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Resource Book: How to Make an Awesome Insect Collection
Resource Book: How to Manage Radical Insects
How to Make a 4-H Insect Collection
Preparing for Insect Judging – CDE
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Welcome to Youth and Entomology

What young person living in Indiana has not spent summer evenings capturing lightning beetles and stuffing them inside glass jars and afterwards lay pondering upon how and why a lightning

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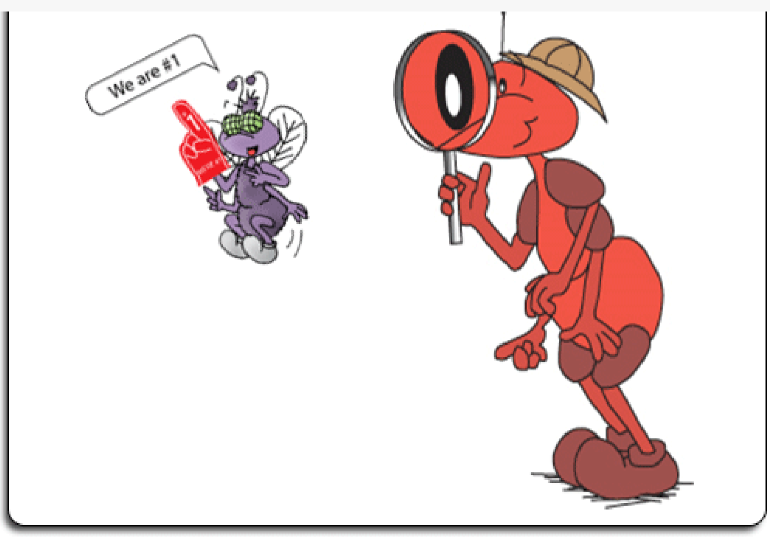

When closely examined, it is easy to discover that insects truly are number #1.

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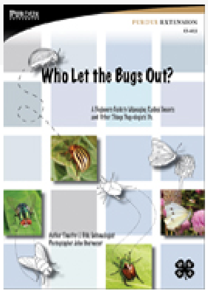
Who Let the Bugs Out?

A Beginner's Guide to Managing Radical Insects

Author: Timothy J. Gibb
Photography: John Obermeyer



This book is designed to be a companion to the "How to Make An Awesome Insect Collection" book for beginning entomologists. It discusses the importance of insects generally and pest insects in particular.

A series of photographs of many common pests is provided together with biological information to help the student recognize the insect, determine its damaging life stage, know its habitat, and predict its damage potential.

Methods and strategies for employing controls are discussed with examples of each so that students gain an appreciation of the philosophy and implementation of Integrated Pest Management (IPM).

To order this book from The Education Store click here.

To order the phone app click here.

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Preface

Insects are everywhere. No one can avoid them completely. They are often a topic of conversation—in the media, around the kitchen table, and over the backyard fence. Nearly every conversation about insects, regardless of how it starts, eventually turns to the yucky, disgusting, annoying, destructive, or deadly insects. This occurs in spite of the fact that the number of harmful insects is surprisingly small when compared to the total number of insect species in our world. Some insects are beneficial. Most insects are harmless. Even so, pest insects and controlling them receive the majority of our attention.

Managing insect pests is as old as human-insect interactions themselves. Many techniques and strategies have been tried. Some have been successful and some have failed. Effective pest management strategies have all been built upon the foundation of accurate identification and an understanding of the insect's life history and habits. Human and environmental safety are paramount and must be part of every insect pest management decision.

Successful pest managers have learned that incorporating several effective control tactics into a management strategy is the most acceptable and effective way to manage pests over the long term. These tactics, coupled with constant human and environmental vigilance, make up the backbone of a practice called Integrated Pest Management, or IPM.

This book is intended to be a companion volume to the 4-H resource manual titled *How to Make an Awesome Insect Collection!* (Purdue Extension publication ID-401). Included are discussions about the importance of insects generally and pest insects in particular. Methods and strategies for employing controls are addressed, along with examples of each, so that students gain an appreciation of the philosophy of Integrated Pest Management.

Photographs of many common pests are provided along with biological information to help students recognize the insect and its damaging or beneficial life stage, know its habitat requirements, and predict its damage potential or value. In many cases, a description and photo of the immature as well as the adult stage of insect are provided, as well as a photo and description of the damage itself.

These photos are formatted similarly to the photos in *How to Make an Awesome Insect Collection!* so that they can be separated and used as flash cards to facilitate learning. This also makes them a handy reference for future use.

Finally, this book briefly introduces beginning entomology students to the many and various careers that “bug-ologists”—also known as entomologists—may choose from

All of the information in this and the Awesome Insect Collection book can be used in 4-H and FFA judging competitions as well as in school curricula. Studying the contents of both books will prepare a beginning entomologist to truly appreciate insects for both the good and bad that they do, and will “morph” casual insect hobbyists into true entomologists.

Importance of Insects

Insects are everywhere. They are, by far, the most common animals on our planet. More than 1.5 million species of insects have been named. This is three times the number of all other animals combined. Even so, some say that the insects that have been given names are only a small fraction of the insects in nature. Many are yet to be discovered.

We can find insects in almost every conceivable habitat. Their size, shape, color, biology, and life history are so diverse that it makes the study of insects absolutely fascinating.

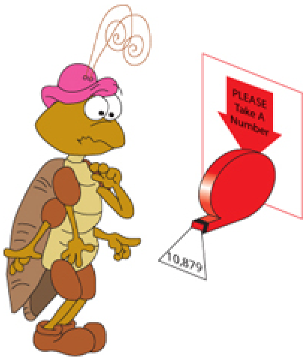
Without insects, our lives would be vastly different. Insects pollinate many of our fruits, flowers, and vegetables. We would not have much of the produce that we enjoy and rely on without the pollinating services of insects, not to mention honey, beeswax, silk, and other useful products that insects provide.

Insects feed on a seemingly endless array of foods. Many insects are omnivorous, meaning that they can eat a variety of foods including plants, fungi, dead animals, decaying organic matter, and nearly anything they encounter in their environment. Still others are specialists in their diet, which means they may rely only on one particular plant or even one specific part of one particular plant to survive.

Many insects are predatory or parasitic, either on plants or on other insects or animals, including people. Such insects are important in nature to help keep pest populations (insects or weeds) at a tolerable level. We call this the balance of nature. Predatory and parasitic insects are very valuable when they attack other animals or plants that we consider to be pests.

Insects are very important as primary or secondary decomposers. Without insects to help break down and dispose of wastes, dead animals and plants would accumulate in our environment and it would be messy indeed.

Insects are underappreciated for their role in the food web. They are the sole food source for many amphibians, reptiles, birds, and mammals. Insects themselves are harvested and eaten by people in some cultures. They are a rich source of protein, vitamins, and minerals, and are prized as delicacies in many third-world countries. In fact, it is difficult to find an insect that is not eaten in one form or another by people. Among the most popular are cicadas, locusts, mantises, grubs, caterpillars, crickets, ants, and wasps.



And insects make our world much more interesting. Naturalists derive a great deal of satisfaction in watching ants work, bees pollinate, or dragonflies patrol. Can you imagine how dull life would become without having butterflies or lightning beetles to add interest to a landscape? People benefit in so many ways by sharing their world with insects.

In spite of all their positive attributes, some insects can cause problems. Unfortunately, most people are more aware of the few insects that cause problems than they are of the many beneficial insects. Uninformed people think that all insects are bad and all are in need of control. We must always keep in mind that the good done by the many beneficial insects far outweighs any bad caused by a few pest species. In spite of this, texts such as this are written about the relatively few insect pests that cause us harm.

