HEALTH

Nutrition

ORGANIC CENTER FEATURED PROJECT
Health Effects of Dietary Exposure to Pesticides

This collaborative project of The Organic Center and Professor Lu of Harvard University will examine the health effects associated with dietary pesticide exposure. Dr. Lu's lab has previously shown that eating an organic diet can decrease exposure to pesticides. Now, we will take that data and re-examine it through the lens of metabolomics, the study of chemical processes that involve metabolites. This research is critically needed; while research studies are increasingly finding pesticides negatively affect human health, public awareness of these findings is low because there are few papers that look at exposure on the dietary level. Although many scientific journal articles have reported adverse health effects related to low-level chronic exposure to pesticides, due to the narrow scope of these studies, many people are still confused about the benefits of avoiding pesticides in food. Most studies focus on one specific chemical or food type or large-scale exposure through proximity to conventional agriculture. This can lead to difficulty in making broad generalizations about the safety of foods with pesticide residues. Additionally, the narrow scope of these studies makes them more difficult to communicate to the public because connecting them to people's everyday lives can be challenging. This project will be directly applicable to consumers by examining levels and frequencies of exposure that are the most common for the general public. In addition to our research, we will communicate our findings with the public to ensure understanding and increase awareness around the issue of pesticide risks.

Study confirms nutritional benefits of organic meat

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While several smaller studies have found nutritional benefits of eating organic meat, until now no systematic reviews have compiled all the latest information about the nutrient content of organic versus conventionally produced meat. This morning, a paper published in the *British Journal of Nutrition* did just that, and found that, based on 67 published studies, organic meat contained 47% higher levels of omega-3 fatty acids than conventional meat. This is important because diets low in omega-3s, especially in combination with high omega-6 diets, are risk factors for cardiovascular disease, cancer, and inflammatory and autoimmune diseases. Diets with high omega-3 intakes, on the other hand, suppress these conditions. The study concluded that the main reason for the beneficial increase in omega-3 fatty acids is likely the high grazing and forage requirements for organic livestock.

Study finds organic dairy has healthier nutritional profile

A new meta-analysis that examined 170 published studies found that organic milk had several nutritional advantages over conventional milk. The study, led by Organic Center Advisory Board member Carlo Leifert of Newcastle University, found that organic milk had 56% higher healthy omega-3 fatty acid levels than conventional milk. In addition to higher levels of omega-3 fatty acids, this study found that organic dairy provides several other health benefits such as higher levels of heart-healthy conjugated linoleic acid (CLA), iron, vitamin E, and carotenoids, all of which are associated with health benefits. The study authors stated that they "concluded that organic bovine milk has a more desirable fatty acid composition than conventional milk."

Pesticide Avoidance and Nutrition

Herbicides, including glyphosate, increase antibiotic resistance in *E. coli* and *Salmonella*

A new study in mBio, a peer-reviewed journal published by the American Society for Microbiology, suggests that the herbicides dicamba (Kamba), 2,4-dichlorophenoxyacetic acid (2,4-D) and glyphosate (Roundup) induce antibiotic resistance in *E. coli* and *Salmonella* bacteria. Researchers subjected bacteria to combinations of different herbicides and antibiotics, including antibiotics commonly used to treat bacterial infections in humans such as ampicillin, ciprofloxacin, and tetracycline. The results demonstrated that *E. coli* and *Salmonella* exposed to low levels of Kamba, 2,4-D and glyphosate were more resistant to antibiotics than bacteria only exposed to antibiotics. Bacteria exposed to the commonly used herbicides activated proteins enabling them to rid themselves of toxic substances creating a defense against the antibiotics. The authors conclude that the common use of chemicals in agriculture, gardens, and public spaces can induce resistance to multiple antibiotics in bacteria that are harmful to humans. Furthermore, "The combination of high use of both herbicides and antibiotics in proximity to farm animals and important insects, such as honeybees, might also compromise their therapeutic effects and drive greater use of antibiotics."

More research shows that an organic diet can reduce exposure to some pesticides

Researchers from the University of California, Berkeley's Center for Environmental Research and Children's Health (CERCH), the University of Maryland's Institute for Applied Environmental Health, and Emory University's, Rollins School of Public Health recently published a paper showing that eating an organic diet reduces the exposure to some pesticides in young children. The study looked at 40 Mexican-American children between the ages of 3 to 6 years old, living in urban and agricultural communities in California. Children were fed a diet of organic food for a week, in between periods of eating a conventional diet, to examine the effects or an organic diet on 23 metabolites reflecting potential exposure to indoor and agricultural pesticides. The researchers found

that concentrations of metabolites of non-specific organophosphate (OP) insecticides (total dialkylphosphates (DAPs) and dimethyl DAPs) and 2,4-D herbicides were significantly lower during the organic diet phase compared to conventional diets. However, metabolite concentrations for pyrethroids, diethyl OP pesticides, and the herbicide metolachlor were not lowered by an organic diet, and several compound-specific OP pesticide metabolites had low detection frequencies, indicating that diet was not an important exposure source. One of the reasons that pyrethroid metabolites were not affected by diet could be that pyrethroids are primarily used as urban pesticides around homes and not commonly applied to food crops. The study concludes that "in general, an organic diet was associated with lower levels of frequently detected metabolites for all children."

Quality and sustainability of organic and conventional food

A new report released by the Swiss Research Institute of Organic Agriculture (FiBL) explores differences in the quality and sustainability of organic and conventional food. The authors review evidence covering the differences in taste, health, and environmental impacts of production and processing to comprehensively assess differences in the quality of organic and conventional food. Findings suggest that overall, organic produce has fewer pesticide residues and heavy metals, and that many organic food products are higher in antioxidants and healthy fatty acids. Organic foods generally have fewer additives, and lifecycle analyses of organic foods have indicated that organic products have a smaller impact on the environment than conventional products.

Eating organic reduces pesticide exposure

A recent study published in *Environmental Health Perspectives* has confirmed that choosing organic does, in fact, reduce consumer exposure to pesticides. The study aimed to (1) estimate long-term dietary exposure to organophosphate pesticide residues for individuals, (2) check the accuracy of the estimates and (3) determine whether choosing organic fruits and vegetables lowered pesticide exposure. Four thousand participants from major cities across the nation completed surveys regarding their fruit and vegetable consumption and the frequency in which they chose organic or conventional produce. Scientists then used the survey data along with data from the U.S. Department of Agriculture Pesticide Data Program on average pesticide residue levels for those same food items in order to estimate the amount of pesticide residues each participant was exposed to on a daily basis. Scientists then checked the accuracy of their estimations by measuring the amount of dialkyl phosphate (DAP)—a by-product created when the body breaks down organophosphates—in the urine from a subset of participants. They also compared the amount of DAP in the urine of people who reportedly ate conventional diets with those who ate organic diets. The results confirmed that their calculations of daily pesticide residue consumption levels were accurate, and that even when consumers chose organic "at least occasionally," they had significantly less of the pesticide by-product, DAP, in their urine than consumers who primarily chose conventional produce.

Clearing habitat near farms does not reduce pathogen crop contamination

A new study published by researchers at the University of California, Berkeley in the scientific journal *Proceedings of the National Academy of Sciences* suggests that the practice of removing surrounding habitat from farms does not reduce crop contamination from disease causing pathogens such as *E. coli*. Previous pathogen contaminations were assumed to occur when wild animals defecated in crop fields, thereby leading to contamination. While this theory was never tested, the concern led to the clearing of wild plants surrounding farms to discourage wildlife from living near and potentially entering farms. Scientists analyzed almost 250,000 tests conducted between 2007 and 2013 in the U.S. and Central and South America to shed light on the contamination risk actually caused by wildlife habitat surrounding farms. Results showed that removing vegetation surrounding farms did not lower the prevalence of *E. coli* or *Salmonella*.

Antimicrobial activity of organic honey fights food pathogenic bacteria

A recent study published in *Organic Agriculture* shows that some organic honey has natural antimicrobial activity that can combat the growth of *Clostridium perfringens*, a food pathogen bacterium known to cause food spoilage and illness in humans and animals. Due to increasing levels of antibiotic resistance in *C. perfringens*, the discovery and development of new antimicrobials are essential. In this study, researchers investigated five different organic honeys from Finland, one from Argentina, and one from Hungary to determine their effectiveness in combating *C. perfringens*. The organic honeys with the highest antimicrobial activity were from Finland with varying levels of antimicrobial activity likely determined by the plants from which the bees collected their honey. One honey sample had no effect on *C. perfringrens*, likely due to heating during processing which may have destroyed the active antimicrobial compounds. Overall, this study showed that organic honey can be effective in fighting *C. perfringens*, and has the potential to be used clinically to fight this foodborne bacterium.

Effects of Pesticides on Humans

Early organophosphate exposure linked to respiratory illness in children

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Organophosphates are one of the most commonly used pesticides in the world. Although they are now restricted for residential use due to human toxicity, they are still widely used in agriculture. A recent study published in *Environmental Health Perspectives* has found a slight association between early exposure to organophosphate pesticides and respiratory symptoms consistent with possible childhood asthma in an agricultural community in California. Three hundred fifty nine children and mothers from Salinas Valley, California participated in the study. Dialkyl phosphate (DAP), a by-product created when the body breaks down organophosphate pesticides, was measured in the urine of pregnant mothers at the beginning of the second and third trimesters. DAP levels were also measured five times in the children between ages six months and five years. When the children reached five years and seven years of age, the mothers were additionally asked to fill out a questionnaire that included questions about their children's respiratory health over the past year. The results found slight associations between higher DAP levels in pregnant women and signs of respiratory illness in five and seven year

olds. Additionally, childhood exposure to organophosphate pesticides, determined from urine samples taken from children when they were between the ages of six months and five years, was also weakly associated with respiratory symptoms and coughing during exercise at ages five and seven.

Low-dose exposure to multiple chemicals may increase cancer-causing mutations
A recent study published in the scientific journal *Carcinogenesis* examined how exposure to low-doses of chemical cocktails found in the environment affect human health. Data on 85 different chemicals were reviewed to determine if they might play a role in the formation of cancerous cells. While many of the chemicals alone were not cancer-causing, they became so in the presence of other chemicals. Exposure to bisphenol-A (BPA)—a chemical commonly used in household plastics—disrupts DNA function and blocks signals between cells in the body. Meanwhile, atrazine is the most commonly detected herbicide in U.S. soil and water, and exhibits weak DNA mutation properties that could disrupt the immune system. Exposure to each one of these chemicals individually is unlikely to cause cancer-causing mutations. However, together they are much more likely to lead to irreparable genetic mutations that could result in the formation of cancerous cells.

Prenatal exposure to the pesticide chlorpyrifos linked to tremors in mid childhood
While the organophosphate insecticide chlorpyrifos—commonly used in conventional agricultural production—has been linked to neurodevelopmental problems, the effects of low-level exposures had not been previously assessed. Now, a study published in the journal *NeuroToxicology* has found that prenatal exposure is linked to tremors in childhood and may indicate a negative effect on the nervous system. To determine the effects of prenatal exposure to chlorpyrifos on motor skills in children, researchers followed 263 children from birth to eleven years of age. At birth, chlorpyrifos was measured in each subject's umbilical cord. At about age eleven, all subjects were given a neuropsychological assessment. The results suggest that children who were exposed to higher levels of chlorpyrifos before birth were more likely to exhibit tremors. "This report adds to the body of evidence suggesting that prenatal exposure to chlorpyrifos, at current standard usage levels, is associated with a range of persistent and inter-related developmental problems," the authors conclude.

