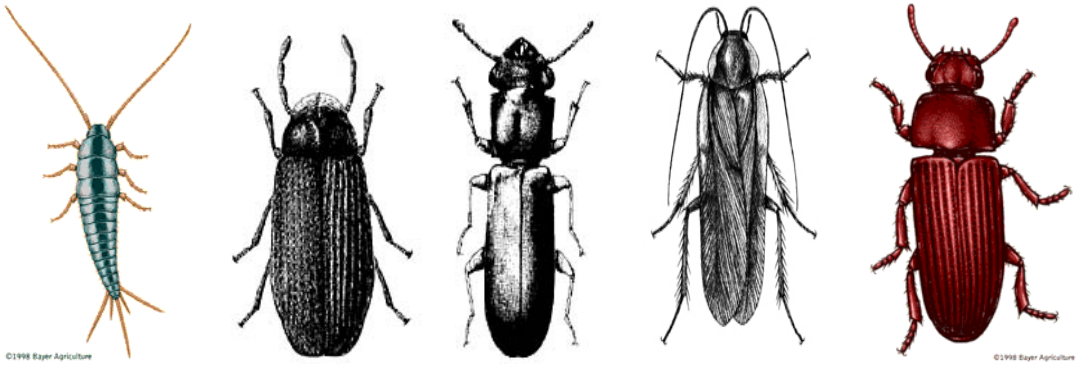
INTEGRATED PEST MANAGEMENT CHECK LIST



INTRODUCTION

Integrated Pest Management is a preventative, long-term, low toxicity means of controlling pests. Though IPM was developed first for the agricultural industry, many museums, archives and libraries are finding IPM principles relevant to the protection of their holdings. Obviously the specific requirements of an IPM plan must be tailored to the specific cultural institution. Before deciding to implement an IPM program, you will need to consider some of the primary advantages and disadvantages of an IPM program over traditional pest management. *Traditional pest management* is defined here as repeated chemical application, without emphasis on understanding the species or number of pests present.

Advantages to IPM

- Decreased use of chemical application will reduce risks to the health of staff members.
- Decreased use of chemical application will reduce the risk of deterioration and disfigurement of holdings.
- Decreased use of chemical application *may* result in a financial savings.
- The environmental improvements made to the facility to implement an IPM program will enhance the long-term stability of the holdings over and above protection against pests.
- IPM may be the *only* solution to some long-term pest problems where chemical application has not worked.
- IPM ultimately allows the institution to have greater control over and knowledge of pest activity in their facility.
- IPM is the pest management technique of choice for major institutions.

Disadvantages to IPM

- IPM will require more staff time than traditional pest management, even if implementation is contracted to a pest management company.
- IPM will require the coordinated effort of all staff members to properly implement.
- IPM *may* initially be more expensive than traditional pest management.

Sites with General IPM Information

NORTHEAST DOCUMENT CONSERVATION CENTER
CHICORA FOUNDATION
NATIONAL PARKS SERVICE
UNIVERSITY OF NEBRASKA - LINCOLN (not strictly IPM, but has a good general discussion of IPM and various types of pest control)

This site links to several sites with general information about pests and pest management. The goal of this site is to help *use* the information found on the web and elsewhere. The check list format, sample floor plan, monitoring chart and identification section will help you compile accurate information about your institution and implement a pest management program that is tailored to the needs and priorities of your staff and institution.

There are both direct links to informative sites and excerpts of pertinent sites inserted into this site. Whenever a portion of another site has been inserted into this site, the heading will provide a direct link to the entire site. Site excerpts preserve the information for this site in case the overall link fails and provide direct access to the exact portion of the site which is relevant to the check list.

Commercial sites are usually linked under parts of the Check List which offer "products". However portions of some commercial sites are also linked to the check list to provide definitions and other valuable information.