4-H and Youth

Introduction

The need for this book grew out of the Indiana 4-H Advanced Entomology project and the 4-H/FFA insect judging competition. The project and the competition require beginning insect collectors to ply their skills for identifying insects into the more difficult challenge of managing insect pests. To effectively manage a pest population, one must not only have the ability to identify the pest and its damaging life stages, and know what the injury looks like, but also to understand what damage to anticipate. To do this requires an intimate knowledge of the pests' biology, behavior, and reproductive cycle. In sum, pest managers must know their adversaries if they are to develop effective pest management strategies for their own use or for recommending to agriculturists, homeowners, or health-care providers.

Pest managers also must have an intimate and working knowledge of control practices. These include—but are not limited to—chemical insecticides. In fact, the most effective and long-lasting controls are usually not pesticides but rather cultural controls. Excluding or preventing pests from becoming established in the first place are the preferred methods of pest management. When pests have become established, the most effective control recommendations often consist of a combination of several management tactics, all employed simultaneously.

Finally, pest managers must be able to incorporate pest-management recommendations into an overall integrated program specific to the situation. There are many control methods, each with its own set of constraints. All management practices must be considered in light of environmental stewardship, the human/pest interaction, and the ever-changing arsenal of chemical pesticides available. Pest management has proven to be quite a challenging job.

Insect pest management is a vast subject, and no one person can thoroughly understand every pest and every management technique. This text includes a broad overview of pest management strategies with a specific emphasis on fifty insects common in most areas of the United States. Examples of pest and beneficial insects from agriculture, animal and human health, turfgrass and ornamentals, vegetables and fruits, and buildings and structures have been included. Studying examples of IPM principles allows students to see the direct impact of a tactic and to learn how to apply those principles to other cases that they may encounter.

The final section of the book offers a discussion on careers in entomology. Pest management is just one of the many career options that entomology students may choose. It is important for beginning entomologists to be exposed to the many different careers that the study of insects may offer. Like specialists in any field, entomologists from several different specialties often must work together to accomplish a larger goal. It is imperative that each be somewhat knowledgeable of the other specialties. This career section will also explore, in a fun and very cursory way, some of the various jobs that "bug-ologists" have. Fictitious case studies provide examples of the kinds of situations these entomologists face and some of the practical benefits that these specialists can offer.

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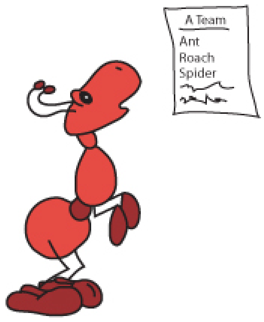
What is a Pest?



We know that certain insects can feed on the blood of people or other vertebrate animals, and can transmit diseases that are very serious health concerns. These are pests. Nearly every kind of plant in nature is food to one insect or another. When insects feed on plants that we as humans don't want them to, they become pests. Agricultural crops and horticultural plants are consumed by a number of different insects and are at risk from the time the seed is planted until the crop is harvested, stored, or consumed. When insects compete for the same foods as humans, we consider them pests. If insects sting, bite, annoy, contaminate, or make life less pleasurable in any way, people consider them pests. Insect pests may damage homes, clothing, or other products that we make, store, or use. Insects that harm us or our animals, destroy our foods, or damage our buildings, structures, or the materials we produce—in short, compete with humans in any way—are called pests.

> *A pest can generally be defined as any animal, plant, or other organism whose biology, behavior, or location places it in direct conflict with humans. Because some insects threaten human health, destroy food, damage structures or landscapes, or cause general annoyance or anxiety, they are considered pests.*

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What is Insect Pest Management?

To make life tolerable, insect pests must be managed. Humans have been battling insect pests for as long as we have shared Planet Earth. The first person that swatted and killed a pesky fly might be considered the grandfather of modern-day pest control! Since that day, humans have devised many methods of dealing with or managing insect pests.

Although physically removing or squashing a bug is the most obviousâ€”and was likely the firstâ€”method used to control pests, cultural control methods were probably not far behind. This required humans to know something of the insectâ€—where it came from, how it got here, and why it is found where it isâ€—in order to implement ways to keep it out. Since then, biological and regulatory controls have been implemented and chemical controls have been developed to manage insect pest populations. We will discuss several of the most common methods of pest control, called control tactics. Although it is not possible to provide an example of all possible control tactics, we will present the major tactics and offer an example of how each might be used in pest management.

These consist of:

- Cultural Control
- Biological Control
- Alternative Control
- Chemical Control
- Mechanical Control
- Regulatory Control

Some insect problems might be managed by a single control tactic, but strict reliance upon a one control tacticâ€—insecticides, for exampleâ€—is almost never adequate. Instead, most problems require a combination of several carefully selected tactics, called a control strategy, for effective long-term management. Strategies, which involve multiple tactics used simultaneously, are the preferred way to manage insect pest populations.

A control strategy is a combination or one or more pest control tactics used together.

Even the use of chemical controls should be balanced with nonchemical approaches to maximize their effectiveness. Likewise, sanitation to remove pest harboring sites may be most effective when coupled with exclusion techniques to minimize the reintroduction of the pests. All strategies are most effective if the life history and biology of the pest are well understood.

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What Is Integrated Pest Management?

Integrated Pest Management, or IPM, is a decision-making process in which observations, including inspection and monitoring, are used to make pest-control decisions based on predetermined management objectives. IPM takes an ecological approach to selecting control methods, combining a variety of chemical and nonchemical control tactics in a way that minimizes risk to people and the environment. This process must include an evaluation and written records to document the procedure and results.

Although the basic components of IPM are always the same, the specific elements of an IPM program vary from one environment or situation to another. IPM dictates that every pest situation be evaluated independently. In all cases, inspection and monitoring provide the necessary facts upon which to base decisions about whether or not to implement control procedures. After making the decision to implement controls, various control options must be carefully selected, based on effectiveness of the tactic and human and environmental safety. Finally, evaluation and record keeping promote informed decisions regarding how long to continue controls or whether or not to make changes.

IPM Components

These five main components of IPM are considered essential:

1. *Inspection*
2. *Monitoring and Tolerance Level Establishment*
3. *Situation-Specific Decision-Making*
4. *Application of Pest Management Techniques*
5. *Evaluation and Record Keeping*

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Inspection

The first step in the IPM decision-making process is a thorough inspection. This is done not only to identify the pest, but also the habitat in which it exists and the nature of its interactions with people. Identifying both the pest and its environment are key to determining the seriousness of the problem and the steps that must be taken to manage it.

Making sound decisions about pest control options requires:

- *accurate identification of the pest involved*
- *recognition of environmental conditions that support or have the potential to support the pest population*

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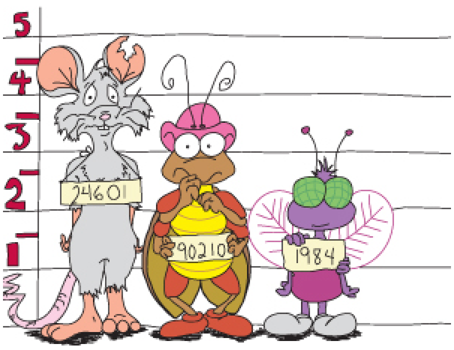
Pest Identification

Pest identification is a step that is sometimes taken for granted. Nevertheless, accurate identification of the pest must always be confirmed. Although this process is one of the most basic elements of pest management, mistakes in identification are still common, especially when many pests are similar in appearance or behavior. Accurately identifying the pest and its damage, recognizing which life stages are present, and understanding the life history of the pest and how it interacts with people are all factors that help a pest manager anticipate damage and exploit the weak links in the pestâ€™s biology. Management efforts should never take place before the pest is properly identified.