Childhood exposure to pesticides negatively affects neurodevelopment in children
A recent article published in the scientific journal *Environment International* has found that pesticide exposure can lead to neurodevelopmental impairment. Researchers from Spain investigated the associations between exposure to commonly used organophosphate pesticides before and after birth on childhood neurodevelopment. Three hundred and five children were randomly selected from public schools in the study area. The children's urine was tested for metabolites created when organophosphate pesticides break down in the body and early exposure to pesticides was estimated using land use maps and data. The researchers found that children with higher levels of pesticide metabolites in their urine tended to test lower for intelligence and comprehension. The

trend was stronger in boys than it was in girls. Researchers also found that children living closer to agricultural cropland after birth were more likely to score lower on neurodevelopmental tests. Children exposed to pesticides prenatally also exhibited negative neurodevelopmental effects but to a lesser extent than postnatal exposure. The authors conclude, "Pesticides thus represent a major public health problem due to their extensive agricultural use and the greater vulnerability of children's brains."

Link between organochlorine pesticides and low cognitive scores in U.S. elders
A study published in the scientific journal *Environmental International* has detected a link between exposure to organochlorine pesticides and low cognitive scores in the elderly living in the United States. Cognitive function was assessed from 644 participants ages 60 – 85 from the National Health and Nutrition Examination Survey from 1999 to 2002 who did not display signs of overt dementia. Subjects were assessed for exposure to six organochlorine pesticides as well as organophosphate and pyrethroid pesticides. Researchers found that while exposure to non-persistent pesticides such as organophosphates and pyrethroids were not associated with changes in cognitive score, organochlorine pesticides were. Elders with high DDT, DDE, and β-hexachlorocyclohexane had two to three times higher risk for low cognition. Those in the top 5 percent or DDT exposure showed 6.5 times higher risk of low cognition. The authors conclude, "The potential role of background exposure to organochlorine pesticides in the development of dementia should be explored in future prospective studies".

Effects of pre- and post-natal exposure to flame retardants in children
Polybrominated diphenyl ethers (PBDEs) are flame retardants that were commonly used to treat household items such as furniture and infant products. In 2004, they were banned from use in household items because of their actions as human endocrine disruptors. Unfortunately, people are still frequently exposed to PBDEs by way of dust in homes that still contain furniture that pre-dates the ban. PBDEs can be transferred from women to their children both before and after birth. Pre-natal transfer happens when flame retardants that the mother has been exposed to reach the baby by way of umbilical cord blood or through the placenta. Post-natal transfer occurs when babies are exposed to flame retardants by drinking their mother's breast milk. Children may additionally be exposed when they consume PBDE flame retardants found in household dust. While there are many life history and environmental factors associated with obesity, one hypothesis supposes that exposure to endocrine disruptors such as PBDEs early in life may also contribute to weight gain later on. Now, a study published in *Environmental Health Perspectives* has examined the association between pre- and post-natal exposure to PBDE flame retardants and body mass in boys and girls in an agricultural community in California. Two hundred twenty-four mothers and their children from Salinas Valley, California, participated in the study. Blood samples were collected from the mothers when they were pregnant or during their delivery, and also from their children when they reached seven years of age. PBDE concentrations were measured and data related to body mass were collected for both the mothers and the children. The results suggest that pre-

natal exposure to PBDEs is associated with higher body mass in seven-year-old boys but lower body mass in seven-year-old girls. Additionally, there was significant association between children's levels (post-natal exposure) of BDE-153 and a decrease in body mass. Researchers suggest that this pattern of higher PBDE levels (and specifically BDE-153) and lower body mass in children may be the result of reverse causality. Because PBDE flame retardants are stored in fat cells, children with higher body mass have more fat cells where PBDEs are stored, making them less detectable in the blood stream. Children with lower body mass, on the other hand, have fewer fat cells to store PBDEs and therefore they are detected at higher concentrations in the blood stream. Overall while this study found little evidence that pre- and post-natal exposure to flame retardants causes obesity in children, it did show differing results between boys and girls, suggesting that PBDEs may be affecting sex-linked hormone signaling. Researchers concluded that "because PBDE flame retardants have been replaced by other potentially endocrine-disrupting chemicals, the obesogenic [obesity-causing] characteristics of these chemicals should also be investigated."

Pesticide exposure has negative long- and short-term effects

A recent study published in the scientific journal *PLOS ONE* has found that farm workers exposed to pesticides experienced negative long- and short term health effects. Researchers used a sample of 246 farmers randomly selected from three Chinese provinces. Participants underwent clinical health evaluations, blood testing and neurological tests before and after the farming season in 2012 and were interviewed to collect data on their pesticide use from 2009 – 2011. Scientists found that more than 70% of farmworker participants had at least one abnormal health result in testing prior to the farming season. Almost 8% of participants had blood chemistry test results indicating abnormal renal function, 10% - 15% exhibited abnormal vitamin, electrolyte and plasma glucose levels, and almost 50% had abnormal results in nerve conduction studies. Furthermore, when tests were repeated at the end of the growing season, researchers found that the percentage of farmworkers with at least one abnormal health result had risen to 95%. "We found that there were extensive long-term and short-term health effects in farmers exposed to pesticides. The former involved peripheral nervous system, white blood cells, liver, electrolytes, and the latter involved blood cells, liver, kidney, electrolytes and peripheral nervous system," the authors reported.

DDT and PCBs exposure can lead to sperm abnormalities

Researchers from George Washington University have found that men exposed to dichlorodiphenyldichloroethylene—a byproduct created when DDT is broken down—and polychlorinated biphenyl (PCB) pollutants during adolescence have more abnormal chromosomes in their sperm. Ninety men from the Faroe Islands donated blood serum and semen samples for the study. Forty of the 90 participants also had umbilical cord blood that was collected and stored from birth as well as blood serum samples taken at age 14 analyzed. Blood serum samples were analyzed for metabolites produced when the body breaks down the pesticide DDT and for PCBs. Semen samples were examined for quality and included measurements of sperm count, percentage of mobile sperm, physical

characteristics and measurements of chromosomal abnormalities. Participants who were exposed to higher levels of DDT and PCBs during adolescence and adulthood had higher incidences of abnormal sperm. While DDT and PCBs were both banned from use in the United States in the 1970s, they can persist in the environment for long periods of time. DDE and PCBs are known bio-accumulators, meaning that they persist in the environment as well as in the tissues of organisms that inadvertently consume them. Humans are typically exposed when they consume animals or animal products that have accumulated the persistent pollutants. "Taken together, the results reported here further demonstrate links between organochlorine exposures and sperm abnormalities and illustrate that the impacts of persistent pollutants on testicular maturation and function need deeper investigation," the authors concluded.

Dietary exposure to pesticides associated with reduced semen quality

A new study out of Harvard University has linked dietary exposure to pesticides with lower sperm quantity and quality in men. Three hundred thirty-eight semen samples were collected from 155 men from 2007 – 2012. The diet of each participant was assessed using a dietary survey. The concentration of sperm and level of movement were analyzed for each semen sample. Pesticide exposure due to dietary intake was calculated using data from the U.S. Department of Agriculture's Pesticide Data Program. After taking into account confounding factors including weight and lifestyle habits such as smoking, researchers found that men exposed to the highest levels of pesticide residue through fruit and vegetable consumption had almost 50% fewer sperm and more abnormally shaped sperm when compared to men who consumed the least amount of pesticides. Importantly, the study points out that lower semen quality was **not** simply associated with the quantity of produce consumed but instead the quantity of fruits and vegetables that were high in pesticide residues. Produce with high pesticide residues included strawberries, spinach and peppers. Men who were exposed to low to moderate levels of pesticides had a greater percentage of normally shaped sperm. Jorge Chavarro, the study's senior author, stressed, "These findings should not discourage the consumption of fruit and vegetables in general. In fact, we found that consuming more fruits and vegetables with low pesticide residues was beneficial. This suggests that implementing strategies specifically targeted at avoiding pesticide residues, such as consuming organically grown produce or avoiding produce known to have large amounts of residues, may be the way to go."

Low-level Roundup exposure may cause kidney and liver damage in rats

A study recently published in *Environmental Health* suggests that low-level exposure to Roundup over a long period of time may cause kidney and liver damage in rats. Researchers fed rats very low levels of Roundup in their water—lower than the amount legally allowed in drinking water in the European Union and the U.S.—for two years after which the animals were euthanized and autopsied. Researchers found that female rats showed three times more signs of kidney and liver damage than the control rats fed uncontaminated water. While researchers found no signs of severe kidney damage, analysis of urine and blood showed biochemical changes consistent with impaired kidney function. To confirm these effects, the researchers compared difference in the genes of

the control rats and the rats fed Roundup. Roundup-treated rats had changes in more than 4,000 genes involved in liver and kidney function. "The results of the study presented here indicate that consumption of far lower levels of a GBH (glyphosate-based herbicide) formulation, at admissible glyphosate-equivalent concentrations, is associated with wide-scale alterations of the liver and kidney transcriptome that correlate with the observed signs of hepatic and kidney anatomorphological and biochemical pathological changes in these organs. In addition, as the dose of Roundup we investigated is environmentally relevant in terms of human, domesticated animals and wildlife levels of exposure, our results potentially have significant health implications for animal and human populations," the researchers wrote.

Acetochlor and cancer risk

A study published in the *International Journal of Cancer* found that occupational exposure to acetochlor increased the risk of developing melanoma, pancreatic, lung, and colorectal cancer. Acetochlor is an herbicide typically applied to plant foliage. It was introduced in 1994 as an alternative to other herbicides such as metolachlor and atrazine that were known carcinogens. More recently however, the U.S. Environmental Protection Agency concluded that acetochlor was potentially carcinogenic based on laboratory experiments with animals. This study—conducted using data collected from the Agricultural Health Study which includes long-term data on the health of agricultural workers from North Carolina and Iowa—is one of the first to examine the relationship between exposure to acetochlor and human cancer risk. In it, 33,484 men provided information on their use of acetochlor and their health from 1999-2005 and then again in 2010-2011. Results suggest that exposure to acetochlor even at very low doses can increase the risk of lung cancer. Results also indicated that high-level exposure to acetochlor may be linked to an increased risk of colorectal cancer. Because this is the first study to assess the carcinogenic effects of acetochlor, further research is needed to definitively answer whether it should be classified as a carcinogenic herbicide.

