

INTEGRATED PEST MANAGEMENT

# Insights

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## Signature Programs



## A Brief History of Resistance

**resistance**, *n.* **1** The action of resisting, opposing, or withstanding someone or something. **2** Natural or acquired ability to withstand disease, infection, or attack by pests.

An early instance of the dual idea of “resistance” and “disease” appeared in a medical manual in 1793. Four decades later, in 1833, the notion of resistance to the action of an antibiotic or drug was published. In the 2000s, we hear increasingly about resistance by insects, weeds, and diseases to human-made attempts to control them.

### Evil, or indifferent?

Of course, for a bug, resistance—the ability of a living thing to withstand a practice or condition that would result in death—means survival. For a timely example, a changing climate can put selection pressure on an organism to a degree where a few individuals with favorable genes survive and reproduce while the remaining neighbors die off. In nature—as well as in human systems such as farming and medicine—conditions and actions are constantly changing. On this stage, integrated pest management (IPM) offers an answer to pests that is flexible, responsive, and effective.

### Three examples

In this issue, we showcase examples of resistance in each of three major pest groups: insects, weeds, and diseases. We speak to ecologist David Mortensen of Penn State University about his work on weed resistance to herbicides. We explore the work of Andrei Alyokhin, an entomologist with the University of Maine, who has been working with the Colorado potato beetle for much of his career. For the perspective on diseases, we consider the research of Quan Zeng at the Connecticut Agricultural Experiment Station, who studies fire blight and other diseases.

As this issue arrives at your door, many people are hearing messages in the media about “pesticide resistance.” What does it mean, exactly? What is IPM and does it help or hinder pesticide resistance? Some pest management tactics seem to contribute to resistance.

Should they be labeled as IPM?

The benefits of IPM are reduced pesticide use and cost-effective pest control. However, supporters



Even the family pet shows resistance, which pervades everyday life. Source: iStock.

of certain pest management strategies want to label their practices as IPM, when arguably, they are neither ecological, nor knowledge-based, nor are they sustainable.

IPM is a systems-level approach that takes into account human and environmental health and economics using a diversity of tactics. IPM is not the reliance on a single tactic year after year until it fails, nor is IPM the addition of tactic upon tactic as resistance develops. IPM promotes the judicious and integrated use of tactics that include mechanical, biological, cultural, and chemical options for the management of both pests and pest resistance. IPM is the integration of strategies in a systems approach. This is true IPM.

### Reference

“resistance, n.”. OED Online. December 2015. Oxford University Press. <http://www.oed.com/view/Entry/163661?redirectedFrom=resistance> (accessed January 12, 2016).



## 2016 Partnership Grants Announced

In 2016, the Northeastern IPM Center awarded more than \$250,000 for research and outreach through its competitive IPM Partnership Grants program.

This year, the projects include efforts to control the spread of the invasive spotted wing drosophila, investigate fungi for biological control, and manage bed bugs.

A new reporting system will allow project directors to contribute project-specific data into an online system that the Center is using to get a better understanding of impacts.

“We want to capture the key elements of each project not only to share with our audiences, but also to assess the impacts of IPM in the Northeast,” said Steve Young, director of the Northeastern IPM Center.

The total amount awarded is \$257,997.

For more information about the projects, visit: <http://neipmc.org/go/DBfx>

## End of an Era of Easy Pest Solutions

The Colorado potato beetle is a beautiful creature, but probably only if you’re an entomologist, an artist of the environment, or a ten-year-old who refers to it as “cool” and puts the word “dude” at the end.

Andrei Alyokhin, professor of entomology at the University of Maine, is interested in the Colorado potato



Colorado potato beetle, *Leptinotarsa decemlineata*. Source: D. Cappaert, Michigan State U., Bugwood.org

to beetle (CPB) because it attacks one of Maine’s most reliable and stable crops: the potato. CPB is native to Mexico and the southwestern United States, but its range has expanded over the last two centuries to cover about 10 million square miles across North America, including Maine.

Growers have traditionally managed CPB with insecticides. However, CPB resistance to insecticides is now prevalent. Alyokhin and his colleagues say that the degree of CPB resistance varies across geographies. So, what is causing this variation and how can this information be used to help improve IPM?