The importance of correctly identifying the pest cannot be overstated, but this does not mean every pest manager must have a degree in entomology. A number of excellent manuals and guides are available to assist with insect identification.

In many cases, the insects are either not present, are hidden, or are in a form that is not readily identifiable. In such cases, identification must be made based on the presence of pest signs, such as holes or tunnels, fecal materials left behind, or damage done to a plant or product. Confirming pest identification is critical. The Internet offers a wealth of instant information, much of which is very good. However, because nearly anything can be posted, the reliability

of Web-based information is sometimes questionable. Written reference materials are still the most reliable sources for entomologists. Recommended texts and field guides are too numerous to list here, but pest managers can obtain suggestions for appropriate pest identification manuals from local University Cooperative Extension Service educators or specialists.

This book also contains information and photographs of the most common pests in the midwestern United States, their damaging stage, and in some cases, accompanying signs that may help a pest manager make a correct diagnosis. It will serve as a great first reference.

During inspections, pest managers should carry along some important tools to assist in accurate diagnosis.

A magnifying lens is important because many insects are small and the identifying characteristics that separate them from other insects are almost invisible to the naked eye. Collecting the insects is almost always standard. Small collection vials can be used to hold the insects while identification is being made, preserve the insect for future reference, or transport it to specialists. Having field guides or other reference books handy is also recommended.

The purpose of the inspection is to gather information that will be used to make pest management decisions. Pest managers performing inspections must be knowledgeable about the types of pests that typically occur in their system, where and how to find these pests, and the conditions that favor pest activity.

> *Effective pest managers anticipate pest activity based on environmental conditions and past occurrences.*

An important and common pest associated with a particular system is called a key pest. There are usually four or five key pests in each system. For example, one key pest found in kitchens throughout much of the world is the German cockroach. White grubs are key pests of turfgrass throughout the Midwest. Codling moths and corn rootworms are key pests in midwestern horticulture and agriculture. Mosquitoes and deer flies are key health-related pests.

Pest managers must be familiar with the key pests in the systems they manage. They should know what time of year infestations may occur and what specific environmental conditions favor their development in order to be alert for signs of key pest activity.

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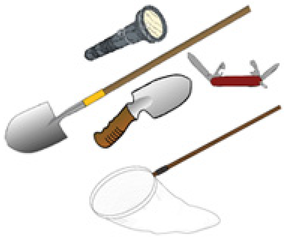
Inspecting

An important component of pest management is inspecting for pests. Routine inspection is usually directed toward the key pests in the system and is designed to detect the presence or absence of those pests. Inspections also note any environmental conditions that may favor the introduction or the development of a pest.

Inspection is hard work. It requires a pest manager to get into places that only pests usually go. Finding pests means that a pest manager must think like a pest. "If I were a cockroach, where would I like to live?" Knowing the basic requirements and preferences of each key pest allows a pest manager to determine how, where, and when to inspect, and what to look for.

Keen powers of observation are the basis for pest inspections; however, there are other tools that can greatly assist pest inspectors. Often they are so valuable that a proper pest inspection cannot be performed without them. For instance, when inspecting for pests in buildings and structures, a reliable flashlight is essential. An inspector would not be able to see into the dark recesses where pests live without one. A shovel or a trowel is essential to inspect for pests underground.

When inspecting for wood or stem borers, a sharp knife is required to open stems or branches. Sweep nets are considered essential when inspecting for potato leafhoppers. These tools are basic requirements for inspectors. Even more specific tools and methods can be required for certain pests. For example, inspecting for the presence of spider mites (tiny arthropods that can threaten plant health) is often done by placing a piece of white paper or an index card beneath a branch and briskly hitting the branch to dislodge the mites. The pest manager counts the number of mites on the paper to decide if a pesticide treatment or some other control measure is necessary.



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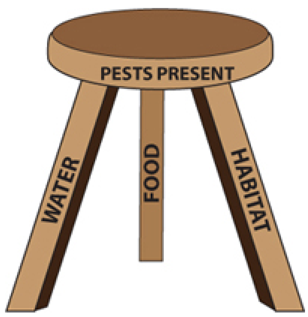
Environmental or Habitat Assessment

SSpecific environmental conditions can contribute to pest invasion or buildup by providing the habitat that pests need to survive. Part of the inspection process is to assess the local environment in relation to the needs of a pest. Every pest requires food, water, and shelter (harborage).



We know that eliminating any of these three essential resources will also eliminate the pest. This can be likened to the legs on a three-legged stool. If any one is removed, the stoolâ€”or, in this analogy, the pestâ€”cannot stand.

Pest managers must inspect for these and other conditions that may favor a pest outbreak. During any inspection, favorable conditions should be noted even if a pest is not detected.

Specific conditions may favor certain pests. Often these are related to weather conditions. For example, some insects do better in warm, dry conditions, while others thrive in moist, cool conditions. Conditions that might favor a specific agricultural pest may include soils that are saturated, have a high pH, or are sandy. Other insect pests may require just the opposite. Factors such as differences in leaf litter, proximity to other food plants, tillage or cropping practices, clutter, or thatch all may favor still different pests.

Professional pest managers understand the specific environmental requirements and preferences of the pests that they manage. This is why knowing the biology and life history of the pest is so important.

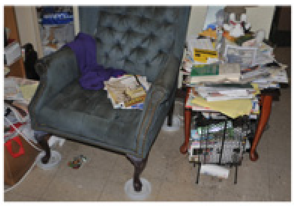
For example, a restaurant that has inadequate kitchen sanitation, a leaky faucet, excessive clutter in the storeroom, a filthy dumpster, and gaps under the doors make it ripe for pest infestation. If pests are not already taking advantage of these conditions, it is only a matter of time before they do. Identifying these pest-favorable conditions is part of a proper inspection.

An important advantage of IPM, as compared to traditional (chemical-only) pest control, is that it identifies and eliminates the conditions that lead to pest infestations before they happen. It is the pest managerâ€™s responsibility to identify habitat conditions that are favorable to pests and tell the client what steps are needed to rectify such situations.

Monitoring

Pest inspectors should monitor for conditions that favor pest outbreaks, including:

poor sanitation (provides food)



clutter (provides harborage)

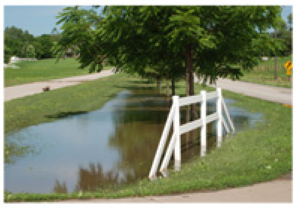
unsealed plumbing (provides entrance)

gaps under doors (provides entrance)

stressed plants attract pests

weed patches provides alternative hosts

Cracks in the soil (provide egg laying site)



poor drainage provides standing water (for breeding sites)

Insect pests are usually thought of in terms of numbers or population size. Monitoring usually follows inspection and measures or gauges the size of the pest population. However, the size of the population alone does not mean much unless it is in some context. Population estimates are given relative to some constant, such as space or time. For example, how many insects are in a lawn is usually measured as the number of insects found per square foot. In horticulture and agriculture, it is the number of insects per plant, per leaf, or per acre. Sometimes populations are estimated as the number collected per time unit (hour, day, or week). Still other populations are measured as the number of insects per sweep of a net or per shovel of soil. This will be covered in greater detail later, but for now it is sufficient to understand that pest managers must estimate pest population size as a function of some standard parameter.

Monitoring may consist of pest observations made by the pest manager or by other people. For example, in a school, custodians, teachers, and staff members should be encouraged to regularly record pest sightings in a log so this information can be communicated to the pest manager. The same is true in homes, factories, or wherever people spend time. Asking those who spend time in the building what they have seen is basic monitoring.

