound impact on insects stems not only from the physical transformation of their habitats but also from the chemical alterations imposed by human activity, highlighting a pressing need for a shift in how we manage and interact with our environment.

Pesticides/fungicides

The battery of pesticides now routinely applied to our landscapes has created toxic miasma for insects that scientists have only recently been able to quantify. Pest control for crops has been around for almost as long as there have been crops.

the Sumerians of ancient Mesopotamia used sulfur compounds to vanquish insects and mites, while the Romans developed early rudimentary treatments to kill off weeds. Over the past century, however, it has been the chemical industry that has shaped a whole new arsenal of deadly weapons against invaders that nibble away or choke crops.

The broad umbrella of pesticides includes fungicides, deployed to eliminate parasitic fungi or their spores. There are also herbicides, used to remove weeds and most famously embodied by glyphosate, sold worldwide as Roundup. The emergence of chemicals of ever-greater potency since the 1970s has handed an edge to farmers in their perennial struggle against pests; glyphosate, according to the Australian crop scientist Stephen Powles, is a "one in a I00-year discovery that is as important for reliable global food production as penicillin is for batting disease." Glyphosate has also been linked to cancers emerging in tens of thousands of people, creating such a burden of litigation for Bayer that the conglomerate announced in July 2021 it was removing the herbicide from lawn and garden products sold in the United States. But as chemical treatments have waged an ever-fiercer war against aphids, knotweed, and other enemies, it has increasingly caught all sorts of other insects in the cross fire. Herbicide use has boomed since the 1990's with the introduction of "Roundup-ready" crops, resistant to the chemical, allowing it to be liberally spread on fields to take out the weeds. This has allowed the chemical manufacturers to target both ends of the process: the Roundup-ready herbicide-resistant seeds, sold by Monsanto, are marketed as the best defense against Roundup, the leading herbicide sold by Monsanto. But it has also led to herbicide leaching into the environment with some unforeseen consequences; glyphosate, for example, is thought to disturb bees' gut bacteria, leaving them more vulnerable to disease.

The impact of fungicides, which target molds and mildews rather than insects, has also surprised researchers. There is a significant corelation between fungicide use and the loss of bees, with lab-based studies finding that fungicides can worsen outbreaks of Nosema, a parasite that attacks honeybees and weakens colonies.

but the most deadly weapons aimed at insects are, as the name would suggest, insecticides, a class that has at its apex a group of chemicals called neonicotinoids. Chemically similar to nicotine- the word neonicotinoid means "new nicotine-like insecticides". this new generation of insecticides was forged by Bayer, the German pharmaceutical giant, and has spawned eight commercially available variants produced by a range of manufacturers. Over the past three decades, neonicotinoids have proved enduringly popular for use on everything from lawns to cropland and are now the most widely used insecticides in the world. The benefits are obvious: not only are the chemicals utterly devastating to sap-feeding pests like aphids, as well as fleas, certain wood-boring pests, and unwanted beetles, they are also considered "systemic" pesticides. This means that the chemicals don't just sit on the surface of a plant; they instead are absorbed and swiftly move through their host's circulatory system, reaching down into the roots and spreading to the extremities of the leaves and other tissues. "Neonics" provide a sort of all-over force field to 140 different types of crop, allowing farmers to be sanguine that their harvest, and livelihood, will be protected from the ravages of insect interlopers without the need for repeated chemical spraying.

In recent years, the all-in-one nature of neonicotinoids has been taken to new extremes. A small amount of the insecticide is now routinely applied to the coating of seeds that are sold to landowners, pushing chemicals into the lifeblood of plants from their very first growth spurt. Since the turn of the millennium, this farming format has become the default, with sales of neonicotinoid-coated seeds tripling in the United States alone.

In a recent Instagram post by Biotactics, a predatory mite provider for plant nurseries. Their entire insectary (12 million bugs) was poisoned by neonicotinoid systemic insecticide. Losing there insectary over night. The way it happened was because the Lima bean seed they were using to grow the food (spider mites) for there predatory mite, was (unbeknownst to them) treated with a fungicide. As They fed their predatory mites with the eggs of the spider mite, Those spider mites, as they were eating the lima bean plants, were metabolizing the neonics into a stronger version of the neonics. The lab results show there qas three times the concentration of neonics in the eggs of the spidermite than the original seed treatment. As in the parents became less toxic than the offspring. And as you zoom out, farmers are applying this to seeds all over the world, what impact does that have on our native species?

Neonicotinoids are now so embedded within the food production of around 120 countries that residues of the insecticide have been found in, among other things, spinach, onions, green beans, tomatoes, and even baby food. In the United States, neonectitides have been detected in drinking water in Iowa, stubbornly remaining even after treatment. When hundreds of people across China had their urine tested in 2017, almost every single sample contained neonicotinoids.

Any latent unease We may have about biting into a neonicotinoid-tinged strawberry is often assuaged by what we feel are correct lifestyle choices, such as opting for organic produce. But while we may be able to bat away a more fundamental rethink of how we make food, there are no such comforts for insects.

The spring of 2008 was a savage one for Europe's honeybees, with millions perishing in France, the Netherlands, and Italy. The losses cut deepest in Germany, where the government had to set up containers along the autobahns for beekeepers to dump their moribund hives. An investigation traced the bee deaths to the use of clothianidin, a neonicotinoid, to stamp out an outbreak of corn rootworm.

