INTEGRATED PEST MANAGEMENT

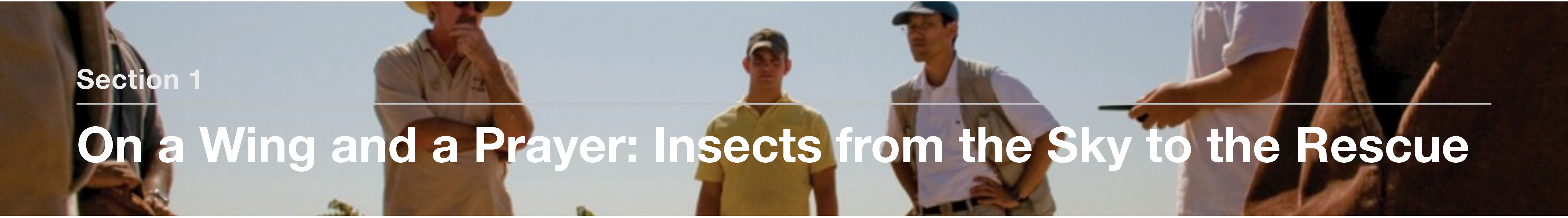
insights

October 2015

Chapter 1

On a Wing and a Prayer: Insects from the Sky to the Rescue

Yong-Lak Park, a professor of entomology at West Virginia State University, has unusual dreams of flying: He wants drones to deploy natural enemies, not pesticides.



Section 1

On a Wing and a Prayer: Insects from the Sky to the Rescue

EXPERIMENTAL AVIATION

Yong-Lak Park and his team conduct field research with a drone. Source: Yong-Lak Park, West Virginia University Entomology.

Yong-Lak Park, a professor of entomology at West Virginia State University, says when it comes to drones, he's just an end-user who pokes engineers for technology to use. But that doesn't stop his dreams of flying: He wants drones to deploy natural enemies, not pesticides.

"I decided that detecting something was not enough," he said. "What if we could detect and deliver good insects to counteract the bad ones?"

He conducts his research in a mountainous area of West Virginia—the entire state, he says, is 70 percent mountains. It typically takes five hours to hike any one of those mountains.

Big Mountains, Few Resources

Growers in the Mountain State do pest monitoring on a shoestring budget. Meanwhile, the Appalachian region suffers from invasive species like gypsy moth, emerald ash borer, southern aphid, brown marmorated stink bug, and insects from the south on the move due to changing environmental conditions.

The state's location is important, tucked between the populous Midwest and East Coast.

“People ask, ‘Hey, can you survey West Virginia for emerald ash borer?’ I can’t do it on foot, but maybe it can be done with an unmanned aerial vehicle (UAV),” he said.

Park presented his work in 2015 at the International IPM Symposium in a session organized by the Northeastern IPM Center. A video of his talk is available on the web.

Technology Advances

New developments in remote sensors and monitors are making it easier for scientists to detect subtle or pronounced changes on the earth’s surface. UAVs are increasingly able to cover large areas in a short period of time and reach hard-to-access areas. A small UAV can be put into a backpack, hiked, and flown. It’s also less tiring for the pilot and the entomologist.

Park began working on aerial delivery of predators in 2012. He designed a drop system, putting small insects in straws inside a specially designed capsule. They test dropped it from a tall building. They checked the bugs and they still had all six legs and two antennae. Furthermore, they could walk, feed, and mate. Aerial delivery didn’t hurt their biological functions. Currently, he is working on applying the concept to various agricultural ecosystems.

“Drones won’t be delivering natural enemies for pest management in the near future,” Park cautions. “However, drones can do what current pest management can’t do—and what current pest management can do, drones can do it more efficiently, safely, and economically.”

It will take time before commercial and legal issues are worked out and deployment of beneficial insects from drones becomes a reality. It is currently illegal to drop any object from a drone in the United States. Park has a large-scale study in the wings, waiting for new FAA regulations and permits.

And with a little help from engineering friends, some good bugs—and one guy who dreams about them—are going to fly.

Chapter 2

Diagnosis from the Air Could Help Farms on the Ground

Machinery can be used to survey large expanses of farmland or environmentally sensitive areas, raising interesting possibilities for the problem of excessive nitrogen inputs in a watershed.

Section 1

Diagnosis from the Air Could Help Farms on the Ground

MOSAIC

A mosaic of several images gives an overview of field conditions. Source: A. Nagchaudhuri, UMDES

You're standing in the middle of a 50-acre field. It's so big that it stretches to the horizon in every direction. Overhead, a Cessna 172—the ubiquitous workhorse of four-seat private planes—is flying. A Terrahawk camera mounted in its belly takes a picture. The same day, a technician hands you a GPS unit so you can walk to a precise point in the farm field and troubleshoot a potential problem spot.

"Precision Agriculture." The expression brings to mind growers using machinery to deploy fertilizers or pest management materials in tiny, exacting amounts. But machinery can also be used to survey large expanses of farmland or environmentally sensitive areas.