IPM CHECKLIST

ASSESSMENT

✓	EXTERIOR STRUCTURE	✓	INTERIOR STRUCTURE	✓	MONITORING SYSTEM
	Is there evidence of damage and debris caused by insects?		Is there evidence of damage and debris (2), (3) caused by insects within the building or within the collection itself?		Create a floor plan of facility, marking off doors, windows, water and heat sources and areas of potential insect activity.
	Are there cracks and/ or holes in the building structure?		Are there cracks or holes in or around the walls, doors or windows?		Select a trap type (2) (3) , (4) for the monitoring system.
	Are there gaps around windows and/ or doors?		Is there food waste in undesignated areas?		Set monitoring traps throughout the facility and mark on the floor plan where they have been placed.
	Are there water sources near the building?		Are there moisture leaks or condensation around plumbing, windows, or climate control equipment?		At monthly intervals record and quantify the catches in each trap on a monitoring chart.
	Is there waste disposal near the building?		What are the ranges of relative humidity and temperature throughout storage and exhibition areas?		Identify the type and life stage of each catch.
	Is there vegetation or mulch placed against or near the building?		Is there excessive paper trash? Is paper trash removed frequently?		Allow traps to remain in the same location for a year of seasonal changes. Additional traps may be added, but generally traps should not be removed until inactivity is confirmed.
	Is there nonessential lighting near the building?				Determine key types of pests found in the monitored area.

THRESHOLD DETERMINATION

✓	DEFINE	✓	CONSIDER	✓	EDUCATE
	What is zero tolerance for your institution in terms of "nondestructive" pests?		To what degree are the collections affected by pest activity as seen in the initial assessment?		What is the formalized consensus on a feasible Threshold Determination?
	What is zero tolerance for your institution in terms of "destructive" pests?		How much money and time can be allotted to IPM implementation.		Who is the IPM leader/liason?
	What is low tolerance for your institution in terms of "nondestructive" pests?		Consider the age and adaptability of the institutional structure. What changes to the structure are feasible?		Which pests are destructive to the collection?
	What is low tolerance for your institution in terms of "destructive" pests?		Should the staff contract an outside company and choose a staff liaison or can the staff take on implementation of an IPM program themselves?		Which pests are not destructive to the collection?
	What is moderate tolerance for your institution in terms of "nondestructive" pests?		All staff understands that they participate to in an IPM plan by reporting pest sitings and defects to the interior or exterior of the building structure to the IPM leader or staff liaison.		Where and how should sitings and structural problems be reported?
	What is moderate tolerance for your institution in terms of "destructive" pests?		Staff agrees on the threshold determination.		What structural defects should be reported to the IPM leader/liaison?

CONTROL

✓	EXTERIOR STRUCTURE	✓	INTERIOR STRUCTURE	✓	NONTOXIC ERADICATION	✓	TOXIC ERADICATION
	Remove vegetation and water sources from directly around the building		Seal cracks and holes in the walls		Information on products (1), (2), (3)		Information on products (1), (2)
	Create a gravel or concrete perimeter around the building.		Install sweeps along the base of doors where access to the exterior is present.		Anoxic fumigation using oxygen scavenger (1), (2), (3)		attractants, including pheromones (1), (2), (3), (4)
	Eliminate trash directly near the building.		Seal windows where cracks are present.		Anoxic fumigation using gases (1), (2),(3)		fumigants (1), (2) , (3), (4), (5), (6), (7), (8), (9), (10)
	Seal holes and cracks in the building structure.		Improve climate control.		Freezing treatment (1)		dry formulations (1)
	Seal cracks around doors and windows		Clean frequently. Paper trash, dust and dirt attract moisture and insects.		Heat treatment (1)		information on safety (1), (2), (3), (4), (5), (6)
,	Eliminate bright night lighting around the building..		Remove carpeting which may hold mold, dust and moisture and conceal the presence of pests.				
			Remove plants, especially flowering plants				
			Create a quarantine room for incoming materials and anything suspected of infestation.				
			Designate areas				

			for food and drink. Keep these areas clean.				

