11 Urban Integrated Pest Management

Integrated pest management (IPM) has its roots in contemporary agriculture, in which questions of economics—cost of treatments versus the value of benefits—are a driving force. Recently, IPM techniques and philosophies with slightly different emphases have been applied to urban pest management, which concerns the direct interactions between people and pests, whether in the innermost parts of a city, in a suburban area, or in a comparatively rural location. Like agricultural IPM, urban IPM applies pest management decisions on the basis of determined need, instead of on the basis of preventive, or prophylactic, philosophy. Calling for a multidisciplinary approach, urban IPM uses various nonchemical and chemical techniques in an overall management strategy.

Unlike agricultural IPM decisions, however, urban IPM decisions cannot be made on an entirely economic basis (Gibb 1999), for often in urban environments no commodity is produced, harvested, or sold. Urban IPM balances the cost of treatments with a human comfort value. Compared with economic gains in agricultural IPM, urban IPM quantifies human comfort value less readily and becomes more subjective when human tolerance of pests and quality of life are considered. Thus, a management decision based solely on the economic return of pest control inputs is unrealistic in an urban environment. Rather, urban IPM is based on the premise that, even in the absence of monetary value, damage can occur and pest management can be justified.

Urban IPM includes a human factor rather than an economic factor in the pest management equation. For example, qualitative aspects such as aesthetics, comfort, health, and peace of mind substitute in many ways for the quantitative economics involved in agricultural IPM decision making. Because many of the qualifying aspects for urban IPM are subjective, they cannot be measured economically. This subjectivity represents a major challenge in urban IPM and can cause it to become very complex and subject to individual interpretation. But the unifying and distinguishing characteristic of all urban IPM approaches is the human factor. Whether a pest is a pathogen, an insect, a weed, or a rodent, an organism that damages homes, structures, clothing, food, or landscape plantings or harms, annoys, or otherwise interferes with people and their activities is considered an *urban pest*.

In urban IPM, social concerns replace economic gains or losses as the driving force behind decision making. Among these concerns are public attitudes, perceptions, and prejudices regarding pests and pesticides and their effects on human activity and the environment. Within the last few years, environmental and human health issues clearly have become prime considerations of regulatory agency personnel. A massive push to decrease human exposure to toxicants of all kinds is under way. Concurrently, a substantial increase in litigation relating directly to pest management and pesticide application is occurring. Rights to be informed of pesticide use, residues, and toxicity levels; rights to pollution-free public environments in which to work, visit, or study; and rights to be free from harmful parasites, disease, and nuisance pests are being legislated. Attaining acceptable levels of pest management without exposing people and the environment to excessive risks from pesticides is the major objective of urban IPM.

The definition of *urban IPM* has evolved over the years as various environmental and social pressures have been brought to bear. Olkowski, Daar, and Olkowski (1991), Owens (1986), and others have had insights into IPM concepts. Their insights and discussions have been considered in the development of the following definition:

> Urban integrated pest management is a process that employs physical, mechanical, cultural, chemical, biological, regulatory, and educational techniques to prevent pests from establishing populations capable of causing unacceptable economic, social, medical, or aesthetic damage. Urban IPM utilizes regular inspections to determine if and when a treatment is needed. Treatments are chosen based on proven records of success and become part of the overall IPM strat-

> egy. Chemicals, when required, are target-specific, low-impact and are made only when and where monitoring has indicated that the pest will cause intolerable damage or annoyance. The IPM program must, as a result, be environmentally, socially, and economically compatible to meet public expectations. (Gibb 1999)

Five main components of urban IPM, whether inside buildings or out-of-doors, should be considered essential. These include the need for (1) inspection, (2) monitoring, (3) situation-specific decision making, (4) pest management technique application, and (5) evaluation and record keeping.

Inspection

In its strictest sense, IPM is simply a decision making process that begins with a thorough inspection to identify the pest and the habitat in which it exists and the nature of its interactions with humans. Identification of the pest and its demographics is key to determining the seriousness of the problem and the management steps that must be taken.

Identification is a step 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 still are made commonly when many urban pests are being studied, especially pests that are similar in appearance or behavior. Accurately identifying the pest, recognizing which life stages are present, and understanding the life history of the pest and how it interacts with people help a pest manager exploit the weak links in pest biology.

