Armed Forces Pest Management Board
Technical Guide No. 29

Integrated Pest Management In and Around Buildings

Published and Distributed by the
Armed Forces Pest Management Board
U.S. Army Garrison Forest Glen
2460 Linden Lane, Building 172
Silver Spring, MD 20910-1230

Office of the Under Secretary of Defense
(Acquisitions and Sustainment)

Revised December 2016
Updated December 2018

Table of Contents

AFPMB Technical Guides

This is one of a series of Technical Guides (TGs) published by the Information Services Division (ISD), Armed Forces Pest Management Board (AFPMB). The AFPMB is a directorate within the Office of the Under Secretary of Defense for Acquisitions and Sustainment that recommends policies and procedures, provides guidance, and coordinates the exchange of information related to pest management throughout the Department of Defense (DoD). As a unit of the AFPMB, ISD collects, stores and disseminates published and unpublished information on arthropod vectors and pests, natural resources, and environmental biology important to the DoD. Other ISD products include country- or region-specific Disease Vector Ecology Profiles (DVEPs). TGs and DVEPs and other pest management information on pest management and medical zoology, are available at the AFPMB Web site, http://www.acq.osd.mil/eie/afpmb.

TGs are not policy documents, they provide technical guidance for the DoD pest management community and others. Accordingly, TGs should not be construed or referenced as policy unless specifically cited in DoD directives, instructions, or other policy documents. DoD pest management policies are described in DoD Instruction 4715.1E, "Environment, Safety, and Occupational Health (ESOH)," DoD Instruction 4715.03, “Natural Resources Conservation Program” and DoD Instruction 4150.07, "DoD Pest Management Program." Other related DoD issuances can be found at http://www.acq.osd.mil/eie/afpmb/issuances.html.

Inquiries, comments or suggestions for improving TGs may be directed to the Chief, ISD, at (301) 295-7476, fax (301) 295-7473 or email osd.pentagon.ousd-atl.mbx.afpmb@mail.mil.

Acknowledgements

The AFPMB is indebted to the many entomologists and others who have given freely of their time and talents to contribute their guidance to this TG. The Board is grateful to Dr. Albert Greene, Ph.D., entomologist with the General Services Administration, National Capital Region, Washington, D.C. Dr. Greene was the major contributing author for the original manual he developed for his agency. That manual was the primary source for this TG. We also express special thanks to Mr. William A. Gebhart, Mr. Kenneth L. Olds and COL Harvey A. Shultz for their tireless efforts in making numerous revisions and additions to the content of the original Technical Information Memorandum (TIM) in order to make it applicable to DoD operations.

In April 2001 the AFPMB cancelled TIM 25, "Devices for Electrocuting Flying Insects", and incorporated its content into this Technical Guide. In December 2001 the AFPMB also cancelled TIM 35, "Termite Inspections" and incorporated much of its content into this Technical Guide. The 2009 update to this TG includes new management recommendations on integrated pest management for culturally significant and historic properties. Weblinks, office symbols, and minor content editing was accomplished in December 2016, and December 2018.

Disclaimer

Any mention of specific proprietary products used in integrated pest management (IPM) does not constitute recommendation or endorsement of these products by the DoD.

Introduction

Integrated Pest Management (IPM) is defined in DoD Instruction 4150.07 (May 28, 2008) as "a planned program, incorporating continuous monitoring, education, record-keeping, and communication to prevent pests and disease vectors from causing unacceptable damage to operations, people, property, materiel, or the environment. IPM uses targeted, sustainable (effective, economical, environmentally sound) methods including habitat modification, biological control, genetic control, cultural control, mechanical control, physical control, regulatory control, and where necessary, the judicious use of least-hazardous pesticides."

IPM has been implemented in DoD pest management programs for many years. One measure DoD uses to track IPM compliance is through the annual DUSD (ESOH) Measures of Merit (MoM) datacall described in DoDI 4150.07 and initiated in 1995 by the Deputy Under Secretary of Defense for Environmental Security. The annual MoM is an effective dashboard for tracking IPM goals and DoD practices by measuring pesticide usage, EPA certification and implementation of installation pest management plans. Properly implemented, IPM:

- minimizes harm to human health and the environment
- reduces the need for pesticides
- minimizes pest resistance
- minimizes pesticide waste

It is incumbent upon all personnel involved in military pest management programs to actively support IPM initiatives and provide resources for implementation. This includes trained and certified pesticide applicators, Pest Control/Pest Management Quality Assurance Evaluators (PCQAE/PMQAE), golf course superintendents, credit card managers, Pest Management Consultants (PMC), Integrated Natural Resources Plan managers, and managers and supervisors responsible for real property, food services and custodial services. It has never been more important for Pest Management Consultants to ensure that IPM strategies and methodologies are incorporated into installation pest management plans, installation program reviews and contracting processes, training for DoD pesticide applicators and PCQAE/PMQAE

This TG is not a cookbook on IPM. Rather, the purpose is to present a sample of techniques and procedures to illustrate the facilities management approach to pest control. All of the methods cited have been tried previously, and all have proved successful in real-world situations. But since buildings vary enormously, no method will work equally well in all circumstances. The challenge of IPM is that it often cannot be delivered by formula. Once the basic principles have been understood, there is no substitute for resourcefulness and ingenuity in developing practical, site-specific pest management solutions. Another objective of this document is to illustrate the variety of control techniques that can be used in IPM.

This TG is a living document and may never be completed. To include all appropriate IPM methodologies would greatly delay the publication of any IPM guidance. Additionally, specialized buildings such as health and dining facilities, food/fabric storage or warehouses and prisons are not specifically included, although many of the same IPM principles still apply.

Outdoor IPM programs will be addressed in future publications. Excellent opportunities for implementing IPM already exist in the control of weeds, turf and ornamental pests, forest pests, and disease vectors.

Information in this TG is designed to be easily inserted into Integrated Cultural Resources Management Plans (ICRMPs) for eligible historic properties and other cultural resources. It is important that pesticide applicators working on DoD installations work closely with cultural resource managers to ensure the pest control treatments do not cause damage to cultural and tribal resources and/or historic properties.

General Guidance

Unique Program. The elimination and prevention of pests in buildings is a distinct facilities services program, not just a custodial function, whether performed by in-house personnel or by contract.

Program Scope. Modern pest management begins with the planning, design and maintenance of buildings. Once buildings are constructed, inspections often reveal pest problems. All personnel responsible for cleaning and solid waste management programs must contribute to effective pest management. IPM is truly a multi-disciplinary function.

Concerns of a Modern Pest Management Program. Modern pest control has evolved into a complex and specialized discipline that includes the application of pesticides. Chemicals are still important, but property managers are now faced with increasing public concern about pesticide misuse, toxic materials in the workplace, and increasingly restrictive regulation. Safer chemicals and treatment methods are continually being developed and should be incorporated into pest control programs when appropriate. At the same time, program managers must be aware that numerous products are ineffective or require special skills to be used effectively. The old-fashioned, often calendar based pest control that consisted of spraying around buildings and chasing cockroaches from one place to another is ineffective, potentially hazardous, and poses an unacceptable liability and public relations risk.

IPM Versus Old-fashioned Pest Control. The modern method of pest control is often termed Integrated Pest Management, or IPM. IPM methodology includes:

- Identifying specific pest infestations
- Controlling these infestations with short-term solutions including pesticides
- Reducing or eliminating the causes of infestation with long-term solutions such as structural modification

IPM methods must be safe and cost-effective. The critical components of IPM programs include cleaning, solid waste management, structural maintenance, pesticide application, and occupant education. IPM differs from old-fashioned pest control in many ways (Table 1).

Table 1. Contrasts between "old-fashioned" pest control and IPM for controlling pests in and around buildings.

Element	Old-Fashioned Pest Control	Integrated Pest Management
Program strategy	Reactive	Preventive pest control
Customer education	Minimal	Extensive
Potential liability	High	Low
Emphasis	Routine pesticide application	Pesticides used when exclusion, sanitation, etc. are inadequate
Inspection and monitoring	Minimal	Extensive
Pesticide application	By schedule	By need
Insecticides in occupied spaces	Sprays and aerosols	Baits
Application of sprayed insecticides	Surface treatment	Mostly crack and crevice
Use of insecticide space spraying and fogging	Extensive	Minimal
Rodent control	Emphasis on rodenticide	Emphasis on trapping, sanitation, and exclusion
Bird control	Emphasis on avicide	Emphasis on exclusion

Attributes of IPM Programs include:

Proactive Program. Old-fashioned pest control methods tended to ignore the causes of pest problems, and instead reacted and temporarily removed a small part of the infestation with chemicals. Although IPM also includes an immediate corrective response that may employ pesticides, it is mainly a preventive maintenance process that controls pests by reducing their food, water, harborage, and entry points. Hence, it is imperative that IPM begin with the structural planning and design process.

Management Process. Old-fashioned pest control relied on the "exterminator" to solve pest problems, often without a pest management professional determining what services were needed and the type of control desired. Lasting solutions usually depend on coordinated initiatives to upgrade sanitation, housekeeping and repair.

Minimal Pesticide Use. Old-fashioned pest control consisted of routine pesticide application whether pests were present or not. IPM consists of routine inspection and monitoring, but treatment only when pests are actually present. Scheduled, repetitive pesticide treatment without regard for pest population dynamics is ineffective and environmentally unsound. IPM can reduce the potential for liability resulting from ecological insults or adverse effects on human health.

Least Toxic Treatment. Non-chemical control alternatives should always be considered first before the use of pesticides. Old-fashioned pest control included the application of excessive amounts of pesticides to exposed areas far from where needed. Baseboard spraying and room fogging is still widely practiced by some in the pest control industry. These techniques are not very effective for killing cockroaches and other insects that live deep within furniture, equipment, or structural elements. IPM requires that pesticides, when needed, be applied with precision and restraint. It emphasizes that only the safest compounds, formulations, and methods of application are appropriate. Insecticide baits are usually preferable to sprays. Sprays, when necessary, should be limited strictly to "crack and crevice" applications. Space sprays and

fogging are reserved for unusual situations where no other solution is practical. Baits are the default method for controlling cockroaches and ants indoors.

Technical Expertise. Old-fashioned pest control technicians did little except operate compressed air sprayers. IPM requires a much higher standard of in-house and contractor expertise to be successful. It is essential that managers have informed technical guidance on all aspects of the pest control effort.

The Pest Management Consultant (PMC). In-house or commercial pest control services that still employ old-fashioned methods, primarily scheduled spraying, cannot be relied on to provide service or advice that is in DoD's best interest. To ensure that pest control in DoD buildings meets the highest standards of safety and effectiveness, the PMC at major command or regional level serves as the installation advisor on pest management. The PMC's office functions as an information center on pest biology and identification, pest control technology, pest control contract administration, and pesticide law. The installation environmental coordinator, pest management coordinator, pest control supervisor and other installation personnel are encouraged to use this resource as part of their "team". Installations requiring assistance in identifying their pest management consultant (PMC) should contact the AFPMB. The major command or regional PMC is available to prepare pest management plans, review installation programs on-site, conduct training workshops for installation personnel, and consult on special problems. Increasingly, these services require reimbursement.

Getting Started: The Six Steps of the IPM Process. The IPM process is mostly common sense. The challenge lies in having enough patience and skill to gradually replace old attitudes and habits. Each pest problem, great or small, usually presents the pest controller with six basic tasks:

- Understanding and Educating the Customer. Most pest control in and around buildings is a service to the occupants and is performed at their request. The IPM process therefore typically begins with people rather than pests. Customer relations are always a two-way street. Educating the customer about pest management is essential, but it is much more effective if the pest controller first understands customer concerns and expectations. Education begins by explaining whether or not the concerns are warranted and the expectations attainable. As in any service occupation, the ability to listen to and communicate with people is absolutely essential.
- Analyzing the Pest Problem. It is fairly simple to identify most pests and why they are present, but an understanding of structural engineering and design may be needed to determine the source of an infestation.
- Taking Short-Term, Corrective Action. Although IPM emphasizes a "preventive maintenance" approach to pest problems, the real world often demands immediate corrective action. In many cases, the use of pesticides for this purpose is unavoidable. However, all concerned must understand that every corrective action will employ the least toxic method.
- Implementing Long-Term, Preventive Action. Ongoing, "built-in" control actions indirectly reduce pests by minimizing their food, harborage, and access. These actions are the heart of the IPM process and a fundamental measure of its success. Sanitation and

exclusion may be difficult to plan, coordinate, and execute but are critical for success. Pest prevention, the "applied facilities management" aspect of IPM, requires that the pest controller have as thorough a knowledge of building operations as of pest biology. For IPM to work, those responsible for sanitation and building maintenance must cooperate with the pest controllers. Exclusion on some historic properties may be difficult due to the exterior condition of the structure. It is important to not damage the exterior or interior finishes. Whenever intrusive measures are to be taken, such as drilling into the foundation or walls, be cautious of visible damage or impacts of the chemical treatments.