EVALUATION

✓	MONITORING SYSTEM	✓	INTERIOR STRUCTURE	✓	EXTERIOR STRUCTURE
	Continued monthly monitoring of insect traps.		Continued assessment of relative humidity and temperature		Continued assessment of physical changes to the exterior building structure.
			Continued assessment of physical changes to the building interior		Continued search for debris and damage left by pests
			Continued search for debris and damage left by pests		

SAMPLE FLOOR PLAN

							17	SINK	16		RADIATOR	DOOR	15						
2																			14
DOOR																			WATER LEAK
3																			
			DRAIN	18							DRAIN	19							
4																			13
DOOR								CRACKS	20										DOOR
5																			12
6		7	WINDOW		WINDOW		8			9	WINDOW	WINDOW	10						11

MONITORING CHART

In order to accurately assess a pest problem, the site should be monitored continuously. The monitoring chart should be filled out on a monthly basis. The best way to use the chart will be to collect all of the traps and assess their contents before deciding whether to replace them with a new trap. The chart below outlines the important information to gather during monthly trap monitoring. The chart coordinates with the floor plan seen above.

DATE	TRAP NUMBER	EMPTY?	**INSECT TYPE**	LIFE STAGE	NUMBER	REPLACE ?	**NOTES**
	1						
	2						
	3						
	4						
	5						
	6						
	7						
	8						
	9						
	10						
	11						
	12						
	13						
	14						
	15						
	16						
	17						
	18						
	19						
	20						

IDENTIFICATION

Identification of pest species and life stage are at the core of any IPM plan. Correct identification allows you distinguish whether or not the pests sited are dangerous to your collection. Identification can also give an idea of how long certain pests have been in the collection and what measures, including chemical and nonchemical, may reduce the presence of particular pests.

However, identification is also the most challenging step in an IPM plan. Even trained entomologists can find identification somewhat difficult at times. On the positive side, identification becomes easier as you begin to recognize the key pests in the collection. It is unlikely that you will be constantly finding new pests to identify and your reliance on trained entomologists can be curtailed fairly quickly.

strategy

There are several approaches to identifying insects. You can compare your catches with images in books or images on the internet. You can contact entomologists on the internet who will identify insects for you and answer pest-related questions. Other options include checking with your local universities and colleges for trained entomologists or hiring a pest management company and working with them.

As you begin to identify insects it will be important to maintain a reference collection which has been accurately identified. A reference collection will help you with future identification and allow you to teach others what pests are common in your institution.

magnification

Magnification of 15 - 30 X is necessary to identify many of the tiny insects that damage archival material. Hand held magnifiers which go up to 30X are available in the U.S.A. for under $10.00.

entomologists on the internet

http://www.sel.barc.usda.gov/selhome/requests.htm
http://www.ipmnet.org/experts.html
http://www.orkin.com/ (go to "Ask us your bug-related questions")
http://ipmworld.umn.edu/chapters/macrae.htm
http://ipmwww.ncsu.edu/urban/cropsci/c07insec/c07insec.html

bibliographies on the internet

http://palimpsest.stanford.edu/byauth/jessup/ipm.html#sec2
http://palimpsest.stanford.edu/bytopic/pest/

image collections and fact sheets on the internet

http://www.orkin.com/
http://www.ent.iastate.edu/list/insect_collections.html
http://entomology.si.edu:591/entomology/art_archive/info.html
http://www.insecta-inspecta.com/html/links.html
http://www.colostate.edu/Depts/IPM/natparks/museum.html
http://www.colostate.edu/Depts/IPM/natparks
http://www.ag.ohio-state.edu/~ohioline/hyg-fact/2000/index.html

EXCERPTS FROM INTERNET SITES

WAAC FROM WAAC NEWSLETTERS
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Update on Nitrogen Anoxia Research at the Getty Conservation Institute

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Shin Maekawa and Kerstin Ehlert

Research projects utilizing the efficacy of a nitrogen anoxia environment for the eradication of insect infestation of cultural artifacts have been conducted at the Getty Conservation Institute (GCI) since 1987. Under contract from the GCI, mortality rates of commonly found museum insects in a nitrogen atmosphere with less than 0.1% oxygen concentration, were evaluated at the University of California Riverside (UCR) in 1990 and 1991. In collaboration with the Getty Museum, practical issues for museums conducting anoxia treatments of their artifacts, such as designing the apparatus as well as selection and effective use of the components were investigated to complement the data collected at the UCR. Adapting the treatment to commercially available fumigation chambers and fumigation bubbles/tents for frequent and large-scale applications has also been investigated.

