

## Chapter 5: Biological Infestations

	<u>Page</u>
<b>A. Overview</b> .....	5:1
What information will I find in this chapter? .....	5:1
What is a museum pest? .....	5:1
What conditions support museum pest infestations? .....	5:2
<b>B. Responding to Infestations</b> .....	5:2
What should I do if I find live pests or signs of pests in or around museum collections? ..	5:2
What should I do after isolating the infested object? .....	5:3
What should I do after all infested objects have been removed from the collections area? .....	5:5
What treatments can I use to stop an infestation? .....	5:5
<b>C. Integrated Pest Management (IPM)</b> .....	5:8
What is IPM? .....	5:9
Why should I use IPM?.....	5:9
What are the statues and mandates for developing and implementing an IPM program? ..	5:9
What are the essential elements of an IPM program? .....	5:10
What types of damage can pesticides do to museum objects?.....	5:10
What is preventive pest management? .....	5:11
<b>D. Developing a Museum IPM Plan</b> .....	5:12
What is the purpose of a museum IPM plan? .....	5:12
What are the responsibilities of staff involved in developing and implementing the museum IPM plan? .....	5:12
What is included in a museum IPM plan? .....	5:13
What is an action plan? .....	5:14
What documentation should be included in the IPM plan? .....	5:15
How do I know if the IPM plan is effective? .....	5:15
<b>E. Inspection and Monitoring</b> .....	5:16
What is monitoring and what is inspection? .....	5:16
Why should I monitor for pests and the environment? .....	5:17
How do I monitor for pests? .....	5:17
What is included in a pest trapping program? .....	5:18
What kinds of traps should I use to monitor for pests? .....	5:18
Should I use pheromone traps and light traps? .....	5:19
How do I establish an insect sticky trap program? .....	5:20
How frequently should I inspect objects and structures for pests? .....	5:21
How do I inspect objects for pests? .....	5:21
How do I inspect structures for pests? .....	5:21
Where should I inspect for pests? .....	5:22
What evidence of pest damage should I look for during inspections?.....	5:22
What tools and equipment do I need for inspections? .....	5:22
When do I isolate and inspect objects? .....	5:23
What procedures should I use to isolate objects? .....	5:23
How long do I need to isolate the object? .....	5:24
How do I determine that I have a pest infestation and what are action and injury thresholds? .....	5:25

<b>F. Control Actions</b> .....	5:26
What control actions will exclude pests from areas housing collections? .....	5:26
What are cultural controls? .....	5:26
What are mechanical controls? .....	5:27
Exclusion .....	5:27
Sanitation.....	5:28
Eliminating Harborage.....	5:29
Eliminating Moisture .....	5:29
Eliminating Food .....	5:29
Habitat Modification.....	5:30
How do I establish a rodent snap trapping program? .....	5:30
How do I clean objects contaminated or potentially contaminated with hantavirus? .....	5:31
What are chemical controls? .....	5:31
<b>G. Identification of Museum Pests</b> .....	5:32
What are museum pests?.....	5:32
Where can I see images to help identify pests? .....	5:32
What are fabric pests?.....	5:33
What are wood pests?.....	5:36
What are stored product pests? .....	5:37
What are moisture pests?.....	5:38
What rodents should I be concerned about? .....	5:39
What other vertebrates can damage museum collections? .....	5:40
What are general pests (perimeter invaders)? .....	5:41
What kinds of health hazards can museum pests cause? .....	5:43
<b>H. Bibliography</b> .....	5:44
<b>I. List of Figures</b> .....	5:46
Figure 5.1 Recommended Freezer Temperatures and Duration of Freezing Cycles.....	5:6
Figure 5.2 Sample Museum IPM Plan .....	5:47
Figure 5.3 Sample Object Pest Incident Report (blank) .....	5:58
Figure 5.4 Sample Object Pest Incident Report (completed) .....	5:59
Figure 5.5 Sample Freezer Treatment Record (blank) .....	5:60
Figure 5.6 Sample Freezer Treatment Record (completed) .....	5:61
Figure 5.7 Sample Pest Trap and Evidence Monitoring Log (blank) .....	5:62
Figure 5.8 Sample Pest Trap and Evidence Monitoring Log (completed) .....	5:63
Figure 5.9 Sample Pest Monitoring Database Report (blank) .....	5:64
Figure 5.10 Sample Pest Monitoring Database Report (completed) .....	5:65
Figure 5.11 Sample Floor Plan with Trap Locations .....	5:66
Figure 5.12 Sample Pest Identification Request Letter (blank) .....	5:67
Figure 5.13 Sample Action Plan (blank) .....	5:68
Figure 5.14 Sample Action Plan: Dermestid Beetles .....	5:69
Figure 5.15 Sample Action Plan: Clothes Moths .....	5:71
Figure 5.16 Sample Action Plan: Powderpost Beetles .....	5:73
Figure 5.17 Sample Action Plan: Stored Product Pests .....	5:75
Figure 5.18 Sample Action Plan: Silverfish .....	5:77
Figure 5.19 Sample Action Plan: Springtails .....	5:79
Figure 5.20 Sample Action Plan: Psocids .....	5:81
Figure 5.21 Sample Action Plan: Molds and Fungi .....	5:83

Figure 5.22 Sample Action Plan: Mice and Rats .....	5:85
<b>J. Index</b>	<b>5:87</b>

# CHAPTER 5: BIOLOGICAL INFESTATIONS

## A. Overview

---

1. What information will I find in this chapter?

This chapter contains information on:

- how to respond to infestations
- how to set up an Integrated Pest Management (IPM) plan for museum collections that is an ecosystem approach to the control of museum pests, and how to evaluate its effectiveness
- how to monitor and inspect for museum pests
- what control actions will exclude museum pests
- how to identify pests that can damage museum collections

The chapter provides information on a range of IPM techniques and tools that prevent and solve pest problems. This includes inspection, monitoring, cultural and mechanical controls, as well as chemical controls if warranted.

The chapter includes a Recommended Freezer Temperatures and Duration of Freezing Cycles chart (Figure 5.1), Sample Museum IPM Plan (Figure 5.2), Sample Object Pest Incident Report (blank) (Figure 5.3), Sample Object Pest Incident Report (completed) (Figure 5.4), Sample Freezer Treatment Record (blank) (Figure 5.5), Sample Freezer Treatment Record (completed) (Figure 5.6), Sample Pest Trap and Evidence Monitoring Log (blank) (Figure 5.7), Sample Pest Trap and Evidence Monitoring Log (completed) (Figure 5.8), Sample Pest Monitoring Database Report (blank) (Figure 5.9), Sample Pest Monitoring Database Report (completed) (Figure 5.10), Sample Floor Plan with Trap Locations (Figure 5.11), Sample Pest Identification Request Letter (blank) (Figure 5.12), and sample action plans for common museum pests (Figures 5.13 - 5.22).

**Note:** Consult with a historic architect to determine the appropriate procedures and materials to use in historic structures.

2. What is a museum pest?

National Park Service (NPS) [Management Policies](#) (2006) section 4.4.5.1 defines a pest as “an organism that interferes with the management objective of the site.” For museums, a pest is defined as any organism that jeopardizes museum resources. For example, if mice or evidence of their activity is found in the collections storage area, they are considered pests. However, if they occur in a meadow, they are part of the habitat and are not considered a museum pest. Other kinds of pests may enter structures containing collections but are not considered museum pests if they do not eat or otherwise damage collections materials. These ‘perimeter invaders’ can indicate other problems, such as insufficient housekeeping or exclusion. See Section G, Identification of Museum Pests, for detailed information on museum pests and how to recognize them and their evidence and traces, such as webbing, rodent smudge marks, and chewing or gnawing.

### 3. What conditions support museum pest infestations?

Museum pest infestations are supported by a variety of poor conditions:

- Specific environmental conditions, including high temperature and relative humidity (RH), which can attract and support moisture pests such as silverfish and mold. Heated buildings attract rodents in the fall as they seek a warm habitat.
- The nature, composition, design and condition of the structure determines how effective a buffer it provides the collections from the exterior environment and the entry of museum pests.
- Poor sanitation and housekeeping in all spaces and structures housing collections provide food, water, and harborage to pests.
- Absence of effective museum policies, practices and standard operating procedures, such as those that restrict food, drink and live plants from areas and structures housing collections.
- Improper storage furniture, such as poorly sealed cabinets and storage furniture that is not raised four to six inches off the floor.

## B. Responding to Infestations

---

### 1. What should I do if I find live pests or evidence of pests in or around museum collections?

Follow these steps if you encounter a live infestation or observe evidence of pests or their activity in or around museum collections.

- **Document what, where and when you see signs of pest activity immediately.** Don't panic. If you rush to kill the pests you may cause more harm to the object (and to yourself) than if you observe it and document its habitat. Before disturbing the evidence, make careful observations of the site, symptoms, and extent of damage to determine if there is an active infestation. Be thoughtful about each step you take. Do thorough written and photographic documentation before safely removing pests and evidence of pests. Consult with your park IPM manager for additional guidance.
- **Isolate infested and potentially infested objects immediately.** Wearing disposable gloves, place infested object in a well-sealed plastic bag. **Do not** carry unbagged infested objects through the collection as eggs, larvae, adult insects, or mold spores can be accidentally dropped and the infestation spread. If an object with suspected mold is damp, isolate it in a lidded cardboard box instead of a sealed plastic bag. Move the infested object to an isolation room outside of the collections area. Determine how long to isolate the infested object. See Section E.16 for information on determining isolation periods.

See Sections F.4 and F.5 and [COG 2/8: "Hantavirus Disease Health and Safety Update"](#), for information on handling mice and rat infestations, [COG 3/4: "Mold: Prevention of Growth in Museum Collections"](#) for information on handling objects infested with mold,

and [Chapter 11, Curatorial Health and Safety](#).

- **Determine the extent of the infestation.** Start at the location where the first infested object was found and inspect the collections/areas in ever widening circles. Immediately isolate additional infested objects as they are found and document the findings.
- **Identify the pests and evidence of pests.** Bag the pest for identification by an expert as necessary. Determine what the pest is through its feeding habits and traces, life stages such as larvae or pupae, shed skins, frass (insect waste, which may be a soft powdery material, granular pellets or stains, depending on the specific pest), fecal remains, urine, grease marks and other indicators. Consult an entomologist or biologist if needed. Identify the suspect pest to be sure that it is a museum pest that will cause damage to museum objects. See Section G for information on identification of pests. Review the pest's biology and inspect all objects the pest is attracted to as a food source or habitat in the area of the infestation. See [COG 3/11: "Identifying Museum Insect Pest Damage,"](#) for additional information.
- **Clean the area surrounding the removed infested object:**
  - Gather and remove all pest remains or traces from the collections area.
  - Retain the pest and all traces as reference material for confirmation from an expert. Store in vials or secure containers and label. This information will serve future staff as a reference. **Do not retain rodents or any traces of rodent infestations.** Properly dispose of traces of rodents following procedures in [COG 2/8](#).
  - Clean the cabinet or shelf with a high-efficiency particulate air (HEPA) vacuum and then a disinfectant, following normal cleaning procedures. HEPA filtration is essential to avoid re-distribution of eggs and frass into the air.
  - Use a HEPA vacuum to clean the floor.
  - **Do not follow these procedures if there is a mouse or rat infestation as they may present a human health risk.** See Section F.5 and [COG 2/8](#) for more information on how to clean the area following a rodent infestation.

2. What should I do after isolating the infested object?

Follow the steps below and select the appropriate method or tool to address the infestation in the object:

- **Answer the following questions to determine how to proceed:**
  - Can the pest and pest traces be simply removed?
  - Are eggs, larvae, immature, pupae, or other life stages present?
  - What is the least damaging approach to treating the infested object?
- **Determine what actions to take,** including cleaning, isolation or other

actions. Determine the life cycle of the pest in consultation with an entomologist or biologist, the park IPM manager and a conservator and monitor the object until you are sure that no more pests are present.

- **Gather and document the following information before consulting with a conservator:**
  - Description of infestation.
  - Type of pest (if unknown obtain expert identification).
  - List of objects and material types involved (ex: wagon with wood, metal, fabric, and rubber).
  - Description of damage such as droppings on surface, loss of material, staining.
  - Description of objects' proximity to infestation (direct or indirect) and location of infestation.
  - Clean-up efforts since discovery of infestation.
  - Description of the area or structure housing the collection, and its environmental conditions such as temperature and RH, and environmental controls such as an HVAC system or portable dehumidifier.
  - List of available supplies such as HEPA vacuum, plastic bags, sheeting, and freezer.
  - Date, time of year and weather conditions when the infestation occurred.
- **Determine the cleaning method for the isolated object** in consultation with a conservator and the regional curator and then **clean the object**. Remove all traces of the pest from the object. Dead pests, larval skins, pupal cases, fecal matter, and nests can attract other pests. If an infestation is limited to a single object and has not progressed too far, careful HEPA vacuuming with HEPA filters may remove the problem.

Before cleaning, ensure the structure of the object can withstand the stress of vacuuming. Use screening material on the HEPA tube when vacuuming museum objects. Cleaning will probably not remove all eggs as some can be microscopic. Review the pest's biology and focus efforts on areas where eggs are likely to be deposited. Dispose of collected pests and waste in a sealed container and remove them and the vacuum bag from the structure immediately so they don't become a source of new infestations.

**Exception:** *Do not vacuum when addressing a mouse or rat infestation, as this increases the risk of transmission of hantavirus. Do not attempt to clean or handle the object until after the isolation period as specified in COG 2/8.*

- **Determine object treatment options** in consultation with a conservator and the regional curator. Determine if treatment is necessary. If so, after considering all options, **treat the object using the least damaging approach possible**. Treatment options, including freezer and anoxic treatments, are described in Section B.4. Some objects may not need any treatment.
- **Determine how long to isolate the object before returning to storage or exhibit** after treatment. The isolation period is determined by the life cycle of the specific pest and can vary from two weeks to several months, so it is critical to identify the pest. Determine the pest's life cycle and monitor the object until you are sure no more pests or any pest life stages, including eggs, larvae and pupae, are present. See Section E.16 for information on recommended isolation periods and Section E.15 for guidance on isolation procedures. Consult the park IPM manager and the regional curator or conservator, and if necessary, an entomologist.
- **Document the treatment.** Record damage to the object, the period of isolation, and any treatments used. Complete a Pest Incident Report, for any infested object. See Figure 5.3, Sample Pest Incident Report (blank). See Section D.5 for additional information on documentation.

3. What should I do after all infested objects have been removed from the collections area?

After all infested objects have been removed from the collections area and isolated; determine how the pests entered and how to prevent reentry in the future.

- **Determine the source of the infestation.** Inspect the area of the infestation to determine how the pests entered and what conditions supported them. If the problem is determined to be gaps in the building envelope, collaborate with facilities management staff to have appropriate repairs made or exclusions installed. If infested objects were brought into the collection, evaluate and modify the policies and procedures as appropriate that allowed this to happen. See Section F.3 for more information on excluding pests from areas that house museum collections.
- **Increase inspection and monitoring** of the area to confirm that you have eliminated the infestation. Increase the number of insect sticky traps or rodent snap traps to determine if pests are still present. For additional information, see Section E.
- **Review the current museum IPM plan** to ensure it is effective. Create a plan, if you do not have one in place, to detect, monitor, and prevent the problem from recurring. See Figure 5.2, Sample Museum IPM Plan, for further information.
- **Modify the museum IPM plan** as necessary.

4. What treatments can I use to stop an infestation?

Consult with the regional curator and a conservator to determine which of the following treatments are appropriate for the contaminated or infested object.

- **Freezer treatment, also called low temperature treatment:**

Freezing is the method of choice for treating most active insect infestations of objects. Use a freezer that reaches at least -4° F (-20° C) or colder. Consult the regional curator or a conservator for assistance in selecting a freezer. Determine how long to freeze the object, based on the freezer temperature, object size, material and packaging.