- Monitoring, Documenting, and Evaluating Results. DoD pest control reporting systems include options for non-chemical control. Accurate record keeping to include the use of DD 1532 forms is necessary to document IPM successes.
- Getting Back to the Customer. Measurement of customer satisfaction is easy to ignore, but critical for program viability. The pest controller's own performance evaluation may not totally coincide with the opinions of others who are more directly affected by the pest problem. Customer satisfaction is a prerequisite for program support.

Inspection

General Inspection Considerations. Most pest problems in a building are discovered and reported by the occupants. Installation and contractor inspection of specific areas where pests have been reported should provide answers to these questions:

- How are the pests getting in, and can this access be reduced or eliminated?
- What food source or other attractant has drawn the pests and can this source be reduced or eliminated?
- Where exactly are the pests living, and can these sites be physically altered, removed, or treated with traps or chemicals?

An example inspection sheet can be found in the “USEFUL REFERENCES” section.

Control Techniques

Common Pest Problems. The following paragraphs describe common pest problems in DoD buildings and the techniques for dealing with them. These general guidelines can be used when preparing contract specifications. Special circumstances may arise that require alternate or modified approaches. Consult a PMC for additional information. Pest management information bulletins should be distributed to tenants to provide information about the pest control program.

Rats

Rats dig burrows around foundations, in earthen banks and in planting beds. They are attracted to debris and food in unsecured waste storage containers. Rat problems originate outside buildings. Rodents usually stay at ground level and below but, if they gain access to wall voids, may climb to upper floors. Rat control starts with three principal operations that do not involve the pest

control contractor: sanitation, housekeeping and structural maintenance. These operations are generally more important than trapping and poisoning.

Securing Garbage and Trash. Since trash may contain food scraps attractive to rats, all collected waste must be stored for pickup in rat-proof containers or kept in a rat-proof room constructed of materials that cannot be easily gnawed. Rats can penetrate gaps greater than 1/2 inch. Compactors should be of a self-contained design and equipped with protective doors that close over the charge box.

Eliminating Unnecessary Storage and Debris. Buildings, grounds, loading docks, and interior space at street level and below should be kept as free as possible of debris that rats can use for shelter. Anything soft, such as rolled carpeting, insulation, or padded furniture, is particularly attractive to rats.

Eliminating Access to Buildings. Rats commonly enter buildings through open or poorly fitted doors and windows, unscreened vents, cracks in masonry, or holes gnawed in weather stripping or utility entrances. Pest controllers should report these conditions to the facilities maintenance or public works department. Contract specifications should require contractors to notify the contracting office when conditions contributing to pest problems are observed.

Bait boxes. Rodenticide baits are normally effective only if there is little alternative food for the rats. Sanitation, is a prerequisite for baiting. Although pest control contractors often place bait boxes around building exteriors, their use on DoD property is not recommended unless other control measures have failed or are impractical. All bait boxes on DoD property should conform to the following EPA guidelines:

- Box anchored in place so that it cannot be picked up
- Box lid secured with fastener or locking tie
- Box of a "tamper-resistant" design, with a protected feeding chamber and constructed of a sturdy material
- Bait placed only in the feeding chamber (not placed in box entrance or inserted into burrows)

Box label with name of rodenticide (multilingual if required) and last date of service

All pesticides must be used in strict accordance with the label directions. Using a pesticide in a manner inconsistent with its label directions is a violation of Federal law.

Tracking Powder. Tracking powder applied deeply into burrows with a hand operated duster is

one of the most effective ways of poisoning rats and may be the only way of poisoning bait-shy individuals. Treatment with tracking powders is most effective in dry weather.

Trapping. Indoor control of rats is accomplished with snap traps and large glue boards. Either may be used outdoors in protected locations. The increased use of drop ceilings in facilities has greatly increased potential rat harborage in public and commercial buildings.

Care must be taken to place traps in safe locations and out of public view. Traps and boards must be checked regularly.

Mice

Mice may enter buildings from the outside, but many mouse problems originate indoors. Although large numbers can build up in food service areas or trash rooms, small numbers can survive practically anywhere. Mice generally nest within 15 feet of their food source and frequently spread through a structure along pipes, cables, and ducts. The increased use of raised flooring for electric cables in telecommunications and computer facilities has greatly increased potential mouse harborage in public and commercial buildings.

Sealing Entry Points. A practical control measure for limited areas is blocking access routes into occupied spaces by sealing utility openings or chases. Young mice can squeeze through cracks just wider than one-quarter inch. Entry points can be sealed with caulk, copper mesh, steel wool, or polyurethane foam. Make sure that whatever method listed above is used; it is not visible and is not contrary to the HPMP for historic properties. Large, open office areas or rooms in older buildings may have so many potential access points that sealing is impractical.

Cleaning and Housekeeping. Sanitation for mouse control is similar to that required for controlling cockroaches. All food and refuse should be stored in sealed containers. Surfaces, crevices and containers should be free of food residue. Refuse should be removed daily. Strict attention to cleanliness is essential for mouse control in food service areas. However, it is often

difficult to achieve a level of office sanitation that actually makes a difference for a scattered, low-level mouse infestation.

Rodenticides. Rodenticide bait or tracking powder is generally not recommended for mouse control inside buildings because of the potential odor from dead mice behind walls. In addition, there is always the chance that tracking powder applied in out-of-the-way locations may be disturbed during future renovation work.

Trapping. Glue boards and snap traps are usually the most effective devices for controlling small numbers of mice. Extreme care must be taken to conceal traps in order to avoid adverse occupant reaction. Windup, multiple-catch traps can be useful for controlling large infestations in kitchens or unoccupied spaces, provided the necessary sanitation and sealing measures are also carried out.

Small Cockroaches

Two species are responsible for most pest complaints and pesticide use in public and commercial buildings in the United States: the "German" and the "brown-banded" cockroaches, each less than three-quarters inch in length. Although it is widely believed that these insects can never be eradicated from the workplace, it is possible to totally eliminate them from a limited area such as an office. However, the degree of success depends not only on control measures, but on occupant attention to detail when it comes to cleanliness and housekeeping. Cockroaches and their egg capsules are continually reintroduced on custodial trash carts and with packaged food. These invaders will not survive and multiply if they cannot find enough to eat.

Sanitation. Cleanup to reduce cockroaches in an office environment must focus mainly on the food residue in and around coffee machines, microwave ovens, refrigerators, trashcans, and furniture where exposed food is stored. Occupants concerned about cockroaches in their workplace must understand their own responsibility for storing all food in tightly sealed containers and for cleaning surfaces on which food is prepared or consumed. Daily afternoon trash pickup is recommended. Removal of corrugated cardboard is especially important since it provides excellent harborage for cockroaches. Dedicated containers with a tight lid and a plastic liner, replaced daily, for disposal of all items will reduce cockroach problems. The most effective cockroach control technique for food service areas and trash rooms is regular steam cleaning or pressure washing of all possible structural crevices and equipment.

Caulking. Permanent reduction of cockroach populations may be achieved by eliminating harborage. A caulking gun is probably the most appropriate symbol of modern pest control. Care must be taken to completely seal the entire crevice so that cockroach access is totally eliminated. Types of space where caulk or grout are most effective include food service areas, restrooms, and janitors' closets. The most common types of cracks to eliminate include: where sinks and fixtures are mounted to the wall or floor, around all types of plumbing, baseboard molding and corner guards, where shelves and cabinets meet walls or door frames, and any cracks on or near food preparation surfaces. Care must be taken to clean surface areas around cracks before applying caulk; surface dirt can reduce the adhesive ability of caulking material. Make sure that whatever method listed above is used; it is not visible and is not contrary to the HPMP for historic properties.

Baiting. Containerized paste or gel baits should be the standard insecticide treatment for cockroaches in most occupied spaces. Bait stations containing hydramethylnone virtually revolutionized cockroach control in the 1990's. The small plastic bait containers should be placed as close as possible to the dark, concealed spots where cockroaches are actually living, preferably adjacent to edges and corners. The most common mistakes in using containerized bait are failure to eliminate nearby alternate food, and failure to use enough containers. For example, at least 2 - 3 bait stations should be placed in infested desks. Containers should be replaced after 3 months or sooner at the beginning of a baiting program if cockroaches are very numerous. The newer transparent bait stations facilitate checking baits for consumption. Gel baits containing Fipronil are most effective when applied in many small dabs, preferably with a syringe-like dispensing tool. The newer insecticide baits are safe and highly effective if carefully injected into crevices.

Crack and Crevice Spraying. Spraying is sometimes the most practical and effective way to apply pesticide in food service areas, restrooms, and trash rooms. Spray must be precisely applied in small amounts only to cracks and crevices. A "crack and crevice" treatment implies that the stream of insecticide is never visible during the spraying process. In historic properties, it is important to make sure that whatever product is sprayed doesn't damage the interior finish, wall paper or painted surfaces.

Sticky Traps. Many types of cardboard or plastic sticky traps are available to help the pest control technician or installation personnel pinpoint sources of cockroach infestation, or monitor areas where occupants have complained but no infestations can be visually detected. Sticky traps are not intended for control but rather to guide and evaluate control efforts as part of the inspection process. If the sticky traps are attached to any interior surface, be cautious to make sure the removal of the sticky trap doesn't damage the interior finish (wallpaper or painted surfaces) or leave a mark on the surface.

Large Cockroaches

Several types of cockroaches grow to over an inch and a half long; these are commonly called waterbugs or, in Florida, palmetto bugs. Large cockroaches may wander along pipes throughout a building, but in temperate climates they live mainly at ground level or below. Treatment should focus on warm, moist areas such as basements, boiler rooms, pipe chases, sumps, and elevator or sewer shafts. In warm climates, even attics and mulched outdoor planting beds may be infested with large cockroaches.

Drying. One of the most effective ways to control large cockroaches in buildings is to reduce moisture by fixing leaks, improving drainage, and installing screened vents to increase airflow.

Sealing Entry Points. Cockroach access routes from wall voids into occupied spaces can be blocked with caulk or grout applied around plumbing and electrical fixtures. Basement floor drains should be fitted with screens or basket inserts that are cleaned regularly.

Housekeeping. In addition to eliminating food residue, reducing clutter is critical for large cockroach control. Large cockroaches like to hide in stacked boxes, cartons, rolled carpeting and any stored paper or cardboard materials, particularly in dark, damp locations.

Baiting. As with the small cockroaches, pesticide control should emphasize the use of baits rather than pesticide sprays. The PMC should be consulted for current recommendations. See the warnings for treatments on historic properties above under the section for Small Cockroaches.

Bed Bugs

During the past decade, a resurgence of bed bugs has been reported globally including the U.S and especially in developing countries. Infestations occur in areas commonly inhabited by military members including barracks, homes, offices, hotels, schools, and long-term care facilities. Bed bug surveillance and control is often complicated. TG 44, "Bed Bugs – Important Biology, and Control Strategies", published by the AFPMB in March 2012 was developed to meet the need for current information and guidance regarding bed bugs and their control and should be consulted for the most current and complete information about bed bugs and their control.