The finding prompted Bayer, the maker of the chemical, to pay compensation to beekeepers--with no admission of guilt.
A decade later in Brazil, around 5oo million bees died in just a few

months, the piles of dead bodies riddled with fipronil, an insecticide banned by the European Union and considered a possible human carcinogen by the United States. Brazil is increasingly awash in agricultural chemicals; since Jair Bolsonaro assumed the presidency, the country has been approving synthetic pesticides and fertilizers, some of them highly toxic, at a rate of around one a day.

"We should be reducing the use of this stuff but we are increasing it," says Filipe Franca, a Brazilian ecologist.

"Brazil is going completely against what We should be doing to save insects."

For many insects, the neonicotinoid era has been a punishingly cruel one that rivals that of DDT, an insecticide that gained infamy via Rachel Carson's Silent Spring and is now almost universally banned. It is probably even worse- neonicotinoids have been calculated to be around 7,000 times more toxic to bees than DDT. According to Dave Goulson, a single teaspoon of imidacloprid is enough to kill as many honeybees as there are people in India.

Neonicotinoids, which are water soluble, routinely seep into the soil and enter streams and rivers, coming into contact with variaty of terrestrial and aquatic insects. The chemicals find their way into wildflowers and taint their nectar and pollen, which are then picked up by unsuspecting pollinators. By some estimates, only 5 percent of the chemical actually stays within the target crop plant itself. Neonicotinoids set to work by assaulting receptors in an insect's nerve synapse, causing uncontrollable shaking and paralysis. While this is easily enough to prove fatal to a small pest like an aphid, the toxin has also been linked to the demise of butterflies, mayflies, dragonflies, wild bees, midges, and other invertebrates such as earthworms.

If insects escape death, there's a decent chance they will suffer a form of brain damage. Bees are shrewd operators able to grasp abstract math and able to pull strings and rotate levers in return for food, but chronic exposure to typical loads of clothianidin has been linked to cognitive damage that may scramble their learning and memory functions. This impaired function can be measured in distance--bees blighted by imidacloprid, another common neonicotinoid, fly shorter distances and for less time than unaffected bees, a crucial distinction for a species that requires repeated productive journeys to survive.

Imidacloprid has been linked to blindness in flies and colony losses among honeybees, while a third neonicotinoid, thiamethoxam, has been fingered as a potential culprit for cutting the reproductive output of bumblebee queens by a quarter. Both honeybees and wild bees need to hunker down in winter, feeding on stored honey or entering a hibernation-like state, but neonicotinoids have been blamed for reducing the chances of emerging safely from this stasis. The lives of bees are so entwined with the chemicals that when samples of honey were taken from around the world, traces of neonicotinoids were found in three-quarters of them.

Soils soaked with neonicotinoids have caused ground-nesting bees to be exposed to fatal levels of clothianidin, while slugs have been turned into toxic repositories that then indirectly kill off the beetles that prey upon and ingest them.

The tendrils of neonicotinoids are reaching deep into the crevices of our environment, from life in the soils and freshwaters to even the skies. A study of migrating white-crowned sparrows in Canada discovered that the birds lost weight just hours after gobbling seeds spiked with imidacloprid, delaying their onward migration and potentially impacting their reproductive success. The chemical, even in tiny doses, made the sparrows lethargic and suppressed their appetite, a symptom that would be familiar to anyone who regularly smokes. This malaise is likely not just a problem for the sparrows--researchers in the Netherlands found that concentrations of imidacloprid beyond a certain level knocked down insect-eating bird populations by 3.5 percent a year, on average.

In southwestern Japan, Lake Shinji is a body of brackish water home to fish, clams, and waterfowl and famed for its dreamy sunsets. In the early l990s, rice farmers near the lake started using imidacloprid, and before long, the populations of arthropods that support the food chain, such as crustaceans and zooplankton, started to drop. To the dismay of locals, next to vanish were the eel and smelt that had seen their own food source diminish. The commercial fishery suffered a collapse it has yet to recover from, as ever-greater levels of imidacloprid are deployed on the nearby fields. The drenched environment of rice paddies is conducive to ferrying chemicals from fields to waterways, but researchers speculate that the same phenomenon could also be playing out in dry plains of wheat or corn.

In the United States alone, almost every corn seed and cotton boll found in a field is treated with neonics. Around half of the seeds in soybeans are, too. In all, neonicotinoids typically cover around 61 million hectares (150 million acres) of American cropland, an area about the size of Texas.
The chemicals tend to accumulate rather than wash through fields, slowly layering new levels of toxicity. The farmland of countries with heavy insecticide use is probably more laden with lethal or deleterious

chemicals than at any point in history. According to one study, the past quarter of a century has seen US agriculture become a whopping forty-eight times more toxic to insect life, with neonicotinoids responsible for almost all of this noxious surge. Across vast, featureless fields, insects are being systematically maimed, befuddled, and exterminated. "Our insects are now playing in a dirty playground and they just don't have the diversity or genetic makeup to withstand this" says Alex Zomchek, an apiculturist at Miami University.

The backlash against the use of pesticides has fueled a small but growing movement within agriculture to shift away from chemicals almost entirely. "Pesticides are absolutely unnecessary," says Jon Lundgren, an entomologist who claims that his own South Dakota farm is plagued by fewer pests by embracing the principles of regenerative agriculture, whereby soils are never left bare, and biodiversity is supported so that insect predators act like nightclub bouncers for the crops, and the farm itself is a mishmash of livestock, crops, and orchards rather than uniform Plains. "In the current system, the natural resource base is crashing" g, Lundgren says.
"The insect apocalypse is just the first sign of this."
Farmers would, ideally, revert to techniques such as rotating crops, carefully managing sowing dates, and doing plenty of weeding with machines rather than sprays. But even scientists who have discovered that crops can still flourish without chemicals point out thiss doesn't necessarily mean the treatments are completely useleless, more that they are being overused in an indiscriminate and destructive manner. "If this was such a great pesticide you would be able to use less of it and maybe see flat levels of total toxicity," says Grozinger on neonics.
"You wouldn't see the increase We are seeing, which is problematic. It suggests it's not in response to an actual issue, like pest control, but some other factor."