Inspection Process

The process for inspecting for pests requires that a pest manager;

1. know the pest
2. identify pest signs
3. recognize the conditions that favor the pest
4. utilize proper inspection tools and techniques



Many common pests are not active during the daytime or when people are present to actually see them. Other pests hide either underground or in places where they are difficult to see. Such pests often build up very high populations without being discovered. By the time they are noticed, their populations are sometimes so high and so entrenched that controlling them becomes very difficult. One principle of integrated pest management is devising a way to monitor so that if a pest invades, it can be discovered and eliminated quickly - well before it has time to reproduce and build up high populations.

> *Insect pest monitors are tools or devices essential to IPM. They are used to:*
>
> - *detect early infestations of pests*
> - *estimate pest population numbers to aid in the decision-making process (for example, to decide whether to apply a control)*
> - *determine how widespread the pests are*
> - *determine if a control strategy is effective and how well it is working*
> - *eliminate a potential pest before it gets started*

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What Are Insect Pest Monitors?

Pest monitors are tools that can be very complex and full of technology, such as infrared sensors, motion detectors, and video surveillance. Other very effective monitors are simple traps that can be homemade, inexpensive, portable, and disposable. Sticky traps are one version of such a pest monitor. These are often used indoors to help manage structural and nuisance pests in a home or school, but variations of these are used in conjunction with pheromone attractants (chemical lures) outdoors. They usually incorporate a plastic or cardboard base covered with a very sticky, glue-like substance. When pests walk or fly into the glue, they become stuck and cannot extricate themselves. Many such traps are available to the homeowner and professional alike. The advantage of such monitors is that they work 24 hours a day, 7 days a week, and 365 days a year. They never need a vacation!

Other monitoring tools include devices that capture insect pests as they wander into and are caught in a trap such as passive pit-fall traps. Most often, however, attractions such as light, scents, or food are used to entice pests to enter the trap. Common pest-monitoring attractant-based devices include black light traps, chemical-attractant (pheromones) traps, food-baited traps, or even simply traps that utilize attractive colors or shapes.

Pest managers monitor pest activity to gather information necessary for making pest management decisions. Monitoring relies on tools such as sticky traps, pitfall traps, and light traps to collect data about pest activity between visits by the pest manager.

Other monitoring methods employ nets to catch insects, either used actively, such as with a sweep or aquatic net, or passively, such as with a malaise trap. Sweep nets are commonly used to monitor for agricultural and horticultural pests. A predetermined number of sweeps of the net are made, passing over plant leaves and stems. Then the number of pests caught in the net are counted, which allows a pest manager to determine the number of insect pests per sweep.

Berlese funnels are another variation of a monitoring trap that uses heat and light to repel, rather than to attract. A sample of substrate, such as leaf litter, soil, or grain, is placed into the holding container on top of a fine-mesh screen. The lights are turned on and left for a time. All small insects or mites in the sample are forced to move away from the light, causing them to fall through the screen and into the collecting jar below.

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How Many Monitors Should Be Used?

There are few established number of traps required or even formulae that dictate the number of traps to employ. The number of monitors to use often depends upon the precision of the desired estimate, the size of the area to be monitored, and what the numbers will be used for. For example, more traps should be used in a food-handling establishment than in a hardware manufacturing plant because pest management is much more critical where food is involved. In addition, a large building with many different areas containing food and water will require more traps than a smaller building. For horticultural or agricultural fields, enough monitors should be utilized to provide a reliable and consistent approximation of the insect population size. Sometimes, recommended numbers of monitors are available from product dealers or from Extension specialists in the area.

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Where To Place Monitors?

It is important to place monitor traps in pest-vulnerable areas (PVAs), which are any areas where conditions are right for a pest to establish and thrive. PVAs are normally those areas where water, food, and shelter are available. In buildings, kitchens and food-handling areas are prime PVAs. Any area where trash is handled is an automatic PVA because of the food availability and the many pest hiding places it provides. In outdoor areas, monitors should be located where they will provide the best information for the area under consideration.

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How Often To Check Monitors?

Traps can be monitored at whatever time interval is deemed appropriate. Often, this is determined by the time resources that a pest manager can devote to monitoring as well as by the urgency of the pest situation. For example, if brown recluse spiders are discovered as a health threat in a school building, intense and frequent monitoring is required so that a pest-management plan can be adopted quickly. On the other hand, where monitoring is being used exclusively to determine if a pest will arrive, traps may only require checking on a weekly or biweekly basis.

Remember that traps must be checked on a regular basis. Checking a set of traps is often referred to as monitoring. It simply involves looking at the kinds and numbers of insects that are captured and recording the gathered information on a form or in a logbook. Light traps capture a large variety of insects, not all of which are pests. These require significant sorting time. Pheromone traps are much more selective in the pests that they attract and can be monitored relatively quickly. Traps that are placed but left unchecked for extended periods lose their value quickly. They certainly cannot provide advance warning of a pest infestation if they are not checked regularly.

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What Can Be Learned From Insect Monitors?

There are many things that can be learned about a pest population from checking monitors, most importantly, the identity of a pest. Correctly identifying the captured insect or insects can be very revealing. It is important to remember, though, that many insects found in a home or landscape or even in an agricultural crop are not pests. Many are actually beneficial, most are innocuous (neither harmful nor helpful), and only a few of the others are serious pests. The status of a pest is relative, since some pose a much greater threat than others. This is covered in more detail in the following section of this book, but for now, it is important to understand that identifying the pest and researching its level of threat are critical to integrated pest management.

Other very important pieces of information that monitoring traps may provide are relative population numbers and distribution. Traps placed in pest-vulnerable areas for twenty-four hours can give a good indication of the population distribution (how widespread the pests are) and the relative size of the infestation (minor, moderate, or severe).

Caution: Having zero counts on sticky traps for a short period (twenty-four hours) does not confirm that pests are absent. However, traps that are well placed for prolonged periods but which are consistently empty provide a reasonable indicator that there are no pests or that a very minor infestation level is present. The same can be said for sampling with a sweep net or another means. A zero count in one sweep or in one area of a field may not mean that there are no pest infestations. To validate population estimates, it is necessary to take multiple samplings that are evenly distributed in time and space.

Keep records of the number of pests trapped; accurate records are important. Professional pest managers utilize prepared log sheets (details will be discussed under the record keeping section of this book). Date, time, specific location, pest identity, and numbers of insects found are the main items to be recorded.

Without a system of surveying a population of pests, managers would be forced to make uninformed decisions that may have unfortunate consequences beyond just wasted resources. For example, without actual evidence, a vegetable grower may assume that a pest is present on the vegetables and, therefore, apply a pesticide. Not only does this waste resources if not needed, but it also creates unnecessary risks to people and the environment. Another incorrect assumption might be that because the pest was once present or because it has been found in a neighboring field, it is also present currently and requires control strategies. It is better to base decisions upon established facts.

Possibly one of the greatest benefits of monitoring is that it can be used as an evaluation tool to assess the effectiveness of any pest-control strategy. For example, comparing the populations of pests before and after a treatment allows a manager to make informed assessments about how effective the treatment is. Monitoring should be considered one of the most basic tools of proper IPM.

> *Monitoring is essential for determining the population size and distribution of a pest as well as to evaluate the effectiveness of control techniques.*

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Decision Making Using Pest Tolerances

There are several important inputs into a decision-making process. Decision making is based largely on pest tolerance levels. Other factors such as site analysis, potential control methods, and safety concerns also play an important part.

Establishing a pest-tolerance level is the first step in pest management decision making. A single insect in a building or a cropping system seldom warrants a treatment, but a large number of pests might. That is why assessing the size of the pest population—the number of pests per building, per plant, per acre, or per animal—is so important. However, it is also true that all pests are not created equal; some pests may be potentially much more damaging than others. Both a termite and an ant may be pests, but while an ant is a nuisance, a termite can cause structural damage to a home, so the termite is the more significant pest. In this case, one termite is more troublesome than a colony of ants. Thus, the potential for a pest to cause damage must be assessed in order to determine if and when the pest must be managed.