During the last eighteen months, research projects were conducted to improve our understanding of the practical issues of the nitrogen anoxia treatment. The required exposure time to completely purge oxygen from a large wooden object was investigated in a nitrogen anoxia environment. We found that a 48-hour period was sufficient for oxygen removal. The Ageless® oxygen scavenger's absorption capacity and speed were re-evaluated by directly monitoring bagged micro- environments. The required amount of Ageless® for producing an anoxia micro-environment (less than 0.1% oxygen concentration) was found to be much smaller than the amount recommended by the manufacturer. The anoxia environment was achieved in less than 48 hours with the recommended amount (20% of bagged air volume). Two types of the Ageless Eye® oxygen indicators were tested as suitable low-cost oxygen monitors for the treatment.

Filmpack 1193® has been found to be the best transparent oxygen barrier film for anoxia treatment. A ten cubic meter reusable tent was produced from the Filmpack 1193® film. The tent was successfully tested with both a nitrogen generator and a liquid nitrogen supply to produce and maintain the anoxia environment. The tests indicate that a large tent is a practical possibility.

The most recent GCI-sponsored study conducted at the UCR concluded that it was not possible to obtain 100% mortality of museum insects in a nitrogen environment with 0.62% oxygen concentration, even with an extended exposure time greater than three weeks. The study also reported that the addition of an elevated temperature or an injection of a small quantity of carbon dioxide will produce the desired full mortality . This presentation will describe the results and progress of these projects.

Silverfish Traps (also contains info on powders)

At the University of Florida, we've found that Boric acid--besides being messy, requiring the pest to traipse through it without apparent incentive--is rendered ineffective, over time, by the humidity in which Silverfish thrive. ... So not only is it messy, unattractive, and physical separated from infested materials, but it also has to be replaced relatively often.

Our Pest Control Division urges us to use silica gel as well. Within enclosed spaces, e.g., map cases, with low rates of air exchange, this seems to work well, reducing humidity in the case and controlling silverfish populations. The interval between replacement is longer for silica than boric acid, and silica can be "reconditioned" (though not easily) for effective reuse. (Given our humidity problems and appropriate apportionment of silica, there seems little danger that we will lower relative humidity below optimal levels for storage of the paper or photographic materials.)

We have also determined that use of silica and other humidity controls merely slow rates of population growth without also reducing and maintaining low(ered) temperatures. Temperature level, however, depends upon the type of Silverfish infestation. Lepisma saccharina, the most common, the actual "silverfish", requires incubation temperatures above 72 degrees F (22 degrees C). Other species, particularly those identified in California, i.e., Ctenolepisma longicaudata, Ctenolepisma urbana, and Ctenolepisma quadriseriata, require higher incubation temperatures. In one of our infested collections, we attempted to maintain temperatures between 65 and 70 degrees F while also dehumidifying for a period of two weeks.

Our Pest Control Division also suggested use of simple home-made traps. The traps, described below, seem to work wonderfully, but may also represent a source of food for other insects which can escape them. The trap is a small glass with smooth sides (a small guide ramp up the outside, i.e., a piece of paper, wrapped around the outside) and partially filled with flour. (I have also mixed boric acid in my traps at home to kill insects which might otherwise be able to escape. I imagine a mixture with silica powder might starve rather than poison the insects.) Assuming your silverfish are attracted, and capture entire populations traps would have to be tended and remain with infested materials for 3 to 4 months minimum.

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Modifications to Home Freezers for Pest Control

The SPNHC Newsletter, Vol. 7., Number 2, August 1993 carries an excellent note by Ann Pinzl on how she was able to achieve -20¢ F (-29¢ C) in ambient air of 40-85¢ F, using a Westinghouse chest freezer model No. FC083TW (R-12 system).

Her local refrigeration technicians bypassed the cold control, increased condenser capacity, added a suction line accumulator to stop liquid refrigerant from returning to the compressor, and added a condenser fan to maintain constant and consistent temperatures. Ann Pinzl, Nevada State Museum, Capitol Complex, Carson City, NV 89710-0001 tel. (426) 586-5593.