An equally important component of an inspection is that of assessing potential human/pest interactions. How the building or landscape is constructed and used, how it is accessed and maintained, how its use and construction affect the local and general environments, and whether any additional regulatory influences are at work all are important pieces of information that can be provided by an inspection. Assessing the building and landscape habitat allows for an evaluation as to relative pest-conducive situations and, therefore, allows prophylactic or preventative solutions to be implemented. Also implicit in the pest equation is a specific evaluation of the human factors involved—personal and company biases, fears, concerns, and pest tolerance levels. Together, these interactions inform decisions regarding appropriate pest management techniques for each situation.

Monitoring

The primary objective of monitoring is to obtain an estimate of the pest population size and distribution. Monitoring begins during the initial inspection and should become an ongoing component of the IPM program. Data obtained from monitoring, coupled with knowledge of pest tolerance levels, allow the manager to assess a problem as severe, moderate, or minor. This process also confirms whether pest damage is evident, increasing, or decreasing. It is not uncommon to find pest treatments applied inappropriately in situations because pests have become inactive or have reached a life stage during which treatments no longer are effective.

Information obtained from monitoring plays an important role in determining the type, intensity, and duration of management techniques required. Only through monitoring can a decision be made regarding whether an action is justified. Monitoring provides demonstrative proof that pesticides or other management tactics need to be applied. Often such justification is necessary to reassure the public. Monitoring helps a pest manager determine a time both to begin a pest control action and to end it.

Perhaps monitoring's most important advantage is that it can be used as an evaluation tool to assess the effectiveness of any pest control strategy over time. Monitoring should be considered one of the basic tenets of effectively designed urban IPM.

Establishing Pest Tolerance Levels

It is unrealistic to expect to eradicate all pests either outside or inside buildings. Notwithstanding the broad-spectrum, long-residual pesticides used in the 1960s and 1970s, it has become evident that eradication of pests is impossible, even if society were willing to accept the negative environmental consequences of the use of these products and regimens. Rather, in most situations, low pest-populations, monitored and managed carefully over time so that they do not increase beyond a certain tolerance threshold, are acceptable. When compared with the potential negative human and environmental health effects of total reliance on chemical pesticides, a low, well-managed pest population is, in fact, preferable.

Education is key to helping establish realistic tolerance levels. Educating clientele about whether, when, how, and where pests harm humans is the first step. Urban-pest managers must recognize that tolerance levels are situation specific. Very sensitive situations may dictate that the presence of even a single pest such as a brown recluse spider exceeds the highest tolerance level; in other situations, even great numbers of pests such as ants may not be a serious threat, and thus a "no action" policy may be the correct response. Tolerance levels also depend on specific sites, clientele groups, locations, and, even, time. For example, pest tolerance levels may be lower in hospitals, daycare centers, or nursing homes because the sick, the young, or the elderly are more sensitive to the pest. Established pest tolerance levels may decrease when large gatherings are expected either in a building or in an outdoor setting, only to rise again after the event ends.

The decision regarding whether to use pest management tactics pivots on tolerance level. Because such decisions in urban IPM are based on more than economics, they can be difficult to make.

Tolerance Levels in Urban Landscapes

In plantings such as ornamentals and turfgrasses, whose values cannot be translated easily into dollars, the IPM issue becomes complicated. Assessment comes to hinge on the relative worth of the plant in its surroundings or on its aesthetic worth. In landscape pest management, even the relative value of a planting can depend on such factors as its location in the landscape. For example, in a residential setting, limited pest damage might be tolerated in a backyard, where relatively few people might see it; the same amount of damage in the front yard would tend to be unacceptable, however. In golf courses, limited pest damage and invasion are tolerable in the rough areas because playability of the course is unaffected. Much lower levels of the same damage are acceptable, however, in intensively maintained fairways. Even less pest damage is tolerated on the tees and greens, and especially on those closest to the clubhouse, where they are played and seen by more people more often.

A decision to manage a pest population depends on two major interacting factors: the size of the pest population and the associated tolerance level. Together, pest population level, species, and host susceptibility determine potential damage to landscapes. Damage usually occurs as a result of the pest's feeding on or otherwise injuring a plant. Tolerance levels must, therefore, also include assessments of potential damage.