Pesticide exposure and childhood leukemia

A new study published in the journal *International Journal of Cancer* has found that increased exposure to pesticides before conception, during pregnancy and after birth increases the risk of childhood leukemia. Childhood leukemia has been recognized as one of the most common childhood malignancies and typically occurs in children 5 years and younger. The study focused on two types of childhood leukemia: acute lymphoblastic leukemia (ALL) and acute myeloid leukemia (AML). Scientists examined 12 case-control studies in the Childhood Leukemia International Consortium that took place in North America, Europe and Australia over a 30-year period. They found that that pesticide exposure prior to conception, during pregnancy and after birth were all associated with an increased risk of childhood ALL. Pesticide exposure prior to conception and during pregnancy contributed to higher risks of childhood AML. Children are more vulnerable to pesticide exposure than adults because they have higher respiratory and metabolic rates. While more research is needed to determine which stage of exposure contributes to the highest risk of developing childhood leukemia, the authors

wrote, "It would appear prudent to recommend that parents and those contemplating pregnancy should limit pesticide exposure in the home during the year before birth and the child's early years."

Pesticide use and risk of shortening nucleotides

A study published in *PLOS ONE* has found a negative association between occupational pesticide exposure and relative telomere length (RTL). Telomeres are long, repetitive DNA sequences found at the end of chromosomes that protect our DNA from damage. Researchers conducted this study over a ten-year period with 568 cancer-free males ranging from age 31 to 98 living in Iowa and North Carolina. All participants filled out surveys, with blood samples taken three separate times over the course of the study. RTL decreased with increasing age, which was to be expected; however, those with higher exposure to the pesticide 2,4-D had shorter RTL. Agricultural use of 2,4-D has been linked to higher incidence of cancer, such as Non-Hodgkin lymphoma, and the decrease in RTL length may be a contributing factor in the development of the disease because as the RTL decreases, chromosomes—which contain most of our DNA—lose protection. These findings suggest that cumulative and more recent use of certain pesticides may be linked to alterations in RTL, which may be a potential intermediate in certain diseases.

Diazinon use by ag workers is associated with elevated lung cancer risk

The Agricultural Health Study investigated the relationship between the use of the organophosphate pesticide diazinon and cancer risk in pesticide applicators, primarily farmers, from North Carolina and Iowa. A recent study published in the *Journal Occupational and Environmental Medicine*, used data from over 25,000 participants to assess whether or not cancer incidence is linked to diazinon use. Results suggest that exposure to diazinon significantly increases the risk of lung cancer in applicants who used the pesticide the most frequently and were likely to have experienced higher intensity exposures based on factors such application method, and the use of personal protective equipment. While the risk of kidney cancer and aggressive prostate cancer was also elevated, the association was non-significant.

Farm workers become ill after exposure to newly marketed pesticides

A recent Morbidity and Mortality Weekly Report published by the Centers for Disease Control (CDC) documents the poisoning of farm workers in the state of Washington after accidental exposure to new pesticides from off-target drift. Twenty people were working in a cherry orchard when they were exposed to pesticides being sprayed in a nearby pear orchard. Within minutes of the exposure, the workers began to experience symptoms including headaches, nausea, respiratory irritation and eye irritation. The crew leader called 911, and the workers were treated at the local emergency department. This is the first report of illness caused by exposure to three newly released pesticides—pyridaben, novaluron, and triflumizole—and highlights the health risks of exposure via accidental pesticide drift for people living and working in agricultural areas.

Pyrethroid exposure linked to cognitive developmental disabilities in children
The use of pyrethroid insecticides has increased drastically as they replace more toxic organophosphate and carbamate insecticides. However, a new study published in *Environment International* has found a correlation between pyrethroid insecticide exposure and decreased mental health in children. Studied were 287 mothers and their children in France, with urine samples collected from mothers during pregnancy and their children at age 6. Pyrethroid pesticide exposure was determined by measuring the concentrations of 3-PBA and *cis*-DBCA, metabolites found in urine after the pesticides are broken down in the body. The children's cognitive ability was also assessed using a psychologist-administered cognitive abilities test. While no correlation was observed between maternal pyrethroid exposure during pregnancy and their children's mental ability, researchers did find that children with higher concentrations of 3-PBA and *cis*-DBCA had poorer neurocognitive abilities, which may interfere with learning and social development.

Fetal exposure to endocrine disruptors linked to genital defect in boys
Hypospadias is a birth defect in which the opening of the urethra (tube that drains urine) is on the underside of the penis instead of at the tip. This type of birth defect is the second most common malformation for males and is suspected to be the caused in part by fetal exposure to endocrine-disrupting chemicals by preventing testosterone production in the fetus leading to an increase in genital malformations. A recent study published in the journal *European Urology* suggests that maternal and paternal exposure to endocrine disrupting chemicals may increase the chance of hypospadias in male children. The study examined 300 patients diagnosed with hypospadias and 302 control participants. All participants ranged from newborn to 12 years of age. A standardized questionnaire was used to evaluate both maternal and paternal exposures to endocrine disruptors including the type of exposure, type of products, timing of exposure, and frequency of product use. Results demonstrated that mothers frequently exposed to endocrine disruptors at work were more likely to give birth to boys with hypospadias than the control participants. They also found that paternal exposure to endocrine disruptors around the time of fertilization was also associated with hypospadias. The authors conclude that this study "strongly suggests that endocrine disrupting chemicals through occupational, professional, and environmental exposure during fetal life are a risk factor for hypospadias."

DDT pesticide exposure in utero increases breast cancer risk
A recent study from *the Journal of Clinical Endocrinology Metabolism* has found a correlation between fetal exposure to dichlorodiphenyltrichloroethane (DDT) and increased risk for breast cancer. While DDT was banned in the United States in the 1970s due to health concerns, the wide use of the pesticide during the 1960s has significant implications for daughters born to mothers who were pregnant at that time. Additionally, DDT is still commonly used in other countries around the world to control malaria-carrying mosquitoes. The aim of this study was to determine if increased levels of maternal DDT exposure during pregnancy was linked to the risk of breast cancer in

daughters. DDT levels were measured from blood collected from women soon after they had given birth between 1959 and 1967. A follow up 54 years after their birth was conducted for the daughters born to those mothers. Results showed that independent of the mothers' breast cancer history, elevated DDT present in the mother's blood during pregnancy predicted a four-fold increase for the daughter's risk of breast cancer.

Gene brings higher risk of Parkinson's after pyrethroid exposure
A new study published in *npj* has found that exposure to the pesticide class known as pyrethroids may make some people more susceptible to Parkinson's disease if they have a common gene. Data collected from 962 participants from agricultural counties in California were analyzed to determine how presence of the gene and pesticide exposure influenced Parkinson's disease risk. The results suggested that alone, neither presence of the common gene nor exposure to pyrethroids increased the risk of developing Parkinson's disease. However, Parkinson's disease risk significantly increased for individuals with the common gene who were exposed to pyrethroid pesticides. Individuals with the common gene but who were *not* exposed to pyrethroids did not have an increased risk for developing Parkinson's. This study is one of the first to find a link between pesticide exposure and genetic risk for Parkinson's.

Exposure to pyrethroids during child development linked to ADHD symptoms
A recent study in FASEB Journal used a number of different methods to determine if exposure to pyrethroid pesticides may result in symptoms similar to ADHD. Pregnant female laboratory mice were fed small levels of the pyrethroid pesticide deltamethrin to mimic the level of exposure that would be expected in humans. Once the babies of the exposed mice were born, their behavior was compared to mouse babies whose mothers had not been exposed to the pesticide. Mice exposed to pesticides during development before birth were more likely to exhibit behavior consistent with ADHD, including hyperactivity, impulsive behavior, and memory and attention problems. Researchers then analyzed data from the National Health and Nutrition Examination Survey, and discovered that children between the ages of six and fifteen who had elevated pyrethroid metabolites in their urine were twice as likely to be diagnosed with ADHD. The authors conclude that together these results "suggest that developmental pyrethroid exposure is a significant risk factor for ADHD."

Maternal exposure to pesticides may harm girls more
A recent study published in the journal Neurotoxicology and Teratology suggests that daughters of women exposed to pesticides early in their pregnancies may have impaired neurodevelopment. Women working in horticultural greenhouses in the early stages of pregnancy and their employers were interviewed to determine if they were exposed to pesticides at their job. Exposed women were then put on paid leave or moved to alternative positions where they would no longer be exposed for the remainder of their pregnancy. Pregnant women not exposed to pesticides were used as a control group. One hundred thirty-three children whose mothers were exposed to pesticides early on in their pregnancy participated in the study. When the children were between the ages of 6 and

11, they underwent neurological development testing. Pre-natal pesticide exposure was associated with delayed response to sound in all children. Additionally, girls exposed to pesticides before birth experienced impaired language function, motor speed and short-term memory.

Exposure to glyphosate "probably causes cancer in humans'

A new study published by the World Health Organization (WHO) has determined that exposure to glyphosate, one of the primary pesticides used on genetically modified 'round-up ready' crops, "probably" causes cancer in humans. Glyphosate is one of the most commonly used herbicides in the world and is found in over 750 different products used on farms and in urban areas. Human exposure occurs through inhalation during spraying and through the consumption of contaminated food and water. The WHO working group assigned the risk level as "probably carcinogenic to humans" after reviewing results from pertinent scientific literature which showed evidence that glyphosate exposure is linked to certain cancers in humans, induces tumors in mice, damages human DNA, and disrupts beneficial intestinal microbes in humans.

Prenatal exposure to phthalates linked to lowered IQ in children

A recent study published in the Journal *PLOS ONE* has found an association between maternal exposure to phthalates—chemicals commonly found in plastics and personal care products—and lowered IQ in their seven-year-old children. Previous studies had found that phthalate exposure in pregnant women has negative effects on their children. For instance, prenatal phthalate exposure was associated with delayed motor development in three-year-olds. However, no previous studies had investigated the effect of prenatal exposure on IQ in school-age children. Researchers studied 328 inner-city women and their seven-year-old children from the Columbia Center for Children's Environmental Health longitudinal birth cohort. Subjects were excluded if they were smokers, had a history of drug abuse, or had other medical problems. Urine samples previously taken from the mothers when they were pregnant were analyzed for chemicals created when the body breaks down phthalates, and their children were given an IQ test. Researchers found significant associations between the level of phthalate exposure in the women when they were pregnant and the IQ of their children. Higher phthalate exposure was linked to lower IQ. This association was stronger in girls than in boys. "These findings are important to inform policy makers of the potentially harmful effects of this class of chemical," the authors concluded.

Organochlorine pesticides in South African catfish pose cancer risk when consumed by humans

A recent study published in *Chemosphere* found that catfish collected from multiple freshwater sites in South Africa contained organochlorine pesticide residues above acceptable levels for cancer risk and hazard index risk for human consumption. Scientists collected fish from three fresh water impoundments, and analyzed their muscle tissue for organochlorine pesticides. They then calculated a human health risk assessment using methods consistent with those of the U.S. Environmental Protection Agency that take into

account the average weight of the consumer, the consumer's average life span, and average daily intake of the contaminated food in question. Using these methods, they were able to calculate whether catfish consumption led to a higher than normal risk of developing cancer (known as cancer risk) as well as the toxic, but non-cancerous effects of catfish consumption (known as hazard risk). They found various organochlorine pesticides in the sampled catfish from all three sampling locations, and fish from all but one of the sampling locations had pesticide levels high enough to pose a cancer risk and hazard risk to humans. These results are particularly troubling because the sharp tooth catfish is an important protein source for many poor, rural communities in South Africa. Additionally, the organochlorine insecticide DDT was detected even though it is not used near the waters where fish are collected, suggesting that dangerous pesticides may be traveling long distances by way of water runoff or by movement through the air.