See recommended freezer temperatures and associated freezing cycles below.

Freezer Temperature	Minimum Period at Target Freezer Temperature	Calculate Additional Time in Freezer	Conditions Essential to a Successful Freezer Treatment	Total Time in Freezer
-4° F (-20° C)	1 week	<p><b>X hours</b> for the center of object to reach freezer temperature. Not to exceed 6 hours.</p> <p>Determine using thermocouple or indoor-outdoor thermometer.</p> <p><b>Y hours</b> for dense or well insulated objects to reach freezer temperature (may take additional time)</p>	-Object is properly bagged and sealed	<b>1 week + X + Y = Total Freezer Time</b>
-22° F (-30° C)	72 hours		-Object is placed in the freezer <i>after</i> the target temperature has been reached	<b>72 hours + X + Y = Total Freezer Time</b>
-40° F (-40° C)	48 hours		-Center of object reaches target temperature under 6 hours	<p>-Object remains in freezer for sufficient time to kill pests</p> <p>-Freezer reaches and maintains target temperature</p> <p>-There is proper air circulation in freezer</p>

**Figure 5.1: Recommended Freezer Temperatures and Duration of Freezing Cycles**

The object must **rapidly** reach the freezer temperature **within six hours**, and stay at that temperature for the amount of time needed to kill insects at all life stages, such as larvae and pupae. **The time needed is dependent on the type of material being frozen and its packaging.** For example, a large package of pressed herbaria specimens will take longer to reach the freezer temperature than a single herbarium sheet.

***It is essential to follow the procedures exactly to ensure success and to avoid creating cold-hardy insects.***

Procedures:

- Wrap the object in acid-free tissue paper and seal in a polyethylene bag before placing in the freezer *that has already reached the target temperature*. Place flexible or delicate objects on a handling board or in a box.
- Use a remote reading thermocouple or indoor-outdoor thermometer to determine if the object has reached the correct temperature.
- After the total time allotted, remove the object from the freezer and leave in the packaging for a minimum of 24 hours, until it has reached room temperature.
- Isolate the object for a minimum of one month following treatment.
- Regularly inspect the object to determine that no insects are present. If you discover additional insects during this period, it means the procedures have not been followed exactly. Determine why the initial freezing treatment failed. Consult a conservator, IPM coordinator and/or an entomologist to correct the problem and find an appropriate treatment method to eliminate the pests.

See [COG 3/6: “An Insect Pest Control Procedure: The Freezing Process.”](#)

- Document the treatment with a Freezer Treatment Record, to be kept with the object’s accession record and IPM records. See Figure 5.5, Sample Freezer Treatment Record (blank), and Figure 5.6, Sample Freezer Treatment Record (completed).

For large objects, use a walk in freezer or a freezer truck. If these are not available, contact a conservator to discuss other treatment options.

*Caution:* Be aware that certain materials such as wax, inlaid wooden objects, and canvas paintings can be significantly damaged by freezing. Contact the regional curator and a conservator to discuss the safety of freezing.

- **Anoxic treatment:** Replacing the air with a gas (nitrogen, argon, carbon dioxide) or using an oxygen scavenger/absorber in a closed space can kill insects and their eggs. Museums and professional pest control companies use a variety of techniques that require special equipment and experience. For more information on anoxic environments and their use in pest control see [COG 3/9: “Anoxic](#)

Microenvironments: A Treatment for Pest Control.”

*Caution:* Control temperature and RH during anoxic treatments to avoid damaging objects.

- **Pesticide application:** Pesticides have generally been phased out for museum collections. However, if a pesticide is proposed for use, it requires park and regional IPM approval through the Pesticide Use Proposal System (PUPS) before application. Consult with the park and regional IPM coordinators, regional curator and a conservator to be sure that the pesticide will not harm objects. See Section F.6, *COG 2/16: “Chronology of Pesticides Used on National Park Service Collections”*, and *MH-I*, Chapter 11, Section D, Hazardous Chemical and Materials Used in Collections Care, for more information.

*Caution:* Pesticides can damage and contaminate museum objects and can affect the DNA of specimens.

- **Conventional chemical fumigation:** All chemical fumigants are classified by the Environmental Protection Agency (EPA) as restricted use pesticides. Any pesticide (general or restricted use) proposed for use on NPS lands or properties requires park and regional IPM approval through PUPS before application. Chemical pesticide fumigation is now rarely used in museums. Only subject museum objects to chemical pesticide fumigation if all other treatments cannot be used. Consult with the regional curator, regional IPM Coordinator, and a conservator before considering fumigation of museum objects.

*Caution:* Fumigants are chemical pesticides which may damage and/or contaminate museum objects.

On rare occasions, it may be appropriate to fumigate a *museum space* to ensure pests are removed. Most chemical fumigation requires a licensed pesticide applicator, specialized equipment and proper skills. Vikane (sulfuryl fluoride) is one product used for fumigating structures; however, it has no residual effects and does not prevent future infestations. (A recent study indicates that it affects protein DNA.) Many other fumigants that were used in museum spaces in the past are now prohibited.

- **Heat Treatment:** Heat treatment is not widely used for museum collections as it has the potential to damage objects. Heat fumigation can be used to kill all stages of pests in structures. However, contents should be removed as heat can damage objects.

## C. Integrated Pest Management (IPM)

### 1. What is IPM?

---

NPS *Management Policies* (2006) Section 4.4.5.2 defines IPM as “a decision-making process that coordinates knowledge of pest biology, the environment, and available technology to prevent unacceptable levels of

pest damage by cost-effective means while posing the least possible risk to people, resources, and the environment.”

IPM uses various techniques to prevent and solve pest problems using knowledge of a pest’s habits, ecology and the environment in which it thrives and survives. These include preventive maintenance, adherence to an established housekeeping plan, rigorous exclusion, sanitation, and a pest trapping program.

IPM is site specific, adaptable to any museum setting, and protects the museum and its collections from museum pests with minimal pesticide use.

2. Why should I use IPM?

IPM provides an effective and sustainable strategy with which to make informed and responsible decisions about protecting collections from museum pests. It focuses on preventing infestations rather than treating them. It uses monitoring and pest identification to determine the most appropriate, effective, low-risk treatment methods. Although pesticides can in some cases be the most appropriate treatment, IPM discourages reliance on chemical treatments and provides safer alternatives.

3. What are the statutes and mandates for developing and implementing an IPM program?

NPS policy establishes IPM as the preferred method for managing pests in park units, directed by presidential memorandum, laws, and DOI and NPS directives and policies as noted below.

Title 7 USC 136r-1 Federal Insecticide Fungicide and Rodenticide Act SEC. 303 Integrated Pest Management states “Federal agencies shall use Integrated Pest Management techniques in carrying out pest management activities and shall promote Integrated Pest Management through procurement and regulatory policies, and other activities.”

President Carter’s August 2, 1979 Integrated Pest Management Memorandum from the President requires all federal agencies to use IPM technology for pest control and to reduce use of toxic pesticides.

Department of the Interior Departmental Manual (DM) and directives mandate the use of IPM strategies and plans, including [517 DM 1 Pesticides: Integrated Pest Management Policy](#) and [411 DM 1 Chapter 15, Section 3 Integrated Pest Management](#).

[Director’s Order \(DO\) #24](#) 4.3.9, Integrated Pest Management requires that staff “approve, keep current, and implement an Integrated Pest Management Plan that addresses the museum collections.”

NPS *Management Policies* (2006) Section 4.4.5.2 Integrated Pest Management Program states “The Service conducts an integrated pest management (IPM) program to reduce risks to the public, park resources, and the environment from pests and pest-related management strategies” and that “The Service and each park unit will use an IPM approach to address pest issues.”

NPS-77, *Natural Resources Management Guidelines* (1991) states that IPM is used to determine when and how infestations are treated, with an emphasis on decreasing pesticide use. It “integrates compatible techniques to maintain pest damage below an unacceptable injury level while providing protection from threats to public health and safety.” Additional

guidelines relating to the IPM program appear in other chapters of NPS-77.

Proposed pest management activities must be conducted in accordance with Director's Order #77-7: Integrated Pest Management.

4. What are the essential elements of an IPM program?

An effective IPM program includes the components listed below. Each component of the IPM program is on-going and the whole process is cyclical in nature. To carry out an effective IPM program you should:

- Gather information about your collections and object materials, the types of pests attracted to these materials, the interior and exterior environmental conditions, and the condition of the building envelope.
- Identify pests that can cause damage to your collections and identify vulnerable collections such as organic materials.
- Review NPS policy to understand how IPM works and your responsibilities when using chemical treatments.
- Establish priorities to focus on tasks systematically. For example, monitor all areas housing collections but concentrate monitoring in areas that house materials that are highly susceptible to museum pests, such as botany specimens and wool clothing.
- Establish action thresholds. Determine how many museum pests in a collection are too many.
- Monitor objects and environmental conditions, and monitor for pests.
- Implement an ecosystem approach to managing and controlling museum pests. Modify pest habitats, use good housekeeping, install exclusions and use non-chemical treatments such as freezer and anoxic treatments.
- Document monitoring and treatments.
- Build consensus by working with other staff in the park. IPM requires coordinated strategies to be effective.
- Evaluate results to be sure your strategies are working. Modify the IPM plan as necessary.

For additional information, see the "[11 Step Process to Developing and Implementing an Integrated Pest Management Strategy](#)" developed by the NPS Biological Resource Management Division's (BRMD) Integrated Pest Management Program. See Section D for information on how to develop a museum IPM plan and Figure 5.2 for a Sample Museum IPM Plan.

5. What types of damage can pesticides do to museum objects?

Pesticides are those chemicals with an EPA registration number used to control pests of any kind. Request pesticides through PUPS after consulting with the park IPM coordinator.

Exposure to certain pesticides can cause the following damage to collections:

- Metal corrosion, including iron, brass, and other light color metals.
- Deterioration of proteins, such as fur, feathers, leather, wool, horsehair.
- Deterioration of paper.
- Shrinking, stiffening, or softening of plastics.
- Color change in dyes and pigments.
- Staining from surface and vapor contact.
- Contamination of objects and specimens that may affect analysis and research, such as DNA sampling.

In the past, museums routinely used pesticides in collections. Many of these materials have left residues on museum objects that may be hazardous to staff and researchers. Pesticides can negatively affect collections for research, for example, pesticides can affect specimen DNA. Search collection documentation for records of previous pesticide use. Be aware, however, that users often did not record pesticide use. Be sure to take precautions when handling the objects. Refer to the *Conserve O Grams* listed below for information on the health and safety risks associated with some pesticide residues found on museum objects.

Pesticides, fungicides and pest repellents listed below were formerly widely used in museum collections. However, some pesticides contain the following active ingredients that are now banned by EPA. None listed below are recommended for use:

- Arsenic (see [COG 2/3: "Arsenic Health and Safety Update"](#))
- Mercuric chloride
- Thymol
- Dichlorodiphenyltrichloroethane (DDT)
- Ethylene oxide (see [COG 2/2: "Ethylene Oxide Health and Safety Update"](#))
- Dichlorvos (Vapona, DDVP) (see [COG 2/4: "Dichlorvos \(Vapona\) Update"](#))
- Naphthalene (moth balls)
- Paradichlorobenzene (PDB) (moth balls)

6. What is preventive pest management?

Preventive pest management refers to actions that are taken to prevent museum pest infestations and conditions conducive to pests. **Inspecting** and **monitoring** for pests and **effective museum housekeeping** are crucial to preventing infestations, environmental monitoring, as well as evaluation of IPM practices and thorough documentation.

Appropriate facility design and construction practices also prevent museum pest infestations. See the San Francisco Department of the Environment's [Pest Prevention by Design: Authoritative Guidelines for Designing Pests](#)

[Out of Structures](#) for more information. See Section F, Control Actions for additional information on preventing pest infestations.

## D. Developing a Museum IPM Plan

---

1. What is the purpose of a museum IPM plan?

The purpose of a museum IPM plan is to provide pest management guidelines to help preserve the park's collections, and to protect the health and safety of staff and visitors. The museum IPM plan:

- Provides a framework with which to make responsible decisions for excluding, monitoring, identifying, and treating pests.
- Identifies the most appropriate and cost effective management solution for the specific pest situation.
- Is used in structures that house collections.
- Is an integral part of the park IPM plan. The curator should work with the park IPM coordinator and the facilities manager to incorporate the museum IPM plan into the park IPM plan.

**Note:** IPM and museum housekeeping are closely connected and should be done in concert.

2. What are the responsibilities of staff involved in developing and implementing the museum IPM plan?

The development and implementation of an effective museum IPM plan involves the individuals noted below.

- **Superintendent** has ultimate responsibility for the park IPM plan and provides sufficient staffing, training, and funding to effectively carry out a pro-active museum IPM plan.
- **Curatorial staff** is responsible for the care of the collections, monitoring for pests in all spaces containing collections, and implementing the museum IPM plan.
- **Park IPM coordinator** establishes pest management priorities for the park, approves or denies proposed pesticide use, assists the museum curator with prevention, detection, and management of pest problems, periodically reviews museum pest monitoring reports, educates staff to detect evidence of pest infestations, and as necessary, consults with the park natural resources and safety staff.
- **Regional IPM coordinator** is responsible for alerting park IPM coordinators of new pest issues and technology, approves or denies proposed pesticide applications on a case-by case basis and serves as the liaison between the park and the service-wide IPM coordinator in providing IPM training and information to develop management strategies.
- **Maintenance staff** is trained in recognizing evidence of pests and contacts the Park IPM Coordinator and curatorial staff if evidence of museum pests is detected. Schedules routine maintenance of, and upgrades to structures housing collections, in consultation with park

curatorial staff.

- **Park safety officer** is consulted on public health issues and any proposed pesticide use. The park safety officer is aware of what pesticides are being proposed for use in the museum and who is using them and ensures that they are used safely.

All staff working in and around museum collections are responsible for implementing IPM practices. This includes:

- eating *only* in designated food areas; there is no eating in collections or work areas such as at desks
- not allowing live flowers or plants in all areas housing collections
- daily pick up of trash in designated food areas to avoid attracting pests

For roles and responsibilities regarding pesticide use see the annual *Policies and Procedures for Submitting 2013 Use Logs and 2014 Proposals for Pesticides, Biological Control Agents, and Genetically Modified Organisms* memo.

3. What is included in a museum IPM plan?

Include the following sections when creating a museum IPM plan:

- **Signature page:** includes signatures of management to approve and key park managers to concur that staff take timely and appropriate actions to conduct the museum IPM program.
- **Introduction and objectives:** describes the IPM plan and its objectives.
- **Statutes and mandates:** lists the legal requirements and NPS IPM policies mandated for all parks.
- **Background and site description:** briefly discusses past pest management methods and describes each area/structure containing museum collections in the park.
- **Staffing responsibilities:** lists individuals by job title and what they are responsible for in relation to IPM.
- **Preventive pest management:** discusses measures to prevent pests and eliminate conditions conducive to pests, through-inspection and monitoring (including routine inspection of area(s)/structure(s)/ housing collections, routine inspection of individual objects in storage and on exhibit, routine inspection and isolation of incoming objects, and pest trapping program), documentation, environmental monitoring and museum housekeeping.
- **Pest identification and action thresholds:** provides information on how to identify pests and defines the action thresholds or the point at which no additional pests can be tolerated.

- **Control actions:** describes various mechanical and cultural controls, including exclusion, elimination of food, moisture and harborage, and habitat modification.
- **Actions if pests are found:** lists the steps to follow when responding to an active infestation and the types of treatments available to stop an infestation, including isolation, cleaning, exclusion, sanitation, freezer treatment, anoxic treatment, and pesticide application.
- **Evaluating the IPM plan:** discusses ongoing monitoring and evaluation and how to determine if the plan is successful, such as comparison of data over time to see if pest levels have decreased, and states the plan should be modified if pest control actions have not been successful.
- **Action plans:** create an action plan for each relevant pest in the appendix. See Section D.4 for more information.