> The likelihood that a pest will cause damage, or pest potential, must be a part of the IPM decision-making process.

The estimated number of pests (population size) usually can be an indicator of the amount of damage to be expected. Think of it as this equation:

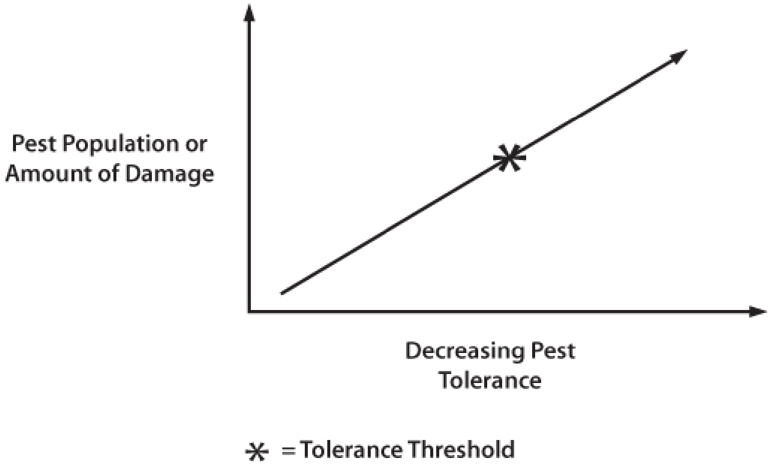
> Pest population size = amount of potential damage

Therefore, an estimate of the damage potential can also substitute for the pest population size. Either of these estimates can be used to determine a pest-tolerance level, which is the maximum amount of damage or the maximum number of pests that can be tolerated in any particular situation.

For example, a person may be able to live with, or tolerate, three flies in a home, but any more than that will make them uncomfortable. In this case, the tolerance level is set at three. Another example might allow 500 grasshoppers per acre as acceptable in a grass pasture, but when the population exceeds 500, the pasture begins to sustain serious damage.

The following graph depicts the relationship between population size or damage potential and pest tolerance:

As the pest population increases, it may eventually reach a point where it is intolerable. That intersection is considered the tolerance threshold.

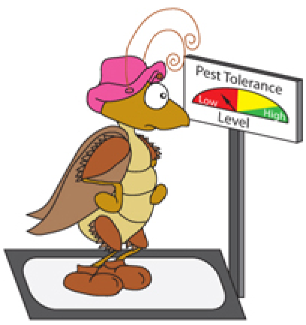


This is the point at which controls must be in place to reduce or maintain the population.

> *Integrated pest management is not geared toward complete eradication of a pest. The goal is to maintain the pest population below the level of pest tolerance. Depending on the system, the tolerance level may be a function of economics, aesthetics, or human health and comfort.*

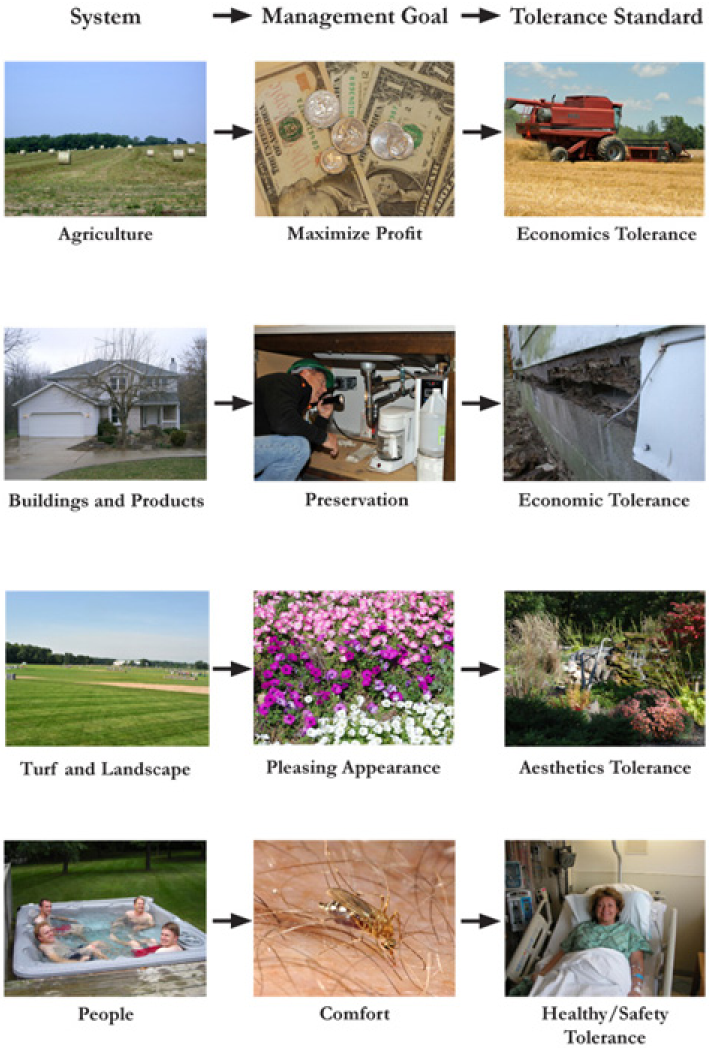
Tolerance levels depend upon the system for which they are calculated. The tolerance threshold concept in IPM was developed for agricultural pest management, but it also applies to turf, landscape, and structural IPM. Each system has a different goal that will determine the number of pests that can be tolerated. In agriculture, the management goal is typically to maximize profit by producing the highest yield with the least production costs, including pesticide application expenses. In turf and landscapes, the management goal is generally to maintain a pleasing appearance in an economically reasonable way. In buildings, the goal is to prevent pests from threatening human health and peace of mind, or harming contents or structures. In all of these systems, the pest manager must determine the level of pest population that can be tolerated without having a negative impact on the system's management goal.

Establishing a tolerance threshold is a simple concept in theory. However, in practice it is more difficult to establish and may vary, depending upon several factors. Consider, for example, that:



1. Not all pests represent an equal threat.
2. Not all environments, people or plants are equally sensitive
3. Pests may be more damaging under certain conditions than others

Factors Influencing Tolerance Levels


System
Management Goal
Tolerance Standard
Agriculture
Maximize Profit
Economics Tolerance
Buildings and Products
Preservation
Economic Tolerance
Turf and Landscape
Pleasing Appearance
Aesthetics Tolerance
People
Comfort
Healthy/Safety Tolerance

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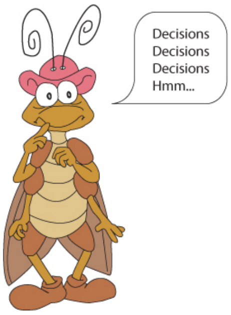
Situational Analysis



It is clear that tolerance levels affect many pest management decisions. But due to the wide range of possible pests, the specific situations in which they may occur, and the variety of people who might encounter them, a list of universally acceptable pest-tolerance levels cannot be established. So, by definition, IPM must also be situation-specific. In addition to considering the various tolerances that affect a situation, pest managers also need to analyze the site as well as the potential control tactics and their safety considerations.

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Site Analysis

A site analysis takes into account factors such as what protection is needed and what the various pest tolerances are. It also includes additional details that will affect the decision to manage a pest. For example, if the pest affects a plant or a crop, a site analysis notes whether the pest is attacking a growing plant or a stored product. It would also include details such as the plant stage of growth, where applicable, and the location of the plant.