Pesticide Presence

Pesticide contamination of water poses health risks for humans
A recent study published in *Environmental Monitoring and Assessment* assessed the health risk of waters contaminated with pesticides to humans. Researchers quantified the levels of contamination in water, sediment, and the *Catla catla* fish for six different pesticides including endosulfan, carbofuran, cypermethrin, profenofos, triazophos, and deltamethrin. Many of these pesticides are frequently used in conventional agricultural production and can contaminate fresh water sources through runoff and seepage. Contamination of water sources that also provide habitat for fish commonly consumed by humans is of particular concern as they provide a clear pathway for human exposure via consumption of contaminated fish that accumulate toxins in their flesh. Researchers found that the pesticides endosulfan and profenofos were detected the most frequently and in the highest concentrations in fish and sediment samples, Profenofos and cypermethrin were the most abundant in water samples. "The concentration of endosulfan, carbofuran and deltamethrin were higher than the permissible limits for fish set by international agencies and pose a potential ecological risk to the aquatic ecosystem and a consequent hazard to human health," the authors reported.

Scientists question safety of glyphosate exposure regulations
A new article published in *Environmental Health* addresses growing health concerns with the increased use of the herbicide glyphosate, the active ingredient in Roundup. The use of Roundup has been skyrocketing over the past decade, with the pesticide touted as a "safe" alternative to other pesticides. Unfortunately, this has led to increased tolerance level regulations without new testing to examine the short- and long-term safety of exposure to glyphosate. This is happened despite new research on the potential hazards of the pesticide and calls from international health agencies, such as the conclusion of the World Health Organization's International Agency for Research on Cancer that glyphosate is "probably carcinogenic to humans." This article pulls together the growing body of evidence showing that glyphosate contamination is widespread, and likely does not break down as quickly in the environment as previously thought. The authors also

show that human exposure to this pesticide is rising quickly, despite being classified as a carcinogen. They point out that current regulations on tolerable exposure to glyphosate are outdated, and do not take the most current scientific research into account.
The study authors conclude with a Statement of Concern, offering several recommendations on studies that are needed to reassess the safety of glyphosate.

Skin absorption of pesticide formulations containing chlorpyrifos, 2,4-D, and glyphosate negatively affects the common toad
A recent study published in the journal *Water, Air, and Soil Pollution* has found that dermal exposure to low levels of the common pesticides chlorpyrifos, 2,4-D, and glyphosate resulted in neurotoxicity, oxidative stress and immunological depression in the common toad. Researchers investigated the effects of low-level exposure on toads by exposing their skin to solutions containing low levels of each pesticide. Blood samples were taken from the experimental toads after 48 hours and a number of bio-indicators indicating stress, inflammation, and immune response were quantified. The results demonstrate that dermal exposure to all three pesticide formulations had negative health impacts on the toads.

Renal disease linked to chronic pesticide exposure in U.S. farmworkers
A study published in *Occupational and Environmental Medicine* has found that chronic exposure to specific pesticides is associated with end-stage renal disease in licensed pesticide applicators. The study utilized data from 320 participants in the Agricultural Health Study from North Carolina and Iowa. All of the cases were male licensed pesticide applicators diagnosed with end-stage renal disease between their initial enrollment in the 1990s and December 2011. Associations between end-stage renal disease and lifetime use of 39 different pesticides, high-level pesticide exposures and pesticide exposure that resulted in a medical visit or hospitalization were calculated. Use of the herbicides alachlor, atrazine, metolachlor, paraquat, and pendimethalin as well as the insecticide permethrin were all associated with end-stage renal disease. Furthermore, pesticide exposure that resulted in medical treatment was also significantly associated with end-stage renal disease. "Our findings support an association between end-stage renal disease and chronic exposure to specific pesticides, and suggest pesticide exposures resulting in medical visits may increase the risk of end-stage renal disease," the authors conclude.

High levels of organochlorine pesticides found in vegetables
A long list of organochlorine pesticides (OCPs) has been identified as persistent organic pollutants, meaning that once they enter the environment, they do not degrade and are often transported long distances from their areas of original application, increasing risk of contamination and unintended exposure. While many OCPs are banned or restricted in countries around the world, they are still used throughout much of India. A recent study published in the journal *Environmental Science Pollution Research* sought to determine the risk associated with consuming vegetables grown conventionally near Delhi, India. There, vegetables were sampled during both the winter and summer months and tested

for the presence of 20 different OCPs. OCP residues were found on all vegetables, the majority of which exceeded the maximum residue levels. Health risk assessments determined that OCP residues were high enough in most cases to exceed the acceptable limits to pose a serious health concern especially for children. "There is an urgent need to prevent further release of OCPs into the environment through strict regulatory measures," the researchers said.

Pesticides found in catfish exceed the permissible limit

A study published in the scientific journal *Chemosphere* has detected high levels of organochlorine pesticides in the muscle tissue of sharptooth catfish living in freshwater impoundments in South Africa. Furthermore they found that eating them may pose a significant health risk to surrounding populations who utilize use as a food source. Scientists collected 20 catfish each from three different freshwater impoundments in South Africa. The fish were tested for organochlorine pesticides including DDT, aldrin, dieldrin, endrin, endrin aldehyde, endrin ketone, endosulfan I, endosulfan II, heptachlor, heptachlor epoxide, alpha-, beta-, gamma- and delta-isomers of hexachlorocyclohexane and methoxychlor. Overall human health and cancer risks through consumption were assessed using U.S. EPA risk assessment methodologies The results found that fish collected from all three water sources were contaminated with various combinations of organophosphate pesticides. Fish from two of the impoundments contained levels of the pesticide dieldrin at concentrations high enough to result in cancer and health risks above what is considered acceptable.

Neonicotinoids found in freshwater across the U.S.

Neonicotinoid insecticides are one of the fastest-growing classes of insecticides worldwide, and have been implicated in the decline of bee populations. Now, a U.S. Geological Survey (USGS) study published in *Environmental Chemistry* has found that they are common contaminants in freshwater across the U.S. USGS scientists sampled a total of 38 streams nationwide in both urban and agricultural areas, and found that 63 percent of all streams contained at least one neonicotinoid insecticides. Imidacloprid was detected most frequently (in 37 percent of streams sampled) and was correlated with urban land use. Clothianidin, on the other hand, was found in 24 percent of streams sampled and was correlated with agricultural land use. Thiamethoxam was found in 21 percent of streams, and dinotefuran in 13 percent of streams sampled. While none of the concentrations exceeded the U.S. Environmental Protection Agency's limits for aquatic life, this study emphasizes the prevalence of low levels of neonicotinoid insecticides in our water sources, and the need to better understand the effects of low-level exposures on wildlife.

Agricultural pesticides contaminate water across the globe

Insecticidal pollution in global water ways receives little attention relative to other pollution sources. Now, a new meta-analysis published in the *Proceedings of the National Academy of the Sciences* has found that surface water pollution from agricultural pesticides "constitutes an excessive threat to aquatic biodiversity."

Researchers synthesized 838 peer-reviewed studies to evaluate the level to which surface waters worldwide were contaminated with toxic agricultural insecticides. Information on surface water contamination from more than 2,500 sites in 73 different countries was gathered to determine if the measured concentrations of insecticides exceeded the legally accepted threshold levels. Analyses showed that in the majority of water samples measured, insecticides were not detected. However, there was no scientific data for almost 90% of surface waters from areas of high agricultural intensity. Of the sites that did test positive for pesticides, more than half exceeded the legally acceptable levels of pesticide contamination. Even more surprising was that highly contaminated waters were present even in the countries with the strongest environmental regulations, with newer insecticides such as pyrethroids accounting for a larger amount of current pesticide contamination. "Reforming conventional agricultural systems and adopting promising approaches from organic farming, including the elimination of pesticides wherever applicable, in concert with the closing of yield gaps on underperforming lands and precision agricultural techniques, are possible ways to meet the twin challenges of providing sufficient food for a growing human population and reversing the global environmental impacts of agrochemical-based high-intensity agriculture," the authors concluded.

Coated seeds drive use of neonicotinoid insecticides

A new study published in the journal *Environmental Science and Technology* has found that neonicotinoid use is increasing rapidly in the United States. Scientists analyzed publicly available data in order to understand how neonicotinoid use has been changing since they first came on the market in 1994. This analysis is unique because unlike the national pesticide survey that estimates and interprets trends in pesticide use, it included data on neonicotinoid-coated seeds which are typically omitted from other pesticide use analyses. The results show that neonicotinoid use began dramatically increasing in 2003 when seed treatments for maize, soybean, wheat and cotton became available. Not surprisingly, they also show that when insecticides from coated seeds are included in the analysis, actual neonicotinoid use in the United States is much higher than had been previously calculated. The widespread use of neonicotinoid-coated seeds "may have unintended consequences, namely resistance in target pests, outbreaks of non-target pests, and pollution with detrimental effects cascading to wildlife," the study notes.

Antibiotics

ORGANIC CENTER FEATURED PROJECT
Production-Related Contaminants in Retail Milk

This research is dedicated to an urgent issue in human health and organic farming may likely provide the solution. Milk consumption in the United States is decreasing, a trend that is particularly worrisome in children whose diets are lacking in calcium and vitamin D. One factor thought to be driving this downward trend is consumer concern regarding the use of production enhancing hormones, pesticides, and antibiotics in the dairy industry. Scientists have hypothesized that exposure to recombinant bovine growth hormone (rBGH), a synthetic hormone, may play a role in causing early onset puberty in girls. Common pesticides have also been implicated as endocrine disruptors, and low-level antibiotic application can lead to development of resistance yet little research exists about what substances consumers are exposed to when they consume milk. This research will quantify the chemicals that consumers of conventional dairy milk are exposed to as well as the extent to which consumers can avoid these exposures by choosing organic. Bovine (cow) milk is an important source of calcium and other nutrients lacking in the diets of many children. It is also the only beverage, other than water, recommended in U.S. Dietary Guidelines. Milk consumption, however, has been decreasing in the U.S. and recent research suggests that increased concern about industry use of production-enhancing hormones and other chemicals, including pesticides and antibiotics, may be contributing to this trend. The use of these chemicals to produce foods commonly consumed by children is of particular concern. Many pesticides are known endocrine disrupters and over-use of antibiotics to enhance growth have led to the dangerous development of antibiotic resistant bacteria. The use of synthetic hormones such as recombinant bovine somatotropin (rbST) or growth hormone (rbGH), which are given to many dairy herds to promote milk production, may also lead to negative health outcomes in milk consumers. The scientific and medical communities have raised concerns that consumption of milk from cows treated with synthetic hormones may be involved in nationwide shift towards an earlier onset of puberty in girls. While federal regulations do require testing of milk for some pesticides and antibiotics, the General Accounting Office (GAO) recently called for FDA and USDA to strengthen their testing programs due to quality concerns. Furthermore, there are no known requirements for testing for the presence of synthetic hormones used in milk production. The Organic Center is collaborating with Dr. Jean Welsh of Emory University to conduct this first-of-its-kind study to determine the extent to which the residues of hormones, pesticides, and antibiotics used in bovine milk production can be detected in retail milk. Additionally we will determine if level of synthetic residues differ between organic and conventional milk. These results will provide much needed information about the risk of exposure to pesticides, antibiotics and hormones through consumption of conventional milk as well as the extent to which these exposures can be avoided by choosing organic dairy.