Farmers have been caught in a "circular addiction," Lundgren says, whereby the use of insecticides has led to continued, and intensified use of chemicals to deal with the consequences of the initial biodiverity loss. But this cycle is never inevitable. Previous generations of farmers managed to reap a decent bounty without bombarding their crops with a cocktail of poisons, so why not now?

Part of the answer lies in the sheer power of agribusiness--the traditional "big six" has morphed through mergers in recent years into an even bigger three: Bayer-Monsanto, Dow-DuPont, and Syngenta-ChemChina-to promote the use of insecticides as imperatives to farmers, who sometimes aren't entirely sure what exactly is in the coating of the seeds they are being sold en masse, as well as to deter lawmakers and regulators from stamping out their use.

Jeff Pettis has seen the clout of industry at close quarters. During his long career as a scientist at the US Department of Agriculture (USDA), Pettis sought to find out what impact neonics were having on honeybees, so he started feeding colonies with protein patties, essentially miniature hamburgers for bees, containing imidacloprid.

The amounts added were minute, at least ten times less than the safe thresholds advised by Bayer. "It was the equivalent of putting five drops in an Olympic-sized swimming pool and mixing it equalily
Pettis says. "We are talking very small amounts." After a few months the researchers could see that new, young bees fed the affected protein were significantly more likely to be struck down by *Nosema* the fungal gut parasite. This impact, the researchers wrote, suggested that pesticides could be a "'major contributor" to increased mortality of bees, including colony collapse disorder, the disastrous phenomenon where bees suddenly abandon a hive.

The pesticide makers then embarked on a campaign that Pettis likens to the tobacco industry's disparagement of science linking smoking to various cancers. His work was criticized for being unrealistic as to what would happen in a field or for attempting to wind the clock back to the bad old days of repeated mass spraying of crops. He noticed that his department was restricting his ability to talk to the press about his findings or to hold public meetings on the topic. He was upbraided by a Republican member of Congress for not "sticking to the script" by talking about neonics. Pettis was demoted; eventually he resigned. "Wherever they could, they would cast doubt," Pettis says. "They were defending the status quo, I suppose."

Pesticide manufacturers have funded groups that dispute research finding neonics are harmful, co-opted previously critical scientists, and backed bee health initiatives that are heavily skewed toward targeting mites rather than chemicals. Emails show that Monsanto, Which is now part of Bayer, attempted to orchestrate a campaign to discredit scientists linking Roundup to cancer concerns, while Bayer has created online videos depicting people worried about pesticides as conspiracy theorists fond of talking to flowers and downplaying the harm caused by the chemicals. "The tuth is, our body handles a;; sorts of chemicals every day, which is normal," a voiceover states over footage of a sugar cube splashing into a cup of tea and a woman applying lipstick.

No one can be quite sure if any of these efforts had a role in subverting lawmakers or triggering Pettis's demotion. “When i lose trust of USDA and my ability to speak to bee diseases and problems, that was just an uncomfortable situation and i chose to resign, Pettis says. “In hindsight there was a lot of pressure. The pressure was coming in a lot of different ways. It was clear the pesticide industry wasnt happy with what i had to say.

Data produced by Phillips McDougall, the leading agribusiness anaysts, show that the five largest pesticide makers sold $4.8 billion in highly hazardous pesticides in 2018, making up more than a third of their total income. Around 10 percent of all sales generated by the manufacturers came from pesticides judged toxic to bees. Maintaining these sales relies, in significant measure, on politicians and the public not being spooked by bothersome scientists or campaign groups.

It was a major blow to the pesticide makers, then, when the European Union opted in 2018 to ban all outdoor uses of clothianidin, imidacloprid, and thiamethoxam, the three most common neonicotinoids. The bloc had previously restricted the use of the chemicals on flowering crops that attract bees, such as oilseed rape, but decided to impose a more sweeping ban after an assessment found that the chemicals still posed a major risk to bees, as well as to the health of soil and waterways. The crackdown was the first major regulatory assault on the insect crisis since the issue exploded in the public realm and was met with jubilation among campaigners. "Authorizing neonicotinoids a quarter of a century ago was a mistake and led to an environmental Disaster” said a triumphant Martin Dermine at Pesticide Action Network Europe on the day of the decision. "Today's vote is historic."

The future

On December 31, 2020, a research paper emerged that resonated alarmingly with the contemporary discourse on the world's "sixth mass extinction event." Authored by two American experts in paleobiology and geology, the study delved into the implications of the previous five mass extinctions for insect populations. Despite the challenges in gauging insect abundance from fossil records, the evidence pointed towards minimal losses in insect diversity during past extinction events. Remarkably, even the Permian extinction, which occurred 250 million years ago and eradicated nearly ninety percent of Earth's species, resulted in merely a "faunal turnover" rather than obliteration for insects. This led the researchers to a profound realization: insects are currently facing an existential threat unlike anything in their history. The study posited, "This is not insects' sixth mass extinction—in fact, it may become their first."