Alyokhin’s team has narrowed the set of possible causes to the number of generations, crop rotation, volunteer potatoes, frequency of resistant alleles, insecticide intensity, and trap rows. It turns out that no single factor could be identified as universally responsible for CPB developing resistance in all of the regions and this is very important in more ways than one.

“We know diversification of techniques is important in managing CPB, but it involves more than just throwing a bunch of practices at it and hoping a few stick,” says Alyokhin. Since the 1970’s, it has been argued that susceptible gene pools of pest organisms, like CPB, should be treated as non-renewable resources. Like preserving the oil and gas deposits buried deep within the earth through conservation, so too can CPB be managed with insecticides, if the chemicals are used in a judicious manner.

Alyokhin and his colleagues write, “The [IPM] ap-

proach requires substantial extra effort to understand the system and to determine the best ways of dealing with CPB.”

—Steve Young

## Resources

Resistance is about pesticides and wild radishes, according to this farmer tunesmith. <http://neipmc.org/go/PDMP>

Cuny C, Friedrich A, Kozytska S, et al. Emergence of methicillin-resistant staphylococcus aureus (MRSA) in different animal species. *International Journal of Medical Microbiology*. 2010;300(2):109–117.

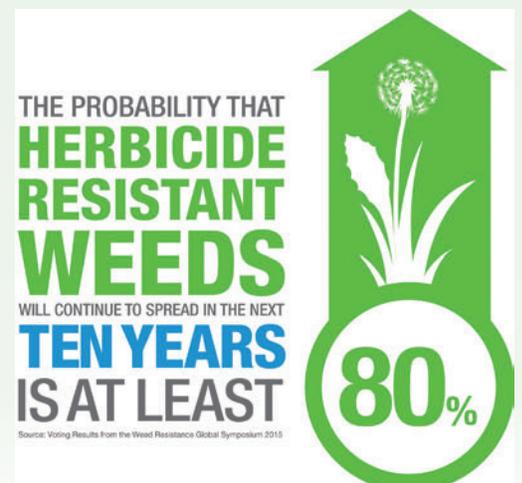
Mortensen, D, et al. (2012). Navigating a critical juncture for sustainable weed management. *BioScience* 62: 75–84.

### Photo Credits

“2016 Partnership Grants Announced.” Northeastern IPM Center partners with stakeholders for IPM. Source: Kevin Judd from iStock components.

“Antibiotic-Resistant Fire Blight.” Fire blight in crabapple and apple. Rebekah D. Wallace, University of Georgia, Bugwood.org

“Photographers Lift Pests’ Poise.” Hesitant dagger moth, *Acrionicta haesitata*, Bruce Watt, University of Maine, Bugwood.org



Voting Results from the Weed Resistance Global Symposium 2015. Source: Bayer

# Eco solutions answer to herbicide resistance

In 2012, David Mortensen and his colleagues published a seminal paper about a problem: a dramatic rise in the number and extent of weed species resistant to glyphosate, a widely-used herbicide.

A little more than a decade earlier, the widespread adoption of genetically modified crops resistant to glyphosate (marketed by Monsanto as Roundup Ready crops) captured the minds of farmers and investors alike, in the agricultural equivalent of a blockbuster movie or drug.

Mortensen, a weed ecologist at Penn State University, argued that the herbicide-and-seed package promoted by industry was not only doomed to fail as a weed control strategy, it was unsustainable, and worse yet, harmful to ecological systems.

## Early warnings

Mortensen and other ecologists voiced concerns from the beginning with industry plans. He believed growers would use the technology on a mass scale and that such use would quickly lead to herbicide resistance in target weeds.

Even so, industry moved ahead, developing glyphosate-resistant soybeans, then resistant corn, then resistant alfalfa, and then resistant sugar beets. Overreliance on glyphosate is the problem. Last year, over ninety percent of the soybeans grown in the US were genetically modified to be resistant to glyphosate. Eighty percent of the corn. Therefore, even when growers are rotating their crops, each year they would be returning to the same seed type calling for the same “single bullet,” the glyphosate-resistant weed strategy.

“By turning to the same chemical strategy every year, we saw a very real likelihood that selection pressure from this single tool, glyphosate, would be great,” Mortensen said. “I was interested in diverse, ecologically-informed agricultural management. A diverse approach mimics how nature works.”