Pig livestock workers likely to carry antibiotic-resistant bacteria

A new study published in the journal *Clinical Infectious Diseases* has found that people who work with swine were more likely to be carriers of multi-drug resistant bacteria, *Staphylococcus aureus*. In the research, 1,342 Iowans were tested for *S. aureus* in their nose, throat and on their skin. They found that swine livestock workers were six times more likely to be carriers of the drug-resistant bacteria than farmworkers who did not have contact with swine.

Antibiotics and antibiotic-resistant bacteria air-borne from feedlots

The rise of antibiotic-resistant bacteria is commonly attributed to the overuse of antibiotics in livestock. Antibiotics are fed to livestock at low levels on a regular basis to enhance growth. They then enter the environment via animal urine, which eventually makes its way through soils and into waterways. Once antibiotics are present in the environment, they can lead to even more antibiotic resistance in bacteria. A new study has now demonstrated that antibiotics are dispersed into the environment via air, as are antibiotic-resistant bacteria from feed-lots, increasing chances of human exposure through inhalation. Particulate matter was collected from feedlots, with air samples collected upwind and downwind. Samples were tested for the presence of antibiotics and for antibiotic-resistant bacteria. Results showed that all samples collected downwind of feedlots contained significantly more antibiotics and antibiotic-resistant bacteria, including some that are known to infect humans. “There is significant potential for widespread distribution of antibiotics, bacteria, and genetic material that encodes antibiotic resistance via airborne particulate matter as a result of the large particles released daily from bed cattle feed yards in the Central Plains of the United States,” the authors concluded.

ENVIRONMENT

Pollinators

Large-scale study correlates neonicotinoid use with honeybee decline

FEATURED

A recent study published in *Scientific Reports* has investigated the link between neonicotinoid use in oil rape fields and pollinator mortality in England and Wales. Oil rapeseed is typically planted using neonicotinoid-coated seeds, is the most commonly planted oilseed in Europe, and is mass flowering, which makes it extremely attractive to honeybees and other pollinators. By combining large data sets with five years of data on pesticide usage and over 11 years of bee health observations, researchers correlated the increase in the use of the neonicotinoid imidacloprid with honey bee colony losses. If this correlation is the result of a causal link, then honey bees are likely being exposed to imidacloprid while foraging on nectar and pollen from flowering rapeseed fields. The study also demonstrated that the use of seed coated neonicotinoids has reduced the use of additional foliar sprays, highlighting the trade-offs between the benefits of neonicotinoids for farmers and negative effects on bees.

Exposure to very low levels of neonicotinoids negatively affects bumblebee brains

A recent study published in the journal of *the Federation of American Societies for Experimental Biology* has found further support that exposure to very low levels of neonicotinoid pesticides, comparable to what is found in nectar and pollen from neonicotinoid-treated crops, is sufficient to harm bees. Researchers carried out a combination of laboratory and field studies in order to determine the effect that very low exposures to neonicotinoid pesticides had on bumblebee brains and hive health. In laboratory tests, bees were fed 2.1 parts per billion of pesticides in sugar water. The bee's brains were monitored, and scientists observed that within three days, the pesticides had accumulated in the brain enough to negatively affect the mitochondria, the primary source of cellular energy. This disruption to brain cells is enough to impair brain function, leading to learning and recognition problems that ultimately hurt the health of the hive. They then fed these low levels of neonicotinoids to bees in hives placed on undisturbed land where they would not have access to floral resources with additional pesticide contamination. They found that in these hives, the size of the colony was reduced by half; the number of brood cells fell by over 70 percent, and the mass of the bee nest declined by over 50 percent.

Three neonicotinoids pose a 'high risk' to bee populations

In a recent report from the European Food Safety Authority (EFSA), the neonicotinoids clothianidin, imidacloprid and thiamethoxam were deemed to pose a high risk to bees when applied as foliar sprays. In a statement, EFSA said, "The protection of bees and the protection of pollinators are one of the essential elements that we consider in the risk assessment of pesticides" This conclusion is consistent with previous reports released by EFSA.

Low levels of glyphosate affect honeybees
A study published in *Experimental Journal of Biology* suggests that exposure to low levels of the herbicide glyphosate—the active ingredient in Roundup™—may negatively affect honeybees. Researchers fed honeybees sugar water with one of three low concentrations of glyphosate, all considered to be below the lethal level, and then tracked their flight path home through an open field. They found that the bees fed the highest of the three sub-lethal doses flew back to their hives slower and took more indirect routes than bees fed the lower doses. Bees were then released a second time. After the second release, control bees had learned the route home and returned to the hive directly whereas bees fed glyphosate continued to take indirect routes. The authors conclude, "These results suggest that, in honeybees, exposure to glyphosate doses commonly found in agricultural settings impairs the cognitive capacities needed to retrieve and integrate spatial information for a successful return to the hive. Therefore, honeybee navigation is affected by ingesting traces of the most widely used herbicide worldwide, with potential long-term negative consequences for colony-foraging success."

Native habitat can protect native bees from the harmful effects of pesticides
Numerous studies have documented the role of habitat loss due to agricultural intensification in driving wild bee population declines. However, little is known regarding the effects of on-farm pesticide use on wild bee populations. Now, a study published in *Proceedings of the Royal Society Biology* has found that pesticide use is directly correlated with declines in native bee populations, but that the presence of native habitat in close proximity to farms may safeguard wild bees from the negative effects of pesticide use. Additionally, the use of agrochemicals typically considered safe for bees—such as fungicides—contributed to the harmful effects. Researchers surveyed wild bee communities in apple orchards with varying amounts of surrounding natural area. They found that as pesticide usage increased, the number and abundance of wild bees decreased. Thus, even agrochemicals considered very low risk to bees had a negative impact when exposure levels were high. Conversely, the authors also found a correlation between the amount of native habitat surrounding farms and the number of wild bee species and their prevalence. As the amount of natural habitat increased, the abundance and richness of native bees also increased, suggesting that an increase in natural area provides wild bees with alternative food and nesting resources, buffering them from the negative effects of pesticide exposure.

"Benign" fungicides negatively affect bumble bees
While pesticides have been known to harm bees, fungicides have generally been considered safe. However, now a study published in the scientific journal *Insects* has demonstrated that exposure to fungicides decreases the overall well-being of bumble bee colonies and puts the next generation at risk for survival. In the study, researchers housed bumble bees in mesh cages in oat fields where they were observed for 29 days. The fungicide, Chlorothalonil, was applied twice over the course of the study on day 0 and day 13. Five colonies were treated with the fungicide and five were used as control

groups. Results showed that the colonies exposed to the fungicide treatments produced less than a third as many workers as the control group, had a biomass less than half of the amount of the controls, and the queen bee only had half the body mass of the control queens. The success of a bee colony depends on the capacity of worker bees to forage and collect nectar as well as take care of the queen. However, with fewer and less efficient forager, the queen suffers, leading to a decline in the overall health of the colony. Results from this study suggest that fungicides are not as benign to bumble bees as previously assumed and should be tested further to determine the lasting impacts on bee colony health.

Low bumblebee diversity in hedgerows next to conventional farms

A recent study published in the *Journal of Insect Conservation* has found that agrochemical use in conventionally farmed fields decreases the benefit of hedgerows to bumblebees. Hedgerows, which are often planted alongside fields and roads, are thought to benefit bee pollinators by serving as bee habitat and by increasing the diversity of flowering plants available for bees to feed on. In order to determine the effects of agrochemical drift from conventional fields on bees in hedgerows, scientists compared the number of bee species and their abundance among 15 hedgerows placed along conventionally farmed arable fields and 15 hedgerows along roads. Findings showed the number of bumblebees foraging in hedgerows alongside roads was two times greater than the number of bumblebees foraging in field hedgerows. They also found that the number of flowering plant species and number of flowers were greater in hedgerows alongside roads than they were in field hedgerows. The authors suspect that agrochemical drift onto hedgerows from the arable fields are driving this result. Insecticide drift from fields could lead to bee deaths, leading to lower abundance and richness of bees in field hedgerows. Also, fertilizer drift from fields could allow fast-growing weeds to crowd out slower-growing plants leading to fewer flowering plants in field hedgerows. "Our results underscore the view that by virtue of reduced agrochemical inputs (and noting that our design eliminates the potentially confounding impacts of crop yield identified by Gabriel et al. [2013]), organic farming could benefit the floral abundance of arable field margins and so promote forage availability for pollinators," the authors wrote.

Wings of honey bees are an exposure site to pesticides

The toxicity of pesticides to honey bees is determined by the harm they cause to bees when they come in contact with the thorax (the segment of the body where the legs and wings are connected). However, no study has investigated bee wings as a pesticide exposure route. Now, a study published in *Environmental Toxicology and Chemistry* has found that pesticide contact with wings can also lead to honey bee death. Six different pesticides, including three neonicotinoid pesticides and three pyrethroid pesticides, were applied to bee wings at different dosages to determine the effects. The results showed that when each of the pesticides was only applied to the wings honey bee, mortality was similar to the mortality levels observed when the pesticides were applied to the thorax. The authors suspect that this is because the pesticides were transported through the body rapidly by the numerous blood vessels found in the wings. This study is one of the first to

suggest that honey bee wings may represent an important site for pesticide exposure, and should be taken in account in future pesticide risk assessments.

Bees prefer neonicotinoid-laced food

A new study published in the scientific journal *Nature* suggests that bees may be addicted to neonicotinoid pollen. Researchers offered honey bees and bumblebees food with concentrations of imidacloprid, thiamethoxam, and clothianidin—the three most commonly used neonicotinoids—as well as insecticide- free food. Bees consistently chose to consume food containing imidacloprid or thiamethoxam over the insecticide-free food. Further analysis indicated that bees could not taste the neonicotinoids in the laced food, suggesting that similar to the addictive affects of nicotine, neonicotinoids may drive bees to consume more of the pesticide-contaminated food than they normally would. If foraging bees "prefer to collect nectar containing imidacloprid and thiamethoxam, they will also bring more neonicotinoid-laced food back to the colony. For these reasons, whole colonies could be exposed to higher levels of these pesticides in the field than had been predicted previously. Thus, mitigation strategies that rely on planting alternative sources of nectar and pollen might not be enough to decrease the risk of poisoning pollinators with pesticides. Instead, long-term changes to policy that include reducing their use may be the only certain means of halting pollinator population decline," scientists wrote.