The current trajectory of human activity—flattening and poisoning landscapes, altering the atmosphere's chemical composition, and creating biological deserts in the name of progress and aestheticism—poses a high-stakes experiment fraught with dire consequences. Insects, having predated human existence and likely to outlast us, are pivotal to our survival. The presumption that humanity can navigate the sixth mass extinction unscathed, disregarding the vital diversity of insect life, is fundamentally arrogant. The insect crisis transcends ecological concern, emerging as a critical issue of human interest.

The legacy we're poised to leave for future generations is a world significantly diminished, where the essence of life is drained from our environment, resulting in a sterile countryside punctuated only by the machinery of agriculture. This scenario, grim as it may be, represents just one potential outcome should the decline of insect populations continue unaddressed. Recent studies have already linked the dwindling bee populations to the constrained production of essential crops like apples, blueberries, and cherries. Beyond the agricultural impacts, insectivorous birds are experiencing declines not just in the manicured fields of France but even in the remote expanses of the Amazon rainforest. With many insect populations around the globe diminishing by 1 to 2 percent annually, the situation is described as "frightening" by Wagner and his colleagues.

The unfolding catastrophe promises to reach an unspecified nadir, a point we have yet to approach. Currently, humanity is on a descent, the end of which remains uncertain.

So how can we reverse this?

Well it goes into a bit.

Christmann believes there is a far more farmer-friendly alternative that could become a blueprint for countries, especially those outside the European Union's pollinator plan.Why not plant herbs, spices, or fruits in the borders and unused spaces at the fringe of fields?
Cucumbers, sour cherries, strawberries the farmer could choose
the best option, but the outcome would largely be the same. A network of pollinator-friendly habitat latticed through landscapes that,
crucially, provides an income for farmers. At first Christmann faced
Skepticism, why hadn't she bought hives of honeybees if she was
bothered about pollination? When were these weedy things growing
near the crops going to actually start making money? But within a
year or so the landowners were delighted. "The farmers felt they were
respected and part of the team," Christmann says.
"For us they are the protagonists of pollinator protection."
Not only have these experiments brought wild bees, flies, wasps,
and other pollinators buzzing back, but they have also resulted in
reduced pest abundance, by as much as half in some cases. Separate
research has shown that encouraging certain predatory insects can

provide a natural shield against crop pests, negating the need to bombard crops with chemicals. Of particular promise is the use of parasitoids, typically wasps or flies. that lay their eggs on or in another insect, ultimately killing them as the larvae grow.

We need to encouragre farmers to do things differently. From planting a few strands of milkweed for monarch butterflies up to embracing the tenets of regenrative agricluture where reduced tilling, a shift away from synthetic fertilizers and pesticides and the planting of cover crops help improve soils and counteract erosion. "I know that agriculture will change, it's not a question of if but when," says the scientist turned no-till farmer Jon Lundgren, who has angst-ridden conversations with other American farmers enticed but wary to break from the orthodoxy.
"We don't have a choice. What's it going to cost you not to change? It's going to cost your farm. Its going to cost your grandkids. Read the writing on the wall. The insect apocalypse is just the first sign of this.

Buglife

IF We PUSH the bounds of optimism further, we can contemplate comprehensive networks of national and international protected corridors, forging capillaries of thrumming insect activity through even biologically impoverished landscapes. Buglife, a British insect conservation group, has used computer models and on-the-ground verification to come up with a pioneering model of this, which the group calls B-Lines. The lines are insect pathways that weave throughout the United Kingdom's towns and countryside, looking on a map like a pile of red sauce spaghetti dropped from a height. The work is often painstaking, involving negotiations with different layers of government and
landowners, but several thousand projects are already underway and the reception to the idea has largely been warm. Buglife's grand ambition is a total of 5,000 kilometers (3,000 miles) of insect corridors, each comprising wild flowering habitat around 3 kilometers (almost 2 miles) wide. But even a fraction of this would allow some imperiled insects an escape hatch from overheated, toxic, boxed-in homes.

The problem of habitat fragmentation has become so appalling
That butterflies risk developing smaller wings and punier flight muscles because they are marooned for generations, says Buglife's chief executive, Matt Shardlow, who suspects that some of the decline in surveyed insects could be down to the simple fact that they aren't
Able to fly around as much, "By fragmenting the habitat and making

the areas in between so inhospitable we are actually cutting back on evolution's chance to respond to the problem," he says.

"As climate
change comes along, we need to provide more stepping stones to help species move again." Insect conservationists like Shardlow spend a lot Of time pondering localized threats to certain species, but increasingly the thinking has become grander- of transnational insect highways, of sweeping bans on chemicals, of revolutions in land use practices, of a new deal for our relationship with the insect world. What if, they wonder, we could call a total cease-fire in the war we've waged on insects, not just in our rural areas but everywhere, even deep within our cities?

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The key is Rooftop gardens. Community-based group Newtown Creek Alliance, who showed me a space that has become both an educational hub and a bulwark of ecological restoration. The aesthetic is remarkable-rooftops carpeted in a gloriously green cacophony of wild grasses and flowers that overlook a backdrop of scrap metal recycling, car repair shops, and other hives of labor.

The roofs host around 9,000 hectares (22,000 acres) of native herbaceous perennials, including wild strawberry, goldenrod, and milkweed, alongside native grasses and shrubs. Much of the surface area is taken up by sedum, giving the tiered roofs a spongy appearance. Some green roofs are intensive, where soil depths are 15 centimeters (6 inches) or more to support trees and larger shrubs. Kingsland Wild flowers has both, matted on top of layers of membranes for drainage, root protection, and insulation. It's a remarkable biological reingeneering of a place that could easily have been surrendered as yet another place unsuitable for wildlife. Bloodgood hops from one hot, exposed paved stone to another stone that is crowded by plants and remarks on the cooling effect of the vegetation.