For information on how to develop an IPM plan, see Figure 5.2, Sample Museum IPM Plan. Adapt this sample Museum IPM Plan by adding specific information about your park, collections, history of pest problems, and past and current pest management methods.

#### 4. What is an action plan?

An **action plan** describes a pest, what to do when you find one, and how to eliminate conditions conducive to pests to prevent a pest situation. Action plans give detailed information about specific types of pests and are included as appendices to the museum IPM plan. Create one for each type of pest that is likely to occur at your site. Include the following information in each action plan:

- **Pest description/biology:** description, biology, and habits of each species of the pest (if there are multiple).
- **Damage:** typical damage caused by the pest, including types of material they are attracted to and what signs of damage to look for.
- **Monitoring and inspection:** the most effective type of monitoring for the pest, including specific directions for inspections and what kinds of traps to use.
- **Action thresholds:** The action threshold or the point at which action must be taken. For example, the action threshold for dermestid beetles is finding one insect or any traces of the insect that indicate an active infestation.
- **Control actions:** including non-chemical and chemical controls that can be used to eliminate, remove, and prevent the pest. Divide these actions into “prevention” and “management” categories.
- **Pest activity on-site:** known history of the pest at the site, including the date and location of past infestations; control actions used and if they were effective.

Customize the action plan to fit the needs of your collection and site. Add

information to the action plan as you acquire it. See Figure 5.13 for a blank sample action plan, and Figures 5.14-5.22 for sample action plans for dermestid beetles, clothes moths, powderpost beetles, stored product pests, silverfish, springtails, psocids, molds, and mice and rats.

5. What documentation should be included in the IPM plan?

Ongoing documentation is a vital part of IPM. Documentation includes recording the date and location of the catches, the number, locations and type of the traps, the types and quantity of pests, the evidence of pest infestations, and the external climate conditions. Use Figure 5.3, Pest Incident Report (blank), and Figure 5.7, Pest Trap and Evidence Monitoring Log (blank), to document the monitoring. Store monitoring data in a pest monitoring database or paper log and retain for ongoing reference. See Figure 5.10, Sample Pest Monitoring Database Report (completed) and Figure 5.8, Sample Pest Trap and Evidence Monitoring Log (completed).

Document all object infestations and area infestations. See Section B.2 for information that should be gathered and documented for each infestation. Complete a Sample Pest Incident Report (blank), Figure 5.3 for every infested object. Record all evidence of pests found in inspections that may indicate an infestation, such as webbing or frass, in a Sample Pest Trap and Evidence Monitoring Log, Figure 5.7. Take photographs where appropriate.

Map results of inspection and monitoring as well as infestations using a copy of the floor plan labeled with the monitoring results. Indicate where pests have been found on the floor plan to the case/shelving unit level to help determine problem areas and how to target IPM efforts effectively. See Section E.7 for more information using floor plans for pest trapping and Figure 5.11, Sample Floor Plan with Trap Locations, for a sample floor plan.

Other documentation includes environmental monitoring data and object treatment records. Use environmental monitoring forms in [Chapter 4, Museum Collections Environment](#), to document environmental monitoring. Object treatment records include cleaning, freezer treatments, and anoxic treatments. Record the treatment for each object in the Interior Collections Management System (ICMS) Preservation supplemental record.

File the object treatment information in the appropriate accession file or catalog folder, as outlined in the *MH-II*, Chapters 2, Accessioning and 3, [Cataloging](#). Retain all IPM information such as the Trap Monitoring Logs, floor plans with trap locations, floor plans with infestation locations, PUPS forms, environmental monitoring reports, copies of object treatment records, control actions and photographs in an IPM binder. Include the brand and chemical names of insecticides and fumigants, as appropriate.

6. How do I know if the IPM plan is effective?

Ongoing monitoring provides data to determine the plan's effectiveness. Regularly evaluate the documentation to determine if the plan is effective through the comparison of year-to-year and month-to-month inspection, monitoring, and trapping records. Determine whether your pest control program procedures are successful by evaluating results of inspection and monitoring; that is, the absence of museum pests in traps, incoming objects, as well as objects in storage and on exhibit.

Review the environmental monitoring data to see if the control actions have

successfully changed the environment. If high RH was a problem, continually take RH readings to see if your actions, such as using a portable dehumidifier, have solved the problem.

Evaluate your implemented control actions on an ongoing basis to determine if they have been effective. For example, review your exclusion activities and determine if the structure is adequately sealed by determining if pests are still entering the structure. If so, reevaluate and improve your exclusion methods to ensure that no pests will enter the structure. Determine if you have met the objectives stated in the IPM plan.

If your IPM plan is effective, you should have satisfactory answers to the following questions:

- Is the structure/building envelope properly sealed?
- Are containers housing collections properly sealed, such as with effective cabinet gaskets, to exclude pests?
- Are there fewer pests in the traps?
- Are there no longer signs of pests in areas and containers housing collections?
- Is the infestation gone?
- Do you effectively work with park staff to accomplish the plan?

If your IPM plan is working well, your time will be spent on prevention and maintenance and not on dealing with live pests and infestations.

## E. Inspection and Monitoring

---

1. What is monitoring and what is inspection?

Although the terms inspection and monitoring are often used interchangeably, they refer to two different activities.

**Monitoring** is systematically and continuously keeping track of all pest activity in collections areas, through routinely inspecting spaces and objects, establishing a pest trapping program to detect pest activity and thoroughly documenting all infestations.

**Inspection** is closely examining spaces and objects for any evidence of an infestation and is a critical part of pest monitoring programs.

2. Why should I monitor for pests and the environment?

**Monitoring**

Monitoring for pests and monitoring the environment is essential to your museum IPM program and provides the following information:

<b>Pest monitoring tells you . . .</b>	<b>Environmental monitoring tells you . . .</b>
Baseline information on the pests in the collection	Baseline information on the museum environment
How pests got into the museum	If exterior weather conditions are driving pests indoors
Where pests are in the museum	If conditions in the areas housing the collections will support or attract pest activity, such as high RH
How many pests are in the museum	If temperature and RH are stable and appropriate
If control actions are working, such as improving exclusion	If control actions are changing the environment, such as adding a humidifier

By monitoring for pests and the museum environment, you can develop strategies to eliminate future access and survival of pests in the collection and evaluate the effectiveness of your IPM plan. Environmental conditions are also extremely important in understanding pest life cycles and habitat requirements. For information on environmental monitoring, refer to Chapter 4, Museum Collections Environment.

3. How do I monitor for pests?

When developing a monitoring strategy, identify materials in the collections and what pests are attracted to those materials as food sources. Determine what areas in the space and structure are most vulnerable to pests and where they are likely to survive. Recognize what environmental conditions support pests. For example, will there be mostly protein eaters because the collection includes many woolen textiles? Are collections housed in a poorly sealed and damp historic structure?

Consider what kind of pests will be attracted to your collections and will be supported in the environment in your building. Know the composition of the collections and be familiar with the life cycles of common pests. This information will allow you to anticipate what pests may present a risk. For example, wool rugs and feathered headdresses that are made of protein can serve as food for dermestid beetles. Understanding the dermestid beetle life cycle will tell you that larvae feed on protein and adults do not feed on objects but seek daylight as they feed on live plants. Place traps on window ledges to detect activity and conduct a thorough inspection of all items made of protein. Work with the park and regional IPM coordinator to develop a strategy to identify likely museum pests and develop a monitoring strategy to determine whether these pests are present.

Monitoring relies on a variety of techniques.

- **Routine inspection of structure(s)/area(s) housing collections.** Routinely inspect the spaces housing collections to look for signs of pests, at least once every six months. Check windowsills and door jambs especially carefully.

- **Routine inspection of objects in storage and on exhibit.** Inspect objects for the signs of pest damage listed below in Section E.12. Do spot checks at least every six months; check more vulnerable objects such as biological specimens and ethnographic objects every three months. House objects in storage on white surfaces so frass and other evidence of pests are readily visible. Storage cabinets should be raised four to six inches off the floor to aid in cleaning. Check cabinets housing collections closely. Lift and examine objects closely and establish baseline inspection data. Map the locations of discovered infestations. Complete a Sample Pest Incident Report (blank), Figure 5.3, for every infested object. See Figure 5.4, Sample Pest Incident Report (completed), for an example.
- **Pest trapping program.** Identify pests moving into and throughout the areas housing collections and the building. Use traps to “zero in” on problem areas where pests may be entering and where collections have been infested previously.
- **Documentation.** Document the inspection and trapping program to provide a baseline and record of problems that can be evaluated over time. Include photographs where possible. See Section D.5 for more information on documentation.

Complete monitoring tasks on a regular schedule as noted below.

<b>Daily</b>	- Inspect rodent snap traps - Monitor and empty light traps
<b>Weekly</b>	Inspect insect sticky traps
<b>Monthly</b>	Replace insect sticky traps
<b>Every 3 months</b>	Check vulnerable objects like biological specimens and ethnographic objects, particularly in spring and fall
<b>Every 6 months</b>	- Inspection of structure/areas housing collections - Spot check objects in storage and on exhibit

These tasks can be incorporated into the park museum housekeeping plan.

4. What is included in a pest trapping program?

A pest trapping program includes strategic trap placement, consistent monitoring, ongoing documentation and evaluation of the results to determine the effectiveness of the program. Pest trapping includes:

- **Insect sticky traps**, used for monitoring and trapping insects. See Section E.7 for more information.
- **Rodent snap traps**, baited with peanut butter or cotton tied to the trap’s trigger, used to monitor for mice and rats. See Section F.4 for information.

5. What kinds of traps should I use to monitor for pests?

There are four types of pest traps. Use them in combination. Decide which kind of trap is most appropriate for a particular place and for the problem.

- **Insect sticky traps** collect insects on an adhesive base. They are used to monitor for pests. Also known as blunder traps, they are available in a box or tent shape, with the tent shape recommended for general use.

Replace them regularly, at least monthly, when they become populated and dirty, or when the adhesive loses its tackiness, whichever comes first. See *COG 3/7: "Monitoring Insect Pests with Sticky Traps"*, and *NPS Tools of the Trade* for additional information.

- **Rodent snap traps** trap and kill rodents, such as mice and rats. They can be baited with peanut butter to attract rodents. **Note:** peanut butter can attract insects. Use cotton or string tied to the trigger bar of the trap to attract mice and rats in search of nesting materials. Live traps and electronic mouse traps are not recommended for use. See Section F.4 for more information.
- **Pheromone traps** are insect sticky traps that include a pheromone attractant specific to one species of insect. Therefore, you must identify the insect before purchasing pheromone traps. They are available for webbing clothes moths, case-making clothes moths, drug store beetles, cigarette beetles, warehouse beetles, varied carpet beetles, black carpet beetles, and the German cockroach. Others are being developed. Pheromone traps have a relatively short life span; the lures must be replaced regularly. See *COG 3/7* for additional information.

*Caution:* Use pheromone traps *only* if you suspect the target pest is present. **Do not use for routine, ongoing monitoring.** Always follow instructions on pheromone trap packaging to prevent attracting additional pests into collections areas. Use these traps *only* in well-sealed rooms. Keep them at least 15 feet from any door that opens to the outside.

**If used incorrectly, there are potential risks to using pheromone traps.** Do not use pheromone traps in areas such as loading docks or cafeterias adjacent to collections storage areas. Never place pheromone traps in direct contact with objects, storage containers or display mounts. See [museumpests.net](http://museumpests.net) for more information.

- **Light traps** are useful for detecting and controlling certain flying insects that are attracted to light. Light traps emit ultraviolet light (black light) that attracts flying insects, particularly flies, beetles, and moths that are trapped on a sticky board or in a bag. Be aware that windows also act as passive light traps, so closely monitor windowsills.

*Caution:* Use light traps *only* if you suspect you have an infestation. **Do not use for routine, ongoing monitoring.** Place light traps carefully to prevent attracting more pests. Monitor and empty light traps daily to ensure that any trapped insects do not attract more pests.

**If used incorrectly, there are potential risks to using light traps.** Do not place light traps in rooms with windows or gaps under doors, as they are likely to attract pests into the room. Do not use light traps outdoors. Do not use these traps where the UV light will fall on light-sensitive collection objects.

6. Should I use pheromone traps and light traps?

**Do not use pheromone traps and light traps routinely as there is a risk that they may attract pests into collections areas.** Only use these traps on a case by case basis in consultation with a conservator and the regional curator. These types of traps are only appropriate in certain circumstances,

such as to monitor for flying insects.

7. How do I establish an insect sticky trap program?

The insect sticky trap program consists of the steps noted below.

- **Step 1. Draw a floor plan of the area to be monitored.** Indicate the locations of all doors, windows, water and heat sources, drains, and HVAC vents. Include furnishings such as museum exhibit and storage cabinets and cases. Note the types of materials housed in all enclosures and the spaces housing collections. For an example, see Figure 5.11, Sample Floor Plan with Trap Locations.
- **Step 2. Number and date the tops of the traps** for quick identification.
- **Step 3. Place insect sticky traps throughout the area to be monitored.** Where possible place the trap against the wall, as pests tend to move along this surface. Critical areas where pests are likely to be found include:
  - Along the perimeter walls
  - In corners
  - Near doors
  - Near windows and other light sources
  - Under furniture
  - Near water sources
  - Near drains and other damp places
  - Near heat sources
  - Inside and outside exhibit and storage cabinets
- **Step 4. Indicate the location of the traps on the floor plan.**
- **Step 5. Inspect the traps on a regular schedule** and record the:
  - Trap number
  - Location of the trap
  - Date inspected
  - Species of pests found in the trap
  - Number of individuals per species found in the trap
  - Life stage of the species, unusual conditions, replacement date for the trap, climate control system, weather conditions and any other useful information.
- **Step 6. Complete the trap monitoring log** (Figure 5.7). See Figure 5.8, Sample Pest Trap and Evidence Monitoring Log (completed), for a completed sample. Enter information into a simple computer spreadsheet or database program. See Figure 5.10, Sample Pest Monitoring Database Report (completed), for a sample pest monitoring database printout.
- **Step 7. Inspect insect traps weekly** during the initial phase of the monitoring period, usually the first three to six months, to identify current problems and solve them quickly. Long-term monitoring will identify problems that can develop later on, as well as seasonal variations throughout the year.

- **Step 8. Refine the trap placement**, as trapping becomes routine. Based on the evidence found, move traps or inspect as needed. Careful placement of traps allows for precise identification of problem areas.
- **Step 9. Replace sticky traps** at least monthly, when they become populated and dirty, or when the adhesive loses its tackiness, whichever comes first. If rodents are inadvertently caught in an insect sticky trap, contact the IPM staff member, who will safely dispose of the trap and rodent.

**Note:** Establish a regular cycle of inspecting and emptying traps as dead pests are a food source that may attract other pests.

8. How frequently should I inspect objects and structures for pests?

**For objects:** Spot check objects on exhibit and in storage once every six months. Inspect pest-sensitive objects every three months, particularly in spring and fall, during breeding season.

**For structures:** Routinely inspect the structure/area housing collections at least once every six months.

Doing several full inspection cycles during times when pests are known to be active (based on monitoring and structure/room inspection) will allow you to determine where pests are frequently located and to target intensive inspection to these areas of known vulnerability. Use trapping results to determine when and where pests are active and breeding in your local climate, and then target inspections to those times.

9. How do I inspect objects for pests?

Inspect objects closely with good lighting and magnifying lenses. Place objects on flat surface lined with a white surface (blotter paper, paper board, tissue) where any fallen insects or traces such as droppings, frass, webbing, and casings can be readily noticed. Examine the underside of furniture and pallets for webbing and insect eggs, and inspect wooden objects for exit holes of wood-boring insects.