The airplane could be measuring normalized difference vegetation index (NDVI), an indicator of the nitrogen needs of the plant. The data could be fed instantly to a robot control system on the ground that applies the appropriate amount of nitrogen to a plant at an exact point in a 50-acre field. This technology raises interesting possibilities for the problem of excessive nitrogen inputs in a watershed.

Aerial View

If we were to fly our plane over the Delaware, Maryland, and Virginia peninsula, called by the locals Delmarva, we'd see signs that chicken and corn feed are big agricultural industries. Upon landing at a private airstrip near the farm field, we might find someone with a background in robotics, vision control systems (of which the Hubble telescope or magnetic resonance imaging (MRI) are examples), and aviation carrying out field research with his team. This person would be Abhijit Nagchaudhuri, a professor of engineering and aviation sciences at the University of Maryland Eastern Shore.

“In the robotics lab,” Nagchaudhuri explained, “we have cameras that help a robot identify objects and I was doing vision-based manipulation and controls work. Just like the cameras are feeding the robot with information, I began thinking about feeding a robot with information from aerial imagery.”

To this end, Nagchaudhuri has been using aerial photography to measure crop characteristics, such as the NDVI, crop water stress index, the density and number of plants, and the size of the final harvest yield. He says he envisions a day when this technology will also be used to measure pests and damage from pests.

Tech Gear to Help Farms

In the above example, when the Cessna 172 with a Terrahawk camera takes a picture, the following happens: The image is instantly georeferenced, meaning every pixel in the image has a global positioning system (GPS) reference assigned to it. A technician takes screen captures from a video and mosaics the entire field together to get a big picture for the 50 acres. He then lays the georeferenced image over a base image and scouts for problems.

Nagchaudhuri presented his work in 2015 at the International IPM Symposium in a session organized by the Northeastern IPM Center. A video of his talk is available on the web. He also coauthored a paper in 2013 in the International Journal of Applied Agricultural Research on the study of using variable rate seeding and remote sensing technologies to optimize corn yield and economic benefit on a farm.

One goal of his project: efficient nitrogen application, which will minimize groundwater pollution and optimize economic benefits for producers.

Nagchaudhuri is now using drones instead of manned aircraft to provide growers with insights into crop health. And healthy, strong crops are best able to withstand pressure from diseases, weeds, and other pests. Someday, growers may spend as much time flying aircraft to understand and manage the nitrogen cycle as they do practicing IPM.

Chapter 3

IPM and the Nitrogen Cycle

Nitrogen management enabled the "green revolution," but there are side effects.

IPM and the Nitrogen Cycle

BLOOD FISH BONE

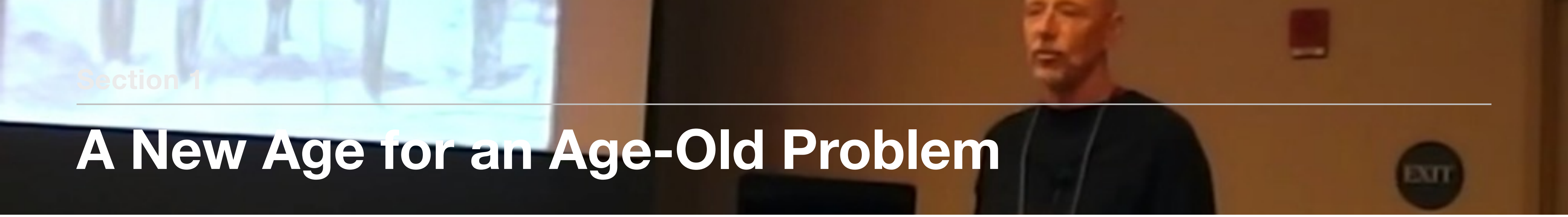
A source of nitrogen-rich fertilizer / Source: iStock

It doesn’t offer as catchy a label as “global warming,” but human-induced changes in the global nitrogen cycle pose engineering challenges just as great and just as critical as coping with the environmental consequences of burning fossil fuels for energy. This, according to the National Academy of Engineering. Nitrogen is central in the production of food. Its management enabled the “green revolution,” huge advances in agricultural yield, but there are side effects. Excess nitrogen can cause major problems in rivers and coastal waters. Yet with too little nitrogen, plants become too weak to defend themselves from diseases, weeds, and other pests.

Chapter 4

A New Age for an Age-Old Problem

Imagine: A fleet of robots maneuvers through a field in which a multitude of different plants—among them carrots, corn, and cauliflower—are growing side by side.



A New Age for an Age-Old Problem

ENGINEERING DEVELOPMENTS

Ken Giles gave a keynote speech on engineering developments in robotics and sensors at the International IPM Symposium. Source: K. Judd, Northeastern IPM Center

Imagine: A fleet of robots maneuvers through a field in which a multitude of different plants—among them carrots, corn, and cauliflower—are growing side by side. A miniature droid equipped with sensors tenderly nurtures the crops, taking various measurements, looking for nutrient deficiencies, water stress, or an impending disease. Challenges that have plagued farmers for hundreds of years could be met with precision care, yielding healthy crops that can withstand nature's elements.