Belatedly, we are waking up to our foolishness--New York now requires new buildings to consider installing green roofs, Detroit is placing bee colonies in derelict areas, Munich is planting flowering strips that have attracted a third of local insect species within just a year, Utrecht is transforming bus shelters into bee sanctuaries. Perhaps, in ecoligist Roel Van Kink's analogy, we are slowly learning how to lift our foot a little off the submerged log and allow insects to rebound.

Using bugs as biocontrol

Approximately 80 percent of the world's animals are insects, with only about 1 percent classified as harmful. The majority are either benign or beneficial, playing crucial roles across all environments. By cultivating areas rich in plant diversity, we can support a vast array of insect species.

Molecular gut-content analysis, a fascinating process used by entomologists to determine the diet of insect predators, involves examining the DNA in a predator's digestive system to identify its prey. This and other methods have shown that predatory insects consume not just herbivorous prey but other predators as well, a phenomenon known as intraguild predation (IGP). IGP is common in both garden and farm ecosystems, where competing predators often target each other. For instance, research has found a significant number of ladybugs with the remains of other ladybug species in their guts. The dynamics of IGP and its impact on the distribution and population of natural enemies and prey depend on various factors, including insect population dynamics, life cycles, pesticide use, and the presence of semiochemicals.

Predators not only target other predators but also prey hosting a parasitoid. Highlighting the complex nature of predation, the relationships among predators, parasitoids, and prey, and between predators and parasitoids themselves, vary significantly.

Beneficial insects rely on specific plant species for food, shelter, and egg-laying sites. Insectary gardens featuring a wide range of plants and floral architectures support the greatest diversity of insects. These insects have evolved specialized mouthparts for their unique feeding methods. The diet of many beneficial insects is a complex mix of nectar, pollen, and prey, varying significantly by species. Thus, the choice of plants in our gardens can greatly affect the well-being of resident beneficial insects.

The shape of flowers plays a crucial role in the accessibility of nectar and pollen for beneficials. Studies, particularly on syrphid flies, have illustrated how flower shape correlates with mouthpart morphology and dietary preferences. There is considerable variation in nectar and pollen consumption among species and in the specific flowers each species visits. This is attributed to the diversity in mouthpart structures within the syrphid fly family alone.

Nectar composition, which includes water, sugars, amino acids, lipids, and proteins, varies based on genetics, environmental stress, and humidity. Nectar is a mix of primary sugars—sucrose, fructose, and glucose—alongside other minor sugars. The amino acids in nectar play a key role in attracting specific pollinators, with different amino acids appealing to various pollinators based on taste.

Other components of nectar, such as lipids, proteins, organic acids, and microbes, serve various purposes, from attracting suitable pollinators to making the nectar less appealing to undesired visitors. Some components act as defensive agents against embryo-threatening microorganisms or serve as visual cues to pollinators. Certain nectars contain substances that either encourage pollinators to linger or to visit as many flowers as possible, enhancing pollination success.

Nectar can also serve protective functions. Over sixty plant families produce extrafloral nectar (EFN), not involved in pollination and produced through specialized structures. This nectar plays a role in attracting natural enemies to the plant, aiding in pest control.

The manipulation of existing populations of beneficial insects through semiochemicals, volatile signals released by plants in response to herbivore damage, highlights another strategy in pest control. Techniques such as employing synthetic herbivore-induced plant volatiles (HIPVs) to attract natural enemies, using synthetic plant hormones to boost natural HIPV emissions, or breeding plants to increase HIPV levels are explored for their potential to enhance biological control.

Despite the intricacies and challenges associated with these techniques, their aim is to leverage nature's complexity for sustainable pest management. However, the vast combinations of semiochemicals and their specific effects on beneficial insects remain a puzzle that only nature fully understands.

parasitoids to control exotic pests,

Scientists are actively exploring the use of predators and parasitoids from pests' native environments as a strategy to control invasive species in new territories. Before the introduction of these biological control agents, thorough evaluations are conducted with oversight from state and federal agencies to ensure there's no negative impact on native insect populations. The approach has shifted away from releasing generalist predators, like the multicolored Asian lady beetle, due to unintended consequences such as nuisance overwintering habits noted since its 1900s release for tree pest control. Now, the focus is on specific predators and parasitoids targeting exotic pests.

The complexity of introducing nonnative predators is highlighted by dilemmas such as managing the hemlock woolly adelgid. This invasive pest threatens entire ecosystems by killing hemlock trees. The debate centers on whether to introduce a beetle from China, which might feed on a few native species in addition to the woolly adelgid, or to risk the collapse of these ecosystems. For the Asian citrus psyllid, another invasive pest, the USDA is testing a parasitic wasp from Asia, ensuring it does not harm native psyllids, alongside exploring native funguses and genetically modified citrus plants resistant to the pests.