Use a long wave UV black light in the dark to detect certain molds that fluoresce under black light on objects. This is difficult to do reliably and requires appropriate training and protective eyewear. Be aware the UV radiation can trigger sporulation in some fungal species.

10. How do I inspect structures for pests?

Thoroughly inspect the areas housing the collection and the entire structure as a variety of museum pests with different biology and living requirements can potentially be supported. Inspect the structure's exterior for access points.

Closely observe spaces for evidence of pests, structural deficiencies, cultural practices that could support pests, all potential food sources (fabrics, organic objects, etc.) and possible harborage sites. Inspect rodent snap traps daily. Routinely check for signs of infestations during housekeeping tasks and ensure that maintenance and interpretive staff look for signs of pests in exhibit areas. Inspect and isolate all new and returning collections objects.

11. Where should I inspect for pests?

Pests flourish when water, food, and harborage are available. All pests need moisture to survive. Focus inspections on finding sources of

dampness that may attract microorganisms and fungus-feeding pests. Watch for spilled water or condensation around water coolers and fountains, de-humidifiers and humidifiers, drains, sinks, and water pipes. Check mechanical rooms, floors, and ceilings for water leaks. Inspect building exteriors for other sources of moisture, such as roof leaks.

Inspect for pests in the following common harborage sites:

- Inside and under drawers, cabinets, and furniture
- Attics and store rooms where rodents or other pests may have made food caches
- Above drop ceilings, and inside elevator shafts and light fixtures
- Fireplaces and chimneys
- Inside electrical equipment and motors (including computers)
- Entry points into the structure and into areas housing collections, such as window sills and door jambs
- Near water sources such as drains and sinks
- Doorways and hallways with outside access
- In stored cardboard or wooden pallets housing collections
- Behind baseboards and wall trim and in inaccessible wall voids which could hold dead animal carcasses. Maintenance staff should do this in consultation with a historic architect.

12. What evidence of pest damage should I look for during inspections?

Different pests cause different types of damage. Search the collections areas and objects for:

- Discovery of flying adult or crawling larval insects
- Moth or beetle pupae
- Pupal tubes or cases
- Insects captured in traps or in ceiling light fixtures
- Chewing or gnawing marks
- Feeding or exit holes
- “Grazed” surfaces
- Presence of feeding debris or fecal pellets/droppings/frass (insect waste, which is usually a soft powdery material) around or below objects
- Shed/cast skins
- Webbing
- Nest/burrows
- Food caches
- Flyspecks
- Hair falling from fur or pelts
- Missing pile from rugs
- Rodent smudge/grease marks
- Odors or sounds
- Infested or damaged food or food packaging
- Bait consumption

See *COG 3/11* for additional information.

13. What tools and equipment do I need for inspections?

Use the following tools and equipment for inspections:

- Flashlight

- Magnifying glass
- Nitrile gloves
- Tape measure
- Camera
- Screwdrivers
- Step ladder
- Mirror to view up chimneys
- Sticky labels or marker for numbering traps
- Long wave UV black light (requires protective eyewear)
- Dust mask (NIOSH-approved disposable filtering face piece respirator with two straps. The park safety officer may require that you wear a respirator for inspections involving mold, bird or bat droppings, or heavy dust. If a respirator is needed, the user must be in a respiratory protection program. For inspections involving rodent infestations, see *COG 2/8*).
- Talc (sprinkle on the floor to detect rodent tracks in rooms not open to the public to indicate mice activity. For use in a historic structure, sprinkle talc onto Mylar®. As talc may be a respiratory hazard, consult with the safety officer before use).

Create a separate tool kit for inspections involving rodents. See *COG 2/8* for more information.

14. When do I isolate and inspect objects?

Inspect and isolate objects when they may bring pests into collections areas or may be infested.

- **For all new objects, and new and returning loans:** Newly accessioned objects and new and returning loans have the potential to introduce museum pests to your collections. To prevent this, carefully **inspect, isolate and monitor all incoming objects** for possible pest infestations or microorganisms before introducing these objects into collection storage or exhibit areas. See Section E.15 for procedures.

**Note:** Be aware that incoming objects, especially incoming objects from archeological sites, may potentially be health hazards. Consult with the regional curator and park resource management staff and see Chapter 11, Curatorial Health and Safety, for more information.

- **For potentially infested objects:** If you suspect that objects may be infested, isolate them immediately and monitor for signs of infestation. An object may potentially be infested if you find evidence of pest activity on or near the object, or have found pests that eat the object's material in nearby pest traps. Determine the isolation period, following procedures from Section E.15 below. Observe isolated objects for signs of pest activity and take appropriate action.
- **For infested objects:** If you find evidence of an infestation during inspection, immediately isolate the objects. Determine what treatments are needed to remove the infestation.

15. What procedures should I use to isolate objects?

Follow these procedures to isolate objects.

- **Isolate objects in a designated isolation room,** away from collections areas. Locate the isolation room adjacent to the shipping and receiving

area. Do not locate it within the collections area. The isolation room must be well sealed and have good lighting. If this is not possible, isolate objects in a well-sealed cabinet outside of the collections area. See Section F for additional information on the importation of pests.

- **Place the incoming object, potentially infested object, or infested object on a white surface, seal in a polyethylene bag and place in the isolation room.** If placing objects in an isolation cabinet, line the cabinet with the white material. Wrap large items in polyethylene sheeting and seal.
- **House objects with evidence of a mold infestation in lidded cardboard boxes** instead of sealed plastic bags, so the mold will not worsen. Ensure that the mold problem is addressed. See Figure 5.21, Sample Action Plan: Mold, for more information.
- **Observe the objects closely for signs of pest activity.** **Note:** Bagging is not considered a treatment by itself. Also, some kinds of insects will chew through the plastic.
- **Handle non-collection materials such as packing materials and exhibit construction materials in the same way but house these separately from collection areas.** Immediately discard any packing materials that cannot be verified as pest-free, such as cardboard, in an exterior garbage container.
- **Clean objects** and remove all pest traces by vacuuming off all webbing, insects, possible insect or spider eggs, and mold with a HEPA filter vacuum.
- **Determine, in addition to isolation, what action to take:**
  - Freezer treatment
  - Anoxic treatment
  - No further action besides isolation

Consult the regional curator and/or a conservator to determine the most appropriate treatment method for any type of infestation.

- **Complete a Pest Incident Report** for all infested objects. See Figure 5.4, Sample Pest Incident Report (completed).

16. How long do I need to isolate the object?

Isolation periods vary based on why you are isolating the object and what pests are involved.

- **For all new objects, and new and returning loans:** Isolate objects for a minimum of one month. Living pests can usually be detected within this period. However, be aware that insect eggs can be dormant for years depending on the species. Mold can also be dormant. Metal, glass, ceramic or stone objects should be thoroughly inspected and cleaned but do not need to be isolated. Inspect objects for signs of an infestation throughout the isolation period.
- **For potentially infested objects:** If you suspect an object may be

infested, determine the best way to treat the object, such as a freezer or anoxic treatment, in consultation with a conservator and the regional curator. Note that bagging is not considered a treatment by itself. After the treatment, isolate the object for a minimum of one month and continually inspect throughout the isolation period. If you discover pests, determine the appropriate isolation period based on the pest species.

- **For infested objects:** If an object is infested, determine the best way to treat the object, such as a freezer or anoxic treatment, in consultation with a conservator and the regional curator. After treatment, determine the isolation period, which ranges from a minimum of one month to several months, depending on the identification of the pest and its life cycle. Consult the regional curator, conservator, entomologist or IPM manager to determine the appropriate isolation period.
- **For objects potentially infested with woodboring beetles:** Woodboring beetles are problematic to eradicate. They can lay dormant for long periods of time so they are difficult to eradicate. You may have an active woodboring beetle infestation if you see exit holes or piles of frass below wood objects.

Isolate the objects for a minimum of 12 weeks at room temperature. Regularly inspect the objects for signs of an active infestation during the isolation period by monitoring for frass falling out of exit holes from larval action. Be careful not to move the objects and dislodge frass from the holes. Old exit holes are dark in color from the wood oxidizing while newer exit holes are usually lighter.

It is preferable to isolate the object in the isolation room for a period of one year, if you have the space. If this is not possible and if no frass has appeared after 12 weeks, you can remove the object from the isolation room. Then double bag or wrap it in two layers of plastic on white paper. Inspect regularly for frass and holes in the plastic for a minimum of one year. Holes indicate that the object is still infested as adult beetles have chewed their way out of the plastic.

17. How do I determine that I have a pest infestation and what are action and injury thresholds?

Action thresholds are used to determine whether you have a pest infestation. The **action threshold** is the point at which pest levels, evidence of pests, and any observed damage to objects indicate that collections will be damaged if action is not taken. For example, if you see a mouse, mouse droppings, or gnawed objects, the action threshold has been exceeded. The **injury threshold** is the point at which the collections have been damaged by pests. The injury threshold cannot be exceeded, as damage to collections objects cannot be tolerated. The action threshold is specific to the pest and is determined by where the pest is found within the structure.

Establish zones to help you determine if the action threshold for a particular zone has been met. For example, zone one is collections storage, zone two is a workroom, and zone three is the entry hall into the building. If a museum pest or perimeter invader is discovered in zones one and two [both areas house collections], follow the steps outlined in Section B. If a museum pest or perimeter invader is discovered in zone three, a non-collections area, determine the source of the infestation and increase

inspection. You will not need to isolate objects.

The presence of museum pests in any part of the structure indicates other problems that may threaten museum collections, such as poor sanitation or exclusion.

While a museum pest is a far greater concern than a perimeter invader (which does not feed on collections), the action threshold is still met if a perimeter invader is found in an area housing collections. The presence of perimeter invaders indicates a problem, such as poor sanitation or insufficient exclusion. Actions still must be taken to prevent more pests from entering the collections area.

Expect to trap more insects in historic structures than in new dedicated or purpose built storage facilities and visitor centers. Determine the various thresholds before starting a monitoring program and include these in the IPM plan. Include action thresholds in each action plan. For more information about action plans, see Section D.4. See Figures 5.13-5.22 for sample action plans.

***The action threshold for any area housing collections is the sighting of ONE larva or adult pest or any traces of the insect or organism.***

## F. Control Actions

---

1. What control actions will exclude pests from areas housing collections?

Cultural, mechanical, and chemical controls are used to prevent pests from getting into, and thriving in the collection. Use one or more of the following actions or tools in a well thought out plan to exclude and control museum pests in areas housing collections.

- **Cultural controls** are policies and procedures that prevent infestations.
- **Mechanical controls** are techniques that limit pest habitats and exclude pests from structures and spaces housing collections, including rodent snap trapping.
- **Chemical controls** include pesticides which kill pests, pheromones which repel or attract pests, and insect growth regulators which prevent development. Proposals to use these tools to prevent or treat infestations must be reviewed and approved on a case-by-case basis prior to purchase and use.

2. What are cultural controls?

**Cultural controls** modify human behavior and include:

- Developing and implementing a good housekeeping plan. See [Chapter 13, Museum Housekeeping](#), for more information.
- Inspecting and isolating *all* incoming collections, including new accessions, new and returning loans, purchases, and field collections, as well as exhibit and storage material *before* placing them in collections storage or exhibit areas.

- Isolating infested and potentially infested objects for inspection and possible treatment.
- Housing objects in well-sealed closed storage and exhibit cases in museums and exhibit spaces.
- Raising storage cabinets four to six inches off the ground to facilitate cleaning.
- Inspecting free- standing objects that are not housed in cases more frequently.
- Prohibiting food, drink and smoking in areas housing collections. Designate an area where staff can eat away from collections, such as a break room. Keep all food sealed in containers with lids.
- Prohibiting decorative live and dried plants within areas housing collections, including furnished historic structures. Use artificial plants and flowers as needed.
- Eliminating plants and mulch adjacent to the structure. Work with a historic architect, park facilities management and cultural landscape staff.
- Properly disposing of trash in sealed containers and removing from building daily, including trash from staff offices and break rooms.
- Maintaining a stable temperature and RH. Keep RH below 65% to discourage moisture pests and be aware that high temperatures can support museum pests. See [Chapter 4, Museum Collections Environment](#) for more information.
- Focusing inspections to find sources of dampness and potential entry points in the structure.
- Ensuring that persons entering the collections areas do not track in pests.

### 3. What are mechanical controls?

**Mechanical controls** include:

- **Exclusion** by creating a tight building envelope by sealing the structure through a range of exclusion techniques and systematically and regularly inspecting the structure's exterior and interior spaces for potential entry points.

Work with a historic architect, and park facilities management and cultural landscape staff to find an appropriate alternative if the treatments described below are not appropriate for the type of structure, including historic structures.

- Sealing, caulking or otherwise blocking:
  - Holes in the exterior of the structure 1/4" or larger to exclude mice and rats, as rodents can fit through very small (1/4" for mice and 1/2" rats) openings.

- Windows or sealing using gaskets and/or weather stripping.
- Gaps and holes, particularly spaces around windows and doors. Larger holes may require a filler such as wire mesh or spray foam insulation prior to caulking.
- Pipe, electrical conduit and HVAC duct wall and roof penetration holes.
- Installing 20 mesh screening on:
  - Window exteriors
  - Air vents
  - Hot air registers
  - Floor drains
- Installing self-closing devices, sweeps and gaskets on all exterior and interior doors in areas housing collections and ensuring that all doors form an airtight seal
- Installing bird and rodent-proof chimney guards over fireplace chimneys
- Repairing cracks and openings in stone and cement foundations with concrete or mortar
- Creating an 18 – 30" wide vegetation free zone, also called a sanitary barrier or 'hot zone,' around the perimeter of structures, preferably full of four inch deep gravel where possible. See [Chapter 7, Museum Collections Storage](#), for more information. Be aware that this treatment may not be appropriate for historic structures.
  - Eliminate mulch and plants next to the building as it provides habitat for insects and rodent, and holds moisture.
  - Eliminate vegetation against the building foundation or walls as this allows pest access and encourages pest activity and inhibits drainage and access.
- **Sanitation** by practicing good sanitation techniques:
  - Emptying all trash containers and removing trash from structure daily
  - Thoroughly clean trash receptacles to remove food residue
  - Keeping areas around dumpsters clean
  - Regularly vacuuming to minimize dust and other particulates, at least monthly. Use a vacuum cleaner with a HEPA filter instead of a broom to clean floors and structures, including floors,

windowsills, walls and cabinet tops. Remove all traces of insects from the structure, such as frass, eggs, discarded skins, and discovered dead insects.

- **Eliminating harborage** sources from the interior and exterior of the structures containing collections:
  - Removing bird and insect nests promptly from building exterior. **Note:** see Migratory Bird Treaty Act of 1918 (16 USC 703-711) to ensure that removing bird nests is legal. See [MH-I, Appendix A](#) for more information.
  - Removing rubble and/or firewood from around the exterior of the structure.
  - Ensuring that dumpsters and other large exterior trash receptacles are kept at a distance from the building and are not directly adjacent to the loading dock.
  - Cleaning gutters regularly.
  - Removing plants such as ivy growing on the structure.
  - Trimming trees and shrubs so that they do not come into contact with the structure.
  - Eliminating clutter from areas containing collections, especially cardboard and wooden or plastic pallets.
  - Storing boxes and other items off of the floor.
- **Eliminating moisture** sources for pests:
  - Eliminating water draining towards structure.
  - Promptly repairing roof, window, building, plumbing or sewer leaks.
  - Insulating cold water pipes to prevent formation of condensation.
  - Monitoring air conditioning units, humidifiers and dehumidifiers for excess moisture.
- **Eliminating food** sources for pests:
  - Properly disposing of trash in sealed containers and removing from structure daily, including trash from staff offices and break rooms.
  - Regularly inspecting wall voids and interior of suspended ceilings for lint, dirt, animal carcasses or other sources of food for pests.
  - Promptly removing dead insects and animals and animal waste from structure.