Ants

Most species of indoor pest ants come from nests located outside the building or inside wall voids. Therefore, the most effective control typically entails sealing up cracks (usually around windows and other locations on exterior walls) where the ants are entering. Close observation on the outside often can help pinpoint these access crevices. Vegetation in contact with the building exterior, such as tree limbs or climbing ivy, should be removed. Containerized, slow-acting bait is usually the most effective type of pesticide treatment for temporary control. Permanent control requires that the nest be located and destroyed.

Many types of ants produce winged queens and males which swarm at certain times of the year. Large numbers of swarmers may pour out of crevices into a room, even in locations that never had a problem with crawling ants. Swarming ants can severely disrupt operations and often result in occupant demands for spraying. In cases where the ants are relatively concentrated, such as at windows, they may be vacuumed and disposed of in an outdoor trash receptacle. However, in some cases, a space spray with a pyrethroid insecticide may be the only practical response. Winged ants emerging inside a building usually die quickly or disperse, so spraying tends to be of little value if not done immediately. Rooms should be unoccupied during a space spray treatment, all electronic equipment should be well covered, and the space should be ventilated for at least several hours before reoccupation. The standard procedure to prevent future swarming is to locate the ants' entry points (and the nest itself, if possible), inject a pesticide into these crevices, and seal up entry points afterwards.

There are three species of ants causing problems that require a special response after positive identification:

Pharaoh Ants. Pharaoh ants are tiny yellowish-brown to reddish-brown ants that can nest in almost any hollow place inside a building. In an office, for example, these ants could come from inside a table leg or room divider, behind a baseboard or switch plate, above the ceiling or under the floor. In warm climates, colonies may be located outside. It is important that sprays not be used for control attempts. Colonies stressed by sprays often respond by dividing. If spray is continually applied, this dividing process results in many widely scattered colonies that infest an

increasingly greater area. A bait specifically labeled for pharaoh ants must be used.

Fire Ants. In warmer climates, fire ants can be a stinging hazard on building grounds, and sometimes indoors. Use of pesticides for fire ant control is usually unavoidable. Treatment often combines injection of spray into individual mounds with use of bait formulations broadcast over wider areas. Baits containing fipronil, introduced in 2001, offer great promise for controlling fire ants. PMCs should be consulted for current recommendations. A non-chemical treatment that is very effective is to force hot steam, under pressure down a wand that is inserted into the heart of the fire ant hill; apply the steam until the queen has been forced to the surface, trap and remove queen and the rest of the fire ants will leave the area.

Carpenter Ants. Carpenter ants are large ants that tunnel in wood. Small numbers in a building may simply be invaders from an outdoor nest that can be controlled by sealing up their point of entry. Large numbers inside typically indicate the presence of a nest within the building. Carpenter ants generally prefer wood that is moist and are considered to be an "early warning signal" of structural leaks or drainage problems. Control consists of locating the nest, injecting pesticide directly into it, replacing the damaged wood, and eliminating or reducing any source of moisture. For these treatments in historic properties, care must be taken whenever drilling into wooden structures or replacing the damaged wood. Check the HPMP or with the cultural resources manager for any limitations.

Miscellaneous Flying Pests

This section includes fruit flies, flies (Order: Diptera), wasps and bees (Order: Hymenoptera), and moths (Order: Lepidoptera). Flying insects are best controlled by exclusion at entry points, sanitation (inside and outside), and vacuuming intruders. Tight seals around windows and screens, doors, utility access holes, and weather-stripping will usually prevent flying insects from entering the building.

Fruit flies

These tiny flies are introduced into buildings many times a day during warm weather, usually as nearly invisible immatures (eggs, larvae, pupae) on or in fruit. Since large numbers of these immatures can develop into adult flies within several days, and since one female fruit fly can then lay several hundred eggs, infestations build up rapidly when sanitation is not rigorous. Adult flies are easily dispersed throughout a structure by the air handling system and by hitchhiking on trash pickup carts. Although fruit flies are totally harmless and cannot bite, many people consider them an intolerable nuisance.

Sanitation. Fruit fly breeding sources are often difficult to find but eliminating the breeding sources is essential. Fruit fly larvae (maggots) require moist, fermenting material in which to develop. Typical sites that generate large numbers of flies include trash rooms and trash pickup carts, can and bottle recycling areas, and any space where food is routinely prepared, dispensed, and consumed. However, there may be dozens of smaller, local sources throughout a building that contribute to the problem. These include leaks under refrigerators, dirty mops, clogged drains, or peels and rinds left in trash receptacles.

Trapping. Fruit fly problems can be greatly reduced by the use of traps. There are many

different trap designs, but all work by using bait to attract the flies into a container. Two of the most effective baits are ripe banana and vinegar. Some traps lure the flies through a funnel or similar "one-way" opening, while others rely on the collected flies eventually drowning in a liquid bait. Homemade traps can be easily fashioned from mason jars fitted with paper funnels, but several inexpensive plastic models are commercially available. Traps are remarkably effective, but problems can arise when either too few are deployed or servicing (removing flies and renewing bait) is too infrequent. An increasing number of pest control contractors are using traps as part of their normal service for fruit fly infestations.

Two types of fruit fly traps that can be set out on the kitchen counter near the infestation site or hung above the problem area.

Space Sprays. Space sprays are not recommended for fruit fly control since the potential for adverse occupant reaction to the pesticide usually exceeds any short-term benefit. However, in cases where very large numbers of flies are severely disrupting operations, a space spray with a pyrethroid-based insecticide may be the only practical response. Rooms should be unoccupied during the treatment, all electronic equipment should be covered, and the space should be adequately ventilated. If the breeding source is not discovered and corrected, sprays will only give temporary relief.

Example of a house fly trap (hung on end of tank cannon)

Example of a wasp and bee trap

Fungus gnats

Fungus gnats are small flies that breed in outdoor soil, potting soil, and organic debris. Their larvae feed on fungi and organic matter in soil, but also chew roots and can be a problem in potted plants and greenhouses. Adult fungus gnats that emerge from houseplants indoors or are attracted indoors may be numerous enough to become a nuisance.

Sanitation. Most of the fungus gnat's life is spent in the immature stages in organic matter or soil, so the most effective control methods target these immature stages rather than attempting to directly control the mobile adults. Reducing excess moisture and organic debris are key to reducing fungus gnat problems. Commercially-available and naturally-occurring biological control agents can also control this pest. Insecticides are considered an important control option in some commercial plant production but generally aren't recommended for fungus gnat management in and around the home.

Most fungus gnat problems in office settings can be resolved by simply letting plant pots thoroughly dry out in between waterings. Water infrequently but deeply. The dryer growing medium will make it harder for any eggs laid and/or larvae that hatch from the eggs to survive and reduce the attractiveness for egg-laying adults. It is also recommended to re-pot plants periodically, particularly when the growing medium has broken down and is retaining too much moisture. Avoid potting mixes made from compost aged less than a year. In addition, it is recommended to remove any decaying plant matter such as fallen leaves, decayed shoots, flowers, fruits, bulbs and roots, which can attract fungus gnats.

Trapping. Sticky traps can be used to trap adults. Chunks of raw potato placed in pots with the cut side down and skin side up, are sometimes used to monitor for larvae.

Biocontrol. Commercially available biological control agents can be purchased to control fungus gnats in pots or container media. Products based on the biological insecticide *Bacillus thuringiensis* subspecies *israelensis* (Bti) are available in retail nurseries and garden centers, making them convenient for home gardeners to use.

Insecticides. If sanitation, trapping, and biocontrol do not provide adequate reduction, pyrethrin or a pyrethroid insecticides may provide temporary, fast-acting control. Be sure the product is labeled for your particular use (e.g., for "house plants") and always read and follow the product's directions. Typical use requires spraying the surface of potting soil and plant parts where adults rest. Do not use residual sprays to fog indoors or attempt to spray adult gnats in flight.

Miscellaneous Crawling Pests

Crawling insects are best controlled (eliminated from buildings) by sealing entry points and vacuuming intruders. Tight seals around windows, doors, utility access holes, and weather-stripping will usually reduce intrusion by crawling insects from outside. Residual insecticides sprayed on surfaces near potential entry points may be effective; microencapsulated formulations should be considered for such applications. You need to ensure that any residual insecticides applied to wooden surfaces or other interior finishes does not mar or discolor surfaces; this is especially important in historic properties.

Spiders. Although fear of spiders is common, dangerously poisonous species are not often encountered in general use buildings. Harmless, crawling spiders are occasionally a nuisance in basements or warehouses. Spiders that build webs in secluded corners or in outdoor locations such as eaves and lights can be removed with a vacuum. Sticky traps can also be used. A brush with stiff bristles can be used to sweep down webs, spiders, egg sacs, etc. Then the brush can be plunged into a bucket of hot, soapy water for a few minutes.

Here is an example of one that will catch and kill hobo, black widow, brown recluse, sac spiders, silverfish, and more. These are non-toxic, relatively safe, easy to use, and usually last for 3 months.

Prevention and Nonchemical Control (excerpted from the UC Davis IPM website: http://www.ipm.ucdavis.edu/PMG/PESTNOTES/pn7442.html): Spiders may enter houses and other structures through cracks and other openings. They also may be carried in on items like plants, firewood, and boxes. Regular vacuuming or sweeping of windows, corners of rooms, storage areas, basements, and other seldom used areas helps remove spiders and their webs. Vacuuming spiders can be an effective control technique because their soft bodies usually do not survive this process. Indoors, a web on which dust has gathered is an old web that is no longer being used by a spider.

Individual spiders can be removed from indoors by placing a jar over them and slipping a piece of paper under the jar to close off the opening. The jar and paper can be lifted as a unit and the spider can be released outside.

To prevent spiders from coming indoors, seal cracks in the foundation and other parts of the structure and gaps around windows and doors. Good screening will keep out many spiders and discourage them by keeping out insects which are their food.

In indoor storage areas, place boxes off the floor and away from walls, whenever possible, to help reduce their usefulness as a harborage for spiders. Sealing the boxes with tape will prevent spiders from taking up residence in them. Clean up clutter in garages, sheds, basements, and other storage areas. Be sure to wear gloves to avoid accidental bites.

Outdoors, eliminate places for spiders to hide and build their webs by keeping the area next to the foundation free of trash, leaf litter, heavy vegetation, and other debris. Trim plant growth away from the structure to discourage spiders from first taking up residence near the structure and then moving indoors. Outdoor lighting attracts insects, which in turn attract spiders. If possible, keep lighting fixtures off structures and away from windows and doors. Sweep, mop, hose, or vacuum webs and spiders off buildings regularly. Insecticides will not provide long-term control and should not generally be used against spiders outdoors.

Crickets. These insects commonly invade basements and crawl spaces, seeking dark, cool, moist areas. They are harmless to humans but the sounds they produce may be annoying, particularly at night. They feed on organic matter and sometimes damage woolen, silk and cotton clothing and other fabrics. Field crickets usually invade buildings late in the summer when fresh vegetation becomes scarce. Crickets may be excluded by closing gaps under doors and around loose-fitting windows and vents to the exterior. Indoor controls should include moisture reduction, sticky traps and, if necessary, a residual insecticide.

Centipedes. Most species of centipedes are harmless. To avoid contact with centipedes, two physical control methods are recommended: general cleanup of debris to eliminate their hiding places and maintenance of close-fitting doors and screening.

Termites

Termites damage wooden structures and incidental wood in steel and concrete buildings, such as trim or molding, paneling, furring strips, or door and window frames. Files, stacked books, or any other cellulose material, such as fiberboard sheathing or insulation panels, may also be attacked. Most termite problems in large office buildings involve subterranean colonies that persist for years on buried scrap wood and constantly explore upwards for new sources of food. These colonies are often a nuisance because of the periodic emergence of large numbers of winged "swarmers" that find their way into occupied space. Swarming termites should be controlled with a vacuum cleaner. A space spray may be unavoidable in rare circumstances. All comments describing ant swarming apply to swarming termites as well.

Spot Injection and Sealing. In masonry buildings with minor termite damage or localized swarming, satisfactory control can often be accomplished with pressurized injection of insecticide directly into the wood, or into the crevices from which the swarmers are emerging. If possible, the crevices should then be caulked or otherwise sealed. It is important when treating historical structures that there is no long-term damage to the materials. Consult with the cultural resources manager.