North America alone is home to over 470 invasive insect species, posing significant threats to biodiversity and agriculture. Invasive species such as Japanese beetles, Asian longhorn beetles, emerald ash borers, and Mediterranean fruit flies contribute to substantial economic losses in the U.S., estimated at a quarter of the agricultural gross national product annually. This situation underscores the urgent need for societal decisions on managing the introduction and spread of plant materials across regions, as the consequences of inaction resemble an unstoppable tidal wave.

the wonder of weeds

While certain plants classified as noxious or invasive weeds should not be encouraged, it's notable that many so-called weeds offer vital resources for beneficial insects. Plants such as thistle, lamb's quarters, chickweed, clover, and dandelion serve as crucial sources of food and habitat for these helpful organisms. Despite the common perception of weeds as adversaries due to their competition with cultivated plants, their presence can significantly benefit the ecosystem. Weeds contribute to the diversity of garden habitats by providing alternative food sources for beneficial insects, thereby enhancing their populations and reducing pest damage.

The role of weeds in supporting natural enemies on farms is well-documented. They assist in balancing populations of beneficial and harmful insects, supply nectar and pollen, and increase species diversity. Some weeds play a crucial role in bridging nutritional gaps for beneficials when preferred insectary plants are not in bloom or prey insects are scarce.

Studies have shown remarkable increases in parasitism rates within agricultural environments that incorporate flowering weeds. For instance, apple orchards with diverse weedy undergrowth have seen significantly higher parasitism rates of pests like tent caterpillars and codling moths compared to those with minimal weeds. Similarly, the presence of certain flowering weeds has been linked to increased parasitism of cabbage worms.

Additionally, weeds can offer alternate hosts to beneficial insects, such as a species of tachinid fly utilizing a ragweed stalk borer in the absence of its preferred host, the European corn borer.

When designing an insectary border, the choice of plants, including the allowance for some weeds, is up to the gardener. Insectary borders are conceived as a complement to natural weedy habitats, providing similar benefits in terms of habitat, food, and prey for natural enemies. By embracing a mix of attractive insectary plants and allowing some weeds to grow, gardeners can create a balanced ecosystem that supports a wide range of beneficial insects, enhancing both the beauty and the health of the garden environment.

Phenology

The intricate relationship between insects and plants is further evidenced by the fascinating field of phenology, which explores the predictability of life cycles in the natural world. Phenology focuses on recurring life cycle events of plants and animals and their correlation with weather patterns. Events like the blooming of maple trees, the arrival of songbirds in spring, the migration of monarch butterflies, and the hatching of eastern tent caterpillars are all closely tied to environmental conditions. Gardeners often observe that warm weather can lead to earlier bud breaks or faster flowering in plants, with many insects also appearing sooner under such conditions. Both flora and fauna rely on temperature, rather than conventional clocks, to gauge the timing of their developmental stages.

Agriculture, deeply intertwined with the rhythm of nature, and our lives, albeit less acknowledged in modern times, have always depended on phenological patterns. Ancient civilizations, lacking modern conveniences like cell phones, relied on the natural progression of events to mark time and predict future occurrences. The precision with which plants and insects keep track of time allows for the monitoring of changes in weather patterns over both short and long terms. Recent observations have highlighted shifts in insect emergence times and locations, with some species expanding their range northward or increasing their reproductive cycles, indicative of broader climate change impacts.

The recorded changes in insect emergence times over recent decades underscore the challenges posed to pest management and the broader implications for ecosystems. Since 1971, phenological events in temperate climates have advanced by approximately two and a half days per decade, translating to a shift of about ten days over the last forty years, coinciding with global warming trends.

Citizen science plays a vital role in recording phenological events, with organizations like the U.S.A. National Phenology Network, the Leopold Phenology Project, and Project BudBurst inviting individuals to contribute to a growing database of observations. Participation in these projects allows gardeners to aid in understanding the effects of climate change on natural cycles.

The expanding range of the mountain pine beetle into higher altitudes in the Rockies, resulting in the decimation of whitebark pines, exemplifies the cascading effects of climate change. This shift affects the feeding patterns of grizzly bears, leading to increased human encounters and changes in hibernation behavior. Such examples underscore the interconnectedness of climate change, phenological shifts, and their broader ecological impacts.

Protecting Beneficial Insects through Landscape Diversity

Conservation Biological Control

Conservation biological control emphasizes the protection and promotion of natural enemies already present in your landscape. This method involves minimizing pesticide use and creating habitats that favor the natural regulation of pests. Habitat modification builds a landscape that boosts the effectiveness of natural predators. While augmentation through intentional insect releases offers temporary solutions, the focus is on fostering a sustainable environment that supports predator and parasitoid populations naturally.

Classic Biological Control

Classic biological control, a practice undertaken by governmental agencies and universities, involves the deliberate introduction of specific predators or parasitoids to manage targeted pests. This method is not typically practiced by individual farmers or gardeners.

Next step: planning your border.

Location

The size of your insectary border is important, yet it doesn't need excessive deliberation. It should harmonize with the rest of your landscape for aesthetic coherence, but the garden's size in relation to its utility for natural enemies doesn't require overcomplication. Aiming to dedicate approximately 1 percent of your home landscape to insectary plantings serves as a solid starting point. This 1 percent could manifest as a singular, strategically placed insectary border or as multiple smaller beds dispersed throughout your property, especially near areas susceptible to pests. For a 1-acre lot, this equates to a 20-by-20-foot (6-by-6-meter) border or a total area of 400 square feet (37 square meters). For a quarter-acre lot, a 10-by-10-foot (3-by-3-meter) border or an equivalent 200-square-foot (18.5-square-meter) area is adequate. While this might seem extensive, remember that any existing insect-friendly plant areas also contribute to this percentage, potentially diminishing the size requirement for a dedicated insectary border. It's essential to recognize there are no strict rules, only the recommended goal of enhancing the environment for natural enemies.