Faced with an infestation emergency, I purchased a GE chest freezer FH22DS, inserted the probe from an indoor/outdoor thermometer (Micronta 63-854, about $10.95 from Radio Shack) (thanks to Tom Strang of CCI for the idea) and was delighted to find that I achieved temperatures of -32¢ C. I noticed a small frost pimple on the outside, however, and called 1-800-GE-CARES for advice. They sent a new freezer the next day (!); unhappily, it wouldn't go below -5¢ F. Since my maverick freezer was now lost in the system, I consulted my local appliance repairman, who explained that freezers are designed to work at -10¢ to +10¢ F to prevent freezer burn. When I explained my need for at least -30¢ C (constant), he cheerfully pulled off the rear control panel, pulled two pins to bypass the thermostat (and explained how to replace them if I needed warrantee service), and opined that I should be able to run the freezer for 3-4 months at a time without damage to it. It stays constant at -35.1° C.

Lisa Mibach

Cool Tools

ExTech Instruments (335 Bear Hill Road, d, Waltham MA 02154; 617- 890-7440) provides inexpensive meters for temperature, RH, pH, conductivity and a multimeter light reading adaptor; possibly their neatest item is a small battery/AC electronic scale with auto zero, tare, measuring grams or ounces in ranges of 1-2000 g or .1-225 g, accuracy 0.4% plus/minus 1 1 digit, from $89. Thanks to Bill Lull of Garrison Lull for the source.

CHICORA FROM THE PEST MANAGEMENT SITE)

Considerations for contracting and working with pest management companies

Some institutions may find that with small staffs it is easier to contract IPM out. This can be a successful approach, but the contract manager must have the budget, authority, and some expertise to coordinate the various activities into an integrated effort. And it is still essential to have staff support to make the program work.

Be very cautious when working with outside companies who claim to be offering IPM. Some are not familiar with IPM. Others may say they offer IPM, but don't actually do so because the fee they are charging isn't adequate to cover the necessary monitoring and the various non-pesticide strategies required. Chemical controls are often cheaper and the company may assume that the client isn't sophisticated enough to know the difference. This sort of practice is rare, but you must be willing to pay for all the activities involved in IPM. The individual components of IPM--inspection, monitoring, injury level assessment, treatment, and evaluation--are typically used by every PCO. Rarely, however, are they integrated or brought together in an organized framework designed to work together to control pests. For example, most pest control firms offer "free inspections." These free inspections, however, undervalue the skills and experience necessary to carry out reliable, comprehensive inspections. Most inspectors also rely only on chemical treatments in response to the problems they identify. Monitoring and production of written reports are likely to be new steps, unfamiliar to many firms.

Consequently, you must set the parameters of an IPM contract with a commercial firm. You will need to specify, for example, the monitoring methods to be used, the frequency of monitoring, and the detail and information in the resulting reports. You may find it helpful to require the use of specific monitoring forms for consistency. Also keep in mind that zero trap catches do not necessarily mean that the pest is absent. It may only mean that the traps are not placed properly. Your agreement with the pest control firm should specify that traps with zero catches are periodically moved to new locations. You should also continue to monitor occupant reports of pest problems, correlating that information with the more formalized monitoring program developed by your PCO.

Your agreement with the PCO should also emphasize the need to explore a wide range of control measures, including: education, redesign of the building or its furnishings, habitat modification, maintenance activities, physical control, and (as a last resort) chemical controls. Education efforts might include requests that food not be brought into the facility or that it be kept in only one area, that food residues be better cleaned up, and that trash be disposed of properly. Redesign efforts might include rat-proofing, use of different trash containers, or use of lights less attractive to insects. Habitat modification might include more aggressive caulking of cracks, screening vents, better cleaning procedures, and repair of water leaks. Physical controls include using traps for mice, vacuuming all new collections, and use of silica-gel dusts in voids. Because of the potential health hazards, institutional liability, potential for damage to collections, and public relations problems, chemical controls should not only be a last resort, but should also be very carefully selected. Also, while the initial costs are likely to be low, most chemicals require constant re-application and their real costs are much higher than might be imagined.