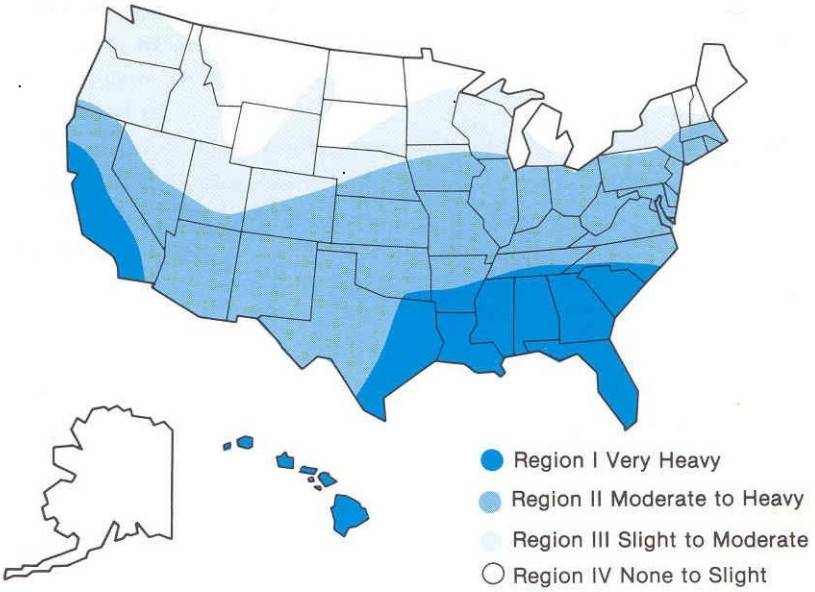
Drilling, Trenching and Fumigation. Subterranean termite problems that cannot be solved with spot injection and sealing must be treated with far more extensive insecticide application. Standard techniques involve pumping the chemical into holes drilled through the building's slab and/or into the soil around the building's foundation. In warm climates, severe infestations of

certain types of dry wood termites that live in dry wood above ground (including furniture) or Formosan termites (subterranean) living in carton nests above ground may have to be controlled with fumigation. These types of termite treatment require specialized contractor expertise and are beyond the scope of this chapter. The cognizant PMC should be consulted for additional information. It is also critical to make sure that the treatment selected doesn't contradict the HPMP; the cultural resources manager should be consulted for any limitations that may apply.

Inspection Schedules. Subterranean termites are usually located in soil with tunnels connecting the nest to outside sources of wood. Early detection and control are necessary to prevent damage to wooden structures and cellulose-containing materials inside buildings. Because contact with air dehydrates termites, they tunnel into wood, often undetected, inside mud tubes. Significant damage can occur even though the surface of the wood is intact. But termites can be detected before they cause structural damage. Careful inspections at regular intervals will detect termite infestations before significant damage occurs.

Installation pest management plans should clearly indicate the appropriate default termite inspection frequency. The plans should also identify structures that require inspections at a different frequency. Termite inspection schedules should be based on relative hazard as indicated on the United States Department of Agriculture (USDA) Forest Service relative hazard map, (Figure 1).

Figure 1. — Relative hazard of subterranean termite infestations in the United States.



Inspection schedules should be established to reflect the following frequency:

(1) Annually at installations in Region 1 (Relative Hazard: Very Heavy) where the PMC has determined that local conditions warrant annual inspections, or where Formosan termites or drywod termites are established.

(2) Biennially at installations in regions I, II, or III (Relative Hazard: Very Heavy, Moderate to Heavy, or Slight to Moderate) where the above criteria are not met.

(3) Triennially at installations in Region IV (Relative Hazard: None to Slight).

Termite inspections should be documented using DD Form 1070.


DD Form 1070.pdf

Birds

Three species of birds - pigeons, starlings and English sparrows - are serious pests when they roost and nest on or in buildings. Their excrement is unsightly, harbors microorganisms that can cause severe illness, and corrodes structural materials. Bird nests may block air intakes, damage the building surface by holding water against it, and contain parasites that can become indoor pests. Bird control is difficult and highly specialized. The PMC or the installation Natural Resources Office can provide additional information on buildings registered under the Historic Preservation program. The cultural resources manager should be consulted for any limitations that may apply before any bird control work is planned that involves modifications or applications to cultural and historic structures.

GSA National Historic Preservation Series document (Note 7, Bird Deterrence Systems) highlights various deterrent systems and the pros and cons for each type and how to protect the historic property.

Concerns of Structural Bird Control. There are three primary requirements that must be met by a bird control program:

- Maximal Effectiveness. In addition to providing long-term protection against pest birds, cost effectiveness must be considered. The utility and appearance of some exclusion devices deteriorate more rapidly than others.
- Minimal Damage to Structure. Permanent physical and aesthetic damage to any structure should be avoided in bird control work, particularly in historical buildings. Repellent systems must be harmless to building materials and finishes and must be reversible, so that if they are eventually removed the building can be returned to its original state; they must also be inconspicuous to passers-by.
- Public Relations. Even the perception that birds are being harmed is likely to draw considerable criticism from individuals, special interest groups, and the media. Bird control efforts, therefore, should always be as humane and discreet as possible.

Bird Management Methods. Several lethal bird management methods have long been used as a last resort. Although they may be appropriate in restricted or specialized circumstances, they are not recommended for large-scale projects, historic structures, or high-visibility sites. Bird management options include:

Contact repellent chemical products. Several different products are commercially available which have been shown to be effective as contact repellents against several bird species when applied according to their respective product labels as liquids to grass (e.g.,

where geese have been feeding), or on perches or resting sites, or as applied directly as a fine aerosol mist (to physically force birds to leave a specified area). The active ingredient is a food grade chemical, methyl anthranilate, which is similar to a natural extract from grapes. Birds seem to find the chemical objectionable but are not detectably harmed by it.

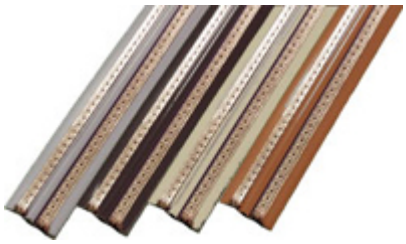
Anti-feedant chemicals. Commercially available anti-feedant chemical products with the active ingredients being specific isomers of anthraquinones, have been proven effective against several bird species (e.g., European starlings, *Sternus vulgaris*) in U.S. Fish and Wildlife Service (USFWS) field tests. They have also been shown very effective at preventing pigeons, seagulls, pelicans, and Canada geese from resting or roosting on various surfaces (e.g., tops of posts, roofs, or pilings) to which the chemical had been applied. A wide variety of bird species seem to find this chemical objectionable to touch, but they are not detectably harmed by it.

- Shooting. Shooting is an effective way to reduce starlings and pigeons in large buildings such as hangers and warehouses. A pellet rifle, or a .22 rifle with cb caps, is an effective tool for this effort. Shooting is species specific (no non-target kills), and has no secondary toxic effects. While no federal permit is required, it is imperative that the individual marksman be trained and experienced in bird identification. To reduce adverse public reaction, the effort should be conducted during non-duty hours by the minimum number of personnel feasible. All dead birds should be carefully handled so as not to attract attention later. Public affairs personnel should be advised prior to the effort to prepare themselves in the event adverse attention is created. While reducing the population with lethal methods eliminates the immediate problem, the potential for birds returning is high. Periodic shooting may be required to keep populations at an acceptable level.
- Toxic Baiting and Toxic Perches. Control by avicides (bird poisons), either added to feed or incorporated into special perches, is undesirable in most situations - there are always more birds to take the place of those killed and adverse public reaction may result.
- Porcupine Wire. There are several anti-roosting products consisting of wire spikes or coils that stick up from ledges to prevent birds from landing. Although usually effective against pigeons if precisely installed, these materials are unacceptable for sites in public view. Their attachment to historic structures poses an unacceptable risk of damage to masonry. Furthermore, smaller birds such as sparrows often use the wire to anchor their nests, adding to its unpleasant appearance. Porcupine wire is most useful for relatively concealed applications on utilitarian structures, such as overhead pipes and beams in garages.

Bird spikes (Porcupine wire)

Repellent Gels. Sticky gels that birds find unpleasant can be applied to ledges with caulking guns. These gels are not recommended in most circumstances because they are eventually degraded by dust and air pollutants and are capable of staining or even spalling underlying masonry. In addition, applying sticky gels can be a messy job. GSA National Historic Preservation Series has a document (Preservation Note 21, Removal of Bird Repellent Gel from Masonry) that is the industry standard for this type of activity.

Electrical Wire. "Shock wire" systems have come a long way in the past few years and are designed to better withstand exposure to water, ice or airborne debris and physical contact during maintenance work on a building's exterior. Since these systems are typically "zoned" for large areas of a structure, a single break or short can disable hundreds of feet of wire.



The track is flexible enough to conform to many surface treatments and it comes in many colors to better match exterior finishes.

- Scaring Devices. Plastic owls and snakes, balloons with eye patterns, brightly-colored objects that turn in the wind, and dozens of other "scarecrow" variations are intended for temporary protection of crops and are almost always ineffective for protecting buildings. Falcon silhouettes may be used to prevent migratory birds from flying into large windows. Recorded distress calls can effectively repel starlings when used by an expert. Various noisemakers and pyrotechnics may also be used to repel pest birds.
- Screening. Barriers and cages of hardware cloth or other wire screen are often the most efficient way to keep birds off and out of limited areas on utilitarian structures that are not in the public view. A 3/4-inch mesh is the largest size that will eliminate sparrows and starlings. Horizontal nesting areas afforded by ledges and window air conditioners can be

eliminated by the use of aesthetic structural materials affixed above them and at a 45 degree angle. Use plastic covers on exterior metal vents to keep robins and other birds from entering the vents and nesting in the ventilation system.

- Tensioned Netting and Pin and Wire Systems. Two relatively new types of systems are the current recommended solutions for bird-proofing on a large scale, on historic structures, or on any high-visibility site. "Pin and wire" installations consist of spring-tensioned stainless steel wires strung at different heights along projecting elements such as ledges, lintels, sills, and string courses. The wires are attached to slender, stainless steel pins inserted into mortar joints. Tensioned netting installations consist of various types of net fabrics stretched taut across recessed elements such as niches, colonnades, and the coffered ceilings of porticos. Wires or cables threaded through the net edges provide an even tension that can be adjusted by turnbuckles. The cables run through hooks or screw eyes that are attached to the building only at mortar joints. When correctly installed, both of these systems are effective, durable, and inconspicuous. When considering tension netting or pin and wire systems on historic structures, review GSA Preservation Note 7 for guidance.
- Dangling Filaments. Migratory swallows can be deterred from nesting under roofs by an easy-to-use and inexpensive system. A 1/4-inch, 4x8 foot CDX plywood sheet is cut into strip slats 1 inch wide. Holes .063-inch in diameter are drilled into the slats at random 8, 10, and 12-inch intervals. Four-foot sections of 60-pound monofilament line are knotted at one end and then drawn through the holes to be left dangling. The slats are nailed onto wood or spot-glued onto concrete and steel using construction adhesive and installed so that the monofilament projects into the flight path of the swallows. When areas behind the monofilament line are bright, the line is nearly invisible to birds. As birds try to land, they contact the monofilament line, which acts like netting, interrupting their flight pattern. Within 48 hours, the surprise of sudden contact stresses the birds to such an extent that they leave the area.

Removing Bird Excrement. Microorganisms that can cause serious illness live in bird droppings. However, infection typically occurs by inhaling these pathogens through the nose and mouth. Therefore, bird excrement is dangerous mainly when it is dry and subject to becoming airborne as a fine dust, particularly when disturbed by sweeping or scraping. Germicides are sometimes applied to accumulated excrement prior to cleaning. However, thorough saturation with water and use of a respirator are usually sufficient protective measures. Many disinfectants are oil-based formulations that may permanently stain building materials. If possible, cleaning efforts should be coordinated with the installation of a modern bird-proofing system and the removal of any old, ineffective systems that are in place. Medical departments are responsible for recommending specific personal protection devices and practices for personnel who remove bird droppings. The following concepts may be among those recommended by the responsible occupational health authority for worker protection.