- Isolating moldy objects and vacuuming with HEPA filter.
- **Modifying habitat** to ensure that pests will not be attracted to structures:
  - Using sodium vapor lighting, which is less attractive to insects, for exterior fixtures. Mount lights away from and not on the structure to avoid attracting pests.
  - Mounting outside lights 30 feet away from the structure facing away from the structure.
  - Locating receiving/unloading area away from collections.

#### 4. How do I establish a rodent snap trapping program?

**Snap trapping, in conjunction with exclusion, is the most effective strategy for eliminating rodents from structures.** Snap traps eliminate rodents and monitor for rodent entry, allowing evaluation of exclusion efforts. These traps also avoid problems of mice and rats dying in inaccessible locations where they will produce a foul odor and attract other pests. Do not use live traps or glue boards as they increase the risk of exposure to rodent urine, feces and associated pathogens. They are also inhumane. Electronic traps are not recommended because they are not always effective and can cause rodents to excrete urine that can potentially spread viruses.

Effective rodent trapping depends on saturating an area with a large number of well-maintained snap traps, using baits that attract rodents, and placing traps where animals will encounter them. Placement is important. Rodents prefer to travel close to walls and objects where the side of their body is close to a surface, rather than going across the middle of a room. Rodents usually continue to use the same pathways. Urine left by rodents on these pathways will show up under a UV light so these pathways can be identified.

- Create a floor plan with the trap locations, following the procedures listed in Section E.7. Number and date each trap. Make sure the number and date will not be obscured by the catch/carcass.
- Set and bait the appropriate quantity of rodent snap traps in each space. Use about eight traps per room; larger rooms need more traps. Place two snap traps on each side of the room's entry points. Adjust traps to snap closed with the least disturbance by filing off manufacturing burrs from the trigger mechanisms and careful setting. Bait the traps with peanut butter or cotton. However, be aware that peanut butter can attract insects. Note that snap traps are also effective without bait.
- Locate traps every six to ten linear feet along walls and runways used by rodents. Put traps behind or under (but not touching) objects, under furniture, against walls, or in other locations where rodents find concealment. Place two traps at each trap station parallel with the wall, or place a single trap with its trigger end against the wall. See *COG* 2/8 for an illustration. Place a Mylar® rectangle beneath each trap, cut one inch wider than the trap, to prevent the spread or absorption of any liquids from the trapped mouse or rat, especially when trapping on a

porous historic wooden floor.

- Inspect rodent snap traps daily.
- To dispose of a trapped rodent, wear gloves and spray the rodent and trap with disinfectant. Minimize handling by placing the trap and rodent in a plastic bag and discard. Treat every rat and mouse as potential hantavirus hazard. See *COG 2/8* for additional information.
- Keep snap traps out year-round for general monitoring, baited with cotton or yarn, which is attractive as a nesting material for female rodents.

For additional information see the CDC's [Clean Up! Snap Up! Trap Up!](#) website.

5. How do I clean objects contaminated or potentially contaminated with hantavirus?

An object that may have been contaminated with hantavirus must be handled with extreme caution. The sighting of any mouse or rat or signs of mice or rats such as droppings or nests **must** be treated as if hantavirus is present. **Do not vacuum.** Wear proper personal protective equipment, including nitrile gloves, when cleaning up mice and rats and their traces. Respirators and associated medical clearance are needed to clean up after heavy infestations. See *COG 2/8* for more information. Immediately double bag the object in plastic and isolate it from the rest of the collection. Keep the object isolated at room temperature. **Do not freeze the object as this extends the viability of the virus. Isolate for a minimum of three weeks. However, a longer period of six weeks is strongly suggested.** The virus is typically viable for 24 - 48 hours, but in some conditions it can survive several days longer.

If the object is wet or damp with rodent urine, virus viability and risk to people is higher. To render the virus inactive, the object must be dried. Wearing personal protective equipment, follow the steps outlined above, and in the *COG* to isolate the object and place a desiccant such as silicone dioxide within the bag. Silica should never come into direct contact with the object. *Caution:* silica is potentially harmful to some materials if they are excessively dried. Once the object is dry, continue isolation for an additional minimum period of three weeks to ensure the virus is deactivated.

**Note:** Do not apply bleach or other solutions directly onto a museum object. As applying bleach directly will damage a museum object, the CDC has indicated that isolation is sufficient treatment to deactivate hantavirus and that normal cleaning can follow the isolation period. Consult with the regional curator and a conservator before proceeding with any further treatments.

6. What are chemical controls?

**Chemical controls** include:

- Pesticides must be submitted and approved through PUPS, including fumigation, localized application of sprays, and dusts used as a crack-and-crevice treatment.
- Crack and crevice treatments involve putting low risk pesticide dusts, such as boric acid, silica aerogel or diatomaceous earth, in a bulb duster

and puffing a thin layer of dust under baseboards and cabinets and in other hidden areas where insects seek concealment. It kills insects but is not harmful to mammals. For additional information, consult the park IPM coordinator, regional curator or a conservator.

While chemical controls may be the most appropriate methods for treating an infestation, **do not** use them on museum objects. They may only be used around objects, not directly on them.

**Note:** The exception is when treating a wood object infested with powderpost beetles. If other treatments are not possible, a trained wood conservator may use localized applications of low-risk, approved pesticides, such as borate, on the affected wood. You must have approval through PUPS before using this treatment.

## G. Identification of Museum Pests

---

### 1. What are museum pests?

Museum pests are biological agents that damage museum collections. These include insects, mold, mice, rats, birds and bats. Pests damage objects through feeding, gnawing, defecating, nesting behavior, and by attracting other types of pests. Museum pests are generally grouped as follows:

- Fabric pests
- Wood pests
- Stored product pests
- Moisture pests
- Rodents
- Other vertebrates, including bats and birds
- General pests
  - museum pests
  - perimeter invaders

Identifying the pest species and its life stage is critical in determining what is happening in the areas being monitored. This chapter provides brief descriptions of certain museum pests. Other pests may be found. For assistance in identifying unknown pests, contact park and regional IPM coordinators, entomologists, the regional curator, or NPS Cooperative Park Study Units. Also seek assistance from entomologists in the Cooperative Extension Service, U.S. Forest Service, state departments of food and agriculture, or at local universities and natural history museums. See Figure 5.12 for a sample pest identification request letter.

Start a reference collection of pests to compare to when identifying new pests and photo-document damage to your collection. These insects can be stored on small squares cut from insect sticky traps and placed in small

plastic boxes or vials. See [COG 11/8: "Curation of Insect Specimens,"](#) for information on making a reference collection of insect pests.

2. Where can I see images to help identify pests?

The following online references contain images of pests that you can use to help identify pests. See Section H, Selected Bibliography, for additional references.

- Center for Invasive Species and Ecosystem Health operated by University of Georgia's [bugwood.org](http://bugwood.org)
- [COG 3/11, Identifying Insect Damage](#)
- Iowa State University's [Bug Guide](#) and [Image Galleries](#)
- [museumpests.net](http://museumpests.net)
- [NPS Integrated Pest Management Information Manual](#)
- Penn State's [Entomology Fact Sheets](#)
- University of Florida's [Featured Creatures](#)
- [whatseatingyourcollection.com](http://whatseatingyourcollection.com)

3. What are fabric pests?

Fabric pests are protein eaters. The two main groups are carpet beetles (of the family Dermestidae) and clothes moths (of the family Tineidae). The larvae of these insects feed on all types of protein-based animal products found in museum collections, such as wool, silk, fur, feathers, leather, horn and carcasses of other arthropods. They are among the few creatures that can digest keratin. The adult beetles and moths do not feed on collections and are often seen at windows seeking a way outside to locate pollen or other food adults depend on.

- **Carpet beetles** are also commonly known as dermestids. Carpet beetle larvae cause damage by feeding on a wide variety of materials including fur, feathers, wool and silk cloth, wool felt, hair, study skins, and taxidermy or trophy mounts. They may not be seen because they hide from light, burrowing deep into objects. The larvae shed their skins as they grow. Look for these skins during inspections. The frass is often granular to touch. Adults are attracted to daylight and come out of hiding to seek pollen from flowers and mate. They may collect along windowsills, a good location to monitor with sticky traps. There are many species of carpet beetles, but the ones described below are commonly found in museums. These beetles can be easily mistaken for other types of beetles that do not damage museum collections. See Figure 5.14, Sample Action Plan: Dermestid Beetles, for more information.
  - **Black carpet beetles** (*Attagenus unicolor*) are the most abundant and destructive of the carpet beetles. They feed on wool, silk, fur, felt, feathers, leather, insect specimens, casein and hide glues, books and bird and mammal specimens and will feed on various plant materials, such as yeast, cereals, seeds, grains and spices. The adult is 1/8- 3/16" long, a solid dark brown or dull black color, and more elongated than the carpet beetles described below. The larvae are less than 1/4" long and carrot-shaped. They are covered with golden brown hairs and have a characteristic "tail" of long hairs at the rear end.
  - **Varied carpet beetles** (*Anthrenus verbasci*) are primarily scavengers. They are common in bird nests, on dead animals, and

in insect collections. They can damage woolens, carpets, wall hangings, hides, horns, and bone objects. Small populations often go unnoticed behind furniture or along baseboards, feeding on accumulated lint, hair, food crumbs, dead insects, and other organic debris. The adult is about 1/8" long, oval to round, blackish with splotches of white, yellow, and black on its back. The larvae are 4-5 mm long, teardrop-shaped, and covered with rows of light brown hairs.

- **Common carpet beetles** (*Anthrenus scrophulariae*) attack carpets, woolens, animal products such as feathers, furs, leather, silks, mounted museum specimens, and pressed plants. The adult is about 1/8" long and black with white scales and a band of orange scales down the middle of its back. The larvae are reddish-brown and covered with brown or black hairs. Larvae are active and move rapidly.
- **Furniture carpet beetles** (*Anthrenus flavipes*) attack upholstery (particularly old horsehair-stuffed furniture) and objects made from wool, fur, feathers, silk, horns, and tortoise shell. The adult is about 1/8" long and is rounded and blackish with variable mottling of yellow and white scales on the back and yellow scales on the legs. The larvae are difficult to distinguish from the common carpet beetle.

Other kinds of dermestid beetle larvae will also feed on textiles and protein materials, including:

- **Hide beetles** (*Dermestes maculatus*) feed principally on leather, animal hide, and bird and mammal skins. The adult is 1/3 to 1/2" long and is reddish brown to black in color, with a white underside with lateral black spots. The 1/2" larvae are black with a broad dorsal band.
- **Larder beetles** (*Dermestes lardarius*) feed on hides, horn, hair, fur, feathers, bird, mammal and insect specimens, skins, human food, and commonly dead cluster flies in attics. The 1/3" long adult is brown to black in color with light or yellowish transverse bands across the wing covers, white undersides with black patches along lateral borders of abdomen, and have clubbed antennae. The 1/2" larvae are hairy with alternating light and dark brown bands.
- **Black larder beetles** (*Dermestes ater*) feed on bone, carcasses, wool, wood, cork, and insulation (materials where larvae also make pupal chambers). The adult is 1/3" long and dark brown to black. The larvae are 1/2" long and yellowish brown with a narrow dorsal stripe.
- **Odd beetles** (*Thyodrias contractus*) feed primarily on dead insects, and will also feed on plant materials, animal skin collections and freeze dried specimens, and attack textiles and fibers made from natural materials such as wool or silk. Male and female adults look different from each other and other dermestids. They are 1/8" long, narrow and yellowish-white in color. The larvae look similar to carpet beetles but will roll up in a ball when

disturbed.

- **Cabinet beetles** (*Trogoderma ornatum*) feed on animal products such as wool, feathers, furs, skins, bee glue, cocoons, and dead drywood termites and on vegetable matter like grains, nuts, wheat, corn, spices, seeds, and tobacco. Adults are 1/8" long and black with red-banded wings with white hairs. The larvae are 3/8" long and reddish-brown with white undersides and two appendages on the tail.
- **Larger cabinet beetles** (*Trogoderma inclusum*) feed on stored grains, woolen clothing, dried insects, dried casein and corn meal. The adult is 1/10 - 1/5" large and light in color.
- **Warehouse beetles** (*Trogoderma variabile*) feed on seeds of all kinds, dead animals, candy, dog foods, dead insects, milk products, starches, stored cereal products, dried grain insect collections, hides, and skins. They are 1/8" long and brownish-black. The larvae are 1/4" long and range from yellow-white to dark brown depending on age.
- **Clothes moths** are small, silvery-beige moths with a wingspan of less than 1/2". They have narrow wings fringed with long hairs. Small grain- and flour-infesting moths are often confused with clothes moths; however, clothes moths have different flying habits. They avoid light and are rarely seen flying. They prefer dark corners, closets, and storage areas, and usually remain out of sight. The primary food of clothes moth larvae is soiled woolens, but they also feed on silk, felt, fur, feathers, and hairs. They often damage woolen clothes (particularly old military uniforms), feather hats, dolls and toys, bristle brushes, weavings, and wall hangings. See Figure 5.15, Sample Action Plan: Clothes Moths, for more information.
- The **webbing clothes moth** (*Tineola bisselliella*) and the **casemaking clothes moth** (*Tinea pellionella*) are the two most common clothes moths found in museums. The larvae are 1/4 - 1/2" white caterpillars with brown heads. They feed on the surface of the infested material. The webbing clothes moth produces feeding tunnels of silk and patches of silken webbing on the fabric's surface. The casemaking clothes moth is rarely seen, since it constructs a cylindrical case of fabric that it carries around to hide and feed in. The color of the larval case will often match the material on which it's feeding. Use this clue to help locate infested materials.
- **Carpet moths** (*Trichophaga tapetzella*) are uncommon in the U.S. but can be imported on fabrics. They feed on hair-stuffed furniture, tapestries, old carpets, furs, feathers, and taxidermy or trophy mounts. These are also general feeders on a variety of dried animal and plant proteins, dead insects and nests, and animal carcasses.

**Note:** Regularly inspect objects vulnerable to clothes moths because clothes moths are difficult to detect *until after* damage has been done.

**Action threshold** for fabric pests is the sighting of one larva or adult insect or any traces of the insect or damage to objects that indicate an active infestation, such as shed larval skin, pupal cases, grazing damage or holes. For management actions, see Section F, Control Actions.

#### 4. What are wood pests?

Objects made of wood are susceptible to attack by a number of wood-infesting pests. Wood-destroying organisms can digest cellulose (termites and some powderpost beetles) excavate it for habitat (carpenter ants). The culprits in museums are usually woodboring beetles or drywood termites. Both can severely damage valuable objects while remaining invisible to the untrained eye.

- **Woodboring beetles** or powderpost beetles, are a group of beetles in the insect families *Anobiidae* (anobiid, furniture, and deathwatch beetles), *Lyctidae* (true powderpost beetles), and *Bostrichidae* (false powderpost beetles). The term "powderpost" comes from the fact that the larvae of these beetles feed and digest cellulose and, given enough time, the appropriate temperature, and adequate moisture, will reduce the wooden object to a mass of fine powder.

Woodboring beetles spend months or years inside the wood in the larval stage. Their development depends on moisture and temperature. Their presence is apparent when they emerge from the wood as adults, usually leaving pin hole openings, often called "shot holes," behind and piles of powdery frass (digested wood that looks somewhat like sawdust) below the object. Depending on the species, holes may be round or oval-shaped and normally range in diameter from 1/32 - 1/8". If conditions are right, females of some beetle species may lay their eggs and re-infest the wood, continuing the cycle for generations. Heavily infested wood becomes riddled with holes and tunnels packed with dusty frass.

Woodboring beetles can attack both hardwood and softwood, although lyctids only infest hardwoods. They can infest wooden objects, frames, furniture, tool handles, gunstocks, books, toys, bamboo, flooring, and structural timbers. Examine museum objects that can be infested by woodboring beetles regularly to detect beetle activity early on. Check beneath or the underside of objects for frass or shot holes. Avoid high humidity and/or moisture levels. See Figure 5.16, Sample Action Plan: Powderpost Beetles, for more information.