Neonicotinoid-coated seeds are bad for wild bees

While a large number of studies have documented the detrimental effects that neonicotinoid pesticides have on honey bees, relatively few studies have focused on how they may affect wild bees. Now, a new study published in the journal *Nature* has shown that the use of neonicotinoid-coated seeds is detrimental to wild bee populations. Researchers used eight pairs of fields, one field in each pair was sown with neonicotinoid-coated oilseed rape seeds and the other pair was sown with seeds coated only with fungicide. They then compared the density of wild bees, the nesting activity of a native solitary bee, the colony development of the bumblebee and the strength of honey bee colonies between each paired field. The study yielded four primary results. (1) There was a decline in the density of bumblebees, and solitary bees in fields where neonicotinoid-coated seeds were planted. (2) Use of neonicotinoid-coated seeds was correlated with reduced nesting in solitary bees. (3) Bumblebee reproduction and colony growth declined in fields where neonicotinoid seeds were planted, and (4) The use of neonicotinoid- coated seeds did not significantly affect the strength of European honeybees. These results suggest that simply using honey bees in environmental risk assessments of neonicotinoids may not accurately reflect the risk to other bee species. The authors conclude that the use of insecticide-coated seeds "can pose a substantial risk to wild bees in agricultural landscapes, and the contribution of pesticides to the global decline of wild bees may have been underestimated."

Effect of chronic field-realistic exposure to the neonicotinoid, Imidacloprid, on honeybee colony health.
A new study published by *PLOS One* shows that the neonicotinoid pesticide, imidacloprid, can have subtle negative effects on bee health. The study, conducted by Researchers from the University of Maryland and USDA-ARS conducted a three-year study to determine how imidacloprid levels within hives changed over time and how chronic low-level exposure to the neonicotinoid, imidacloprid effected honeybee colonies over time. Beehives in the field were fed bee food containing 5, 20, and 100 μg/kg of imidacloprid and then monitored for short term and long term colony performance. Samples were also taken from within the hive to test for pesticide residues. Researchers found that long-term colony survival rates decreased as the pesticide concentration increased and that colonies exposed to higher levels of pesticides had higher pesticide residues in their hives. Overall the study demonstrated that that while low level doses of imidacloprid were not likely to be the sole cause of bee declines, chronic, sub-lethal exposure to neonicotinoids at high field-realistic levels has negative impacts on hive health.

Neonicotinoid pesticides and parasites together negatively affect bumble bees
As bee populations decline, scientists are directing their research to understand what factors are negatively affecting bee health and what can be done to help them. Because of the large role that the European domestic honey bee plays in crop pollination, particularly on expansive farms, the majority of research has been focused on managed colonies. However, native bees, which also contribute important pollination services to our crops and wild plants, are also experiencing declines. Now, a recent study published in *Journal of Applied Ecology* has found that neonicotinoid pesticides and parasitic infections are negatively affecting the bumble bee. Researchers exposed bees to different combinations of the neonicotinoid pesticides thiamethoxam and clothianidin and to a gut parasite to understand how they affected bumble bees individually and in combination. They found that exposure to the pesticides reduced the productivity of workers, was linked to earlier worker bee mortality, and decreased the overall productivity of the entire hive. Even more striking was researchers showed that parasitic infection combined with pesticide exposure significantly reduced the survival ability of the queen bee. These results confirm previous findings that demonstrate the detrimental effects of neonicotinoid exposure to bees, and further show that the effects may be magnified when pesticide exposure is combined with environmental stressors such as parasitic infections

Soil Health

ORGANIC CENTER FEATURED PROJECT
Soil Health in Organic Farms

Directed by Principal Research Scientist Elham Ghabbour and Professor Geoffrey Davies, the National Soil Project (NSP) at Northeastern University is collaborating with The Organic Center to examine some of the benefits organic agriculture may have on soil health. We are also working with the Rodale Institute and OFRF on soil health communication. Specifically, this project will quantify the amount of sequestered carbon in organic farm top soil samples for comparison with corresponding conventional samples to determine differences in levels of humic acids (HA), fulvic acids (FA), and humin (HU) in the soils. These efforts will result in a reference database that will enable agronomists, farmers and environmental scientists to correlate soil health and productivity with agricultural practices, which will be an essential tool for maintaining and improving the quality of our nation's soil through organic farming.

Healthy, productive soils are a treasured resource that we often take for granted. Long-lived HA, FA and HU represent the sequestered carbon content of a soil. They are components of the microbially-resistant soil organic matter (OM), and are essential because they help to retain water, act as soil buffers, improve soil texture/permeability, regulate our climate, and support many other healthy soil functions. Unfortunately, soil OM is under threat: massive quantities of mineral fertilizers used in conventional farming destroy OM, degrade the land and additionally pollute the water by run-off. The long-term health of the soil is jeopardized by this widespread soil management practice, emphasizing the importance of organic management for the long-term health of soils.

The primary objective of this project is to collect and analyze organic farm top soils from all 50 US States for comparison with conventional samples. Our secondary objectives include continuing to educate the public at large about the equal importance of safe air, soil and water, introducing our conventional and organic soil database as a reference tool to relevant organizations, and developing standards for regulation of commercial humic products and arable land assessment. We anticipate that the results of our efforts will be significant in academia and in their practical application in organic farming. The NSP database will be an invaluable tool for scientific investigations, including the study of relationships between OM, HA, FA and dissolved organic carbon contents, and for modeling the global carbon cycle. Furthermore, our data will be directly useful to organic farmers, who rely on soil quality, through bench-marking that will facilitate remediation, maintenance and conservation of soil resources. Additionally, HA measurements are important for the regulation of errant soil remediation products that are now on the market.

Long-term study confirms benefits of organic farming for soil organisms

FEATURED

A recent study published in *Agronomy for Sustainable Development* has confirmed that organic farming is beneficial for soil organisms. The study compared soil organisms among fields that had been managed using different farming practices for 14 years as part of a long-term study. The study fields were managed conventionally, organically, or using conservation agriculture techniques. Conventional plots utilized synthetic pesticides and fertilizers to maximize yield. Organic plots were managed using non-synthetic pesticides and fertilized with green manure. Weeds were managed by tilling the soil. Conservation systems did not till the soil, used grass cover crop and only used minimal organic-based pesticides when necessary. Scientists quantified soil chemistry, microbial communities, and communities of larger animals that live in the soil such as earthworms, beetles and nematodes. "Long-term conservation and organic alternative cropping systems improved the abundance and/or biomass of soil biota and altered the structure of the soil food web compared to a conventional system," the study reported. Abundances of larger soil animals increased from 100 to 2,500% and microorganisms increased from 30 to 70% over the conventional field with conservation agriculture demonstrating the healthiest and most diverse soils.

Organic management in apple orchards increases beneficial fungal diversity in soils

Arbuscular mycorrhizal fungi (AMF) live in cooperative relationship with many plants. Living in the soil with plant roots, they obtain sugars from the plant and, in return, bring minerals and nutrients from the soil to the plant's roots and protect the plant from root pathogens and predators found in the soil. Because of the great services they provide plants, they are considered an essential part of a healthy soil ecosystem and of great benefit to the health of crop plants. While variations in agricultural soils affect the abundance of AMF, very few studies have disentangled these factors with the importance of farming practices, and geographic variation in driving AMF abundances. In order to address this question, a recent study published in *Molecular Ecology* set out to (1) identify AMF in the roots of orchard apples and (2) determine the role of soil chemical properties, management type (organic vs. conventional) and geographic location in driving AMF diversity. Researchers sequenced the DNA of 120 apple tree roots from 24 orchards to determine the number and abundance of AMF in their roots, and then compared those results with soil, management, and geographic factors for each orchard. They found that soil characteristics and farming system were most important in shaping AMF communities. Organically managed orchards had higher AMF diversity than conventionally managed orchards and AMF diversity declined as soil fertilization increased. The authors concluded that "a combination of organic orchard management and moderate fertilization may preserve diverse AMF communities on apple trees."

Microbial communities in organic soils suppress pathogens

Organic soils support much higher levels of biodiversity than conventional soils. It has been hypothesized that this abundance of 'good' soil organisms works to suppress soil pathogens such as fungi or bacteria that attack plant roots. A recent study published in the journal *Applied Soil Ecology* tested to see whether the soil pathogen flax wilt was

suppressed more in organic soils than conventional soils. Three sets of organic and conventional soils were collected from the field, and a wide range of physical, chemical and biological properties were measured. Comparisons included, but were not limited to, the soil's ability to hold water, total carbon, total nitrogen, pH, microbial biomass, and number of bacterial species. Flax plants were then planted in the soils and inoculated with the flax wilt pathogen. All soils were then disturbed by adding grass and clover. Researchers found that the microbial communities in organic soils were much more resilient, allowing them to more effectively suppress the flax wilt than microbial communities in conventional soils. These results corroborate the hypothesis that healthier, more resilient soil microbial communities commonly found in organic soils are important for pathogen suppression and key measures of soil health.

Organic agriculture and soil health

A study published in the journal *Sustainable Agriculture Research* supports previous findings that organic agricultural practices improve soil health by increasing and improving microorganism activity, nutrient availability and soil structure. Organic practices restrict the use of synthetic chemicals for pest control and fertilization, instead using techniques that incorporate organic matter such as manure or compost into soil. These practices help control excess nitrogen and phosphorus, and stimulate the growth and activity of beneficial soil organisms. Because the soil's overall health is dependent on a combination of biological, chemical, and physical properties such as the presence of microorganisms, nutrient availability, and the size of soil particles soil management must be a holistic process taking into account many variables.

Organic farming increases soil health and plant nutrients

A new study published in *Organic Agriculture* has found that peach and apple orchards grown under organic management have healthier soils, and plant tissues have more nutrients. Soil samples and leaf samples were collected from peach and apple orchards grown under conventional and organic agriculture for comparison. Results demonstrated higher levels of active fungi bacteria and nutrients in the organic orchard soil, and apples and oranges grown organically had higher levels of phosphorus and copper in their leaf tissues. "Organic fruit production practices harbored both greater microbial activity and higher concentrations of some plant and soil nutrients, and are anticipated to promote better soil health and productivity than conventional practices," the authors concluded.

Biodiversity

FEATURED

Organic methods support higher levels of biodiversity

A new study has shown that the number and abundance of beneficial predatory insects and spiders are higher both on organically farmed land as well as their surrounding non-agricultural land when compared to conventional farms and their surrounding land. Researchers surveyed spiders and beneficial beetles on six organic and six conventional vineyards in Italy. They found that in general the diversity of beneficial insects and spiders was greater on organic vineyards and in the forest patches adjacent to them, suggesting that the beneficial effects of organic farming methods reach beyond the farm. As a result, the authors recommended that organic agricultural systems "should take priority."

FEATURED

Organic farming enhances the diversity of beneficial predatory insects

A new study in the *Journal of Applied Ecology* has found that tachinid parasitoids, a group of flies that prey on crop pests, are positively affected by organic farming. Scientists set out to investigate the effect that organic farming had on parasitoid populations at different landscape scales. They compared the abundance and number of species of parasitoids at the local scale by comparing nearby organic and conventional farms. They examined how farming method affected parasitoid diversity the larger landscape scale by comparing the abundance and species diversity of parasitoids over large swaths of land that contained different proportions of organic and conventionally farmed land. The results suggest that organic farming boosts the diversity of tachinid parasitoids at both the local and landscape level for arable lands. Organic farms had both higher abundance and species richness of parasitoids than conventional farms, and landscapes that had a higher proportion of organic land also had higher parasitoid diversity. "To restore parasitoid diversity, the promotion of organic agriculture should aim to increase both the total extent of organic farming and the connectivity of individual farms. As the benefits of organic farming to biodiversity clearly spread beyond individual farm boundaries, any assessment of organic farming should consider these positive externalities," the authors concluded.