- Worker Protection. All personnel working with accumulated bird excrement typically wear a full-face respirator with a High Efficiency Particulate Air (HEPA) filter for screening particles of 0.3-micron size. Dust and particle masks do not give complete

protection. In addition, all personnel should wear protective coveralls, gloves, boots, and hats.

- Application of Water. Droppings are usually easier to clean when they are dry and crusted. Nevertheless, prior to removal, all excrement must be saturated with water to prevent the debris from becoming airborne. If a hose is used on the exterior of buildings, water pressure should be low. A hand-held compressed air sprayer filled with water is also satisfactory and will reduce run-off. Higher pressures may be used for hosing small amounts of excrement off sidewalks and pavement.
- Nonmetallic Tools. On historic structures, only nonmetallic tools (such as plastic spatulas and brushes with natural fiber or nylon bristles) should be used to remove excrement. Tools that can easily damage building surfaces, such as coarse wire brushes, should not be used under any circumstances.
- Disposal. Removed excrement should be collected in plastic bags, sealed, and disposed of at a sanitary landfill.
- Public Protection. Bird excrement removal on public buildings should not be performed during normal working hours and should be scheduled for weekends, if possible. All work should be done from the outside of the building. Barricades and signage must be provided to keep the public clear of the work site during all operations.

Bats

Throughout history bats have aroused the curiosity and interest of men. Bats are highly beneficial wild mammals and not flying rodents. They belong to a unique mammalian order called Chiroptera (*chiro*= hand, *ptera*= wing). Bats are more closely related to primates (monkeys, humans) than they are to rodents. Bats of the United States feed primarily upon insects. While most bats feed on night-flying insects, a few species found in the southern U.S. eat fruit or nectar. An insect-eating bat eats about its weight in food every night. This means that even a small colony, of several hundred individuals, consumes hundreds of pounds of insects a year. Natural bat roosts are caves and tree hollows. A few species have readily taken their abode in houses thus gaining for themselves the name of "house bats.” Bats found in North America are almost entirely beneficial to man. Infrequently they become nuisances or pose public health problems. Unfortunately, most bat complaints arise from an exaggerated fear of bats, not from actual damage; however, some form of management is justified and the type of management depends on the problem.

Fear of rabid bats, plus sensational news coverage, has historically engendered the use of potentially dangerous chemicals to kill bats in buildings. This had the potential to create a public health hazard by increasing contacts between humans and sick bats, and possibly exposing people to pesticides through contact, inhalation, or ingestion of contaminated food. There is currently no chemical properly labeled under FIFRA for use by PMPs to control bats in their roosts. Bats can become infected with the rabies virus, as can dogs, cats, raccoons, skunks or any other mammal. Most species of bats usually develop the paralytic and not the frenzied form of rabies, and they usually die quietly. The infection rate for house-dwelling bats is very low,

ranging from 1 per 2000 (0.05%) in the southeastern bat to 4 per 1,130 (0.35%) in the Brazilian (= Mexican) free-tailed bat. Not picking up bats found on the ground or other accessible location will reduce your chance of getting rabies from bats to virtually zero. Batproofing or exclusion is the soundest long-term solution for the management of house bat infestations. Concise details of the biology, behavior, associated human rabies risks, and preventive recommendations for bats commonly found in the U.S. are presented in the PDF file "Bats and Rabies," jointly developed by Bat Conservation International (BCI) and the U.S. Centers for Disease Control and Prevention (CDC) and is publicly available on the CDC website www.cdc.gov .

House bat problems vary widely due to multiple types of structures, construction materials, age, and other factors. No single method can solve all problems. IPM, which uses a combination of methods and tools, is the most effective long-term approach for house bat management. Bat IPM may use physical exclusion, habitat modification, biological, and/or chemical controls. One of the best deterrents against house bats is to improve the energy efficiency of a house by insulation, weather-stripping, and caulking. These energy-saving methods, besides lowering heating or cooling costs and providing long-term batproofing, are in compliance with the intent of Executive Order 13423: *Strengthening Federal Environmental, Energy and Transportation,* which requires federal facilities to implement actions to reduce energy loss in buildings.

During the day bats rest in dark secluded roosts, like caves, hollow trees, in attics of buildings, and under bridges. In winter when insects are scarce, some bats migrate like some birds do, while others hibernate in caves, trees, or buildings. Most bat species bare only one baby per year, so it takes bat populations a long time to recover from natural or human destructive events. Bats are long-lived animals but this varies by species. The little brown bat can live up to 35 years (at least one captive specimen did so). Some bat species found in Florida can 10-12 years. Bats typically frequent the same roost year after year, even if only seasonally.

Surveillance. Physical and visual inspections must be done by trained PMP technicians or biologists to detect bats and bat sounds, or locate bat droppings (guano). Specific inspection criteria are available in several bat (e.g., BCI) or pest management (e.g., NPMA) websites and technical guides listed elsewhere in this TG. Visual observations by building occupants or facility managers are critical to locate potential daytime resting sites. Surveys are to be performed when requested by building occupants. If exclusion devises have already been installed make sure they are in good condition and properly installed and all access points are properly sealed. Remember that most bats are able to squeeze through very narrow slits and cracks; the little brown bat can enter a space 5/ 8 x 7/ 8 inch. The big brown bat can squeeze through an opening 1-1/4 x 1/2 inch.

It is very important to correctly identify (ID) the bat species causing the problem. Most bats are protected species. It is important to work closely with both the installation cultural resources manager (when working on historic buildings) and the natural resources managers (most are biologists and can help with bat ID). If the bats involved are protected, under the Endangered Species Act (ESA) or state or local law, you will need to contact the U. S. Fish and Wildlife Service for recommendations for their management, control, or even handling. It is important to contact the state wildlife agency for any state requirements, permits, or prohibitions. No control or exclusion should be attempted while pups too young to fly are still in the roost.

Control Options. Exclusion is the most effective long-term ecologically viable method to eliminate bats from structures. Additional non-lethal techniques, like precisely targeted temporary placement of bright lights or durable containers of repellent moth flakes (or moth balls), may also have some benefit in specific settings. As stated above, no chemicals are currently labeled for direct lethal control of bats in the U.S., and the protected status of most native bat species makes any attempt at lethal control of those species illegal.

The placement of bat houses (artificial bat habitats) near structures from which bats are soon to be excluded has gained a lot of popular support, but their acceptance and use by various species of subsequently displaced house bats and their real utility as alternative bat shelters has been variable and not well documented, so far. Nonetheless, at least limited efforts to erect such structures may yield positive public relations. The practical numbers, most desirable locations, and total economic costs of such an effort must be taken into consideration before it is begun. In case it is decided to place such bat houses, several sources of products, designs and related materials and references are listed below.

Bat Houses. There are many sources of bat houses and building plans. Bat Conservation International (BCI) (http://www.batcon.org/index.php) offers lots of information, references and links to other sources. Free bat house plans and placement advice are at http://free.woodworking-plans.org/bat-house-plans.html. The Pennsylvania Game Commission has free plans for three sizes – small, large, and bat condominium. The bat condominium is an elevated 8’ x 8’ multi-chambered structure with ventilation and space for a maternity colony. The purpose of the community bat house is (1) to save bats in numbers sufficient to suppress local insect pest populations, and (2) to reduce nuisance problems associated with the eviction or exclusion of maternity colonies of bats from structures. Unfortunately, neither has yet been proven reliably effective as intended. In fact, the very act of attempting to exclude a maternity colony (i.e., by definition, a population with currently developing young, very probably including non-flying pups) is specifically illegal in most cases. In every case, the correct ID of the infesting bat species is critical for the most effective possible design and placement of any bat house, if you expect it to be used at all.

Typical medium sized bat house on a post.

Bat "condo"

The popularly often repeated concept that “If you are going to exclude bats from buildings, it would be best to have other shelter available to them nearby to reduce the likelihood of them reentering the buildings you have just evicted them from,” is internally inconsistent and somewhat confusing.

Bat exclusion from historic structures requires close coordination with the Cultural Resources Manager to ensure that there is no visible change to the exterior of the building and anything done within the structure is accounted for in an ICRMP, historic property management plan (HPMP) or programmatic agreement (PA). As detailed above, once bats are located in the structure, a correct species ID and finding all their entry/exit points is critical. Sealing off such entry/exit points may be problematic or easy. Most of such exclusion work like sealing, caulking, and screening, should be done on the interior of the building if at all possible.

"Paper Mites"

Pin prick-like biting sensations, usually on exposed skin and often producing inflammations that resemble insect bites, can be a persistent problem in some offices. Occupants tend to blame these "bites" on some sort of pest infestation, typically fleas (which are extremely rare in office buildings) or "paper mites" (which do not exist). Affected spaces are often sprayed with a pesticide in the absence of any evidence that pests are responsible. "Paper mites" are generally caused by a cleaning or indoor air pollution problem rather than by a pest. Only rarely are the specific culprits in "paper mite" cases positively determined, although there are often strong suspects. Shards of fiber glass insulation (such as from batting above drop ceilings), particles from newly installed or old worn carpet and carpet pads, and paper dust from separating forms and computer printouts along tear-lines are some of the most common proven causes of pin prick-like irritations. The dry air of many workplaces not only makes skin more sensitive to these tiny particles, it increases the static electricity that is responsible for the particles "jumping" onto exposed skin (sometimes the static-charged bits are mistaken for living bugs). Any activity that stirs up accumulated dust, such as office renovation or the purging of old files, often leads to a "paper mite" outbreak. In cases where there is no obvious explanation, or multiple factors are suspected, an industrial hygienist may be called in to investigate.

The Role of Management. The most common mistake of management in "paper mite" situations is to automatically request a pesticide treatment and thereby become liable in the event occupants experience adverse reactions to the chemical. The second most common mistake is for

supervisors to dismiss the complaints of biting as total fabrications. Although there are cases where people imagine they are being attacked by unseen parasites, most bite-like sensations in offices involve a genuine source of skin irritation. The circumstances can be further complicated, since health care professionals unfamiliar with the "paper mite syndrome" frequently misdiagnose the resulting welts as insect bites. Others may believe that microscopic dust mites are involved. These are real organisms but cause respiratory distress rather than bites. Finally, it is normal for the coworkers of a person complaining about "paper mites" to develop a heightened sensitivity to their own skin irritations, often simply through the power of suggestion. Management must treat all concerned with sympathy and respect, but emphasize that pesticide treatment cannot be undertaken without confirmation that a pest problem exists.

Inspection. An inspection of the affected area should be carried out by a pest control professional who understands that pests may not be involved. Usually when real pests are present, they are abundant and readily seen. The most common types in office buildings are mites coming from bird nests or from concealed infestations of rodents. Occasionally fleas living on guard or working dogs will bite people who work in the vicinity. If a thorough investigation fails to produce any specimens, a non-pest cause is probably responsible. Nevertheless, it is standard procedure to monitor the area with sticky traps. In addition, occupants should be instructed to capture anything they suspect is biting them on a piece of clear adhesive tape. The PMC will identify all such samples submitted from installations. Even a single parasite specimen is justification for pesticide treatment. However, the captured items are typically bits of debris or tiny, harmless insects that are commonly present in buildings.

Inspection for Airborne Particles. When it is reasonably certain that there are no biting pests in the affected space, the pest control program is no longer involved.