- **Drywood termites**, unlike subterranean termites, establish colonies in dry, sound wood with low levels of moisture and do not require contact with the soil. They are primarily found in the coastal southern states, California, and Hawaii, but are easily transported elsewhere in lumber, furniture, and wooden objects. Drywood termites seek wooden objects of all kinds for a food source and feed across the grain of the wood, excavating chambers connected by small tunnels. The galleries feel sandpaper-smooth. Dry, six-sided fecal pellets are found in piles where they have been kicked out of the chambers, in spider webs or in the galleries themselves. A swarming flight of winged reproductive termites can occur anytime from spring to fall, mostly occurring at night.

- **Subterranean termites** live in colonies underground or aboveground in secluded, moist areas. They feed on cellulose and attack wooden structures. They are very destructive and capable of collapsing entire buildings.
- **Carpenter ants** (*Camponotus pennsylvanicus*) are large, 3/8 - 1/2" long, with shiny black bodies that sometimes appear reddish-brown. They excavate wood not to feed on it, but to make galleries for nests. Carpenter ants are indicators of a moisture problem as they excavate wood with 15% moisture. Damp wood or wood invaded by wood rot fungi is especially susceptible, but any wood in a structure may be affected if it contains the right amount of moisture. They eat protein, such as other insects, and carbohydrates, such as sweet honeydew from aphids. Carpenter ants can enter structures where tree branches come into contact with the roof, other parts of the structure such as windows, holes in the foundation, foundation vents, heating ducts and air-conditioners, or along power or telephone lines. The frass is very coarse, closely resembles sawdust from a hand saw and has insect body parts in it.

**Action threshold** for wood pests is the sighting of one larva or adult insect or any traces of the insect or damage to objects that indicate an active infestation, such as exit holes or frass below objects. For management actions, refer to Section F, Control Actions.

5. What are stored product pests?

Many museums include objects made in part of seeds, nuts, grains, spices, dried fruits and vegetables, and other foods. Stored product pests, or "pantry pests," can infest objects containing these foods. The most common are the cigarette and drugstore beetle. See Figure 5.17, Sample Action Plan: Stored Product Pests, for more information.

- **Cigarette beetles** (*Lasioderma serricorne*) are named for being a pest of stored tobacco, but are also a serious pest of flax, spices, seeds, dried plants, books, and crude drugs. This beetle has been called the "herbarium beetle" because of the damage it can cause to dried herbarium specimens. They have also been found infesting rodent bait. The adult beetle is light brown, 1/8" long, with a distinctive hump-backed look. The small larva is grub-shaped and whitish, with yellow-brown markings on the head and long hairs that make it appear fuzzy.
- **Drugstore beetles** (*Stegobium paniceum*) feed on a wide variety of foods and spices, particularly paprika or red pepper. They are also a serious pest of books and manuscripts, and have been known to chew through tin foil and lead sheeting. The adult beetle is similar to the cigarette beetle.
- **Saw-toothed grain beetles** (*Oryzaephilus surinamensis*) feed on cereal products and can readily penetrate packaged foods. The adults are 1/10" long, flat, narrow, and dark brown. The larvae are extremely small and rest in a C shape.
- **Lesser grain borers** (*Rhyzopertha dominica*) feed on whole grain products, wood and paper. Adults are 1/8" long and a shiny red brown to dark brown.

- **Red flour beetles** (*Tribolium castaneum*) feed on flour, processed grains and museum specimens. They are 1/7" long and are shiny and reddish-brown. The larvae are 3/16" long and yellowish-white.
- **Confused flour beetles** (*Tribolium confusum*) are principally a pest of stored cereals, flour, and spices, but also infest some museum specimens, including herbaria and freeze-dried animal specimens. They are 1/10 - 1/5" long and are a dark reddish-brown.
- **Foreign grain beetles** (*Ahasverus advena*) feed on mold growth in grains but do not actually damage grain. They are 1/10" long and reddish-brown. They indicate a moisture problem in the museum.
- **Cadelle beetles** (*Tenibrioides mauritanicus*) feed on a wide variety of stored, whole grain and processed products as well as wood objects. They are 1/3" and a shiny black color. The 1/3" long larvae are gray-white with black heads with two horn-like projections.
- **Spider beetles** (Various genera and species) feed on plant and animal materials and processed foods and often bore into wood, textiles, jute, linens, cellophane, plastic, cardboard, and packaging materials. They can digest keratin and commonly infest animal skins, wool, and feathers. Adults are 1/16 - 3/16" long, oval to cylindrical, red to black and shiny. Larvae are small C-shaped grubs.
- **Red-legged ham beetles** (*Necrobia rufipes*) primarily attack animal matter and food materials such as dried and smoked meats and also attack bones, hides, mummies, vegetable matter, museum specimens, silk, cotton, and wool. The adults are 1/8 - 1/3" long, and are dark metallic blue with red legs. The 3/8" long larvae are white with a dark brown head.

**Action threshold** for stored product pests is the sighting of one larva or adult insect or any traces of the insect or damage to objects that indicate an active infestation, such as feeding damage or exit holes. For management actions, refer to Section F, Control Actions.

6. What are moisture pests?

Not only is moisture a threat to collections itself, it may attract a number of moisture-loving pests such as silverfish and psocids that can do additional damage. Molds are a threat in damp conditions and can attract insects that feed on those molds.

- **Silverfish** (*Lepisma saccharina*) and **firebrats** (*Thermobia domestica*) eat fabrics, paper and sizing, and glue and paste in book bindings. They are omnivorous and will eat protein materials as well as cellulose. They are especially damaging in dark, damp storage areas. They have a distinct carrot shaped body, short legs, long slender antennae, and three tail-like appendages. Silverfish hide in cracks and crevices such as in the gap between the floor/wall molding. Their frass is granular to the touch. See Figure 5.18, Sample Action Plan: Silverfish, for more information.
- **Springtails** are an indicator of a moisture problem but are not

considered a museum pest. They are wingless insects, about 1/16 - 1/8" long that feed on microscopic mold, and usually target damp or moldy materials, wallpaper, and new plaster. They vary in color and can be white, gray, yellow, orange, metallic green, lavender or red. Springtails often come in through gaps in the door or window on the ground level. See Figure 5.18, Sample Action Plan: Springtails, for more information.

- **Psocids** or booklice, are tiny insects, less than 1/16" long, and range in color from clear to light gray or light brown. Wingless psocids are commonly called booklice because they often infest damp, moldy books and feed on the mold growing on paper and the starchy glue in the binding. Psocids also infest objects such as dried plants in herbaria, insect collections, manuscripts, cardboard boxes, and furniture stuffed with flax, hemp, jute, or Spanish moss. Although psocids cause minimal damage, their presence indicates a moisture problem and the likely presence of damaging molds. See Figure 5.20, Sample Action Plan: Psocids, for more information.
- **Molds** are fungi that can cause damage or disintegration of organic matter. Although they lack roots, stems, leaves, or chlorophyll, molds occur nearly everywhere and fungal spores, essentially the seeds of the fungus, are easily transported. When moisture and other environmental conditions are right, molds can appear and cause significant damage to wood, textiles, books, fabrics, insect specimens, and many other objects in a collection. Their growth can be rapid under the right conditions. Whether molds attack suitable hosts in the museum depends almost exclusively on the presence of moisture. When moisture becomes a problem, molds will likely become a problem too.

***To avoid mold and other museum pests, do not house or exhibit museum objects in humidity above 65%. Be aware, however, that some molds can grow at a lower humidity.***

“Active” mold is often damp, smeary and varies in color, including black and green, and requires prompt action. “Inactive” mold is dry, often powdery and usually white in color, but can become active again under certain environmental conditions including high RH. Both active and inactive mold can be health risks and require proper personal protective equipment when dealing with infestations. Consult the park safety officer for mold clean-up procedures and protective measures. See Figure 5.21, Sample Action Plan: Molds, for more information.

**Action threshold** for moisture pests is the sighting of one larva or adult insect or any traces of the insect or organism or damage to objects that indicate an active infestation, such as feeding damage. For management actions, refer to section F, Control Actions.

7. What rodents should I be concerned about?

Rodents can cause extensive damage to museum collections through nesting, excreting, chewing, and soiling collections with dirt and grease. Rats in particular have powerful teeth capable of chewing through concrete, aluminum, plaster, and wood but have more difficulty gnawing on smooth surfaces. Mice and rat nests provide habitats to insects, such as carpet beetles fleas, ticks, and bed bugs, which can create a secondary pest issue in the structure.

Rodents present a human health risk to employees and visitors as they are disease vectors and hence cannot be tolerated indoors. Due to rodent related deaths, regular rodent inspections in NPS structures are now required. See Section G.10 for information on diseases spread by mice and rats. **The most effective way to deal with rodents is to exclude them from the structure.** See Figure 5.22, Sample Action Plan: Mice and Rats, for more information.

- **Mice** are the most common indoor rodent pests and include house mice, deer mice and white-footed mice. They breed year round and can produce large numbers of young each year so mouse populations can easily explode if conditions are right for their survival. Mice are exceptionally agile; they can jump 12" or more off the floor and squeeze through spaces only 1/4" in diameter, the size of a pencil. They are most active in the night. House mice rarely travel more than 30 feet from their nest to food, while white-footed mice may travel over 200 feet to food. Mice are curious, easy to snap trap, prefer to eat human foods, and chew on many collection materials for food and nesting.
- **Rats** include roof rats, Norway rats, and wood or "pack" rats. They produce less young than mice, about 20 per year. Rats can jump three feet high, climb vertically and swim. They can squeeze through holes 1/2" in diameter. Rats range from 100 - 150 feet from their nest. They damage structures by gnawing corners of doors, infesting attics, basements and crawl spaces, etc. Rats may create large nests, using upholstery materials from furniture and items brought in from outdoors. Pack rats may steal items from collection storage for their nests.
- **Squirrels** primarily damage structures by gnawing their way into attics, damaging insulation, and nesting. They infest attics, wall voids, crawl spaces, and chimneys and enter buildings through trees and branches within ten feet of the buildings, electricity utility lines, fire escapes, chimneys and occasionally downspouts. Squirrels can introduce fleas and ticks into a structure creating potential for secondary pests and human health risks.
- **Chipmunks** cause structural damage by digging under building foundations. They infest basements, wall voids, attics, crawl spaces, and chimneys and enter buildings through trees and bushes close to the structure and openings near the foundation of the structure.

**Action threshold for rodents is the sighting of one rodent or any traces of rodents or damage to objects that indicate an active infestation, such as droppings, fresh gnawing, and grease marks along walls.** For management actions, refer to section F, Control Actions.

8. What other vertebrates can damage museum collections?

Birds and bats can also infest structures housing collections.

- **Birds** may roost or nest on the exterior of structures and on occasion gain access to the interior containing museum collections by entering through attics, eaves and vents. Professional exclusion is key to keeping birds out of, and off structures as bird nests harbor other pests, such as dermestids, mites, and bat bugs, and bird droppings that can

damage objects. Birds can present a human health risk through diseases in their droppings such as histoplasmosis. Swallows and pigeons are a particular problem for many museums. Contact your IPM Coordinator, wildlife biologist, and safety officer for assistance. Note that some birds are protected species under the Migratory Bird Treaty Act and removal must be planned accordingly.

- **Bats** should be excluded from human occupied structures. They rarely directly damage collections objects but their roosts provide harborage for potential indoor insect pests and mites. They seek harborage in attics, wall voids and occasionally basements. Their droppings (guano) provide food for insects, stain ceilings, walls, and historic furnishings and cause a strong odor. Bats may carry rabies and their guano may contain histoplasmosis, two serious diseases that affect people. Contact your IPM Coordinator, wildlife biologist and safety officer for assistance, consult a professional and check the [Bat Conservation International](#) website. Note that some bats are protected species and removal must be planned accordingly.

**Action threshold** for other vertebrates is the sighting of one pest or any traces of the pest or damage to objects that indicate an active infestation. For management actions, refer to section F, Control Actions.

9. What are general pests?

Any household pest may become a pest in a museum. Many kinds of pests can get into a structure that has a moisture problem or that has not been well sealed. Cockroaches, crickets, spiders, ants, millipedes, lady bugs, flies, wasps, and other common insects can invade and infest museums, visitor centers, historic house museums and other structures. Their nests and carcasses can attract many other kinds of pests that damage the collections. Some are museum pests as they can cause direct damage to collections through nesting and feeding behavior. Other pests, called perimeter invaders, do not eat collections but can indicate sanitation and moisture problems and areas where exclusion measures need to be implemented.

The following general pests are considered **museum pests**, as they will feed on museum collections:

- **Cockroaches** can present risks to museum items by feeding and defecating on items. They can present health risks to people in occupied structures. It is critical to identify the species of roach in order to develop an effective management strategy.
  - **German cockroaches** (*Blattella germanica*) are omnivorous, live indoors and are the most common cockroach found in the U.S. They feed on starches, sweets, grease, meat products, soap, leather, paper, glues, animal skins, and hair. They are especially attracted to objects stained with sweat. They damage objects through chewing and depositing various bodily fluids through fecal spotting and regurgitation. They prefer warm temperatures and are commonly found in kitchens. German cockroaches are the most prolific cockroach.
  - **Brown-banded cockroaches** (*Supella longipalpa*) feed on paper, starchy materials, furniture, clothing and cardboard. Adults are 1/2" long and light brown with two light brown horizontal stripes on the

back. These roaches prefer higher temperatures and drier areas. They are often found behind picture frames.

- **American cockroaches** (*Periplaneta americana*) feed on paper products as well as anything else available to them. They vary widely in size from 1 3/8" to 2 1/8" long and have reddish-brown wings with light markings around the perimeter.
- **Oriental cockroaches** (*Blattella orientalis*) feed on a wide variety of food and decaying organic matter and often damage or contaminate paper and starchy goods. They prefer moist environments and can live outdoors in mulch. Adult males are about 1" long and females about 1 1/4" long. They are usually shiny black but may vary to reddish-dark brown.
- **House crickets** (*Acheta domesticus*) commonly enter structures at the onset of cold weather. Like cockroaches, they are omnivorous and will eat protein and cellulosic materials. These include textiles (wool, silk, linen, and cotton), leather, animal skins and fur. They are attracted to stains.
- **Camel Back crickets** (*Ceuthophilus maculatus*) enter structures in extreme weather (excessive rain, extended heat) and are attracted to cool and humid environments. Although not generally considered a museum pest, these crickets can damage stored objects if the problem goes unchecked for some time and the crickets cannot find suitable food.

The following general pests are considered **perimeter invaders** because they can infest museums but will not eat collections objects:

- **Ants** are social insects, similar to termites and certain bees and wasps. They live in large cooperative groups or colonies consisting of queens, males and workers. The six most common ant species that infest structures are the pavement ant, thief ant, crazy ant, field ant, Pharaoh ant, and Argentine ant. Other than carpenter ants that damage wood, ants are not generally considered museum pests. However, many ants can damage wood, paper, glue, and other organic materials. Most are attracted to foodstuffs and may present health hazards. An ant problem indicates excess moisture and inadequate pest exclusion and sanitation.
  - **Odorous house ants** (*Tapinoma sessile*) eat a wide variety of human foods, particularly sweet food. They are dark brown to black and 1/8" long. Their name derives from the rotten coconut-like odor they emit when crushed. They nest in wall and floor voids and are attracted to warm, moist areas.
  - **Crazy ants** (*Paratrechina longicronis*) will feed on most human foods, though they prefer living and dead insects and seeds. They nest in floor voids and carpeting or next to structure foundations and are attracted to moist conditions. They are dark brown to black, 1/8" long and have long legs and antennae.
- **Spiders** are not considered museum pests but can be a risk to human

health and safety. Some medically dangerous spiders include the brown recluse spider, the widow spiders, and the aggressive house spider. Spiders may indicate problems with sanitation and exclusion. The presence of spiders may indicate the presence of other insect pests upon which they feed, and their webs can indicate where insects are entering the structure.

