MANAGE INSECTS On Your Farm

A Guide to Ecological Strategies

Miguel A. Altieri and Clara I. Nicholls
with Marlene A. Fritz

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Sustainable Agriculture Network

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Cover photos (clockwise from top):

Mixed annual clovers in a Chico, Calif., almond orchard help invigorate the crop's ability to withstand pests while attracting beneficial insects. Robert L. Bugg, UC-Davis.

Sevenspotted lady beetle. Russ Ottens, Univ. of GA.

ARS entomologist Marina Castelo Branco collects plant samples for a pollen library that documents plants that attract insect pests. Scott Bauer, USDA-ARS.

Syrphid fly. Vincent J Hickey, M.D.

Back cover: Predatory stink bug nymph on eggplant. Debbie Roos, North Carolina Cooperative Extension

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SARE works to increase knowledge about — and help farmers and ranchers adopt — practices that are profitable, environmentally sound and good for communities. For more information about SARE grant opportunities and informational resources, go to www.sare.org. SAN is the national outreach arm of SARE. For more information, contact:

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Miguel Altieri and Clara Nicholls, University of California-Berkeley, felt that the bulletin topic could be expanded, and authored this manuscript to explore the concept of ecological insect management in greater detail.

Marlene Fritz, University of Idaho Extension communications specialist, working with SAN staff, edited the manuscript, contacted numerous farmers, scientists and educators, wrote the farm features, and fleshed out the how-to sections of the book. Marlene also solicited and edited additional sections by experts in the other areas of ecological pest management.

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Andy Clark
Sustainable Agriculture Network
Beltsville, MD
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1 Introduction

AGRICULTURAL PESTS — insects, weeds, nematodes and disease pathogens — blemish, damage or destroy more than 30 percent of crops worldwide. This annual loss has remained constant since the 1940s, when most farmers and ranchers began using agrichemicals to control pests.

Agrichemical methods of protecting crops are costly to the farmer, potentially harmful to the environment and, despite widespread use, have not proved 100-percent effective. Problems persist due to pest resistance and the uncanny ability of pests to overcome single-tactic control strategies.

A National Academy of Science 1997 Proceedings paper, "A Total System Approach to Sustainable Pest Management," called for "a fundamental shift to a total system approach for crop protection [which] is urgently needed to resolve escalatory economic and environmental consequences of combating agricultural pests."

Many farmers are seeking such an approach, one that relies less on agrichemicals and more on mimicking nature's complex relationships among different species of plants and animals. Known as "ecologically based pest management" or simply "ecological pest management," this approach treats the whole farm as a complex system.

The old approach strives for 100 percent *control* of every pest using one strategy or agrichemical for each pest. The new approach, ecological pest management, aims to *manage* the whole farm and keep pests at acceptable populations using many complementary strategies. Ecological pest man-

Dave Clark, USDA ARS

A crimson clover cover crop prevents erosion, improves soil, fixes nitrogen and attracts beneficial insects.

agement is a *preventive* approach that uses "many little hammers" or strategies, rather than one big hammer, to address pest problems on the farm or ranch.

Ecological pest management employs tactics that have existed in natural ecosystems for thousands of years. Since the beginning of agriculture — indeed, long before then — plants co-evolved with pests and with the natural enemies of those pests. As plants developed inherent protective mechanisms against pests, they were helped by numerous partners in the ecosystem, for example:

- Beneficial insects that attack crop insects and mites by chewing them up or sucking out their juices
- Beneficial parasites, which commandeer pests for habitat or food
- Disease-causing organisms, including fungi, bacteria, viruses, protozoa and nematodes that fatally sicken insects or keep them from feeding or reproducing. These organisms also attack weeds.
- Insects such as ground beetles that eat weed seeds
- Beneficial fungi and bacteria that inhabit root surfaces, blocking attack by disease organisms

Scott Bauer, USDA ARS

Aleiodes indiscretus wasp parasitizing a gypsy moth caterpillar.

By integrating these natural strategies into your farming systems, you can manage pests in a way that is healthier for the environment and eliminates many of the problems associated with agrichemical use. Knowing the life cycles of pests and understanding their natural enemies allows you to better manipulate the system to enhance, rather than detract from, the built-in defenses available in nature. Another National Academy of Science report (1996), *Ecologically Based Pest Management* (EBPM), stated that EBPM "should be based on a broad knowledge of the agro-ecosystem and will seek to manage rather than eliminate pests" in ways that are "profitable, safe, and durable."