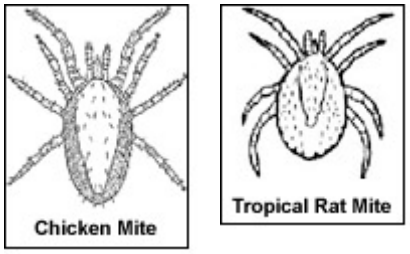
Remedial Action. It is not unusual for a pesticide application to bring temporary relief to occupants with a "paper mite" problem. Part of the relief may be psychological, though sprays do settle irritating particles and decrease static electricity. Although it is unethical and sometimes illegal for pesticides to be used in this fashion, the same results can be obtained by legitimate means. A program of frequent damp cleaning, including carpet washing with water only, is often an effective short-term response while efforts are made to identify and eliminate the source of the irritation. Cleaning by vacuuming rather than wiping is not recommended; unless the vacuum is equipped with a HEPA filter, more dust may become airborne. Use of humidifiers or air purifiers can be of tremendous benefit if the affected space is not too extensive. It may be worthwhile for some employees to seek the advice of a dermatologist or other medical specialist, since techniques such as the use of moisturizers and the avoidance of harsh soaps are frequently prescribed to minimize irritation problems.

Mites

Mites can significantly impact operations because of the annoying and uncomfortable bites in which they inflict. They can also be a complicated pest control problem due to their small size. Mites have variable life cycles and hosts. Some are public health pests, but are not controlled through pest control.

Mites are generally small in size (0.1-2.0 mm) and can be difficult to see. Mite problems are

often detected when persons report being bitten by a mite, small insect, or other organism. Mite infestations on humans can cause skin irritation (dermatitis), due to the biting and physical contact with the mite, and itching. Common mite species that cause such problems include the Tropical Rat Mite (*Ornithonyssus bacoti*), Spiny Rat Mite (*Laelaps echidninus*), Northern Fowl Mite (*O. sylviarum*), Tropical Fowl Mite (*O. bursa*), and Chicken Mite (*Dermanyssus gallinae*).



The mites that cause allergies (house dust mites, *Dermatophagoides* spp.) and invade the skin and cause scabies (scabies mites, *Sarcoptes scabiei*) are important pests of humans, but are not readily controlled through pest control methods. Control of house dust mites involves thorough cleaning of furnishings. Scabies mites are transmitted from person-to-person through direct contact. Control is through clinical treatment of mites on the infected individual(s).

Mites that pose a pest problem are associated with plants and animals. Plant mites feed on plants and may be noticed crawling on desks or other surfaces near house plants. These mites are a minor nuisance because they do not bite humans. Animal mites are a greater problem because they feed on humans in the absence of their normal host animals. The house mouse mite (*Liponyssoides sanguineus*) can transmit rickettsialpox, a benign, self-limited febrile disease. The disease is currently most commonly reported in urban areas of the northeastern and midwestern U.S. but may occur wherever house mice (*Mus musculus*) and their mites are found.

Introduction. Most common pest species of animal mites are introduced into buildings via their host birds or rodents. They remain close to or on their animal host, primarily in its nest. Such nest parasites reproduce, develop, and spend most of their life in the nest, periodically coming to the host almost exclusively for a blood meal. If the host abandons its nest or is killed, the mites must find another blood source, often quite a distance from their old nest. In occupied buildings the only substitute blood meal source available may be humans.

Mite infestations are frequently reported by persons who have felt like they are being bitten or have evidence of bites on their body. There are other conditions that may cause a person to feel like they are being bitten. These conditions may include airborne irritants or even dry skin during periods of low humidity. In offices, affected persons may report being bitten by “paper mites”, which is to say that they believe they are being bitten by mites associated with the paper in the office. A psychological condition known as Delusions of Parasitosis may also lead persons to believe they are infested with small mites, insects, or other organisms. Even if these

other causes are suspected, PCOs should make every effort to determine whether an actual pest is involved.

Management options. Management of mites is dependent upon finding and eliminating the source of the infestation. Often this means collecting and identifying specimens to determine the host animal. Mite specimens can be easily collected in a couple of different ways. Adhesive tape can be used to tap the surface where the mite is observed or where the person feels the mite biting. Once collected the tape should not be doubled over so that the specimen will remain intact and allow proper identification of the specimen. Another method is to place the specimen in a vial containing alcohol using a small paint brush. To do this, wet the bristles of the brush with the alcohol in the vial and tap the mite with the tip of the brush; the mite will stick to the wet bristles. Place the tip of the brush into the vial to release the specimen. Another tool that can be used to collect mites are sticky traps placed around the affected location(s). The specimen should be taken or sent to an entomologist for identification. Proper identification will require a microscope or powerful magnifier. Identifications should determine the mite host, usually bird or rodent, or whether it is a plant mite.

Inspection. Whether the mites can be IDed or not, the source should be identified in order to adequately control the infestation. First, the person(s) affected by the mites should be interviewed. Typical questions should include where on their body they are being bitten and when. Determine whether biting is occurring in a specific room or part of a building. Ask if any rodent or bird control has been conducted at the site recently. Second, a visual survey should be conducted to observe where mites might gain entry into the building and locate any signs of birds or rodents such as nests, harborages, roosts, rubmarks, droppings, or gnawing. For rodents, identify pathways that may lead to harborages. Inspect the interior of buildings to include hanging ceilings, attics, and crawl spaces. Look outdoors for roosting and entry points. Mite infestations are often the result of birds or rodents abandoning a nest or having been eliminated by exclusion or lethal control measures.

Control Options. Prevention is the best method for managing mites. Prevent bird nesting and roosting on buildings and exclude rodents from entering and establishing harborage in buildings. If a building is infested with rodents or birds and they require control, surveys should first be performed to determine the location of the harborage or nests. Eliminating rodents or birds without removing the nest or controlling any parasites in their nest will lead to nest parasite infestations. Nest removal and disposal before eliminating these pests may eliminate most mites, but, an insecticide/acaricide application may still be needed to ensure their elimination. For existing infestations where mites are visible, a dilute soap solution sprayed on the mites and then wiped up is an effective control method. Vacuuming can also help remove mites if the vacuum bag is promptly disposed of afterward.

Properly labeled insecticidal dusts may be applied in attics, walls, and crawl spaces. If they remain dry and undisturbed, they can provide a long-term residual control of mites. If a rodent or a bird comes into contact with such an insecticidal dust, they and possibly their nests might be indirectly treated for mites, as well. Insecticide foggers might control mites that are exposed in a room, but they will not have any effect on those mites or other pests that do not come into adequate contact with the mist.

Public Relations

General Guidance. Old-fashioned pest control did not require much understanding or support from customers. Pesticides were expected to overwhelm pests. Sometimes this happened; other times it did not. The pest control effort operated more or less independently. IPM has the potential to provide long-range, effective control with reduced reliance on pesticides. Cooperation is required, however, because IPM often depends on structural modifications and sanitation performed by others. Customers must also support ongoing surveillance programs and often must tolerate slow-acting controls and occasional low-level pest sightings. PMPs and activity pest management personnel should educate, encourage, and convince potential customers through a comprehensive public relations (PR) effort. They should thoroughly educate supervisors and others up through the chain of command, such as installation engineers and commanders, to gain critical support and cooperation.

Acceptance of Slow-Acting Controls. Easy to use, long-lasting baits and pheromone traps are often less toxic and more effective than sprays but may not eliminate certain pest infestations, such as pharaoh ants or grain moths, for several weeks. Many IPM techniques may fall into the category of slow-acting controls. The servicing technician must be able to convince occupants/customers to resist the urge to "reach for the spray" even when occasional sightings occur. Occasional sightings are common with baits and traps because, unlike "quick knock-down" agents, insects and animals frequently may be observed returning to their nests with the newfound food that baits provide.

Structural Modifications. Sometimes the need for structural modifications imposes the greatest constraint on a successful IPM program - particularly if customers and suppliers outside the pest management shop are not educated and convinced of value of these modifications. These two groups are often key to ensuring that such modifications are completed; however, they can balk at the cost or effort involved in this "extra" work.

Educating facility users involves pointing out pest "expressways, freeways, and hideouts" (you must use terms that have an impact on the user) and discussing their connection to the pest problem. What one lives with on a daily basis may not necessarily be what one sees. Discussing and, more important, demonstrating the ease of caulking, taping, and repairing small, medium and large cracks and holes, while pointing out how they will aid in further exclusion, will go a long way towards helping to minimize overall use of chemicals.

Surveillance. Although pest managers place and retrieve survey devices, it is the occupants who must live with them. Don't just install survey devices without an explanation - use the opportunity to sell your program. Taking the time to discuss the importance of surveillance - why it is often essential to proper control and should precede actual pesticide application - contributes to a truly successful IPM program.

For example, cockroaches sighted by workers may come from the attic, basement, or outdoors. A full-scale application of pesticides in the working spaces will often eliminate only part of the pest population, and often not even the majority of it. Explaining this to the building manager might get their enthusiastic cooperation with your surveillance program. Tough customers might respond to a call from the command PMC or another senior PMP. People are often quite amazed

that others take an interest in "their" problem. Customers must protect survey devices in place and not move them around or throw them away. They must also be willing to accept sightings, whether in or near the traps themselves. Most of all, they must accept new methods of doing business.

Successful cooperation also depends on prompt, reliable servicing by the pest management technician and correct follow-up actions once surveillance reveals a problem. Traps and baits must not be placed only to be ignored until the next frantic (and likely frustrated) call from the customer. Show interest in "their" problem!

Tolerance of Occasional Low-Level Sightings. Scheduled preventive chemical control may preclude most flare-ups in pest populations. However, this method is costly, uses unnecessary pesticides, and accelerates resistance to the chemical in use and occasionally to ones not yet introduced. Food service managers and others may sometimes "sacrifice" cleaning, to save money and manpower, when they expect the pest control service to come in and take care of their pest problems. And if chemicals are expected to do the trick, managers may delay or postpone the actual long-term repair and renovation efforts absolutely needed for effective pest management.

Sanitation. The best control program will fail if pest management personnel cannot convince their customers to eliminate competition with alternative food sources. Prerequisite cleaning must be emphasized as the essence of any IPM program. The pest manager must convince decision-makers that saving money on cleaning immediately increases the cost of pest management and does not save money in the long term.

Design a handout specifically addressing "their" problems: that roach baits cannot out-compete grease, leftover food and standing water; rodent baits cannot out-compete uncovered garbage; pet food left in bowls will probably be more enticing than a smaller, containerized bait station. Focus on "their" major problems. Consider designing a miniature poster for a particular facility, encouraging good sanitation as a major part of pest control. Most people don't enjoy working around cockroaches; they need to be convinced that they can make a difference in reducing pest populations (as the pest management expert, you are only there to help them).

Customer Education. PMP and activity personnel (pest control supervisors, quality assurance evaluators and others) should be proactive in educating customers and workers on their role in urban IPM public relations efforts, which may include face-to-face on-site briefings, demonstrations, newsletters and handouts.

Useful References

The references listed here provide useful information on specific areas of IPM.

GSA Preservation Notes for Historic Properties

Preservation Note 7: Bird Deterrence

Preservation Note 21: Removal of Bird Repellent Gel from Masonry

General IPM References

Example Pest Management Inspection Sheet

Websites

Websites listed here provide useful information on IPM. This list is not comprehensive; there are many more available and new ones are going on-line often.

- UC IPM Online (http://www.ipm.ucdavis.edu/index.html) Great source for pest management personnel to pull information from or provide to installation personnel.
- Cooperative Extension System Offices (http://www.csrees.usda.gov/Extension/) This home page links to each county by state. Nearly every county extension service office has local information on pests and control options specific to their area. Also, some counties have very active and knowledgeable Master Gardeners to field questions or provide anecdotal information.
- EPA IPM Principles and Factsheets (http://www.epa.gov/opp00001/factsheets/ipm.htm) This site offers science-based research results in easy to read and understand format.
- Internet Center for Wildlife Damage Management (http://icwdm.org/) This site has everything you will ever need from pictures of damage to control measures and their effectiveness, to equipment, references, and resources. This is an expanded electronic version of their Prevention and Control of Wildlife Damage, 1994.
- Biological Control: A Guide to Natural Enemies in North America (http://www.nysaes.cornell.edu/ent/biocontrol/) includes extensive information on potentially useful biological control agents.