- **Scorpions** are not considered museum pests but are a hazard to human health and safety. They are most common in the Southwest but other species are found in Florida, Hawaii and the Southeast. The bark scorpion is the only type with a life-threatening sting; however, others are venomous.

**Action threshold** for general pests is the sighting of one larva or adult insect or any traces of the insect or damage to objects that indicate an active infestation. For management actions, refer to section F, Control Actions.

10. What kinds of health hazards can museum pests cause?

Mice and rats (commensal and native) are known to spread plague, typhus, rat-bite fever, lymphocytic choriomeningitis virus, trichinosis, salmonella food poisoning, tularemia, leptospirosis, endemic relapsing fever, Rocky Mountain spotted fever, and Q-fever. Rodent parasites, such as fleas and ticks, contribute to the spread of some of these diseases. Deer mice (*Peromyscus maniculatus*) are the most common transmitters of hantavirus, but the virus is also carried by the cotton rat (*Sigmodon hispidus*), rice rat (*Oryzomys palustris*) and white-footed mouse (*Peromyscus leucopus*). Refer to *COG 2/8* for more information. Microorganisms such as mold also present health risks to those with allergies. Spiders and scorpions can have poisonous bites. Bat and bird droppings are associated with histoplasmosis, psittacosis, and cryptococcus.

## H. Selected Bibliography

---

- Burke, John.: “*Anoxic Microenvironments: A Treatment for Pest Control.*” *Conserve O Gram* 3/9. National Park Service. 1999
- Cumberland, Barbara. “Museum Collection Integrated Pest Management Plan, Klondike Gold Rush National Historical Park-Seattle Unit.” National Park Service, 2009.  
<http://www.nps.gov/klse/parkmgmt/upload/KLSE-MUSEUM-COLLECTION-IPM-PLAN-draft-2009.pdf>
- Dawson, John. “The Effects of Insecticides on Museum Artifacts and Materials.” In *A Guide to Museum Pest Control*, edited by Lynda A. Zycherman and J. Richard Schrock, 135-150. Washington, D.C.: Association of Systematics Collections, 1988.
- Dawson, John, and Thomas J.K. Strang. “Solving Museum Insect Problems: Chemical Control.” *Technical Bulletin* 15 (1992). Ottawa: Canadian Conservation Institute.
- DiSalvo, Carol, Gerard Hoddenbach, Jerry Johnson. National Park Service Public Health Program. “Mechanical Rodent-Proofing Techniques: A Training Guide For National Park Service Employees.”  
[http://www.nps.gov/public\\_health/info/eh/vector/nps\\_rp\\_manual\\_v2.pdf](http://www.nps.gov/public_health/info/eh/vector/nps_rp_manual_v2.pdf)
- Eckstein Walli, Amanda and Joan Bacharach. “*Hantavirus Disease Health and Safety Update.*” *Conserve O Gram* 2/8. National Park Service. 2014. <http://www.nps.gov/museum/publications/consereogram/02-08.pdf>
- Florian-Mary-Lou. *Heritage Eaters; Insects & Fungi in Heritage Collections*. London: James & James, 1997.
- Geiger, Chris A. and Caroline Cox. “Pest Prevention by Design: Authoritative Guidelines for Designing Pests Out of Structures.” San Francisco Department of the Environment, 2012.  
[http://www.sfenvironment.org/sites/default/files/fliers/files/final\\_ppbd\\_guidelines\\_12-5-12.pdf](http://www.sfenvironment.org/sites/default/files/fliers/files/final_ppbd_guidelines_12-5-12.pdf)
- IPM Working Group. Museumpests.net. <http://museumpests.net/>
- Klein, Denise. “Identifying Museum Insect Pest Damage.” *Conserve O Gram* 3/11. National Park Service, 2008.  
<http://www.nps.gov/museum/publications/consereogram/03-11.pdf>
- Mallis, Arnold. *Handbook of Pest Control*. Sixth Edition. Cleveland: Franzak and Foster, 1990.
- Merritt, Jane. “*Mold: Prevention of Growth In Museum Collections.*” *Conserve O Gram* 3/4. National Park Service, 2007 <http://www.nps.gov/museum/publications/consereogram/03-04.pdf>
- National Park Service. “Guidelines for the Handling of Pesticide Contaminated Collections.” *Conserve O Gram* 2/19. 2002. <http://www.nps.gov/museum/publications/consereogram/02-19.pdf>
- \_\_\_\_\_. Biological Resources Management Division. “Integrated Pest Management.”  
<http://www1.nrintra.nps.gov/BRMD/ipm/> (Available on NPS intranet)
- \_\_\_\_\_. Biological Resources Management Division. “Integrated Pest Management Manual.”  
<http://www.nature.nps.gov/biology/ipm/manual/ipmmanual.cfm>
- \_\_\_\_\_. Biological Resources Management Division. “Policy, Guidance, & Common Pest Issues.”  
<http://www1.nrintra.nps.gov/BRMD/ipm/policy.cfm> (Available on NPS intranet)
- \_\_\_\_\_. Biological Resources Management Division. “Rodent Management.”  
<http://www1.nrintra.nps.gov/BRMD/ipm/rodent.cfm> (Available on NPS intranet)

- Pinniger, David B. *Insect Pests in Museums*. London: Archetype, 1994.
- \_\_\_\_\_. *Pest Management in Museums, Archives and Historic Houses*. London: Archetype, 2001.
- \_\_\_\_\_. "Managing Insect Pests: Alternatives to Pesticides." *Conserve O Gram* 3/8. National Park Service, 1998. <http://www.nps.gov/museum/publications/consveogram/03-08.pdf>
- Strang, Thomas J. K. "Preventing Infestations: Control Strategies and Detection Methods." *CCI Notes* 3/1. Canadian Conservation Institute, 1996. <http://www.cci-icc.gc.ca/resources-ressources/ccinotesicc/3-1-eng.aspx>
- \_\_\_\_\_. "Controlling Insect Pests with Low Temperature." *CCI Notes* 3/3, Canadian Conservation Institute. 1997. <http://www.cci-icc.gc.ca/resources-ressources/ccinotesicc/3-3-eng.aspx>
- \_\_\_\_\_. "Detecting Infestations: Facility Inspection Procedure and Checklist." *CCI Notes* 3/2. Canadian Conservation Institute, 1996. <http://www.cci-icc.gc.ca/resources-ressources/ccinotesicc/3-2-eng.aspx>
- University of Minnesota. Radcliffe's IPM World Textbook. 2011. <http://ipmworld.umn.edu/>
- Webb, Jane Thompson and David Pinniger. "What's Eating Your Collection?" Birmingham Museums and Collections Trust. <http://www.whatseatingyourcollection.com/>

## I. List of Figures

---

Figure 5.1 Recommended Freezer Temperature and Duration of Freezing Cycles.....	5:6
Figure 5.2 Sample Museum IPM Plan.....	5:47
Figure 5.3 Sample Object Pest Incident Report (blank) .....	5:58
Figure 5.4 Sample Object Pest Incident Report (completed) .....	5:59
Figure 5.5 Sample Freezer Treatment Record (blank) .....	5:60
Figure 5.6 Sample Freezer Treatment Record (completed) .....	5:61
Figure 5.7 Sample Pest Trap and Evidence Monitoring Log (blank) .....	5:62
Figure 5.8 Sample Pest Trap and Evidence Monitoring Log (completed) .....	5:63
Figure 5.9 Sample Pest Monitoring Database Report (blank).....	5:64
Figure 5.10 Sample Pest Monitoring Database Report (completed).....	5:65
Figure 5.11 Sample Floor Plan with Trap Locations.....	5:66
Figure 5.12 Sample Pest Identification Request Letter (blank).....	5:67
Figure 5.13 Sample Action Plan (blank).....	5:68
Figure 5.14 Sample Action Plan: Dermestid Beetles .....	5:69
Figure 5.15 Sample Action Plan: Clothes Moths .....	5:71
Figure 5.16 Sample Action Plan: Powderpost Beetles .....	5:73
Figure 5.17 Sample Action Plan: Stored Product Pests.....	5:75
Figure 5.18 Sample Action Plan: Silverfish .....	5:77
Figure 5.19 Sample Action Plan: Springtails.....	5:79
Figure 5.20 Sample Action Plan: Psocids.....	5:81
Figure 5.21 Sample Action Plan: Molds and Fungi .....	5:83
Figure 5.22 Sample Action Plan: Mice and Rats.....	5:85

## Sample Museum IPM Plan

Prepared by:	_____	_____
	Title	Date
Recommended by:	_____	_____
	Park Curator	Date
Approved by:	_____	_____
	Superintendent	Date
Concurred by:	_____	_____
	IPM Coordinator	Date
Concurred by:	_____	_____
	Chief, Facilities Management	Date
Concurred by:	_____	_____
	Public Health/Industrial Hygienist	Date

**Figure 5.2 Sample Museum IPM Plan**

## Table of Contents

- A. Introduction and Objectives**
- B. Statutes and Mandates**
- C. Background and Site Description**
  - Collections Storage Facility
  - Furnished Historic Structure
  - Visitor Center/Museum
- D. Staffing Responsibilities**
- E. Preventive Pest Management**
  - Inspection and Monitoring
    - Routine Inspection of Structure/Area(s) Housing Collections
    - Routine Inspection of Objects in Storage and on Exhibit
    - Routine Inspection and Isolation of Incoming Objects
    - Pest Trapping Program
  - Documentation
  - Environmental Monitoring
  - Housekeeping
- F. Pest Identification and Action Thresholds**
- G. Control Actions**
  - Exclusion
  - Eliminating Food
  - Eliminating Moisture
  - Eliminating Harborage
  - Habitat Modification
- H. Actions if Pests are Found**
  - Responding to Infestations
  - Treatments for Infested Objects
    - Cleaning
    - Freezer Treatment
    - Anoxic Treatment
    - Fumigation/Pesticides
- I. Evaluating the IPM Plan**
- J. Action Plans**

**Figure 5.2 Sample Museum IPM Plan** (continued)

## A. Introduction and Objectives

This Museum Integrated Pest Management (IPM) plan was developed to protect collections from museum pests. Museum IPM is essential to eliminating conditions that support pests. It uses a variety of techniques to exclude pests in areas that house collections, including preventive maintenance, effective housekeeping, and mechanical and cultural control actions. Ongoing evaluation is critical to determining the effectiveness of the plan. The plan may be modified based on the results of the evaluation.

The objectives of the museum IPM plan are to:

- Eliminate, reduce, or prevent the presence of pests and pest damage in areas housing collections by modifying human behavior to eliminate food, water, harborage and environmental conditions that support pests.
- Eliminate, reduce or prevent the presence of pests in areas housing collections through proper design of the structure, storage and exhibit areas, and exterior landscaping.
- Reduce pesticide use in collections.
- Define the roles and responsibilities of staff in relation to museum IPM and housekeeping duties.
- Ensure that all staff, including those who do not have specific assigned IPM roles, understands park management objectives, and their roles and responsibilities in implementing IPM.
- Establish a comprehensive inspection and monitoring program and action thresholds.
- Document control actions, inspection, and monitoring, and include the date and person who implemented the action.
- Evaluate the effectiveness of the IPM program and modify the plan based on evaluation results as necessary.

## B. Statutes and Mandates

All actions outlined in this plan are in accordance with the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), 7 U.S.C 136-136y; the Federal Code of Regulations (40 CFR); President Carter's 1979 Integrated Pest Management Memorandum from the President; Department of the Interior *Departmental Manual (DM)*, Part 517, Chapter 1, Integrated Pest Management Policy; *DM*, Part 411, Museum Property Management; [Director's Order \(DO\) #24 4.3.9](#), Integrated Pest Management; National Park Service (NPS) *Management Policies* (2006); NPS - 77 Natural Resources Management Guideline; and the NPS *Museum Handbook, Part I*, Museum Collections.

## C. Background and Site Description

The park's museum collections are housed in various locations and structures in the park; a storage facility, furnished historic structure, and on exhibit in the visitor center/museum. The structures are composed of different material and have different modifications that exclude pests. All areas housing museum collections are regularly inspected and monitored for evidence of pests, areas of potential pest access and attraction, moisture problems, and identification of susceptible objects. Dataloggers are used to monitor temperature and RH in each structure. Excess moisture is a major contributor to potential pest problems so the RH must never exceed 65%. The RH has fluctuated seasonally in the past but has not exceeded 65%. The park has a *Housekeeping Plan for Museum Collections* (2012) and *Collections Management Policy (CMP)* (2012) that document IPM activities.

- **Collections Storage Facility**

The collections storage facility is constructed of metal and brick with a pitched roof and a concrete pad floor. It is a standalone, purpose-built structure consisting of one floor with two exterior doors and no windows. Maintenance staff collects all garbage and vacuums the floors with vacuums fitted with HEPA filters. Curatorial staff performs all other housekeeping and cleaning tasks. The collections are housed in well-sealed museum-quality metal cabinets.

- **Furnished Historic Structure**

The furnished historic house, built in the early 20<sup>th</sup> century, is constructed of a cement block and stone

**Figure 5.2 Sample Museum IPM Plan** (continued)

foundation with a slate shingle roof. A steel frame supports the brick walls. There are three exterior doors and several single pane sash windows on both floors. The floors are a mix of original hard wood and carpet. Maintenance staff collects garbage and vacuums with HEPA filters daily. Curatorial staff performs all other housekeeping and cleaning duties. Rooms on the first and second floor are fully furnished with original furnishings, and are on view by the public on self-guided tours. Museum objects are on open display and are not enclosed in cases. A large yard with several trees and garden plots surrounds the structure.

- **Visitor Center/Museum**

The Visitor Center/Museum is an adapted concrete block structure. Maintenance staff collects trash and vacuums with HEPA filters daily. There are nine exhibit cases in the museum area. The exhibit room is carpet over concrete, with drywall and plaster ceilings and walls.

#### **D. Staffing Responsibilities**

The individuals noted below are responsible for the development and implementation of this museum IPM plan:

- *Superintendent* has ultimate responsibility for the park and museum IPM programs and ensures sufficient staffing, training, and funding to effectively implement and maintain a pro-active museum IPM program.
- *Park curator* is responsible for the care of the collections, monitoring for pests in all spaces containing collections, and implementing the museum IPM plan.
- *Park IPM coordinator* establishes pest management priorities for the park, approves or denies proposed pesticide use, assists the museum curator with prevention, detection, and management of potential and current pest problems, periodically reviews museum pest monitoring reports, educates staff to detect evidence of pest infestations, and if necessary, consults with the park natural resources staff.
- *Regional IPM coordinator* is responsible for alerting park IPM coordinators of new pest issues and technology, approves or denies proposed pesticide applications on a case-by case basis and-serves as the liaison between the park and the service-wide IPM coordinator in providing IPM training and information to develop management strategies.
- *Maintenance staff* is trained in recognizing the potential signs of pests and contacts the Park IPM Coordinator and curatorial staff if signs of museum pests are detected. Schedules routine maintenance of, and upgrades to structures housing collections, in consultation with park curatorial staff.
- *Park safety officer* is consulted for public health issues and any proposed pesticide use. The park safety officer is aware of what pesticides are being proposed for use in the museum and who is using them and ensures that they are used safely.

All staff working in and around museum collections are responsible for adhering to IPM practices such as prohibiting food in collections areas.