The style of your insectary border can range from formal, with sharp edges and meticulous design, to informal, featuring a mix of plants that require minimal upkeep and display vibrant colors. Integrating the design of the insectary border with the overall aesthetic of your existing landscape ensures it complements rather than disrupts your garden's appearance.

Targeting just 1 percent of your property for insectary plantings is an excellent preliminary goal. Many insectary plants are not only beneficial but also visually appealing. Incorporating them into foundation plantings can introduce color, texture, and structural diversity to areas of the landscape that might otherwise lack interest.

Size and style

Begin the design process of your insectary border by carefully considering its placement. The location is crucial because some natural enemies, like hoverflies, larger parasitic wasps, tachinid flies, and robber flies, can travel great distances, while others, such as ladybugs, ground and rove beetles, smaller parasitic wasps, and the larvae of many predators, have a much smaller home range. There are two approaches to creating your border:

1. **Integration Approach:** Instead of designating a specific border, incorporate plants known to support beneficial insects throughout your existing landscape. This method aims to enhance the structural and floral diversity of your landscape, potentially increasing the variety and number of beneficial insects on your property. This approach is how I began my insectary plantings, integrating beneficial plant species into my existing perennial gardens, vegetable garden, and shrub beds.

2. **Dedicated Border Approach:** Alternatively, you might choose to deliberately design and install a dedicated insectary border. This approach requires more planning than the integration method, particularly concerning wind and sun exposure, as many beneficial-supporting plants thrive in full sun and less windy conditions.

The proximity of your insectary border to other garden areas is another important consideration. For example, to enhance pest control in your vegetable garden, placing your insectary border nearby can be beneficial. Studies have shown that beneficial insects like hoverflies can travel significant distances from their food sources; however, placing an insectary border closer to the pests you aim to control maximizes its effectiveness.

When deciding on the placement of an insectary border, remember that "close" is a relative term. On a smaller property, such as a quarter-acre lot, almost any location can effectively support pest control efforts. For those with larger properties, more strategic placement may be required to optimize the border's impact on pest populations.

Farmscaping

Farmscaping, essentially creating an insectary border but on a significantly larger scale, involves the deliberate design of a farm landscape to support beneficial insects throughout the year. As defined by Rex Dufour, farmscaping aims to promote biodiversity on farms by integrating insectary plantings, hedgerows, and cover crops in a comprehensive approach to support natural enemies. This strategy allows for the natural enhancement of predation and parasitism rates alongside commercial crops, offering insights for home gardeners as well.

Dufour advises starting the farmscaping process by identifying the natural enemies desired to combat specific pests, then tailoring insectary plantings accordingly. An example of this is the practice on organic lettuce farms in California, where intercropping with sweet alyssum attracts hoverflies, whose larvae prey on aphids affecting lettuce, leading to a reduction in aphid populations.

Farmscaping employs various strategies, from simple to more intensive. A basic approach may involve incorporating strips of beneficial insect-supporting crops like alfalfa and buckwheat, which provide nectar and shelter, or allowing certain crops to flower post-harvest to support the next generation of natural enemies. More complex strategies might include annual flowering insectary blends or perennial plantings around crop fields, with the most comprehensive plans incorporating permanent features such as windbreaks and hedgerows to enrich ecological diversity and habitat complexity.

The effectiveness of insectary plantings is enhanced by their proximity to the crops they are meant to protect. Allocating 3 to 5 percent of a field to insectary plantings can create a supportive environment for a wide array of natural enemies, with dedicated areas also facilitating the overwintering and year-to-year sustainability of these populations.

Unused land patches, such as those around irrigation ditches or field corners, can be transformed into biodiversity islands by planting species favorable to natural enemies. This concept is applicable to home gardens, with an emphasis on managing weeds until the insectary plants establish.

Beyond supporting beneficial insects, farmscaping offers the potential for secondary crop production. Many insectary plants, including culinary herbs and flowers suitable for bouquets, have dual purposes for harvest or sale. However, Dufour cautions against selecting plants that could inadvertently harbor pests or diseases, underscoring the need for careful plant choice in farmscaping efforts.

Design

Once you've selected the site, size, and style of your insectary border, start sketching some initial designs with reference to the current landscape and existing structures on your property.

Using large graph paper can help maintain scale. Begin by outlining your house, garage, shed, pool, and any other significant structures to get a sense of the existing layout. There's no need for perfection, but understanding the general curves and angles will aid in planning.

Next, incorporate any current gardens, beds, and borders into your sketch. Aim for a border design that complements the existing landscape. For landscapes with soft curves, mimic this in your border. If your yard features sharp, angular designs, a rectangular insectary border might be more appropriate. Use your sketches to experiment with various shapes, sizes, and orientations, keeping a good eraser at hand for adjustments.

Moving on to plant selection, review the plant profiles from previous discussions, focusing on those suitable for your hardiness zone and desired bloom times. It's crucial to ensure a staggered bloom period to provide continuous nectar, pollen, and prey from early spring through to fall or year-round in warmer climates. This ensures that natural enemies have consistent resources.

In terms of plant architecture, introduce a variety of heights, widths, and structures to diversify the border's appearance. Avoid limiting your selection to a single plant family; instead, opt for a mix of flower types, including shallow, tubular flowers, daisy-like flowers, and delicate umbels. While color and aesthetics are important, diversity should be your primary goal.

Although it's helpful to plan on paper, you might prefer to arrange the actual plants within the garden space to get a better sense of how they'll look and interact. This approach allows for adjustments based on mature plant size, color, and structure, ensuring both visual appeal and functionality for attracting beneficial insects.