Other IPM Techniques and Procedures

General Guidance. This section provides IPM techniques and procedures that are commercially available. Much of the specialized knowledge required for an effective structural IPM program can be more accurately described as applied facilities engineering and management rather than applied biology. However, the background of most urban entomologists and other applied biologists generally tends to be strongest in pest biology and pesticide technology. Although basic concepts of cleaning, sealing, and pest-proof storage of food and garbage are often discussed in pest control training, they are rarely presented in sufficient detail to allow a pest management professional to evaluate specific options.

The technology and procedures of the custodial, pressure cleaning, solid waste removal, and sealing industries are part of a rapidly expanding array of non-pesticidal (i.e., not involving classical chemical pesticides) methods that have been successfully used to combat pests in buildings. Although pesticide application is a valid and necessary part of the IPM process, one of the central tenets of IPM is to emphasize a non-pesticide approach whenever possible. The following outline is intended as a brief introduction to some alternatives to pesticides and illustrates some of the tools now available to PMPs.

Solid Waste Management

General Housekeeping for Building Occupants. Keep sugar, cream, coffee and other foods in sealable, pest-excluding containers. Refrigerate other foods. Do not store food in desks. Have a dedicated container available in food areas for food remains and employees should be instructed to use the labeled container(s) for food wastes.

Trash Receptacles. Discussion items for this topic should include: designs and materials for interior and exterior use and problems with usage; design and distribution of dedicated containers for food residues; plastic liners and thickness (mils) recommendations for general use, recycling containers, etc.; and custodial maintenance and cleaning of receptacles.

Trash Collection. Discussion items for this topic should include: custodial pickup schedules; design, use, and maintenance of mobile drums and utility carts; and trash chutes.

Trash Holding Areas. Discussion items for this topic should include: trash rooms, recycling holding areas, compactor zones at loading docks, refrigerated holding rooms; and general recommendations for location, design and management.

Non-compacting Holding Containers. Discussion items for this topic should include: the differences between conventional rear load and container service, cans and other receptacles for rear load service, front end load dumpsters, and open top debris service.

Compaction Equipment. Discussion items for this topic should include: stationary vs. self-contained; various self-contained designs, including double-rams for recycling programs, vertical packing models, small-volume indoor models; pad, access, space, and electrical requirements. Additional topics include waste volume formulas and standards to determine correct compactor size; "doghouses," multi-cycle control systems, interlock switches, pressure gauges; and the problem of tampering by personnel.

Odor Reduction. Discussion items for this topic should include ozone generating units and non-ozone odor reduction technology (e.g., granular products, spray systems). Optional ozone generators may be attached to the compactor at additional cost. Ozone is a powerful oxidizer that breaks down odor molecules and converts them into water vapor and other odorless, harmless gases. Ozone generators produce ozone automatically using a low-wattage "corona discharge." The most common generators do not require the addition of chemicals and only incidental, routine service. Odor reduction reduces attractiveness to pests.

Grease Storage. Discussion items for this topic should include equipment and procedures.

Solid Waste Management Information Sources. Trade journals such as Waste Age, Biocycle, and World Wastes feature articles and advertisements on solid waste management procedures, supplies, and equipment. Waste Age magazine provides an annual "Industry Yellow Pages," which is a consolidated source of information on waste industry services, supplies, and equipment. You can contact them at Waste Age, P.O. Box 8908, Boulder, CO 80328-8908.

Cleaning

Discussion items for this topic should include: a basic review of sanitation and cleaning problems, procedures and inspection for various facilities; general custodial contractual overview

and relationship with solid waste management programs; the limitations of traditional cleaning methods; and resources of the Cleaning Equipment Manufacturers Association.

Steam Cleaning. Discussion items for this topic should include: designs, capacities, and uses, with emphasis on compact, portable equipment for kitchens, trash rooms, pallets, etc.; electric models, handheld vs. wheeled, various attachments; and centralized, wall-mounted systems.

Hot Pressure Washing. Discussion for this topic should include: designs, capacities, and uses, with emphasis on compact, portable equipment for kitchens, trash rooms, pallets, etc.; electric models, handheld vs. wheeled, various attachments; and centralized, wall-mounted systems.

Cold Pressure Washing. Discussion items for this topic should include: various designs, capacities, and uses, with particular emphasis on compact, portable equipment for kitchens, trash rooms, pallets, etc.; electric models, handheld vs. wheeled, various attachments; and centralized, wall-mounted systems.

Cleaning Agents. Discussion items for this topic should include the issue of disinfectants (cf. GAO/RCED-90-139 EPA Lacks Assurance Disinfectants Work) and the use of other additives (e.g., soaps and/or caustic degreasers).

Air Purification Equipment. This may be of importance for "paper mite" and dust mite remedies.

Sealing and Exclusion

Permanent sealing of pest harborages and runs will reduce populations of pests such as cockroaches. The long-term benefits of sealing are reduced pest management costs and reduced reliance on pesticides. Sealing techniques can eliminate cracks and crevices in offices, food areas, loading docks, machine areas, etc. Typical sealable areas include joints between different elements of construction, expansion joints, foundation cracks, utility runs, wall-floor junctions, door thresholds, window frames, rolled edges of stationary equipment, floor molding, bumper rails, etc. Energy conservation literature is an excellent source for techniques and procedures.

Caulking and Related Sealing Products. There are many types of caulks on the market, so labels should be read prior to use. Some caulks are flammable and can cause respiratory and dermal distress. Joints larger than 1/2 inch wide and 1/2 inch deep should first be stuffed with fiberglass insulation, plumber's oakum, copper gauze, or similar filler. The most important step in successful caulking is preparing surfaces in accordance with (IAW) the product label. Dust, grease, old caulk, and paint chips should be removed. Surfaces should be cleaned with water or specified solvent and then primed to ensure adhesion.

A 10 oz. tube of caulk covers 96 linear feet to a width and depth of 1/8 inch or 24 linear feet to a width and depth of 1/4 inch. A caulking gun is recommended, but rope cords or tubes may be used for small jobs. Cordless electric guns or industrial equipment can be used for larger jobs.

Construction materials to be treated and other local conditions (humidity, need for elasticity, etc.) may determine what type of caulk should be used. Oil-based caulks are inflexible and short-lived. Water-based acrylic latex applies easily and dries quickly. Some can be painted almost immediately. Butyl rubber seals very well and resists water, but a stringy appearance may preclude use where appearance matters. Silicone, a good multipurpose material, is easily applied

with a caulking gun, sticks to most surfaces and is unaffected by moisture and UV radiation. Silicone acrylic latex can be used outdoors or indoors. Caulk is available in white, clear, and various colors.

PMCs can provide additional information that has been prepared by the National Pest Management Association (NPMA) and the USACOE.

Waterproofing Membranes. Discussion items for this topic should include bituthene and similar materials. FCGS 07111, CEGS 07111-3-82.

Weatherstripping. Discussion items for this topic include: materials for crevices (e.g., extruded polyethylene rope, wax-polymer adhesive cords, sealing tapes; seal, sweep, and door threshold products, including overhead rolling and hangar doors, rubber, synthetic, and bristle designs.

Metal and Metal Fabrics. Discussion items for this topic should include gauges for rat-proof sheet and expanded metal; steel wool, Stuf-fit™ copper mesh, rolled hardware cloth.

Concrete and Cement. Discussion items for this topic should include; various small-volume products and procedures; correct mixtures and thicknesses for ratproofing; cap blocks for concrete block walls; rapid setting cements, ASTM C-928.

Screening, Grills, and Plugs. Discussion items for this topic should include: gauges for rat-proof hardware cloth and other materials, mesh sizes for screens; include design and installation of window, door, vent, and intake screening, basket screens and sleeves for floor drains, dumpster drain hole screens, plugs for weep holes, hinged anti-rat plugs for toilets.

Air Curtains. Discussion items for this topic may include design, installation, and maintenance.

Strip Doors. Discussion items for this topic should include penadore hanging strips and other products.

Rat and Squirrel Guards. Discussion items for this topic should include flat, disk, cone, barrel, and rotating tube designs for pipes, cable, and wires.

Bat Exclusion. Discussion items for this topic should include: basic procedures; various check-valve designs and applications (e.g., draped netting and one-way net doors, funnel cone/chute devices, collapsible pipes or bags; use of smoke generators, air flow indicators, and other devices to find access holes). For details see Timm, R. (ed.). 1983. Prevention and Control of Wildlife Damage. Great Plains Agric. Council, Wildlife Resources Comm., Nebraska Coop. Extension Svc., and Greenhall, A. M. 1982. House Bat Management, U.S. FWS, Resource Publ. 143.

Ventilation and Indoor Drainage

Soffit Vents. Discussion items for this topic should include: the Brenner design and others.

Other Vent Designs. Discussion items for this topic should include: floating shuttle and hinged flap products.

Sump Pumps and Other Problem Areas. Discussion items for this topic should include: procedures for excluding pests from sump pump areas; identification of other problem areas amenable to IPM.

Designing for Pest Management

Outdoor Lighting. Some pest problems in and around buildings can be reduced by proper selection and placement of outdoor lighting. Many nocturnal flying and crawling arthropods are drawn to exterior lights. Once attracted, they may find their way into buildings through cracks and crevices and open doors or windows.

Bulbs vary in brightness, intensity, and associated radiated heat. Reducing wattage or luminous area (reflectors) reduces light and heat, making the bulb less attractive to insects. More heat is generated by standard filament bulbs and flood lights than by sodium vapor or fluorescent bulbs.

The color and type of light are also important. Lights with mercury vapor or fluorescent bulbs produce much higher levels of insect-attracting ultraviolet (UV) light than do sodium vapor lamps. Wavelengths of light attractive to most insects are in the 330-370 nm UV range. Switching to high pressure, or low pressure, sodium vapor bulbs will make lights much less attractive to insects. More insects are attracted to white incandescent, blue mercury vapor, and fluorescent lights than to yellow light produced by sodium bulbs. Since sodium lamps change perceived colors to yellowish, pinkish, brownish, or gray tints, they should only be used where color definition is not important.

Lights mounted on buildings near entrances can be moved and placed on poles away from the buildings. If lights can't be moved from entrances, they should be used only when needed. Lights outside buildings can be blocked (shaded) in the direction from which insects typically come, and the light can be directed toward important building zones to minimize attracted pests.

Landscaping and Grounds Maintenance

Pest Barriers. Open areas. Discussion items for this topic should include gravel foundation strips for rodent and other pest deterrence; mowed verges for tick control; pruning away tree limbs in contact with walls and removing climbing ivy to discourage ants and spiders; removing debris and dense vegetation, such as ivy and similar groundcover, to discourage rodents and snakes; mulch types and application in relation to invertebrate pest harborage (e.g., smoky brown cockroaches, millipedes). For more information contact the National Arborist Association, 174 Route 101, Bedford, NH 03102; phone: 603-472-2255.

Fencing. Discussion items for this topic should include: deer exclusion fences; fencing techniques to exclude burrowing animals (e.g., >6-in. "L" bend outward below ground line).

Other Exclusion Methods for Vertebrate Pests. Discussion items for this topic should include planting bed surface and subsurface mesh, and tree shields and collars to deter mouse, vole, rabbit, and deer feeding.

Playground Equipment and Design. Discussion items for this topic include: rodent prevention principles for outdoor school or daycare space (e.g., pier-supported rather than slab-based play equipment, use of resilient synthetic surfacing rather than sand, mulch, or turf, considerations for location, fencing, and plantings). For more details contact the National Recreation and Parks Association, 2775 South Quincy, Suite 700, Arlington, VA 22208; phone: 703-820-4940.

Drainage. Discussion items for this topic should include principles to reduce mosquito/midge breeding areas adjacent to or near structures.

Monitoring and Detection

Discussion items for this topic include capture for monitoring vs. control - see next section.

Sticky Traps for Cockroaches and Other Crawling Insects. Discussion items for this topic should include: designs and sizes; proper placement and use; baited or un-baited; warnings about supposed pheromone baits for German cockroaches; problems with non-removal of these traps and occupant misconceptions of their purpose. Other topics might include the distinction between these traps and glue boards for mice, and electric cockroach trap models that have sticky sheets as a component.

Stored Product Insect Traps. Discussion items for this topic should include: various pheromone trap types and designs; light traps; deployment patterns and procedures.