The commercial PCO should maintain detailed records of all pesticide applications. Included should be information on the target pest, the product used, the active ingredient of the product, the dilution used, the date applied, the total amount used, where (exactly) the product was used, the individual who applied the pesticide and completed the report, and any additional information which might be important (for example, complaints about the smell, or damage to collections). Require that you be given a copy of label and a material safety data sheet (MSDS) for each pesticide used in and around your institution. The label copy will let you know that the chemical is appropriate for the reported problem while the MSDS will tell you want to do if there is an accident during application or if someone complains that the pesticide is affecting them.

The evaluation process of even a commercial IPM program is essential. The contract manager should examine five areas: the monitoring program itself (Is it reliable? Does it provide the information necessary to make good treatment decisions?), the injury level (Does the level selected provide adequate advance warning of problems? Does it protect your collections?), the treatment activities (Are they successful, i.e., have pest populations declined? Are written records being appropriately maintained?), the integration of services (Is communication adequate? Do all those involved understand how their actions affect the collections?), and the education program (Are staff members receiving adequate information about how to help control the pest problems?).

Even if your institution can't implement an IPM program right now, you can redefine your normal methods of pest control.

Begin by making sure that your PCO signs in every time he or she visits your institution. Not only is this a good security measure, but it will also allow you to better track performance. Have a staff member accompany them--again a good security step and it also re-enforces your involvement in the decision-making process of pest control.

Use a standard sheet for your PCO to identify pest problems and recommended treatment. Let the firm know that from now on you want treatments for real problems--not simply "preventative" squirt and spray visits.

Questions to ask include:
Do you know what is being sprayed? Or why it is being sprayed?
Do you see evidence of pests in spite of these treatments?
Does anyone on staff accompany the PCO during his or her visits?
Do you receive a written statement of the findings and work after each visit?

If you feel that "preventative" treatments are essential, have your firm identify products for you that need to be applied less often. While these more effective pesticides are often more expensive, this additional cost should be off-set by the reduced visits. For example, there are insect growth regulators suitable for use with cockroaches that provide excellent long-term control. There are also baits which may provide superior performance to what your institution is using right now. Explore the different options by asking questions.

Begin a dialog with your PCO to identify the cause of your pest problems. A good firm will be interested in working with you to find these problem areas and suggest changes--like taking out the trash more often, keeping the staff lounge cleaner, and removing branches overhanging your building. Most PCOs are genuinely interested in making you satisfied and keeping you as a client--they just need to know that you want a different kind of service.

And if your current company can't provide you with what you need, find another firm who is interested in working with you.

For example, if you have a monthly "squirt and spray" contract mentioned earlier, notify the pest control firm that you wish to have them spray only twice-a-year. There are appropriate pesticides which provide this level of kill. Notify the pest control firm that you will need a copy of the pesticide label and the material safety data sheet for every chemical they use in and around your building. Accompany their staff throughout the building. Have their staff provide a detailed written report for each visit, including changes that you should make to reduce the pest problem.

Through even these simple steps you can begin to take control of your pest control problems. Remember that simple solutions to complex problems do not exist and that it is always easier to prevent an infestation than it is to eliminate the pests once they have become established in your collections.

Water sources in archives and museums

Many insects are attracted to damp areas. Sources of water and potential insect habitats include water pipes running through collections, restrooms, kitchens, water fountains, custodial closets, and climate control equipment. Standing water on a roof or in other locations can raise humidity levels and provide an excellent environment for insects.

Openings around pipes should be sealed, as should cracks in the walls or foundation. A planting-free zone of about 12 inches should be maintained around buildings to discourage insects from entering. Exterior plantings should be properly cared for and not over watered. The area around foundations should be graveled and graded away from the building to avoid basement flooding.

Use of traps to monitor insect activity

Effective implementation of a pest management program requires routine monitoring of pest activity. Routine monitoring using traps provides information about the type of insect(s), their entry points, the number of insects, where they are taking up residence, and why they are surviving. This information allows for identification of problem areas and development of a species-specific treatment program.