Tolerance Levels in Urban Buildings and Structures

Perhaps even more subjective than the process of determining treatment thresholds in landscapes is that of determining pest tolerance levels in urban buildings. As in landscape IPM, tolerance levels are determined according to the pest's potential to cause harm or annoyance and by the residents' personal tolerance levels, factors both influenced by the site/environment. The issue may be confounded further when personal health or safety issues are at stake. For example, the number of ants that personnel in an office building might tolerate before implementing a costly management practice is greater than that of brown recluse spiders, simply because of the potential negative consequences associated with each pest. Even if all buildings and locations were identical, tolerance levels would differ because each person has a unique zone of comfort. For instance, even if an individual became convinced that he or she would not be bitten, stung, or contaminated in any way by a specific pest, comfort levels might remain low insofar as the individual was uncomfortable "just knowing" that a pest was present in home or office.

Situation-Specific Decision Making

By definition, IPM in urban environments (buildings or surrounding landscapes) must be site specific. Because of the multiplicity of possible site-specific variations, a list of universally acceptable thresholds for pest tolerance cannot be established. Significant differences occur depending, for instance, on whether the landscape is a home lawn or an athletic field. Parks, cemeteries, and rights-of-way all have significantly different uses. Even within a landscape, pest tolerances depend on several factors known only to those managing the grounds. Factors such as upcoming events, expected traffic use differences, site-specific weather conditions, and irrigation stresses, soil types, and seasonal changes all play roles in IPM decision making.

On landscape plantings, factors such as pest life stage and plant variety and development, health, and susceptibility to the pest must be known. Environmental factors such as irrigation, soil compaction, plant susceptibility to the pest, as well as the interaction of myriad other possible stresses potentially affecting the plant also must be accounted for in a formula predicting when a pest population should be controlled. In certain instances, specific numbers have been generated to give a general idea of pest thresholds and acceptable damage tolerances (Schumann et al. 1997). It must be remembered, however, that these are general guidelines only and should be adapted to the specific circumstances of the site and to the pest in question.

Likewise, certain urban structural environments such as hospitals or food production plants are especially sensitive to pests. Health and food contamination concerns drive pest tolerances in these structures to levels lower than those in parking garages or in nonfood warehouses. Even within a single residential or public structure, localized areas such as kitchens and bedrooms are more sensitive than basements, attics, and patios, and a unique pest threshold exists for each environment.

As a result of these variables, no published table of pest tolerance levels could apply universally: pest tolerances must be established on a case-by-case, situation-by-situation basis. Before attempts to establish a tolerance level are made, it is crucial to thoroughly understand the pest, its habitat, and the people it affects. Prior understanding of these issues helps a manager avoid the pitfall of basing treatments on impulses.

Potential advantages gained by applying pest management tactics must be weighed against application costs. This comparison is always at the heart of urban IPM. Although direct treatment-costs such as personnel time and resources, golf course down time, or inconvenient use restrictions of an area in a building while pesticides are being applied are measured with relative ease, the less-direct costs, such as strained public relations and the potentials for negative environmental side effects and for associated lawsuits, often are more important.

Urban pests must be managed so that people can function and live in the way they have become accustomed to. Urban IPM encourages pest management tactical choices based on a comparison of the advantages gained with the possible costs and disadvantages accompanying a decision to treat. Site-specific judgments must be made in each instance and must take into account potential perils to humans and pets (e.g., direct exposure to chemicals). Preventing environmental contamination by considering the fate of the pesticide through time and space, as it is affected by factors such as proximity of surface- or groundwater, type of soil, and density of plants also is required. Experience and sound judgment, together with a conscientious consideration of each of the aforementioned factors, are at the heart of site-specific determinations.

Human-Health Concerns

Urban pests may damage plantings, structures, and furnishings; cause annoyance; or create serious human-health concerns. Wasps can sting, fleas can bite, and flies can spread germs and other disease agents. In addition to harming people directly through biting or stinging, pests also can cause serious health threats simply by being present. For example, fecal material, dander, the discarded skins of insects during growth, as well as the expired bodies of past generations, break down over time. During decomposition and over time, fine particles can become airborne and, when inhaled by a person already predisposed to asthma, can cause severe complications. Cockroaches, dust mites, and, recently, house mice and lady beetles all have been implicated directly in human allergies and asthma (Rosenstreich and Eggleston 1997; Sporik et al. 1990).