For plants, pest managers must determine factors such as pest life stage as well as plant variety and development, health, and susceptibility to the pest. Environmental factors such as irrigation and soil compaction, as well as the interaction of many other possible stresses potentially affecting the plant, also must be accounted for in a formula predicting when a population of pests should be controlled. In some instances, specific numbers have been generated to give a general idea of pest thresholds and acceptable damage tolerances. Remember, though, that these are general guidelines only and should be adapted to the specific circumstances of the site and to the pest in question.

Sometimes managing pests in landscapes depends on several factors known only to those who manage the grounds. Factors such as upcoming events, expected traffic-use differences, specific weather conditions, irrigation stresses, soil types, and seasonal changes all play roles in IPM decision making.

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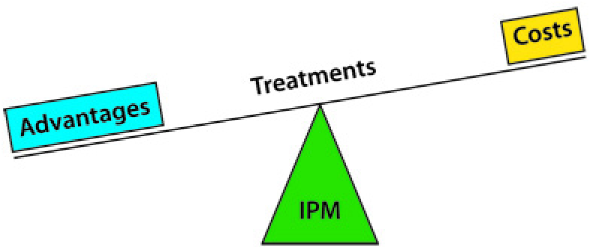
Control Method Analysis

Potential advantages gained by applying pest management tactics must be weighed against implementation costs. This comparison is always at the heart of IPM. Direct-treatment expenses, such as chemical costs, personnel time, and resources, are relatively easy to calculate. Indirect costs, such as re-entry or harvest restrictions, are more difficult to calculate, but they are often very important. Downtime for golf courses or athletic fields as well as access restrictions in buildings while pesticides are being applied must be considered. Even less easily measured costs, such as strained public relations or the potential for negative environmental side effects or lawsuits, must be taken into account.



Safety Analysis

Insect pests may damage plants, structures, and furnishings; cause annoyance; or create serious human-health concerns. Insect feeding may reduce a plantâ€™s ability to produce fruits or grains, or insects may feed on the produce directly, thus contaminating human food supplies. Insects can sting, bite, spread germs, and transmit diseases. At the same time, we know that chemical pesticides can also negatively impact people and can cause irreparable damage to the environment.

Over the years, society has come to depend on chemical pesticides as the primary tool for managing insects. Strict reliance on and overuse of chemicals have, in some instances, created a pesticide treadmill, requiring more and more chemicals in order to achieve consistent results. The potential for direct human exposure to pesticides as well as for indirect exposure through environmental pollution has become an important and volatile social issue. The dilemma faced by pest managers is that such concerns have not lessened public expectations for pest-free buildings and for high-quality, damage-free products. Fortunately, new pest management technologies, as well as the integrated pest management philosophy, are helping make this possible.

Unrealistic expectations regarding pest-free environments often confound IPM efforts. Realistic IPM expectations recognize that some level of pest presence may be acceptable, provided the long-term health of individuals or plants is not at risk. IPM requires a great deal of public education. Changes in public perceptions and tolerances of pest presence and damage must be adopted before the full range of IPM benefits can be achieved.

In summary, IPM encourages pest management practices based on a comparison of the advantages gained with the costs and disadvantages of a decision to treat. Site-specific judgments must be made in each instance and must take into account any potential perils, such as direct exposure to chemicals for humans and pets. Pest managers also must work to prevent environmental contamination by considering the fate of the pesticide through time and space as it is affected by factors such as proximity to surface- or groundwater, type of soil, and density of plants. Experience and sound judgment while conscientiously considering each of the above factors are at the heart of site-specific decision making.

Integrated pest management has the same objective in both the urban and the agricultural environment. Protecting human interests from damageâ€”and not necessarily killing pestsâ€"is the basis of IPM. Decisions should be made on a situation-specific basis and must be consistent with an overall pest management plan

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Implementing IPM Control Options

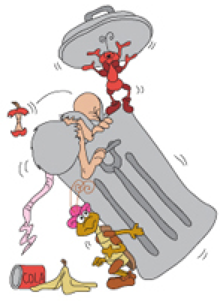
The terms “pest control” and “pest management” often are interpreted as synonyms. There is a crucial, though subtle, difference between them, however. Pest control traditionally has relied only on chemical remedies for pest problems. In contrast, pest management involves a deliberate evaluation process resulting in one or more carefully chosen control option - pesticides being one - to fit each situation. Pest management requires an understanding of pest-population levels and the possible applications of different control tactics in a pest management framework. In pest management, pest-tolerance levels are established and used as decision-making guides to clarify whether action against a certain pest is desirable.

In IPM, the word “integrated” implies a multidisciplinary or combined approach, whereby several management options can be brought to bear on a single problem. This combined approach is considered the most environmentally healthy and the most viable long-term strategy available. And choosing from a variety of possible management strategies ensures that the best management fit is achieved for a particular site. The better the fit, the less the chance of undesirable consequences.

Once the decision is made to implement a management procedure, the next step is determining which tactics are appropriate. Arriving at such a decision is seldom a simple process. It is made simpler, however, when the pest manager has a thorough understanding of the environment; the biology, life cycle, and ecology of the infesting pest; and the available management options. Often the best method for choosing a specific tactic is to compare all evident advantages to all possible limitations. Factors such as effectiveness, ease of application, environmental impact, and a host of other on-the-job experiences will be of value to decision makers.

IPM involves many potential actions, including human education, pest habitat modification, horticultural/agricultural design or redesign, and physical, biological, regulatory, chemical, and cultural control methods. When using chemical controls, “least toxic” chemical control methods should be considered.

The major control tactics used in pest management are worth further consideration because each may play a part in the control of certain insect pests, depending upon where, when, and how they occur. Pest managers must recognize and understand the merits of each. Below is a basic description and an example of how each can be used in integrated pest management.



Trash Can Provide Everything Pests Need
Food, Water, Harborage

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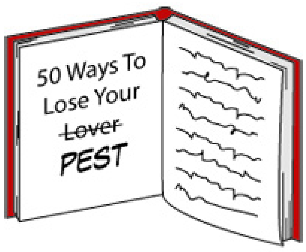
Prevention

A significant part of pest management is done well before a building or a landscape is constructed. Designing with pest management in mind is one of the most effective urban IPM techniques available. Both structures and landscapes can be designed that will (1) make it difficult for a new pest to enter and to live and (2) make subsequent management tactics much more efficient.

Simple control methods such as sealing up entry holes, placing screens on windows, or cleaning off equipment when moving from one field to another, will all help prevent pests from entering.



A great amount of educational effort has recently gone into a program to teach that the movement of firewood is risky because the emerald ash borer can hitch hike from infested to non-infested areas.

Professional pests managers know that if a pest does not arrive, they will not have to worry about controlling it. An ounce of prevention is worth a pound of cure!

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Cultural Control

Once established, pests become part of the environment. They affectâ€”and are also affected both directly and indirectly byâ€”every practice occurring in their environments. Controlling pests by changing living habits or environments is known as cultural control. Many cultural practices can be manipulated, to the detriment of pests. Making the environment less favorable to pest survival and reproduction is the goal of cultural pest control. In urban buildings, sanitation often is the most important cultural control.

Denying pests access to food, water, and a place to live, through increased sanitation makes it difficult for pests to enter or to persist once they are present.

In landscape management, it is generally accepted that healthy, vigorously growing plants can withstand more pests than can plants that are stressed. In this way, cultural practices such as mowing, fertilizing, pruning, mulching, and irrigating all indirectly affect pest injury. Inattention to these management practices can create stressed plants that attract pests. Proper identification and alleviation of these stress factors through cultural management changes are some of the longest-term and most environmentally-conscious methods of pest control in the landscape.