What might seem like a scene from *Star Trek* is indeed the direction that some growers are heading. The Northeastern IPM Center recently organized a session on this topic at the International IPM Symposium in Salt Lake City, Utah.

Experts see big opportunities in one area: how growers spray pest management materials. New machines could help farmers manage the droplet size of materials, reduce application rates, and mitigate spray drift. They could also minimize worker exposure and materials deposited on the ground. Making payloads smaller will reduce demands on farm vehicles, enable higher operating speeds, and boost productivity.

Prevention and Precision

Three objectives form the trifecta of precision IPM: efficacy of application, protection of non-targets, and productivity.

"Any successful technology has to improve one and at least be neutral on the other two," said Ken Giles, a professor of engineering at the University of California at Davis (UCD), who was one of the keynote speakers at the session.

In an orchard, a successful example of this technology turns off spray nozzles between trees. Scientists collected data that showed a 15 to 40 percent reduction in materials when they used this technology.

Today, with sensors becoming more sophisticated, machines can get a better sense of the shape of the tree, and use mechanical actuators to better reach the target.

Another example is found in a lettuce growing operation.

"Lettuce grows very quickly, so the target is always changing," said Giles. "To make matters even more difficult, only six to eight percent of the land is covered with the target crop."

He and his UCD colleague David Slaughter did sensing and applicator work that allowed them to adjust the width of spray on the target, and deployed it in a 12-row system in lettuce. The result: a 60 to 80 percent reduction in materials used, and a 90 percent reduction in soil deposition in material that should have been on the plant.

"This system is now very common in the Salinas Valley of California," said Giles.

Giles has seen some of his team's developments take 10 to 15 years to come to market. But when they do, they have spread very quickly with many vendors providing products and services.

Robots in the Sky

Giles also sees big opportunities for crop protection using unmanned aerial vehicles (UAVs). In one recent study, his UAVs sprayed only water. Then, his team applied for a Part 137 exemption that allowed them to spray an active ingredient. They were required to follow the same aviation rules that apply to crop dusting. Looked at in terms of productivity, the UAVs were fast—in fact, multiple times faster. In an area where terrain, slope, and turns meant ground vehicles could cover one acre per hour or less, UAVs were able to cover three to seven acres per hour.

This idea may not be ready for mainstream use just yet: some product labels have specific instructions that preclude UAV use, and conflicts over airspace could arise, as manned commercial crop dusters operate in the same space.

While engineering developments can take several years to get to market, these new technologies could soon meet all three objectives of precision IPM: efficacy of application, protection of non-targets, and productivity.

Chapter 5

Moving Integrated Weed Management into the Future

Automated systems could identify each and every plant in a farmer's field and then go on to manage the undesirable ones.

Section 1

Moving Integrated Weed Management into the Future

ENVISIONING SYSTEMS

An artist's rendering could be the future of automated weed management. Source: Steve Young, Northeastern IPM Center

On one level, integrated weed management (IWM) is all about diversification. Rather than relying solely on one or two herbicides, farmers employ a multiplicity of weed-fighting strategies including tillage and other mechanical tools, cultural practices, and methods for depleting the weed seed bank.

But on another level, IWM as currently practiced isn't really integrated. Why not? Because it is still managing every weed the same regardless of location or season. In the future, automated systems could identify each and every plant in a farmer's field and then go on to manage the undesirable ones. A robot could determine the weed species and its key features, like whether it is known to be resistant to mowing or spraying, if the seed is long-lived, or if parts of the plant can regenerate. The same robot, equipped with several different weed control tools, could apply the appropriate micro-treatment directly onto the target weed. An individual pigweed, for example, would be spritzed, snipped, or flash flamed in an instant.

While the idea is enticing and exciting to think about, one of the biggest hurdles now is to identify weeds in diverse field and weather conditions. In addition, the idea of a robot moving stealthily through a corn field still has to be accepted by the public, not to mention growers.

What will it take to overcome these challenges to move IWM to a level that makes it more applicable, widely adopted, and truly integrated? These will be addressed at the upcoming American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America meetings in Minneapolis, Minnesota. See the Resources section for a link.

Chapter 6

Resources

Resources from the October 2015 edition of *IPM Insights*

Northeastern IPM Center

Resources

IPM Practitioner's 2015 Directory of Least-Toxic Pest Control Products is now available online. http://neipmc.org/go/BKbG

Curious about how detection dogs are trained to find bed bugs? http://neipmc.org/go/eaxL

The National Park Service has a valuable page on West Nile Virus and the biology of the mosquito. http://neipmc.org/go/rCjJ

Experts in engineering, agronomy, ecology, computer science, pest management, and law discuss high-tech management of pests in crops. Video recording of session from International IPM Symposium 2015. http://neipmc.org/go/nbxG

Looking Ahead to Automated Integrated Weed Management: Presentation to be given at upcoming American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America meetings in November 2015. http://neipmc.org/go/jRCD

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Chapter 7

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