It also should be recognized that many individuals are intolerant of pesticide residues in the environment. Some people may oppose pesticides on the basis of fear or prejudice whereas others are sickened physically by pesticides, even at low concentrations. A condition called *environmental sickness*, or *multiple chemical sensitivity*, is linked to exposures to chemicals in the environment (Ziem 1992). A theory called *toxicant-induced loss of tolerance* might explain why overexposure to a single environmental pollutant (not always a pesticide) leads to heightened sensitivity to several other unrelated substances, including pesticides, in the environment (Miller 1997).

Concerns have arisen and debate has ensued about the issue of children's exposure to pesticides (NRC 1993) and whether there is a correlation between exposure and acute or chronic health disorders. Although this issue still is being debated, neither side questions that human health can be affected negatively when pesticides are misused. What should be recognized by all is that pesticides used properly are part of a safe and effective IPM program. In decisions regarding whether to use pest management tactics, *trade-offs* (advantages due to decreases in pest populations, and potential disadvantages due to management applications) must be considered.

Over the years, society has come to depend on chemical pesticides as the primary tool with which to maintain pest-free landscapes and buildings. Strict reliance on and overuse of chemicals have, at times, created a pesticide treadmill, by which more and more chemicals have been required to achieve consistent results. Because of the constant and intimate human presence in urban environments, perceived health risks due to pesticide applications in these areas have increased. The potentials for direct human exposure to pesticides as well as for indirect exposure through environmental pollution have become important and volatile social issues. The dilemma faced by urban IPM is that such concerns have not lessened public expectations for pest-free buildings or for high-quality, damage-free plantings (Sadof and Raup 1997). Even without the aid of many of the chemical management tools of the past, pest managers still are expected to provide pest eradication in homes and buildings as well as pest- and damage-free plantings in the landscape. Fortunately, new pest management technologies are helping make this possible in the urban environment.

Unrealistic expectations regarding pest-free environments often confound IPM efforts. Realistic IPM expectations recognize that a degree of pest presence may be acceptable, provided the long-term health of individuals or plants is unaffected. Urban IPM requires extensive public education. Changes in public perceptions and tolerances of pest presence and damage must be effected before the full range of IPM benefits can be achieved.

Integrated pest management in the urban environment remains, in many ways, similar to that in the agricultural environment. Protecting human interests from damage—and not necessarily killing pests—is the basis of urban landscape IPM. Management strategies can be chosen from among chemical, cultural, mechanical, biological, and/or regulatory options. Decisions should be made on a site- and situation-specific basis and be consistent with an overall pest management plan.

Application of Pest Management Techniques

The terms *pest control* and *pest management* often are interpreted as synonymous. There is a fundamental, though subtle, difference between them, however. *Pest control* traditionally has involved a one-dimensional emphasis on pesticidal remedies for pest problems. *Pest management* is not a reaction but a deliberate process of treating a pest with a management tool such as a pesticide. Pest management requires an understanding of pest population levels and of possible applications of a number of different control tactics in a pest management framework. In pest management, pest thresholds are established and used as decision making guides to clarify whether action against a certain pest is desirable. In addition, pest management, instead of stressing reliance on a pesticide, stresses integration of at least two approaches to managing complex or severe pest problems.

In any IPM program, accurate determination of the need for intervention depends on many situation-specific and use-specific factors. Therefore, IPM in urban environments has come to focus on (1) preventing buildings and landscapes from being invaded by pests and (2) offering an array of potential management techniques when infestations do occur.

In IPM, the word *integrated* implies a multidisciplinary approach whereby several management options can be brought to bear on a single problem. Such an approach is considered the most environmentally healthy and viable long-term strategy available. Choosing from a variety of possible management strategies ensures that the best management/site fit is achieved. The better the fit, the less the chance of undesirable consequences.

Once it has been determined that a management practice should be implemented, a decision should be made regarding appropriate tactics. Arriving at such a decision seldom is a straightforward process. It is made simpler, however, when the pest manager has a thorough understanding of the environment, the biology, the life cycle, and the ecology of the infesting pest and of the available management options. Often the best method for choosing a tactic is to compare all evident advantages with all possible limitations. Factors such as efficacy, application ease, environmental impact, and a host of other on-the-job experiences will be of value to decision makers.