In addition to reducing pest damage, shifting your farming system to ecological pest management will bring multiple benefits to your operation. For example, moving from monoculture to longer rotations improves water- and nutrient-use efficiency. Cover crops planted to attract beneficial insects also suppress weeds, improve the soil, provide moisture-conserving mulch, fix or store nitrogen for subsequent crops and contribute to overall nutrient management goals.

About *Manage Insects on Your Farm*

Pests of agricultural crops include weeds, insects, pathogens and nematodes. This book is focused mostly on managing *insect* pests, but it addresses all crop pests to some degree, because no pest or category of pests can be addressed in isolation. The ecological pest management strategies presented here will contribute to overall ecosystem health.

We first lay out the principles behind ecologically based pest management. Then, we describe strategies used by farmers around the world to address insect problems within the context of their whole farm systems. A full section is devoted to how you can manage your soil to minimize insect damage. Flip to Chapter 5 to learn about beneficial insects you can put to work for you. Photos of some beneficials and pests can be found on pages 50–54.

COVER CROP SYSTEM DETERS PESTS

In Lancaster County, Pa., Steve Groff built a farming system based on cover crops, intensive crop rotation and no-till. Although he designed his crop and vegetable farm without targeting specific pests, Groff and the scientists using his farm as a real-world laboratory have documented significant benefits in pest management, including:

- Increased populations of beneficial insects in cover crops
- Reduced populations of Colorado potato beetles in tomatoes
- Delayed onset of early blight in tomatoes
- Minimal to no aphid pressure on any of his crops
- Reduced cucumber beetle damage in pumpkins
- Tolerable levels of European corn borer, thanks to releases of the parasitic wasp, *Trichogramma ostriniae*
- Reduced weed pressure, although monitoring and managing weeds are still a top priority on his farm

Those benefits come at some cost, however. Groff spends more time managing his complex system to ensure that cover crops are seeded and killed at the right time and to scout for weeds. Moreover, he monitors soil temperature because no-till and cover crop residues delay soil-warming in the spring.

Not all pest management problems have been solved, either. Spider mites still attack Groff's tomatoes, particularly in dry years, while slugs sometimes hide under cover crop residues in wet years. Nonetheless, consider the numbers. Groff has cut pesticide use by 40 percent and seen soil organic matter increase by almost 50 percent with a 10 percent net increase in yield averaged over all crops. "It's working for us," Groff says.

Groff's system is described in greater detail on pages 60–63.

R. Weil, Univ. of Maryland

Steve Groff's cover crop of cereal rye and flowering rapeseed provides multiple benefits compared to neighboring plowed fields.

Eric Brennan, Univ. of Calif.

Workers harvest celery next to a strip of bachelor button flowers planted to attract beneficial insects.

Throughout the book, we present specific examples of successful pest management strategies. While some examples may fit your farm or ranch, most are crop- or climate-dependent and will serve mostly to stimulate your imagination and help you better understand that while every system is unique, the general principles of ecological pest management apply universally. Use this book as a stepping-stone to develop a more complex, more diverse system on your own farm. Look for "Tip" boxes throughout the book for specific suggestions.

This book does not address the multiple ecological benefits of further diversifying your farm or ranch by integrating livestock into the system. If you also raise animals, consult other information resources about the management and benefits of integrated crop-livestock systems (Resources, p. 104).

In short, nature has already provided many of the tools needed to successfully combat agricultural pests. This book aims to describe those tools and present successful strategies for using them to manage insects on your farm or ranch.

2 How Ecologically Based Pest Management Works

To bring ecological pest management to your farm, consider three key strategies:

- Select and grow a diversity of crops that are healthy, have natural defenses against pests, and/or are unattractive or unpalatable to the pests on your farm. Choose varieties with resistance or tolerance to those pests. Build your soil to produce healthy crops that can withstand pest pressure. Use crop rotation and avoid large areas of monoculture.
- Stress the pests. You can do this using various management strategies described in this book. Interrupt their life cycles, remove alternative food sources, confuse them.
- Enhance the populations of beneficial insects that attack pests. Introduce beneficial insects or attract them by providing food or shelter. Avoid harming beneficial insects by timing field operations carefully. Wherever possible, avoid the use of agrichemicals that will kill beneficials as well as pests.