For example, trees under stress due to any cause are relatively attractive and susceptible to wood borers and other insect pests. Landscape managers must understand the interactions that irrigating, fertilizing, mowing and pruning, soil compacting, and other human activities have on potential plant-pest problems.

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Biological Control

Biological control occurs in nature all around us. Animals preying on or becoming parasites to other animals, or diseases that kill animals or plants are all agents of biological control, or more commonly called biological control agents. When we refer to the "balance of nature," we are often talking about natural biological control—one organism in the environment controlling another. In IPM, biological control is a method of managing pest populations by manipulating parasites (parasitoids), predators, or diseases (pathogens) in the pest's environment, to the detriment of a particular pest population.

Parasitoids (Parasites)

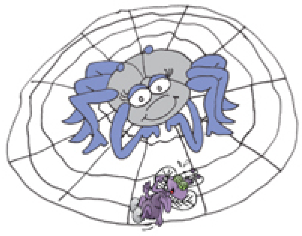

This tiny wasp develops within the caterpillar slowly killing it. The white pupae on the outside of the caterpillar are evidence of the infestation. They will each emerge as an adult and continue the cycle.

Parasitoids are often called parasites, but the term parasitoid is more technically correct. By definition, insect parasitoids have a free-living adult stage and an immature life stage that develops on or within an insect host and ultimately kills it. After feeding on host body fluids and organs, most parasitoids leave their hosts to pupate or emerge as adults. Most beneficial insect parasitoids are wasps or flies, although other insects may have life stages that are parasitoids as well. Parasitoids usually complete their life cycles much more quickly and increase their numbers faster than predators, even though a parasitized host does not die as quickly as those eaten by predators.

Parasitoids are often the most effective natural enemy of pest insects, even though they may not be readily visible. Sometimes pest populations actually increase after pesticides are applied. This can happen when a chemical insecticide kills the parasitoids before they can kill their host, or the pest insect. Once free of the natural parasitoids, the pest insect is then free to increase in number.

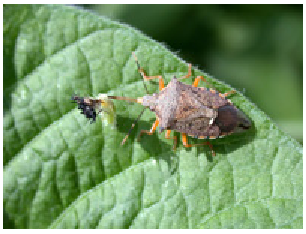
Predators

Insect predators can be found in almost all agricultural and natural habitats. They are usually bigger than their prey and consume them very quickly. Predators are known for their ability to actively search out and destroy their



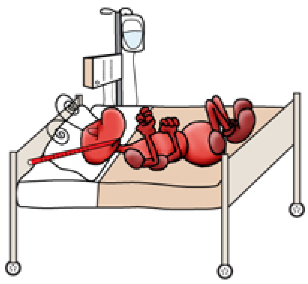
host. Some, such as the praying mantis, are generalist predators, meaning that they will feed on nearly any insect that they can catch. Others are specialists, meaning that they will search out only a certain species or a certain life stage of an insect on which to feed. Their ability to search and destroy makes them very effective natural enemies of insect pests. Predators should be credited with controlling many would-be pests. Common predators include beetles, bugs, lacewings, flies, midges, and wasps.

Most beneficial predators will consume many pest insects during their life span, but some predators are more effective at controlling pests than others. Many predators may have only a minor impact on a pest population by themselves but they still contribute to overall pest management when their effect is combined with the effects of other predators and/or biological control agents.



Predators, in either the larval or adult stage, search out and eat insect pests. Some have a voracious appetite and can consume many pests, ultimately reducing the pests' population.

Pathogens



Pathogens are naturally occurring biological agents—such as bacteria, viruses, fungi, protozoans, and nematodes—that infect and kill insect hosts. Like humans, insects can be infected by pathogens. Under favorable conditions, such as high humidity or pest abundance, pathogens may quickly multiply to cause disease outbreaks or epizootics that can decimate an insect population.

Entomologists and agriculturists are just beginning to truly recognize the value of naturally occurring pathogens in the prevention of insect outbreaks. Insect pathogens are one of the reasons that pest populations do not become problematic every year. Many pathogens have been identified, while many more are at work in the environment but have yet to be discovered.

Grub infested with insect pathogenic nematodes.

Of those that have been identified, some pathogens have been mass-produced in laboratories and are now available to pest managers for use against insect outbreaks. Some of these microbial insecticides are still experimental, while others have been available for many years. Formulations of the bacterium *Bacillus thuringiensis*, or Bt, for example, are widely used by gardeners and commercial growers. And several species of nematodes can be purchased to control many different pests in landscapes, turfgrass, greenhouses, and urban structures.

As a group, these products are referred to as biorational or microbial insecticides because they are applied in a manner similar to conventional pesticides even though they contain a microscopic life form. One main advantage of insect pathogens is safety. They are relatively specific to select groups of insects and sometimes even target specific life stages. As such, they do not harm the environment or nontarget animals, such as beneficial insects, pets, wildlife, or humans.

Unlike chemical insecticides, microbial insecticides can take longer to kill their target pest. Also, they are usually more expensive to use, and they must be applied to an environment in a way that will allow them to survive. To be effective, most microbial insecticides must be applied to the correct life stage of the pest, so pest managers must understand the life cycle of the target pest.

Microbial insecticides are compatible with the use of predators and parasitoids, which may help to spread some pathogens through the pest population. While beneficial insects are not usually affected directly because of the specificity of these microbial products, some parasitoids may be affected indirectly if their hosts are killed. Insecticide applicators should note that although microbials are nontoxic to humans in the conventional sense, safety precautions should always be followed to minimize exposure.

Pathogens can be important management tactics for many insect pests and are important components of an IPM strategy.

Biological control, the practice of using living organisms to control pests, is not a new science, but it is a control tactic that is beginning to see greater acceptance in insect pest management. Evidence of biological control efforts exists from ancient times and significant control was achieved through the introduction of biological controls in the early part of the twentieth century. However, with the introduction of modern synthetic chemical insecticides, especially during the latter half of the twentieth century, biological control became a largely forgotten science. New chemical insecticides were cheap and appeared to be “cure-alls.” But this perception was unfounded, and as the disadvantages of synthetic chemicals became more evident and public demands for more environmentally friendly methods of pest control grew, biological control agents were sought after once again.

Biological control offers many advantages over conventional chemicals. The most important advantage is that biological control methods can be less hazardous, both to people and to the environment. Once introduced, they can continue to be effective without further human intervention. Some instances of introduced biological control agents have been successful, while others have been disappointing. Of course, care must be taken to avoid introducing biological control agents into the environment only to realize later that these “controls” have become pests themselves. Case in point: Asian lady beetles were introduced into America to help manage aphids in agricultural crops. Now they have become a common nuisance pest in homes throughout much of the United States.

Predatory or parasitic organisms feeding directly on pests have shown promise for controlling pest populations. In nature, many different parasites or predators can be found, each with a unique ability to persist, seek out, and kill potential hosts. Pest-specific diseases also have been used with varying degrees of success in the management of pest populations. Successful organisms, mostly fungi and bacteria, have been propagated in the laboratory and are now commercially available.

Naturally occurring biological control agents probably are more important than most people imagine. Insect pests usually are controlled naturally by beneficial arthropods and diseases, which can moderate or often prevent outbreaks of pest populations. It is telling that landscapes that are not intensively managed are seldom prone to serious pest outbreaks. Society has learned, through hard-won experience, that when the natural balance is upset by chemical or cultural interference, pests readily move in. Therefore, careful consideration must be given to how each management input can affect a system's beneficial organisms.

Identifying and conserving naturally existing plant and animal biological control organisms are logical steps in IPM implementation. Maintaining a balance between pests and their natural controls will diminish the need for pesticides, save money, and greatly benefit the ecosystem.