Pest Prevention by Exclusion

Preventing pest entry or spread is a fundamental IPM objective. On a national and a statewide basis, regulatory agencies help prevent the spread of pests by enforcing requirements on shipping food commodities, sod, and other landscape materials from one location to the next. A great number of diseases and insect pests are held in check by such regulations. Understanding how pests move and are introduced into a new location allows circumvention of pest distribution. Routinely inspecting, cleaning, and disinfecting equipment, transportation vehicles, and other materials in which pests might be introduced from one site into another is also an important practice requiring knowledge of pest presence and biology.

Additionally, efforts to eradicate a small pest-population before it becomes established are desirable. Governmental agencies actively monitor for the invasion of suspected pests and stand ready to perform localized, intensive eradication procedures in an effort to stave off permanent establishment of new pests. On a local basis, urban-pest managers using similar tactics can help prevent movement and establishment of pests from an infected area into a new site. The first step is routine monitoring.

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.

Landscape Design

Urban landscape IPM begins in the designing phase, with a goal of minimizing potential pest problems. Early decisions as to variety selection and placement, soil and seedbed preparation, planting, irrigation, fertilization management, use, and aesthetics are aspects considered by effective IPM planners. Continuously maintaining plant vigor and decreasing environmental stress through appropriate cultural management are key to warding off pests and allowing plants to recover from infestation rapidly.

Landscape pest problems often can be avoided simply by selecting plant varieties that are well suited to the site and to the purpose for which the landscape is being used. Choosing plant species that are certified tolerant or resistant to pests is part of that design. Laboratory and field screening of plant varieties and cultivars resistant to pests has been underway for several decades. Methods involve choosing plant genotypes relatively tolerant of, resistant to, or undesired by pests and, subsequently, combining these genetically resistant traits with other desirable traits. Lists of resistant or pest tolerant plants should be studied, and plant selections made as part of a predetermined landscape design. Even minimal efforts in the initial design of landscapes and in the selection of plants can pay huge dividends later if pests invade.

Well before the first seedling is planted, many more pest problems can be prevented by planning. Site selection and seedbed preparation are two often-overlooked areas. Type and grade of soil, movement of water and air, slope of the land, and proximity of other landscapes, buildings, and water sources all will influence future pest potentials.

Seeding properly prepared beds with the best match of plant variety and ensuring that optimal irrigation and fertilization practices can continue also are important preplant decisions that a pest manager should help make. These factors should be considered carefully and, when necessary, modified to facilitate decreased pest problems.

Building Design

Like landscape design, building architecture and layout are potentially important factors to consider in pest management (Figure 11.1). “Building pests out” of a structure simply means “making the invasion and the persistence of pests there difficult.” Decreasing a pest’s initial attraction to a building by

Figure 11.1. Like landscape design, building architecture and layout are potentially important factors to consider in pest management. Photo courtesy of T. Gibb, Purdue University.

modifying lights, eliminating food and water sources, and restricting harborage sites greatly diminishes the susceptibility of a building to pest invasion. Easy entrance to the building can be denied pests by means of open door and window policies, screens, and door sweeps, and through the use of sealants in foundation cracks and in plumbing and electrical conduits. Ensuring that air intake and air handling systems are working properly and are closed off adequately is important. Controlling temperature and humidity and restricting or eliminating food sources through sanitation and food handling procedures can prevent pest proliferation inside a building and are essential elements in structural IPM. Choosing and modifying mechanical equipment such that it is easy to inspect, clean, and treat for pests makes IPM possible in many urban structures.

Cultural Controls

Once established, pests become part of the urban environment. They affect their surroundings, but also are affected—directly or indirectly—by every practice occurring there. Many cultural practices can be manipulated to the detriment of pests. Making the pest environment less conducive to 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 harborage through increased sanitation makes it difficult for pests to enter or to persist once they are present.

In landscape management, it is accepted generally that healthy, vigorously growing plants can withstand more pressure from disease, weed, and inspect pests than stressed plants can. Doubtless, cultural practices such as mowing, fertilizing, pruning, mulching, and irrigating all affect pest populations indirectly.