Organic rice cultivation supports aquatic biodiversity

A recent study published in *Basic and Applied Ecology* sought to understand how the use of agrochemicals, water management and mechanization in conventional rice fields affected biodiversity and whether organic rice cultivation techniques could provide a solution. For the study, researchers sampled species richness and abundance in conventional and organic rice fields as well as natural ponds, with the latter expected to have the highest diversity because they provide undisturbed habitat. Biodiversity from all three habitats were compared from four of each type of habitat. As expected, findings showed natural ponds exhibited the highest levels of biodiversity. Although conventional and organic rice fields did not significantly differ from each other in the number of different species sampled, many of the species collected from organic rice fields were only found in natural ponds and not in conventional rice fields suggesting that organic

rice fields supported a more natural assemblage of organisms. Furthermore, the macroinvertebrates typically found in ponds and organic rice fields but not conventional rice fields were natural predators. "Our results should be seen as an incentive for sustainable production with less impact on the environment," the authors wrote.

Organic farming supports habitat specialist mammals

Mammals play an important role in agricultural systems, yet very few studies have examined the influence that organic and conventional farming systems have on small mammal richness and diversity. Now, a study published in *Agriculture, Ecosystems and Environment* has found that the abundance of small mammals that are habitat specialists is greater on organic farms than conventional farms. Argentinian researchers set small mammal traps to compare the small mammal communities between multiple pairs of organic and conventional farms. They found that organic farms had an increased abundance of habitat specialist species. "Considering the important positive role that small mammals have on food webs in agricultural systems, the maintenance of high population numbers may be important for biodiversity conservation," the authors wrote. While many studies have demonstrated that organic farms host higher diversity of soil microorganisms, beneficial insect predators, pollinators and birds, this study suggests that organic farming systems may also have an important role to play in biodiversity conservation of mammals.

Density of pest insects determines harm from neonicotinoids to beneficial predators

Neonicotinoid pesticides have been criticized for the harm they may cause to non-herbivore insects such as bees. Now, a growing body of literature suggests that their use may also indirectly harm beneficial insects that prey on insect pests. One recent study published in the scientific journal *Crop Protection* found that when wheat was treated with neonicotinoids, lady beetles—which are predators to aphids—were negatively impacted, and to what extent depended on the density of the aphids on the wheat plant. Two experiments were performed. In the first experiment, wheat plants were treated with high and low dose drenching of thiamethoxam and then used to rear aphids for 24 hours. These aphids were then fed to their natural predator, the ladybeetle larvae. Young ladybeetle larvae at the second instar had significantly higher mortality after eating aphids reared on neonicotinoid-treated wheat than those that consumed aphids from untreated wheat. In the second experiment, researchers fed ladybeetle larvae aphids that were feeding on neonicotinoid wheat in different densities. They found that when there were fewer aphids feeding on a single wheat plant, each aphid consumed a greater amount of pesticide. When the density of aphids per plant increased, the amount of pesticide present in each aphid decreased. Accordingly, ladybeetle second instar larva consuming aphids that had been feeding in low densities were most negatively affected, exhibiting slower walking speeds than the instar larvae that consumed aphids feeding at high densities. More studies are needed to determine if these interactions occur in the field, but future non-target risk assessments should include potential harm to beneficial insects.

Exposure to sub-lethal levels of insecticide alters behavior of jumping spiders
A new study published in the journal *Functional Ecology* demonstrates that low-level exposure to organophosphate insecticides can alter the individual behavior of jumping spiders, an important beneficial predator in agricultural systems. Young jumping spiders were collected from orchards and raised in the laboratory. Spiders' behaviors including hunting ability were quantified before and after exposure to the organophosphate insecticide phosmet. Repeatability or the consistency of behavior in a particular scenario for individual spiders was also measured for spiders exposed to the insecticide and those that were not. While exposure to low levels of the insecticide did not change the average behavior between spiders that were exposed and the control group, there was a significant change in the behavior of individual spiders after exposure, with repeatability decreasing by 23% and different behavioral traits altered between male and female spiders.

Increased biodiversity reduces pest problems on farms
A new study published in *Science Advances* has found that farming practices that promote biodiversity also increase natural pest control on farms by increasing the number of beneficial predators that attack crop pests. Researchers compared insect diversity on 53 cornfields in South Dakota. They found that farms that had more insect species that were abundant and evenly distributed across the farm also had fewer pest problems, suggesting that adopting methods that benefit biodiversity on farms is not only more environmentally friendly and sustainable but also increases benefits to farmers such as pest control, which can increase profits.

Farming method more important for farm biodiversity than landscape
A recent study published in the journal *Landscape Ecology* has found that using organic methods is more important in determining the amount of beneficial predator insects on farms than having diverse landscapes. Scientists compared the effects of landscape composition, habitat quality related to organic and conventional farming, and other characteristics such as hedgerows to determine the diversity of aphid natural enemies using a modeling approach. Forty pairs of organic and conventional winter wheat fields were sampled for ladybirds, carabid beetles, and parasitoids—all aphid predators. The data were then included in a model accounting for farming method, landscape heterogeneity, and natural elements such as hedgerows. Researchers determined that using organic methods was most important in determining whether or not farms had high beneficial insect diversity because they also had high habitat quality. "Organic farmers implement assemblages of practices, which are generally less disruptive than those of conventional farmers, especially because of the lack of synthetic pesticides. In our study, these practices were associated to a more abundant and diversified vegetation (due to weeds and wheat), creating a favorable microclimate and offering resources (e.g., alternative food) to insects," the researchers noted.

Flame retardant Dechlorane Plus accumulation in birds
A new study published in the journal *Science of the Total Environment* has found that the flame retardant Dechlorane Plus (DP) is accumulating in birds. DP is a flame retardant

added to hard plastics used in electrical equipment such as computer monitors and television. It was developed as an alternative to an older flame retardant banned in the 1970s and is being considered to replace another flame retardant recently banned due to its toxicity to humans and persistence in the environment. However, the fact that DP does not bind to plastics raises concerns that it may easily contaminate the environment, creating a health hazard for humans and wildlife. Researchers measured DP levels in the tissues of seven different bird species collected in the Shimentai National Nature Reserve in South China. DP was found in all birds tested. However, levels were higher in birds that exclusively eat insects than in birds that eat both insects and plants. This result suggests that DP is a bio-accumulator. Instead of breaking down over time, it accumulates in the tissues of animals that consume it. Insectivorous birds are at risk for high levels of exposure when they consume insects with high levels of DP in their tissues. Not surprisingly, researchers also found that birds collected in urban areas that were close to electronic waste sites also had higher levels of DP flame retardant in their tissues.

Organic farms increase biodiversity on nearby conventional farms

Many studies have demonstrated that organic farms harbor higher biodiversity than conventional farms. However, until now, few studies have examined whether the presence of organic farms influences the amount of biodiversity on surrounding conventional farms. A recent study, published in the *Proceedings of the Royal Society of London B – Biological Sciences*, has shown that plant biodiversity in conventional farming fields increases when organically farmed fields are present in the surrounding landscape. Researchers sampled weed species in 465 French wheat fields in which included organically and conventionally managed fields. Samples were collected over a four-year period and were taken from the field core (center of the crop) and field margin (the land between the field border and first row of crops). The study found that similar to previous studies, organic farming fields harbored higher weed diversity than conventional farms and that diversity was higher in field margins rather than the field core. They also found that when organic farms were in the landscape, conventional farms were more likely to have higher levels of weed diversity—suggesting that the benefit of having an organic farm nearby, outweighed the negative effects of conventional farming methods, such as herbicide applications, on weed diversity. Because wild plants provide food and habitat for beneficial insects, pollinators and other animals, maintaining weed diversity is important for all biodiversity. While organic farms provide the most benefit to biodiversity, the presence of even some organic farms among conventional farms benefits biodiversity across the entire landscape.

Frogs and their wetland habitats in Iowa are contaminated with agricultural pesticides

Amphibian populations in the United States and around the world have been declining due to habitat degradation and loss. Now, a new study, published in *Science of the Total Environment*, has found that frogs found in Iowa wetlands are accumulating a large number of different pesticides in their tissues, including up to eight different fungicides, the largest number reported to date. Researchers compared restored wetlands and existing

wetlands for agricultural nutrient and pesticide content in the water, sediments and in the tissues of leopard and chorus frogs, two common amphibians. Thirty two different pesticides and products from pesticide break-down were detected across all of the wetlands sampled, with the herbicide atrazine the most frequently present and with the highest concentrations. Seventeen pesticides composed of eight fungicides, four herbicides, and five insecticides were detected in frog tissues. These results are particularly concerning because they demonstrate the extent of our water contamination. Amphibians are particularly sensitive to environmental toxins, and even low doses of agricultural chemicals have been shown to directly impact amphibian health. For example, atrazine—the most commonly detected herbicide in this study—negatively impacts reproduction, physiology, physical characteristics, and behavior in frogs. Additionally, pesticide exposure and disease outbreaks in amphibian populations are highly correlated.

Nanomaterials interact with agricultural pesticides, increasing toxicity to fish

Fish populations are exposed to a large number of environmental pollutants that run off from agricultural, industrial and urban land. As technology progresses, so do the number of new pollutants in our environment. A new study published in *Ecotoxicology and Environmental Safety* has found that carbon nanotubes—a type of nanomaterial used for cleaning purification in aquaculture operations—may interact with pesticides, increasing the toxic effects to exposed fish. Scientists exposed Nile tilapia to small doses of carbon nanotubes, the pesticide carbofuran and combinations of the two. They found that the exposure to the carbon nanotubes alone did not result in toxicity, but that when fish were exposed to both carbon nanotubes and carbofuran together, the toxicity of carbofuran increased five times and the fish experienced decreases in oxygen consumption and swimming capacity. The authors suggest that the observed result is because nanotubes are likely acting as pesticide carriers, increasing the exposure and accumulation of these chemicals in fish.

Organic crop farming results in less nitrogen loss than conventional crop farming

A recent study published in *Agriculture, Ecosystems and Environment* has found that organic cropping systems have less nitrogen pollution than conventional cropping systems. Nitrogen pollution occurs in agricultural systems when excess nitrates contaminate groundwater or when the greenhouse gas nitrous oxide is released into the air after fertilizer applications. To determine the extent of nitrogen pollution from these different farming systems, researchers selected five organic and two conventional fields for comparison over a three-year period. Nitrate leaching from the soil was measured by collecting water in buried ceramic cups. The nitrate levels in the collected cups represent the amount of nitrogen left in the water after they passed the depth of plant roots and would likely remain unchanged as it entered the groundwater supply. Nitrous oxide emissions were measured by taking air samples during hours of farm operation. Levels of nitrogen pollution were analyzed and scaled based on the area and yield of each farming system. While nitrogen pollution varied from year to year based on such factors as changes in climate, the overall results showed that when scaled by yield—a more

conservative estimate as organic farms typically have lower crop yields than conventional farms, nitrate leaching was still 9% lower in for organic farms and nitrate emissions were 14% lower.