Capture and Trapping

Vacuum Cleaners. Discussion items for this topic should include: their uses as "clean-out" tools for cockroaches; cleanup of swarming termites and ants; control of immature fleas; removal of rodent droppings to aid in monitoring; capture of orb-weaving spiders and cleanup of webs. Other topics might include mini, portable, backpack, and shop models, specialized "suction samplers" (e.g., Johnson Southwood), and HEPA filtered models; efficiency at capturing particles, capacity, cord vs. cordless, horsepower, attachments, and cost; and recommendations for disposal of contents. For more details, contact the International Sanitary Supply Association, 7373 N. Lincoln Avenue, Lincolnwood, IL 60646-1799; phone: 708-982-0800, Fax: *x*-1012.

Electric Traps for Cockroaches. Discussion items for this topic should include warnings about needlessly elaborate commercial varieties of the Zap-Trap and Bio-control Devices.

Non-Electric Trapping Devices for Flies. Discussion items for this topic should include: various flypaper products; homemade and commercial fruit fly and filth fly trap designs; the nature, sources, and relative efficacy of liquid baits for such fly traps.

Traps for Wasps and Bees. Discussion items for this topic should include: basic types and designs of yellow jacket traps and honey bee swarm traps (from low-tech fish-over-the-tub-of-water to various commercial designs with attractant baits). Yellow jacket traps catch lots of wasps but are not always effective for abatement; Various designs of honey bee swarm traps and bait boxes may offer some benefit for abating (at least detecting) Africanized bees in some areas.

Rodent Glue Boards. Discussion items for this topic should include types and techniques and caveats about animal rights groups.

Rodent Snap Traps. Discussion items for this topic should include trap types and techniques.

Live Traps for Other Vertebrate Animals. Discussion items for this topic should include: windup, multiple-catch mouse traps; single-catch live traps for mice; at least a short discussion about use of these traps vis-a-vis animal rights groups and the high mortality of captured mice; cage traps for other vertebrates, including birds; baiting and trap placement; techniques for

disposal of captured animals; and caveats about state and local laws and animal rights groups.

Other Vertebrate Traps. Discussion items for this topic should include gopher and mole traps; federal state and local regulations regarding legality, required permits, and humaneness of specific devices regarding specific targeted pests; and caveats about animal right groups.

Bird Deterrence

A study of bird deterrent systems performed for the General Services Administration (GSA) in 1980 found that audio repulsion (distress calls), scare systems (plastic owls, rubber snakes), and poisoning (baiting) have no long-term effects on pigeons or starlings in an urban environment. The study also found that tactile systems (sticky gel, porcupine wire, and electric shock) are harmful to masonry as well as ineffective. A report by the Air Force Bird Aircraft Strike Hazard (BASH) Team concluded that ultrasonic devices are ineffective because pest bird species cannot hear the wave-lengths of sound produced. Many other studies have confirm these conclusions.

The attraction of birds must also be considered. Trash and garbage must be covered. Ponds and shallow pools of fresh water will attract birds to rest and feed. Transfer stations and trash-holding areas must not be located near airfields or runways or other sites in need of protection.

Advances in plastic netting and wire anti-roosting systems offer a nondestructive solution for eliminating a variety of nesting and roosting habitats at historic buildings. Anti-roosting wire systems, also known as "pin and wire" and "trip wire," consist of a series of parallel wires of differing height, supported by narrow pins and held under tension by small springs to prevent pigeons from gaining a foothold on ledges. Plastic netting, initially developed for agricultural use, provides a vertical or horizontal barrier to areas where birds seek shelter and build nests. There are many types of netting and a variety of attachment methods. Only a few of these are acceptable for use on historic buildings.

New non-lethal chemicals have recently shown a lot of promise against multiple species of pest birds as essentially contact repellents (e.g., those containing food grade methyl anthranilate as their active ingredient) or as anti-feedants (those containing certain isomers of anthraquinones as their active ingredients). Pest birds shown to be affected strongly, yet non-lethally, by these products (actually by their active ingredients) in numerous controlled and field tests have included Canada geese, pigeons, starlings, seagulls, et al.

Control of Wood-Destroying Insects and Other Organisms

Moisture Control

Moisture control for wood-destroying insects (WDIs) and other wood-destroying organisms (WDOs) should include remediation of all sources of structural moisture, including soil contact, roof leaks, water flow off roofs, seepage, prevailing rain, poor grade of wood, plumbing leaks, and condensation.

Moisture Meters

Discussion items for this topic should include: types, uses and relative benefits of moisture meters which can be excellent tools for determining the percent moisture content in such wood

as siding, decking, joists and rafters, structural timbers, and utility poles. Some portable devices give a direct reading when two probes are inserted into a wood member. Newer "pad" types use a Radio Frequency (RF) density detection technology and do not need to penetrate or mar the wood. A variety of moisture meters are available, priced from $180 to >$400, and can be found in supply catalogs for wood preservation, forestry, pest management, and scientific equipment.

Electro-Gun

Discussion items for this topic should include localized infestations of drywood termites or other wood-destroying insects (WDIs), and operational and safety considerations of these during use.

Cold Treatments

Discussion items for this topic should include various liquid nitrogen dispensing systems, (mainly for localized infestations); and operational and safety considerations of these during use.

Heat Treatments

Based upon the principle that insects in any stage cannot survive if the temperature is raised to 155^{o} Fahrenheit. Whole pieces of structural wood, furniture or decorative wood items (e.g., carved pieces of art) are heated in "batches" inside special chambers, to a specific temperature for a specific time (e.g., 155^{o}F for >30 min.). Alternatively specific walls, rooms or whole buildings may be "tented" and then heated in place, to a specific temperature for a specific time (e.g., >155^{o}F for >60 min.) to try to kill infesting populations of certain wood destroying organisms (e.g., drywood termites, certain wood boring beetles).

In place heating of whole buildings, rooms, or walls are difficult to heat and to ensure that pests have been eliminated, and collateral damage to the structure or fixtures can be a problem and be hard to assess. The heat sources currently in use are primarily either large electric heaters or (more typically) portable high capacity forced air gas-burning (usually propane) heaters.

Similar techniques used against non-wood infesting pests (e.g., bed bugs, cockroaches) have shown good results (efficacy) in recent controlled and applied trials (not further addressed here).

This technology (heating wood to a minimum core temperature for a specified minimum time interval) is a cornerstone of "disinsection" of solid wood packing material (SWPM) certifications of "pest free" status for wooden items in international trade and quarantine. This is the only non-chemical technology recognized as sufficient wood treatments by several countries (e.g., China, Brazil, and at least 27 other countries), especially for SWPM used as dunnage or supporting struts in sea or air freight shipments.

Currently, wood (including SWPM) must be heated to an internal (core) temperature of at least 71.1^{o}C (= 159.98^{o}F) for at least 75 min. to be considered "insect free" for international trade and quarantine purposes. This was the result of specific pests (i.e., the Asian Longhorned Beetle, the Emerald Ash Borer) introduced into the U.S. from the Orient, and certain nematodes of conifer species introduced from the U.S. into some European countries in the 1990s. For more details, search on: www.aphis.usda.gov/import_export/plants/plant_exports/wpm/inddex.shtml .

Sand Barriers

Discussion items for this topic should include: the functional concepts, efficacy, and relative cost of precisely sized basaltic (or granitic) sand barriers for termite exclusion as vs. other termite

exclusion technologies and products.

Basaltic sand is carefully screened to separate out particles that are too large for termites to remove and too small for them to get between. Barriers of such sand are an effective barrier to most U.S. species of subterranean termites. These barriers should be at least four inches thick and treated with a long-lasting herbicide to prevent root penetration. Additionally, buildings protected by this method must be inspected periodically to ensure that termites have not built tubes over the top of the barrier. The technique and the aggregate material are currently available in Hawaii and a few other places in the U.S.

Stainless Steel Screening

Discussion items for this topic should include: the concept, operational installation, efficacy and relative costs of the use of fine (about 42 x 42 mesh/inch) stainless steel mesh under a building to prevent subterranean termite infestation. The concept is that fine stainless steel screening buried in the soil during construction effectively prevents termite movement up into that structure. It is a relatively expensive control but has the distinction of not introducing toxic materials into the soil. Periodic inspections may still be needed to ensure that no termites have build mud tubes up over the outside of the screen (effectively passing around it) and it may not offer any protection against species which normally infest above the ground level (e.g., drywood termites).

Nematodes

Discussion items for this topic should include: the general concepts, efficacy, and relative costs involved in the use of insect pathogenic nematodes to control a termite infestation. Lab and field trials have historically shown that the most promising insect parasitic nematode species are not very effective, hard to keep going and very susceptible to moisture fluctuations in surrounding soil. They are currently not recommended for protection against termites, nor for elimination of a current infestation of any of the most common termite species in the U.S.

Detection Methods and Equipment

Discussion items for this topic should include operational details, effective use, and relative costs of detection trained dogs, moisture meters, borescopes and other fiber optic devices, stethoscopes and other listening devices, (e.g., Insecta-Scope™). Visual inspections by a trained PMP may involve bump helmets, knee pads, various probes, hammers (to “sound” structural elements), extensible and adjustable mirrors, strong lights (many use very bright LEDs), and magnifiers.

Treated Wood

Discussion items for this topic should include: the concepts, operational aspects, efficacy, relative costs, and perceived hazards involved in use of preservative treated wood to prevent or limit damage to structures by WDIs/WDOs.

Wood decomposes as the result of feeding by decay fungi. It is also subject to damage from termites and other insects feeding on or burrowing through it. Simply preventing decay helps prevent insect damage because most insects are attracted to wood that has been softened by decay. The use of preservative-treated prevents decay. Good design and construction practices for wood protection include:

- Protecting wood from absorbing moisture from the soil

- Protecting joints and end grains from water entry
- Promoting rapid run-off of rain water with roof overhangs and drip edges
- Supplying adequate ventilation for crawl spaces, attics and other places where water condenses on wood surfaces, and
- Protecting finishes on all exposed wood

The Wood Protection Council of the National Institute of Building Sciences (NIBS) has developed an extensive document on wood protection - *Guidelines for Protecting Wood from Decay and Termites*. For more information, contact Wood Protection Council, National Institute of Building Sciences, 1201 L Street NW, Washington, DC 20055; (202) 289-7800. Detailed information on various aspects of wood protection is also available from a number of trade associations and government agencies:

American Plywood Association, P.O. Box 11700, Tacoma, WA 98411; (206) 565-6600.

American Wood-Preservers Association, P.O. Box 286, Woodstock, MD 21163; (410) 465-3169.

California Redwood Association, 405 Enfrente Drive, Suite 200, Novato, CA 94949; (415) 382-0662.

Cedar Shake and Shingle Bureau, 515 116th Avenue NE, Suite 275, Bellevue, WA 98004; (206) 455-1323.

National Forest Products Association, 1250 Connecticut Avenue NW, Washington, DC 20036; (202) 463-2700.

National Wood Window and Door Association, 1400 East Touhy Avenue, #G-54, Des Plaines, IL 60018; (708) 299-5200.

Southern Forest Products Association, Box 52468, New Orleans, LA 70152; (504) 443-4464.

Western Wood Products Association, 522 SW 5th Avenue, Yeon Bldg., Portland, OR 97204; (503) 224-3930.

Ultrasonic, Electromagnetic, and other Electronic Devices

Electromagnetic exclusion or control devices, ultrasonic repellent or control devices and **outdoor** devices for electrocuting flying insects should not be used on DoD installations. This does not apply to **indoor** use of selected devices, carefully placed, for electrocuting flying insects. Pest surveillance traps and monitoring equipment, such as non-electrocuting mosquito light traps, may also be used by trained personnel. For additional information see:

References:

DASD(E,E&S) Memorandum, 30 March 1978, Electromagnetic Devices for the Control of Pests.

DASD(E) Memorandum, 9 August 1988, DoD Policy on Electrically Operated Pest Control Devices.

U.S. Air Force Wright Laboratory Report WL-TR-2-3-33, April 1992, Ultrasonics as a Method of Bird Control.