Inattention to these management practices can create stresses that encourage the development of 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, understanding that high populations of weeds in a turfgrass stand are good indicators of stressed turfgrass and subsequently resolving such stress problems, be they irrigation, traffic, soil compaction, or other, can diminish the need for herbicides. Likewise, 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.

Biological Control

Using living organisms to control pests is not a new science, but this approach is beginning to see greater acceptance in urban pest control. Biological control lends itself more readily to landscape situations but has implications to indoor pest populations, as well.

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. With the introduction of modern synthetic chemical insecticides, especially during the latter half of the twentieth century, however, biological control became a largely forgotten science. New chemical insecticides were cheap and seemed to be "cure-alls." But, as has been discussed, this perception was unfounded. As the disadvantages of synthetic chemicals became evident and public demands for more environmentally friendly methods of pest control grew, biological controls again were sought. Biological controls offer many advantages over conventional chemicals. Chief among these advantages are the facts that biological controls can be safer both to people and to the environment and, once introduced, can continue to be effective without human intervention. Certain instances of introduced biological controls have succeeded whereas other types of controls have been disappointing. Of course, care must be taken to avoid introducing biologicals into the urban environment only to realize later that they have become pests themselves.

Figure 11.2. In nature, many different parasites or predators can be found, each with a unique ability to persist, to kill, and to seek out potential hosts. Photo by Scott Bauer, Agricultural Research Service, U.S. Department of Agriculture, Beltsville, Maryland.

Predatory or parasitic organisms feeding directly on landscape pests have shown promise in their abilities to control landscape pests. In nature, many different parasites or predators can be found, each with a unique ability to persist, to kill, and to seek out potential hosts (Figure 11.2). Pest-specific diseases also have been used with different degrees of success in the management of pest populations. Successful organisms, mostly fungi and bacteria, have been propagated in the laboratory and now are available commercially.

Naturally occurring biological control agents probably are more important than one might imagine (Zenger and Gibb 2001). Insect pests usually are controlled naturally by beneficial arthropods and pathogens that can moderate or often prevent outbreaks of pest populations. It is telling that landscapes not managed intensively seldom are 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. Thus, careful consideration must be given to the effect that each management input can have on a system's beneficial organisms.

Identifying and conserving naturally existing floral and faunal pest-control organisms are logical steps in IPM implementation. Maintaining an equilibrium between pests and their natural controls will diminish the need for pesticides, save urban dwellers money, and benefit the urban ecosystem greatly.

Overuse of nonselective chemicals interferes directly with the potential of naturally occurring beneficial organisms. Spot treatments and appropriate monitoring of pest distributions allow urban-pest managers to avoid the overuse of chemicals and, thus, the negative effects on nontarget beneficials. 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.

In summary, urban-pest managers need not wait for the discovery of new or better biological controls but can develop their own through conservation and encouragement of naturally occurring predators and parasites.

Alternative Pesticides

Toxins such as azadiractin, rotenone, abadilla, and pyrethrin all are derived from plants. Although these are not, technically, biological pesticides, they are materials with a botanical origin that offer some of the same pest management advantages that true biological controls do.

As discussed under "Biological Controls," fungal, bacterial, or viral diseases can be used to control certain pests. Biological microbes (or microbe derivatives) also are effective tools in urban IPM. Several such materials have been developed for use in landscape as well as in structural pest control.

Discovering new and better alternative control agents is an active area of research promising to affect the future of urban-pest control significantly. To date, these agents have been effective as bait or as broadcast or foliarly applied sprays. New technology and biochemistry also have aided the proliferation of urban IPM. Certain pesticides have been developed that are engineered to be taken up and transported systemically through a plant, thereby improving efficacy and decreasing nontarget toxicity. Biotechnology now aims to incorporate the genes responsible for producing toxins through insertion into the plant. Significant progress in the field of molecular genetics has been made on a number of plants.

Chemical Pesticides

Use of synthetic chemical pesticides also is an important aspect of most IPM strategies. Chemical treatments are especially effective because they can be applied with relative ease, are quick acting, and can bring a high pest-population down to an acceptable level rapidly. When used in this manner and for this purpose, chemicals can be an integral part of an IPM program. Only when pesticides, to the exclusion of other techniques, are relied on continually to maintain pest populations at low levels do problems arise.