Remember, the goal is to create a visually appealing border that also supports a wide range of natural enemies. Don't be afraid to rearrange plants if your initial layout doesn't meet your expectations or the needs of the beneficial insects you aim to attract.

Companion planting

Pairing beneficial insect-attracting flowers with vegetables is one effective way companion planting can foster a balanced landscape. Pests provide the protein, while the carbohydrates come from flowering herbs and other plants incorporated through companion planting.

Gardeners and farmers utilize companion planting for various reasons. Firstly, it maximizes space by leveraging different growing layers, such as growing vine crops up a fence and planting low-growing herbs at their base. Companion planting can also cater to specific nutritional needs, for instance, by planting nitrogen-fixing legumes with or before nitrogen-hungry crops. It often serves as a diversionary tactic; a plant's strong odor might mask a desirable plant from pests. Additionally, companion planting can divert pests from targeted crops through trap cropping, where pests are lured to a preferred plant, then eradicated.

From saving space and fixing nitrogen to repelling pests and luring them to trap crops, the benefits of companion planting techniques are clear to the farmers and gardeners who implement them.

Integrating a variety of species and flowering plants in a vegetable garden not only attracts natural enemies but also complicates the search for host plants by pest insects. Interspersing preferred host plants with others can serve to divert pests, whether by alternating crop rows on a farm or simply increasing species diversity in a home vegetable garden.

Inter planting

Interplanting, or intercropping, reduces pest densities by disrupting resource concentrations and diverting pests. This method involves growing various crops together to enhance structural diversity, creating favorable habitats for beneficials and facilitating insect migration between crops. By introducing diversity and potential nectar, pollen sources, and alternate prey, interplanting increases the presence of predators and parasitoids.

On a large scale, interplanting might include different crops in alternating rows. In a home garden, it might be as simple as underplanting tomatoes with a mix of lettuce and sweet alyssum, where the tomatoes provide shade for the lettuce, and the alyssum attracts parasitic wasps that control aphids on the lettuce. High yields and reduced weed presence demonstrate the effectiveness of utilizing all available garden space. For instance, an old neighbor successfully interplanted peppers and eggplants with dill and coriander, benefiting from the market sale of herbs and the natural enemies attracted to the flowering plants.

Cover cropping

Cover Crops and Their Benefits

Cover crops play a vital role in providing nectar for beneficials when prey are scarce, helping many beneficial insects through the winter by offering undisturbed shelter. Their mere presence leads to increased populations of natural enemies in early spring. Beyond supporting natural enemies, cover crops also reduce soil erosion, add organic matter to the soil, enhance fertility, filter pollution, and suppress weeds. However, it's important to note that some cover crops might attract specific pests. For instance, crimson clover could draw tarnished plant bugs, and a mix of clover and legumes might attract several species of pest stink bugs. While cover crops generally do more good than harm by attracting insects to the landscape, attracting specific pests is an outcome to avoid. Before selecting cover crops for your area, consulting with local agricultural extension experts is advisable for tailored advice.

Creating Hedgerows

Beneficial species often prefer the habitat provided by woody plants over that of annual and herbaceous plants. Research indicates that trees and shrubs, which support a diverse array of host insects, offer permanent habitat and possibly pollen and nectar, tend to have the highest diversity of parasitoids. Installing a hedgerow is an effective way to increase the presence of woody plants on your property.

The ability of hedgerows to boost beneficial insect abundance and activity is increasingly recognized, though more research is needed to fully understand their impact. A study in California found that 78 percent of insects living in mature hedgerows were beneficial, suggesting that hedgerows significantly contribute to beneficial insect populations and biological pest control. In 2009, the USDA's Natural Resources Conservation Service (NRCS) supported the installation of fifty-seven miles of hedgerows on California farms, highlighting the practice's growing adoption. The NRCS offers farmers specific plant lists for hedgerow construction and provides guidance on their establishment and maintenance.

Beetle banking

Beetle banking is a conservation practice that involves the creation of elongated, semi-permanent raised berms throughout crop fields, which are then planted with grasses. This approach serves as an effective habitat creation and companion planting strategy to bolster populations of crucial predatory insects, specifically ground beetles. By naturally encouraging beetles to climb upward to avoid moisture, beetle banks are constructed a foot higher than ground level and planted with native bunch grasses, providing a dry and warm habitat for these insects during the winter months.

Farmers are advised to tailor the size of these banks to their farm's specific needs, incorporating at least three different species of native bunch grasses. Ground beetles are heralded as vital for farms and gardens because they prey on pest insects at vulnerable stages in the soil. Some ground beetles exhibit specialized behaviors, such as extracting snails from their shells or following slug trails, effectively reducing slugs and their eggs.

Research indicates that beetle banks not only support a greater diversity of ground beetle species but also benefit other beneficial insects, including rove beetles, ladybeetles, spiders, and native bees. Farmers might place a bank every 10 to 20 acres, ideally situated down the center of a field to complement existing natural edges. Home gardeners can create "beetle bumps"—raised, circular areas within their lawns, planted with a variety of native bunch grasses.

These beetle banks and bumps serve as year-round resources for beetles and add aesthetic value to the landscape, resembling a miniature prairie. Minimal maintenance is required; they need weeding until the grasses are established, and an annual trim to 6 to 8 inches high in the fall promotes new growth. Removing grass straw post-mowing enhances sunlight exposure and dries out the area. Planting should involve regionally native grasses, started indoors or heavily seeded directly in the fall, to establish a beneficial habitat for ground beetles and other beneficial insects.