EBPM relies on two main concepts:

Biodiversity in agriculture refers to all plant and animal life found in and around farms. Crops, weeds, livestock, pollinators, natural enemies, soil fauna and a wealth of other organisms, large and small, contribute to biodiversity. The more diverse the plants, animals and soil-borne organ-

isms that inhabit a farming system, the more diverse the community of pest-fighting beneficial organisms the farm can support.

Biodiversity is critical to EBPM. Diversity, in the soil, in field boundaries, in the crops you grow and how you manage them, can reduce pest problems, decrease the risks of market and weather fluctuations, and eliminate labor bottlenecks.

Biodiversity is also critical to crop defenses: Biodiversity may make plants less "apparent" to pests. By contrast, crops growing in monocultures over large areas may be so obvious to pests that the plants' defenses fall short of protecting them.

Biological control is the use of natural enemies — usually called "beneficial insects" or "beneficials" — to reduce, prevent or delay outbreaks of insects, nematodes, weeds or plant diseases. Biological control agents can be introduced, or they can be attracted to the farming system through ecosystem design.

Naturally occurring beneficials, at sufficient levels, can take a big bite out of your pest populations. To exploit them effectively, you must:

1) identify which beneficial organisms are present;
2) understand their individual biological cycles and resource requirements; and
3) change your management to enhance populations of beneficials.

> *"It's a subtle effect, but over time the advantage increases. Your system moves slowly toward a natural balance and your pest problems decrease."*
>
> — Zach Berkowitz, California vineyard consultant

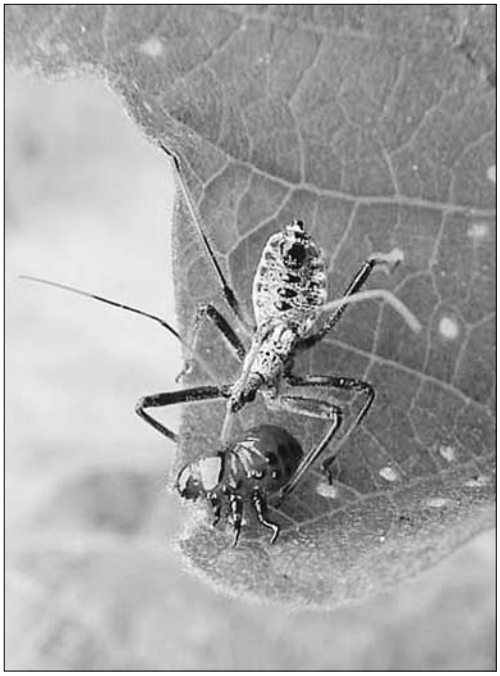
The goal of biological control is to hold a target pest below economically damaging levels — not to eliminate it completely — since decimating the population also removes a critical food resource for the natural enemies that depend on it.

In Michigan, ladybugs feed on aphids in most field crops or — if prey is scarce — on pollen from crops like corn. In the fall, they move to forest patches, where they hibernate by the hundreds under plant litter and snow. When spring arrives, they feed on pollen produced by such early-

BIOLOGICAL CONTROL VOCABULARY

When farmers release natural enemies, or **beneficials,** to manage introduced pests, they are using biological control tactics. ***Classical*** biological control is the importation and release of beneficial insects against exotic pests. When farmers add a species of natural enemy to a field where it is not currently present, or present only in small numbers, they are using ***augmentation*** biological control: they can either ***inundate*** a field with large numbers of natural enemies or ***inoculate*** it with relatively few at a critical time. When they conserve the augmented natural enemies or the ones that are already present in and around their fields, they are using ***conservation*** biological control. ***Parasitoids*** — a class of beneficials — are parasitic insects that kill their hosts.

Debbie Roos, North Carolina Cooperative Extension



Jack Kelly Clark, Univ. of Calif.

(above) Southern green stink bug eggs being parasitized by *Trissolcus basalis.*

(left) Assassin bug feeding on Colorado potato beetle larva.