Recently, great strides have been made in the development of low-impact chemistries. Environmentally friendly, narrow-spectrum, selectively less-toxic pesticides have been developed by the chemical industry. As these have been registered by the Environmental Protection Agency, older, higher impact, less environmentally compatible pesticides have been removed from the market.

Targeting in Time and Space

The solution to a certain pest problem does not always depend on a new or better pesticide. Often the difference between success and failure in decreasing a pest population lies in knowing where, when, and how to apply the selected control technique. Such knowledge usually is based on a study of pest habits and biologies.

Application timing of many landscape management techniques can be improved through the use of pathogen, weed, and insect phenological models that track the development of pests by using temperature as the dependent variable. The use of temperature-based models or of tracking phenological indicator plants can suggest to pest managers an appropriate timing for applications. Timing specific treatment applications according to these models has proved much more advantageous than timing them according to a calendar spray schedule.

Targeting pesticide applications to those sites where monitoring has determined a need for control (*spot treating*) decreases the amount of pesticide applied and conserves natural controls already in place (Figure 11.3). Integrated pest management dictates that spot treatments replace blanket treatments wherever possible.

Figure 11.3. Targeting pesticide applications to those areas in which monitoring has determined a need for control (spot treating) decreases the amount of pesticide applied and conserves natural controls already in place. Photo courtesy of T. Gibb, Purdue University.

Using new technologies to deliver pesticides directly into locations where pests are present (that is, in the *target zone*) diminishes the probability of exposure to nontarget organisms, decreases the quantity of pesticides needed for treatment, and increases pesticide efficacy. Replacing baseboard with crack and crevice 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 taken up systemically and diffused throughout the plant, ultimately killing only those insects feeding directly on it.

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

Evaluation and Record Keeping

Not only is methodical record keeping an important tool providing historical data, but it can help the manager evaluate control techniques over time. After pest management practices are incorporated into urban areas, their efficacy must be evaluated. Decisions to continue, to increase, or to suspend a pest management practice should be made only in light of the effects of its previous use. Evaluations can be educational in the long run and are an especially crucial feature of IPM.

Site-specific factors such as pest-infected area size, exact location, population estimates, damage amounts, symptoms, dates, and, where appropriate, weather conditions leading up to infestation are types of information that should be recorded. When examined in relation to the effect of current IPM practices, such information allows pest managers to make informed decisions. As a rule, thorough record keeping provides a database from which future pest management decisions can be made.

In conclusion, urban IPM programs are based on the same basic philosophies that agricultural IPM programs are. Minor differences occur because urban IPM involves pest/human interactions that may occur in buildings or landscapes in which health and social concerns are crucial factors. Inspection and monitoring tools dictate the application of various management tactics through a decision-making process that considers potential injury by pests as well as potential injury from pest control tactics. Urban IPM strategies are, ultimately, a compilation of many common sense decisions based on a sound understanding of the pest, the environment, and the social implications of one or more control tactics.

Appendix A. Glossary

Environmental sickness. An illness linked to exposures to chemicals in the environment.

Integrated. The quality of being an outcome of several management options brought to bear on a single problem.

Multiple chemical sensitivity. See environmental sickness.

Pest control. A one-dimensional emphasis on pesticidal remedies for pest problems.

Pest management. A deliberate process of treating a pest with a management tool such as a pesticide.

Spot treating. Targeting pesticide applications to those areas in which monitoring has determined a need for control.

Target zone. Locations in which pests are present.

Toxicant-induced loss of tolerance. A theory that may explain why overexposure to a single environmental pollutant (not always a pesticide) leads to heightened sensitivity to several other unrelated substances, including pesticides, in the environment.

Trade-off. Potential advantages due to decreases in pest populations, and potential disadvantages due to management applications.

Urban integrated pest management. A process with five main components, whether inside or outside of buildings: (1) inspection, (2) monitoring, (3) situation-specific decision making, (4) pest management technique application, and (5) evaluation and record keeping.

Urban pest. An organism that damages homes, structures, clothing, food, or landscape plantings or harms, annoys, or otherwise interferes with humans and their activities.

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Technical Resource Center for IPM in Public Schools. 2002. Homepage, <http://www.entm.purdue.edu/schoolipm>