Overuse or misapplication of nonselective chemicals interferes directly with the potential of naturally occurring beneficial organisms. Pesticides have been shown to have the opposite consequences of their intended use if they kill the naturals controls that hold a pest population in check. Releasing a pest population from its natural biological checks and balances may set the stage for a dramatic and often devastating resurgence of a pest population.

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Alternative Control

Toxins such as azadirachtin, rotenone, nicotine, and pyrethrin all are derived from plants. Although these are not technically either biological controls or synthetic chemical pesticides, they are materials with a botanical origin that offer some of the same pest management advantages as true biological controls and chemical pesticides. These are part of a group called alternative controls.

Alternative controls are botanical pesticides.

Alternative controls also includes biological microbes (or microbe derivatives). Several such materials have been developed for use in pest control. Discovering new and better alternative-control products is an active area of research that promises to have a significant effect on the future of pest control.

New technology and scientific advances have given IPM new tools for controlling pests. Some newer pesticides have been designed to be taken up into the plant, which make them more effective and less likely to harm insects other than the target pests. Advances in biotechnology have allowed "pieces" of genetic code that are toxic to insects to be inserted and expressed in plants, making them resistant to insect feeding. Also, scientists have worked to grow plants that are resistant to specific insect pests. These are areas that will continue to see significant and exciting developments for alternative controls.

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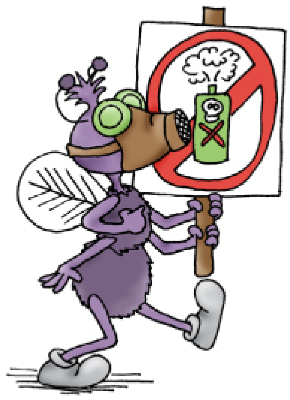
Chemical Control

The word “pesticide” is often used as a synonym for “insecticide,” but this is actually incorrect. Pesticides refer to a broad group of chemicals designed to control pests. While insecticides are one type of pesticide, there are many other types of pesticides as well. Some other examples are herbicides, which are used to control plants, and rodenticides, which are used to control rodents.



There are many different kinds of insecticides. Some, such as sulphur and arsenic, have been used for more than 3,000 years. Others are just being developed today. Because there are so many insecticides, they can be grouped in many different ways, including by chemical makeup, by how they work, by their form, and by what insects they target. For example, insecticides are often placed into groups or classes of chemistry, depending on how they are synthesized. They are given common names that can relate back to the specific chemical name or chemical structure.

Other times insecticides are grouped by the method in which they kill insects, or their mode of action. These insecticides may kill by interfering with a specific part of the insect’s nervous system, growth and development, or digestion.

Still other ways to describe insecticides involve their mode of entry, or how they get into an insect’s body. Some are ingested while the insect is feeding, some are taken in as the insect respires, and others rely on contact with the insect’s epidermis.

In practical applications, pest managers may group insecticides by what insects they control, while in other situations, they group them by what formulations the insecticide is purchased and used (liquids, granules, fumigants, etc.).

> *Pest managers must understand the insecticides that they use, including the common and chemical names, modes of action, modes of entry, formulations, and target pests affected.*

Use of synthetic chemical pesticides is an important component of most IPM strategies. Chemical treatments are especially effective because they can be applied with relative ease and can quickly bring a high pest population down to an acceptable level. When used in this manner and for this purpose, chemicals can be an integral part of an IPM program.

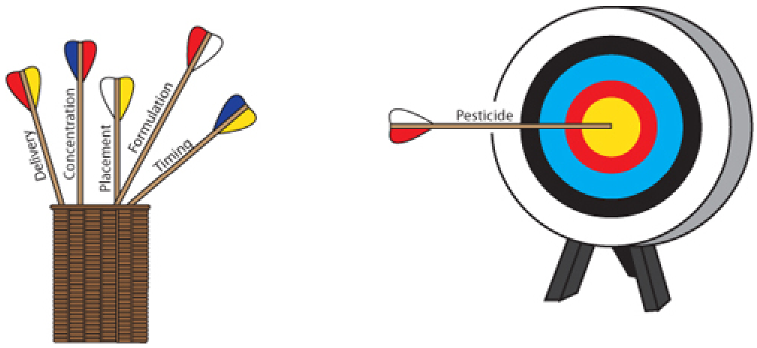
When pesticides are continually and exclusively relied upon to maintain pest populations at low levels, problems inevitably arise. Pesticides are toxic and are designed to kill. As a result, there is always a potential threat of pesticide poisoning to people or other animals that are not the target.

Chemical pesticides are notorious for their ability to move from an intended target zone to another. They may move through water or air into an unintended zone, where significant damage may occur to people, nontarget animals, plants, or the environment. Chemical pesticides may also change forms—from liquids to gases or from solids to liquid—and pose very significant risks.

> *Sound IPM requires selecting only those insecticides that have the correct formulation, concentration, and proven result for the pest and site intended.*

It is unrealistic to expect to eliminate all pests. Notwithstanding the broad-spectrum, long-residual pesticides used in the 1960s and 1970s, it has become clear that complete eradication of pests is impossible. In most situations, small pest populations that are monitored carefully over time and managed in such a way that they do not increase beyond certain tolerance levels become acceptable. When compared with the potential negative human and environmental health effects that complete pest elimination would cause—not to mention the costs of total reliance on chemical pesticides—a low, well-managed population is preferable.

Recently, great strides have been made in developing “low-impact” chemistries. These are environmentally friendly, narrow-spectrum (more targeted), least-toxic pesticides that have been developed by the chemical industry. As the U.S. Environmental Protection Agency registers these for use, other older, “high impact,” and less environmentally compatible pesticides, are being removed from the marketplace.



Always use the best pesticide delivery, concentration, placement, formulation, and timing when shooting for IPM.

The solution to a specific pest problem does not always involve a new or better pesticide. Often the difference between success and failure in managing a pest population lies in knowing where, when, and how to apply a selected pesticide.

Targeting pesticide applications to only those areas where monitoring has determined a need for control (spot treating) decreases the total amount of pesticide applied and conserves natural biological controls already in place. IPM dictates that spot treatments replace blanket treatments wherever possible.

Using new technologies to deliver pesticides directly into the area where pests are present—that is, the target zone—diminishes the probability of exposure to nontarget organisms, decreases the quantity of pesticides needed for treatment, and increases pesticide effectiveness. For example, replacing whole-room or even baseboard treatments with crack-and-crevice-only applications is one way of targeting pesticides in buildings and structures. Injection techniques may be used to deliver ever smaller amounts of pesticides into soils or trees in the urban landscape. Select pesticides also may be absorbed and distributed throughout the plant, ultimately killing only those insects feeding directly on it. This is another example of targeting. Spot-treating crops, rather than treating the entire field, where inspections have indicated that pests are present is a method of targeting pesticide applications in agriculture.

Targeting is sound IPM.

Timing of insecticide applications is critical. IPM dictates that pesticides only be applied when they can prevent pest damage. In some instances, only one stage of an insect is damaging. Therefore, knowing when the pest does its damage is important. Application timing must be a part of an IPM strategy.

Proper timing of pesticide applications is sound IPM.

Professional IPM continually incorporates new procedures and technologies into pesticide-application methods, thereby decreasing both the populations of pests and the negative risks associated with pesticide applications. Development of pesticide-laced baits has greatly improved the ability of structural pest managers to control rodent and insect pests, such as mice, rats, ants, cockroaches, and termites. Baiting techniques significantly decrease the amount of toxic materials applied in the urban environment and yet achieve pest-population controls equal to or better than traditional methods.

> *Good IPM strategy requires the use of the most effective pesticide applied at the best possible time and in the best possible manner to only those areas that are known to harbor damaging levels of pests.*