“We must move toward cropping systems that favor and enhance ecosystem services and away from stand-alone action against weeds using single-bullet approaches,” Mortensen said.

Other ecosystem services, apart from suppressing weeds, are increasing organic matter, enhancement of soil, retention of nitrogen—not sending it in the form of agricultural runoff into the Chesapeake Bay. Crop yield is a type of ecosystem benefit, but our agricultural system, he says, needs to deliver these other ecosystem services, too.



One of the worst glyphosate-resistant weeds is Palmer amaranth. <http://neipmc.org/go/eCTp> Source: Howard F. Schwartz, Colorado State University, Bugwood.org

## Misleading

To address glyphosate resistance, industry has developed new genetically modified crop cultivars that are resistant to other traditional herbicides, among them dicamba and 2,4-D, but, Mortensen and others have argued, this is not sustainable. Much like playing with fire, the longer you are at it, the more likely you are to get burned.

“These so-called solutions, of adding 2,4 D and dicamba in soy and corn cropping systems, are not robust enough against evolutionary weed resistance,” Mortensen said.

Mortensen and his team recommend a solution of integrated weed management (IWM) practices—using multiple approaches that are knowledge-based and rely on ecological principles.

## Debunking the Single Bullet Theory

More than 200 weed species have been reported to have developed resistance to 155 different herbicides in 61 countries and 66 crops, according to the International Survey of Herbicide Resistant Weeds.

Mortensen would like to see fees from the sale of chemicals and biotechnology seeds be directed toward public university research and education that promote adoption of IPM and IWM among farmers.

Mortensen’s biggest question these days is this: How do we make more room at the table for people with diverse points of view? In politics, as in ecology, single bullets fail. And scientists like Mortensen are taking cues from nature, which uses abundance and diversity to proliferate and accomplish work.



## Photographers Lift Pests’ Poise

How do you get a hesitant dagger moth to smile for the camera? Thanks to a grant made by the Northeastern IPM Center, you don’t have to figure that out.

People have long needed resources to identify pathogens, insects, mites, and harmful organisms. To address this, the Bugwood Network, based at the University of Georgia, began archiving and cataloging high-quality images by taxonomical category. In 2011 and 2012, the Center funded a team led by Karen Snover-Clift of Cornell University to develop the Northeast Region Bugwood Node.

To date, 4,572 images have been submitted through the Bugwood-Cornell node to the network. They cover 843 subjects and have been viewed 1.6 million times since inception in 2012.

So, no need to get your smartphone out and persuade your pest of choice to pose. You can just go to <http://www.ipmimages.org/> and start browsing.

—Jana Hexter

# Antibiotic-Resistant Fire Blight



**F**ire blight, which is caused by the bacterial pathogen *Erwinia amylovora*, is a devastating disease of apples. The antibiotic streptomycin has remained the staple tool of fire blight prevention. Since 1972, streptomycin resistance of *E. amylovora* in apples has spread, making control of this disease even more difficult.

Several studies have shown that antibiotic use and misuse in both humans and animals poses a risk to the environment and potentially to human health (see Resources). Evidence suggests that the extensive use of antibiotics is a force in the emergence of resistant pathogenic microorganisms. In addition, the agricultural use of streptomycin could increase antibiotic resistance in our environment. However, the effects on human health of streptomycin resistance in plant pathogens such as *E. amylovora* have not been studied extensively in the United States.

Quen Zeng, a bacteriologist at the Connecticut Agricultural Experiment Station, studies plant diseases caused by bacteria. His current project, in collaboration with the Northeastern IPM Center, explores fire blight pathology and disease management.

Zeng is surveying streptomycin resistance in pathogen populations in New England to ascertain whether streptomycin remains an effective

management tool. Early identification of diseased populations could help reduce the spread of resistant fire blight. Zeng's short-term goal is to help growers with their needs and develop additional IPM techniques to control this disease. His long-term goal is to raise awareness of streptomycin resistance and promote IPM practices that can reduce the risk of inducing streptomycin resistance.