The most commonly used insect traps are sticky traps, available from most hardware and grocery stores. Several types are available: flat traps, rectangular box-shaped traps (motels), and tent-shaped traps. Many conservators recommend the tent traps as the easiest to handle. Whatever type and brand is chosen, consistency should be maintained so that data can be interpreted accurately.

The basic procedure for monitoring is as follows: 1) identify all doors, windows, water and heat sources, and furniture on a building floor plan; 2) identify likely insect routes, and mark trap locations on a floor plan; 3) number and date the traps; 4) place the traps in the area to be monitored, as indicated on the floor plan; 5) inspect and collect the traps regularly; and 6) refine trap placement and inspection as necessary, according to the evidence collected. Relocate traps if initial results are negative and try again.

If infestation is suspected in a particular area, place traps every 10 feet. Care should be taken to insure that traps do not come into contact with collection materials, since the adhesive can cause damage. Checking the traps 48 hours after placement will identify the area most seriously infested. Traps should be inspected weekly for at least three months and should be replaced every two months, when they are full, or when they lose their stickiness.

Documentation is essential; monitoring will be useless without it. The number of insects, the types of insects, and their stage of growth should all be recorded for each trap. Dates and locations of trap replacements should be noted. Detailed records should also be kept of any other evidence of insect activity, such as live insects, insect droppings, or dead insects.

Once insects have been trapped, they must be identified to determine what threat they pose to collections. There are several good books that provide drawings and descriptions of common library and archives pests; these are listed in the bibliography. An excellent resource for identification is the local or state Agricultural Extension agency, which will usually identify insects free of charge (the insect must be sent to them, and the entire body must be intact). Other potential resources include the biology department of a local university or a local history museum with an entomologist on staff.

Chemical erradication

Common chemical treatments used to control insects include aerosol sprays; attractants (which lure insects into traps, sometimes killing them); baits and pellets (which are eaten by the insects); contact and residual sprays (normally sprayed into cracks and crevices; these kill on contact and/or by absorption of the pesticide when the insect walks through the residual); dusts (e.g., boric acid or silica dust, which dehydrate insects or interfere with internal water regulation); fogging concentrates (these use equipment that suspends a pesticide and oil formulation in the air); fumigants (these expose infected material to a lethal gas); and residual and vapor pest strips (the insect absorbs pesticide by walking across residual pest strips, while pesticide evaporates from vapor pest strips to become a fumigant). Repellents (such as mothballs) are also sometimes used; these are meant to discourage rather than kill insects.

Fumigants are among the most toxic of pesticides; other pesticides are usually suspended in a liquid and sprayed, so that they tend to settle out of the air. Fumigant gases remain in the air and can easily spread over a wide area. **Ethylene oxide (ETO)**, a gaseous fumigant, was commonly used in libraries and archives until the 1980s; many libraries had their own ETO chambers. ETO is effective against insect adults, larvae, and eggs. It poses serious health hazards to workers, and there is evidence that ETO can change the physical and chemical properties of paper, parchment, and leather. Acceptable limits on ETO exposure have been steadily lowered by the government, and most existing ETO chambers in libraries cannot meet these restrictions. Some residual ETO remains in treated materials, and little is known about the long-term risks to collections and staff from off-gassing toxins. ETO should be used only as a last resort; materials should be sent to a commercial facility and allowed to off-gas for at least several weeks before being returned to the library or archives.

Identifying insect debris and damage

How do we recognize that our things are under attack from insects? Here in Hawai'i, vigilance is needed. Be alert to the following signs:

Live insects, either adults or larvae. Be sure to examine objects closely, as silverfish, booklice and other insects can be difficult to spot because of their size, color and reclusive habits.

Insect remains: dead insects; termite wings; casings or skins shed by larvae as they mature and molt; empty egg cases of cockroaches (a hard dark pod attached to walls, etc.), and webbing of clothes moths (a small cocoon or threads) are irrefutable signs.

Frass: this is the product of the insect's digestion, a fine powdery sawdust or a hard sand-like material which collects in the holes and tunnels excavated by the insects. The color of the frass usually will be similar to that of the food the insects are digesting. If a small pile of frass is found under an object each time the floor around it is swept, that object probably has an active insect population. It's important to note evidence like this before you sweep or vacuum it away!