Long-term studies support benefits of organic farming

A new paper published in the journal *Sustainable Agriculture Research* examines results from six of the oldest grain crop-based experiments comparing organic and conventional farming methods with the goal of communicating both the benefit of long-term comparison trials and environmental and economic findings for organic agriculture. Although these long-term organic farming system experiments were established to gather baseline agricultural data, they have provided evidence suggesting that transition from organic to conventional agricultural production can be done successfully. Long-term experiments analyzed include the Farming Systems Trial conducted by the Rodale Institute, the Sustainable Ag Farming Systems at the University of California at Davis, the Variable Input Crop Management Systems at the University of Minnesota, the Wisconsin Integrated Cropping Systems Trials at the University of Wisconsin in Madison, the Beltsville farming systems project at USDA-ARS in Beltsville, and Long-term Agroecological Research at Iowa State University. All of the studies showed an increase in soil health, productivity, water quality, and economic benefits for farmers when they employed organic systems. "These results suggest that organic farming practices have the potential to reduce nitrate leaching, foster carbon sequestration, and allow farmers to remain competitive in the marketplace," the authors concluded.

Organic farming methods reduce water pollution

A recent study published in *Sustainable Agriculture Research* has found that organic farming methods can be used to reduce water pollution in U.S waterways. The leaching of nitrate from farming soil into water drainage systems is a major source of water pollution in the upper Midwestern states. In attempt to reduce the environmental impacts associated with heavy fertilizer use in conventional agriculture, some producers have begun to investigate organic methods. To determine the true impact organic farming practices have on water quality, USDA initiated a long-term study in 2011. For three years, data were collected to compare nitrate pollution from plots with organic and conventional crop rotations as well as organic pastureland. Researchers found that nitrate loss via water in the conventional cropping systems was twice as high as nitrate loss from the organic cropping system, and that the organic pasture system lost the least amount of nitrate. "Results of this study suggest that organic farming practices such as the application of composted animal manure and the use of forage legumes and green manures with extended cropping rotations, can improve water quality in Midwestern subsurface-drained landscapes," the authors concluded.

GMOs

Genetically engineered rice may make weeds stronger
A recent study published in the journal New Phytologist has demonstrated that genetically engineered crops may pass on extra benefits to nearby weeds. Scientists bred domesticated rice plants with wild weedy relatives of rice. They compared the growth rate and reproductive success of two types of rice hybrids. One hybrid type was created by breeding rice genetically engineered to be resistant to glyphosate with wild weedy rice relatives. A second hybrid type was created by breeding non-GE rice with wild weedy rice relatives. When the GE and non-GE hybrids were grown together, the GE hybrids grew larger and produced more seeds than the non-GE hybrids. This is the first study to demonstrate that the accidental escape of genes from genetically modified plants may lead to more aggressive weeds—even when glyphosate is not used.

Climate Change

Organic farming can help mitigate climate change
Agriculture accounts for 35% of greenhouse gas emissions worldwide, but a new study supports the idea that conversion to organic agriculture may be a climate-change solution. A recent study published in *Science Bulletin* supports previous research by showing that organic farming methods could mitigate climate change by sequestering carbon in the soil and decreasing greenhouse gas emissions. Researchers found that practices such as replacing chemical fertilizers with organic manure and using crop residues as forage for cattle significantly reduced greenhouse gas emissions and increased storage of carbon in the soils. “Solely utilizing chemical fertilizer on the farmland not only led to increased greenhouse gas emissions, but also deteriorated the quality of the soil,” according to the findings.

SUSTAINABILITY

ORGANIC CENTER FEATURED PROJECT
Coming Soon - Net Positives of Organic Production

The Organic Center is pleased to announce the launch of a project in collaboration with the Sustainability and Health Initiative for NetPositive Enterprise (SHINE) at the Harvard School of Public Health looking at the benefits of organic for the environment and human health. Traditional models of examining environmental and health effects focus on ways to decrease negative impacts, known as our environmental or health footprints. This project takes a different perspective: rather than looking at how organic decreases our footprints, it focuses on the benefits organic provides, known as our environmental or health handprint. By combining decreased footprints with increased handprints, this project will be able to identify the net positives of organic food and farming. The research team at Harvard will develop a life cycle analysis with a statistical model that analyzes Net Positives to examine a thorough compilation of data over the last few decades. They will focus their analyses on two areas: climate change and human health. These two areas are hot topics in the media, and top reasons that consumers choose organic. They also align with future policy decisions and Whitehouse action papers, so we will be able to get relevant science into the hands of policymakers as they develop critical decisions that organic might play a role in supporting.

FEATURED

Organic can feed the world sustainably

An article published in the scientific journal *Nature Plants* has found that organic farming has an important role to play in sustainably feeding an ever-growing global population. Researchers from Washington State University reviewed 100 studies to determine how organic farming measures up to conventional food production in terms of productivity, environmental impact, economic viability, and social well-being. They found that while organic agriculture does produce lower yields when compared to conventional agriculture, organic farms are more profitable, deliver more environmental benefits, and are healthier in terms of increased nutritional benefit and reduced dietary pesticide exposure than conventionally produced foods. Furthermore, they found that organic agriculture provides social benefits and contributes substantially to human health by reducing occupational hazards such as pesticide exposure. In spite of these benefits, the authors cite significant barriers to the adoption and growth of organic agriculture including lack of research funding to develop new tools and technologies for organic growers, economic barriers, lack of information, and difficulty in overcoming negative biases. “Organic agriculture has been able to provide jobs, be profitable, benefit the soil and environment, and support social interactions between farmers and consumers… The challenge facing policymakers is to create an enabling environment for scaling up organic and other innovative farming systems to move towards truly sustainable production

systems. This is no small task, but the consequences for food and ecosystem security could not be bigger. To make this happen will require mobilizing the full arsenal of effective policies, scientific and socioeconomic advances, farmer ingenuity and public engagement," the authors conclude.

Organic farming can simultaneously improve pest control and yield
A new study published in the journal *Landscape Ecology* sought to determine how farming type and landscape heterogeneity affect pests and their natural enemies and to understand how these changes influence yields. Researchers compared insect diversity on conventional farms, new organic farms and old organic farms and collected data on the amount of pasture and the length of field borders for each farm. They found that different pest species were affected differently by differing amounts of landscape complexity with some pest species and that some pest species, such as aphids, were reduced in organically farmed fields due to an increase in natural predators while others exhibited no change based on farming type. These results suggest that under organic farming, it is possible to reduce aphid pests and increase yields by supporting predator insect communities.

Organic management improves soil and yields
A new study published in the journal *Renewable Agriculture and Food Systems* has found that farms under organic soil management systems can produce yields equivalent to conventional management systems and those organic methods that incorporate residues into the soil improve the soil nutrients and reduce weeds. Researchers examined the use of crop residues in a corn-cabbage rotation system. They measured factors including yields, nutrient uptake, weed biomass and soil nutrients for both organic soil management practices and conventional soil management practices. They found that under organic management, weed biomass was lower by 22 – 47%, total soil nitrogen was higher by 7 – 4%, and yields did not significantly differ between the two management types.

Yield gap between organic and conventional farming lower than previously thought
A new study published in the Journal *Proceedings of the Royal Society Biology* has found that the yields of organic crops are higher than previously thought, particularly when organic farmers use environmentally friendly farming techniques. Researchers from the University of California, Berkeley, carried out the largest meta-analysis comparison of organic and conventional crop yields to date, synthesizing results from 115 studies with over 1,000 observations. By including this large body of data and using a more rigorous statistical methodology, this study found that the gap in yields between organic and conventional was lower than had previously been reported, and that some organic management practices (such as multi-cropping and crop rotations) can shrink that yield gap even further, reducing the yield gap from 19 percent to only 8 to 9 percent. Additionally, the study notes a bias in the direction of conventional agriculture in data from the literature comparing organic and conventional yields. This means that the yield gap reported by this study, which uses the most comprehensive available data, is probably overestimated and the true yields of organic are likely even greater. "The yield gap that we detected is actually surprisingly small when one considers the historic

underfunding of research in organic agricultural management and in breeding of seeds for organic conditions," said Professor Kremen, one the study's authors. "Coupled with our finding that crop rotation and multi-cropping (two practices that are well known to build soil fertility and health, reduce pest and diseases, and improve water use efficiency) improve the organic-to-conventional yield ratio, we suggest that additional agronomic research and breeding for organic could further reduce the remaining gap, leading to environmentally friendly and productive agriculture." The study authors conclude that "reducing the yield gap between organic and conventional agriculture (or more accurately, between biologically diversified versus chemically intensive farming systems) has the potential benefit of reducing the loss of biodiversity and ecosystem services often associated with conventional agricultural methods, and thus promoting a high-yielding agriculture that is relatively environmentally and wildlife-friendly compared with conventional systems."

GMO farming less profitable than conventional and traditional farming

A new study published in *Ecological Indicators* evaluated the costs, benefits, environmental performance and sustainability of different agricultural methods used in Argentina to produce maize over the last 25 years. The study assessed three different farming systems: traditional, conventional, and genetically modified organism (GMO) based farming within Argentina and compared those results to Mexico, Brazil, Italy, and the United States. Researchers found that GMO-based maize production did not improve sustainability or crop yield compared to conventional high cropping systems or low intensity systems. When production costs were taken into account, GMO-based systems were not as profitable as previously thought. GMO-based farming systems were also found to be less sustainable because they rely heavily on non-renewable resources, contributing negatively to the environment over time. A combination of traditional and conventional farming techniques would yield the same if not better results that GMO farming, and have fewer negative environmental impacts.

New study finds that organic farming pays

A new study published in the Proceedings of the National Academy of the Sciences shows that organic farming is more profitable to farmers than conventional farming. Scientists from Washington State University analyzed data from 44 previously published studies encompassing 55 different crops across 14 countries. To develop a more accurate picture of farm economics the authors also included data from different cropping systems in their analysis, recognizing that farmers income is often derived from multiple crops planted over several seasons. They found that even though organic farming typically results in a lower yields than conventional farming, the premium that organic farmers receive for their products makes organic 22 -35% more profitable. The authors also found that there is room for organic agriculture to grow. If organic farmers were to completely forgo the premium, profits from conventional farming would still only be 5 -7% higher than organic. This means that even if an increase in organic production were to result in a decrease in organic premium prices, organic farmers would still be making a larger profit than conventional farmers. While this study did not include environmental costs or

benefits of conventional or organic farming in the economic analysis the authors note " If we also put a price on the negative externalities caused by farming, such as soil erosion or nitrate leaching into groundwater, then organic agriculture would become even more profitable because its environmental footprint has been shown to be less than that of conventional agriculture" The article concludes "We found that, in spite of lower yields, organic agriculture was significantly more profitable than conventional agriculture and has room to expand globally. Moreover, with its environmental benefits, organic agriculture can contribute a larger share in sustainably feeding the world."