His work to date suggests that streptomycin remains an effective fire blight management option for the non-organic apple grower in New England. However, there is risk of the pathogens acquiring resistance. Zeng emphasizes the need to develop effective biological controls and other novel management strategies to supplement the use of antibiotics in fire blight management.

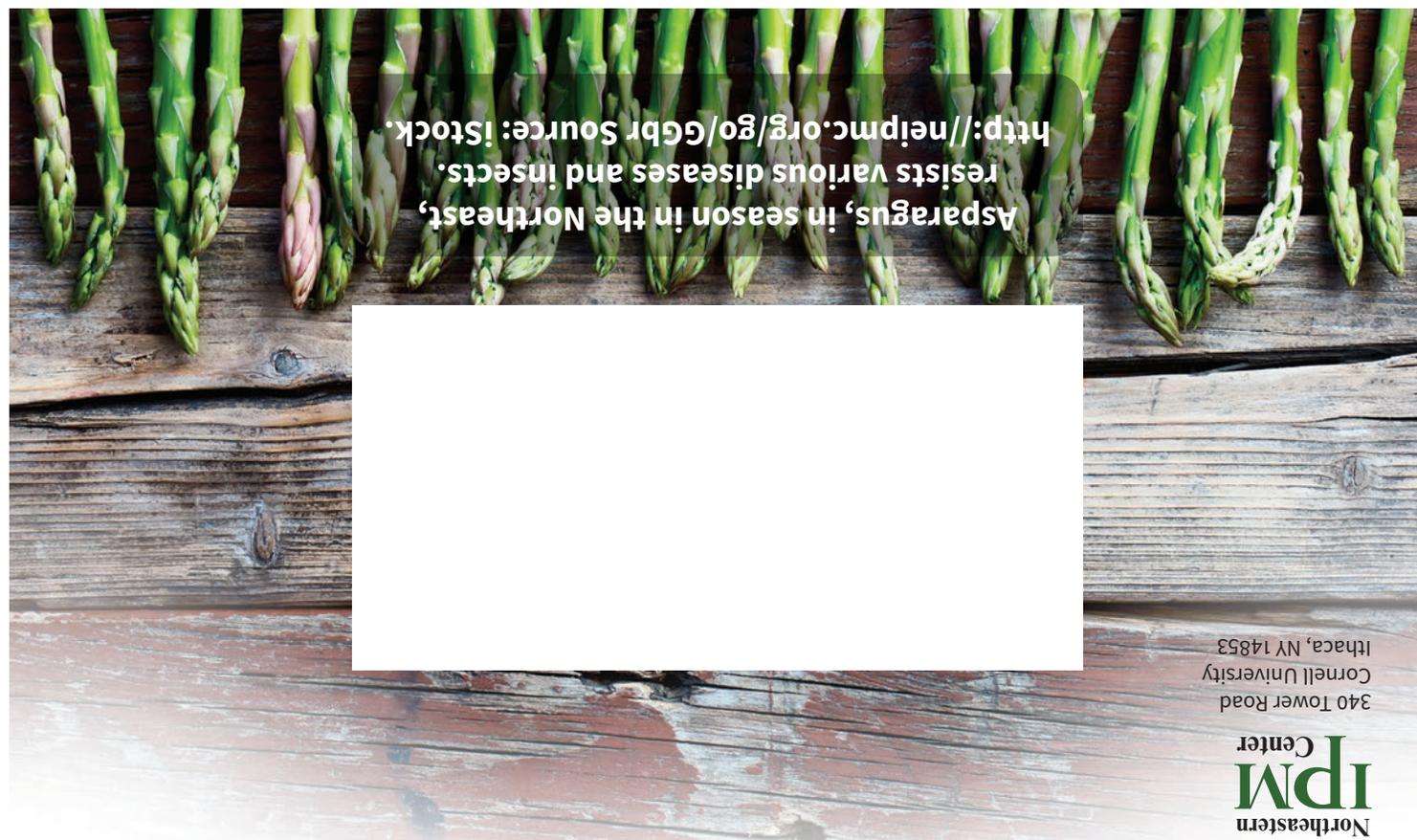
— Yifen Liu

## Credits

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Asparagus, in season in the Northeast, resists various diseases and insects. <http://nepimc.org/go/Gbbr> Source: iStock.