Visible damage: thin areas and small holes in textiles, ragged edges and 'skinned' areas on paper, small holes with clean edges in objects where the larvae have emerged as adults. Once again, close inspection is sometimes needed to detect these signs. Clothes moths may concentrate on seams and other hidden spots. Subtle skinning of paper occurs as silverfish graze across the surface. Exit holes in wood are a sign that adults have emerged and some damage already has been done; since the activity occurs inside the wood, it is unlikely you'll see any
larvae at work.

Smell, sound: specially trained dogs can detect insects via these senses; some people are able to hear insects in wood, and to smell cockroaches. You can use your fingers to lightly tap across wood surfaces and listen for differences in sound to reveal hollow areas below, indicating tunneling.

Spiders sometimes take up a position near insect activity to capture strays. Spiders, centipedes and geckos do not harm objects, and are predators of insects which do.

The Insects

You can identify insects by checking references listed in the bibliography, or having them identified by an entomologist (see below). Try not to
squash insects you want identified; try to place the specimen, dead or alive but intact, in a vial such as a film container. Knowing precisely what insect you are dealing with is critical; for example, the time needed to fumigate for termites is shorter than is needed to kill wood-borers, so if you have the latter, some standard fumigations will not be successful.

Termites create tunnels through wood as it is consumed by the adults, resulting in serious structural damage. There are no flight holes, as with woodborers, but there is a sand-like frass. Termites can move from structures into furniture, picture frames, etc., and eat other cellulosic materials besides wood; they also tunnel through other materials on their way to a food source.

Woodboring Beetles including Powderpost and Death Watch Beetles, lay their eggs on wood which is then tunneled through by the larvae, sometimes for years before eventually emerging as adults through small holes. The powderpost beetle generates a very fine talcum powder-like frass.

Silverfish prefer high humidity and dark conditions. They move quickly and will eat anything containing starch, including adhesives and the coatings on papers, and also digest cellulose (paper).

Carpet beetles go by a variety of names. Adults feed on pollen, and may be brought indoors on fresh flowers. The larvae prefer dark, dirty areas, and eat fabrics, plant materials, fur, and feathers, usually grazing across the surface, resulting in obvious damage, or a general shabby look.

Dermestids include Larder and Hide Beetles and are voracious. The larvae consume animal skins and dried plant materials, then cause damage to wood as they burrow in to undergo pupation (metamorphose to adult form).

Clothes moths: as they feed, the larvae of the Casemaking Clothes Moth enclose themselves in a case spun out of the material they are feeding on, whereas the Webbing Clothes Moth larvae leave a trail of silk as they go. Both eat fur, feathers, woolens and dried plant materials, gradually thinning the food source down by grazing on the surface.

Booklice are tiny and a pale color. They feed on mold and other dead insects, but will also graze on paper and paste.

"Bookworms"/Cigarette and Drugstore Beetle larvae burrow through books and bindings, creating a hole in each page as they pass. They also eat dried plant materials.

Cockroaches damage paper, cardboard, clothing and furniture by eating starch, mold, proteins and other residues on the surface. They also
stain materials with their droppings, and adhere their egg cases to objects.

freezing infested objects

Some objects can be frozen. This is a very effective way of killing adults, larvae and eggs. The freezing process goes as follows:

1.Wrap the object in a sheet, towel or some other type of absorbent material. This material will collect any condensation.
2.Place the wrapped object in a plastic bag, press the air out of the bag, and seal the bag tightly.
3.Place the bagged object directly into a freezer for at least two weeks. Self-defrosting freezers should be avoided because they are very dry, and don't maintain a steady temperature as they cycle.
4.When you remove the object from the freezer, leave it in the bag and wrap it in towels or blankets so that it will reach room temperature slowly over a period of several hours.

Do not freeze objects which are made up of layers of materials such as paintings, lacquerware, photographs, ivory. Freezing could cause disruption and damage to these layers. Objects which are made up of one material, such as wood, or paper, or wool are the best candidates for freezing.