#### **E. Preventive Pest Management**

- **Monitoring and Inspection**

Monitoring shows trends in pest activity and allows you to prioritize your management efforts. It allows you to systematically and continuously keep track of all pest activity in collections areas, through routinely inspecting spaces and objects, establishing a pest trapping program to detect pest activity and thoroughly documenting all infestations. Monitoring also tracks by date; housekeeping, modifications on the structure and other activities that

**Figure 5.2 Sample Museum IPM Plan** (continued)

may affect pest occurrences. Inspection includes close examination of spaces and objects for any evidence of an infestation and is a critical part of pest monitoring programs. Inspecting and monitoring for pests and monitoring the environment and human use of it provides quantitative and qualitative information important to preventing infestations. Staff conducts the steps outlined below to monitor for pests.

– **Routine Inspection of Structure(s)/Area(s) Housing Collections**

Schedule routine inspections of all areas housing collections. Do a regular and thorough search of the entire structure containing collections at least once every six months. Inspect all doorways and hallways with outside access as well as windowsills monthly. When using an insect sticky trap program, inspect traps weekly.

Inspect for evidence of museum pest infestations. Search the collections areas and objects for:

- Discovery of flying adult or crawling larval insects
- Moth or beetle pupae
- Pupal tubes or cases
- Insects captured in traps or in ceiling light fixtures
- Chewing or gnawing marks
- Feeding or exit holes
- “Grazed” surfaces
- Presence of feeding debris or fecal pellets/droppings/frass (insect waste, which is usually a soft powdery material) around or below objects
- Presence of frass falling from voids (ceiling tiles, electrical switch plates, etc.)
- Shed/cast skins
- Webbing
- Nest/burrows
- Food caches
- Flyspecks
- Hair falling from fur or pelts
- Missing pile from rugs
- Rodent smudge/grease marks
- Odors or sounds infested or damaged food or food packaging
- Bait consumption

Inspect for pests in the following common harborage sites:

- Areas inside and under drawers, cabinets, and furniture
- Attics and store rooms where rodents or other pests may have made food caches
- Above drop ceilings, and inside elevator shafts and light fixtures
- Fireplaces and chimneys
- Inside electrical equipment and motors (including computers)
- Entry points into the structure and into areas housing collections, such as window sills and door jambs
- Near water sources such as drains and sinks
- Doorways and hallways with outside access
- In stored cardboard or wooden pallets housing collections
- Behind baseboards or wall trim and in inaccessible wall voids which could hold dead animal carcasses. Maintenance staff does this in consultation with a historic architect.

Use these tools for inspections:

- Flashlight
- Magnifying glass
- Nitrile gloves
- Tape measure
- Camera
- Screwdrivers
- Step ladder

**Figure 5.2 Sample Museum IPM Plan** (continued)

- Mirror to view up chimneys
- Sticky labels or marker for numbering traps
- Long wave UV black light (requires protective eyewear)
- Dust mask (NIOSH-approved disposable filtering facepiece respirator with two straps. The park safety officer may require that you wear a respirator for inspections involving mold, bird or bat droppings, or heavy dust. If a respirator is needed, the user must be in a respiratory protection program. For inspections involving rodent infestations, see [COG 2/8: “Hantavirus Disease Health and Safety Update”](#)).
- Talc (sprinkle on expected rodent pathways, such as against floorboards to detect rodent tracks in rooms not open to the public to indicate mice activity. For use in an historic structure, sprinkle talc onto Mylar®. As talc may be a respiratory hazard, consult with the safety officer before using).

Create a separate tool kit for inspections involving rodents. See *COG 2/8* for more information.

Record any evidence of pests found in spaces housing collections, such as food caches, frass or rodent smudge marks, in Figure 5.7, Sample Pest Trap and Evidence Monitoring Log. Complete a Pest Incident Report, Figure 5.3, with the discovery of any pests, damage, or pest evidence on museum objects. Keep one copy of the Pest Incident Report in the Museum IPM Binder and one copy with the accession or catalog folder.

– **Routine Inspection of Objects in Storage and on Exhibit**

Routinely inspect collections objects on exhibit and in storage for the signs of pest infestations described above. Do spot checks every six months in collections areas in and around objects. Spot check biological, natural history, and ethnographic objects every three months. Document all findings and complete a Sample Pest Incident Report (blank), Figure 5.3, if pest evidence is found on objects.

– **Routine Inspection and Isolation of Incoming Objects**

Inspect and isolate all incoming objects, including new and returning loans, for possible pest infestations or microorganisms before they enter the collections storage or exhibit areas.

- Upon receiving the objects, immediately place them in the isolation room for inspection and isolation.
- Locate the isolation room adjacent to the shipping and receiving area. Do not locate it within the collections area. The isolation room must be well sealed and have good lighting. If this is not possible, isolate objects in a well-sealed cabinet outside of the collections area.
- Inspect objects using good lighting and magnifying lenses on a table with a white surface (or over white paper) where any fallen insects, frass, etc. can be readily noticed.
- Examine the underside of furniture and pallets for webbing and insect eggs.
- Inspect wooden objects for exit holes of wood-boring insects.
- Use a UV black light in the dark to detect some kinds of mold on objects. Place objects with evidence of mold in a lidded cardboard box and isolate them.
- Isolate all objects for at least one month before they enter collection areas. Living pests can usually be detected within this period. However, insect eggs can be dormant for years depending on the species. Mold can also lie dormant. The exception is objects made of metal, glass, ceramic, or stone, which need to be inspected but not isolated. Consult the regional curator, conservator, IPM manager or entomologist to determine the appropriate isolation period.
- Re-inspect objects for signs of an infestation throughout the isolation period.

**Figure 5.2 Sample Museum IPM Plan** (continued)

- If pests or evidence of pests are found during inspection, follow the steps listed in “responding to Infestations” in Section H below. Remove pest evidence by vacuuming it off with a HEPA filter. Treat potentially infested objects with a freezer treatment, mechanical cleaning, or other appropriate method.
- Similarly handle non-collection materials such as packing materials and exhibit construction materials but house these separately from collection areas. Immediately discard any packing materials that cannot be verified as pest-free, such as cardboard, in an exterior garbage container.

– **Pest Trapping Program**

Physical controls such as traps include insect sticky traps, rodent snap traps, light traps, and pheromone traps. Inspect traps monthly under normal circumstances, and every one to two weeks when infestations are present or suspected. Inspect rodent snap traps daily. Replace traps every few months. Record the following information for each trap:

- Trap number
- Trap location
- Inspection date
- Pest species
- Number of individuals per species found in the trap
- Life stage of the species, unusual conditions and replacement date for the trap and other useful information
- Photographs of unidentifiable species

Refer to the schematic diagram of the building housing collections and for each numbered trap. Record data about pests found in each trap on a trap monitoring log. See Figure 5.11, Sample Floor Plan with Trap Locations, and Figure 5.7, Sample Pest Trap and Evidence Monitoring Log (blank).

Locate traps in collection and non-collection areas:

- Along perimeter walls
- In corners
- Near doors
- Near windows and other light sources
- Under storage and other furniture
- Near water sources
- Near drains
- Near heat sources
- Inside and outside exhibit and storage cabinets
- Near objects out in the open or that are pest susceptible

When using rodent snap traps, place two traps at each trap station parallel with the wall, or place a single trap with its trigger end against the wall. Locate trap stations every six to ten linear feet along walls and runways used by rodents. Place traps behind objects, under furniture, against walls, or in other locations where rodents find concealment. Bait all rodent snap traps with peanut butter or cotton tied to trap’s trigger to catch and control pests. Note that snap traps are also effective without bait.

Regularly empty all types of traps so they do not attract other pests.

– **Documentation**

Retain all IPM inspection and monitoring records permanently in the following:

- **IPM Binder:** file all related data, including printouts of pest monitoring data, environmental monitoring reports correlating to pest monitoring reports, Pest Incident Reports, Freezer Treatment Records, site inspection worksheets, copies of Pesticide Use Proposal forms, annual pesticide use logs, dated control

### Figure 5.2 Sample Museum IPM Plan (continued)

actions records (such as pesticides, exclusion improvements, freezer treatment, or anoxic treatment), Material Safety Data Sheets (MSDS), pest identification documentation, and pertinent contacts.

- **Catalog record:** records information about a specific object and its history of pest problems and associated treatments.
  - **IPM information system:** includes pest monitoring data, including the species and quantity of pest caught, trap location, type of trap, and date of the catch. Information is recorded in an electronic format such as a computer database or a hard copy such as a paper log. See Figure 5.10, Sample Pest Monitoring Database Report (completed) and Figure 5.8, Sample Pest Trap and Evidence Monitoring Log (completed).
  - **NPS Intranet Pesticide Use Proposal System (PUPS) database:** propose/request the use of pesticides and annually report the park's Pesticide Use Log. The system is accessible at: <https://irma.nps.gov/PUPS/>
- **Environmental Monitoring**  
Correlate museum environmental monitoring data with pest monitoring data to determine if environmental conditions are causing pest problems. Note extremes in RH and temperature. Compare pest monitoring data with exterior weather conditions, as extreme conditions can drive pests indoors. Compare trends in pests, especially moisture-indicating ones (such as silverfish, booklice, and springtails) with information from the datalogger records as monitoring continues.
- **Museum Housekeeping**  
The IPM plan is an integral part of the museum housekeeping plan. The housekeeping plan outlines scheduled cleaning of the collections and non-collections areas and also outlines policies and procedures to limit pest infestations such as food and plant restrictions.

### F. Pest Identification and Injury and Action Thresholds

Identify and document species as specifically as possible (genus, species). Maintain a reference collection of dead pests for identification purposes. Encourage maintenance staff to bring pests to curatorial staff labeled with the date, time, and exact location of catch. Record all finds in the computer database or paper log. See the documentation section above for more information. Create action plans for pests as appropriate.

The action threshold is the point at which pest levels indicate that collections will be damaged if action is not taken.

**The action threshold for organisms identified as “museum pests” is the sighting of one larva or adult museum pest, any traces of the pest, or damage to objects that indicate an active infestation.** When action thresholds are exceeded, proceed with control actions.

### G. Control Actions

Pest control methods rely on good exclusion, housekeeping, reductions in harborage available to pests, and continual trapping. These usually eliminate the need for pesticides. These include cultural and mechanical control actions, described below.

#### • Exclusion

Exclusion is critical and extremely effective. Pest entryways may be as small as hairline cracks in walls or as large as gaps under a door, holes around pipe traces, uncapped chimneys, open doors, or the complete absence of screens on windows. Entry holes for rodents can be as small as 1/4" in diameter.

Correct exclusion deficiencies by sealing through:

- caulking
- carpentry repairs
- door sweeps
- gaskets

### Figure 5.2 Sample Museum IPM Plan (continued)

- screens
- filters on air vents and hot air registers

Use sealant such as:

- caulk
- cement
- urethane expandable foam
- copper wool
- copper mesh
- other suitable sealant

#### • **Eliminating Pest Food Sources**

Work with staff to ensure that all cultural controls relating to eliminating pest food are followed. Ensure that staff is aware of the policies relating to food and drink in structures housing collections.

- Be alert to possible sources of food available to pests throughout the building while performing inspections.
- Regularly inspect wall voids, attics and interiors of suspended ceilings for possible food sources.
- Regularly check attics for dead insects or animal carcasses. Promptly remove and properly dispose of pests and their traces.
- Remove all possible sources of pest food materials, including decorative live plants, live flowers, food, and dirt. Do not allow live or potted plants in structures containing museum collections. Use artificial plants and flowers.
- Do not allow any food into areas housing collections. Designate an area away from collections where staff can eat, such as a break room. Keep all food sealed in containers with lids.
- Properly dispose of trash in sealed containers and remove from building daily, including trash from staff offices and break rooms.

#### • **Eliminating Moisture**

- Identify and concentrate inspections on sources of dampness that may attract microorganisms, fungus feeding beetles, flies, mites, silverfish, booklice, springtails, and other pests.
- Promptly repair plumbing, sewer, roof, window, and building leaks.
- Insulate cold water pipes to prevent the formation of condensation.
- Correct sub-floor moisture problems by increasing ventilation or by placing moisture barriers beneath buildings, if appropriate, in consultation with the facilities manager and a historic architect.
- Correct poor drainage slopes away from the building in collaboration with maintenance staff.
- Maintain a stable RH and temperature with an allowable seasonal drift in areas housing collections. Keep spaces cool and dry (below 65% RH). See *MH-I*, Museum Collections Environment, Chapter 4 for more information on environmental controls.

#### • **Eliminating Harborage**

Work with facilities management and a historic architect where appropriate to find ways to eliminate harborage.

- Remove clutter and debris from areas housing museum collections.
- Move boxes and other items stored on floors to shelving and cabinets and keep them neatly arranged.
- Establish an 18 - 30" wide vegetation-free zone of gravel four inches deep around buildings that house museum collections to create a hostile environment for pests. This may not be appropriate for some historic structures. Work with facilities management to find an alternative solution.
- Keep area next to building foundations free of grass and bushes and trim back tree and shrub limbs that provide shelter and food for insects and other animals or serve as “vegetation ladders.” Work with facilities management to find an appropriate solution for historic structures.

- Promptly remove bird and insect nests from building exteriors.

**Figure 5.2 Sample Museum IPM Plan** (continued)

- Eliminate any animal burrows under buildings that house museum collections.
- Remove piles of wood, stone, building materials, trash, and other material near structures housing collections.
- Work with facilities management to fill low spots in the ground that accumulate water run-off, and eliminate other water-holding sources.
- Keep the areas around garbage dumpsters clean. Regularly remove garbage and immediately clean up spills.

- **Habitat Modification**

- Deny birds roosting or nesting opportunities on or against structures that house museum collections.
- Mount outside lights 30 or more feet from structures housing museum collections rather than mounting on structures to prevent pests from being attracted towards the lights.
- Use high-pressure sodium vapor lamps around buildings that attract fewer insects and are more energy efficient.

## **H. Actions if Pests are Found**

- **Responding to Infestations**

Follow the steps noted below to stop an infestation and prevent it from recurring.

- Document what, where and when you see signs of pest activity immediately.
- Isolate the infested object immediately. Wearing gloves, place infested object in a well-sealed plastic bag and double bag. **Never** carry infested objects through the collection without thoroughly isolating them as eggs or larvae can be accidentally dropped and the infestation spread. Move the infested object to an isolation room outside of the collections area.
- Determine the extent of the infestation. Start at the location where the first infested object was found and inspect the collections/areas in ever widening circles. Immediately isolate additional infested objects as they are found and document the findings.
- Identify the pests and pest traces.
- Clean the area surrounding the removed infested object.
- Clean the object.
- Determine object treatment options in consultation with a conservator. Document the treatment.
- After treatment, determine how long to isolate the object before returning to storage or exhibit.
- Determine the source of the infestation. Collaborate with appropriate staff to address the problem.
- Increase inspection and monitoring of the area to confirm that you have eliminated the infestation.

**Note: Do not follow these procedures if there is a mouse or rat infestation.** Follow the procedures listed in *COG 2/8* to avoid risk of hantavirus.

- **Treatment for an Infested Object**

Before treatment, identify the pest to determine that it is a museum pest and will cause damage to museum objects. Contact the park IPM coordinator for assistance.

- **Cleaning:**
  - Remove all traces of the pest from the object. Dead pests, larval skins, and nests can attract other pests.
  - If an infestation is limited to a single object and has not progressed too far, careful vacuuming with HEPA filters may remove the problem. Before cleaning, ensure the structure of the object can withstand the stress of vacuuming. Use screening material on the HEPA attachment/tube when vacuuming museum objects. Cleaning will probably not remove all eggs, as some can be microscopic. Review the pest's biology and focus efforts on areas where eggs are likely to be deposited. Remove the vacuum bag from the building immediately so it does not become a source of new infestations. After cleaning, determine if further isolation time is needed.

### Figure 5.2 Sample Museum IPM Plan (continued)

- Determine the life cycle of the pest and monitor the object until you are sure no more insects will hatch. Use this method to clean old or non-active infestations.

**Note:** When addressing a mouse or rat infestation, **do not sweep or vacuum**, as this increases the risk of transmission of hantavirus.

– **Freezer Treatment, also called low temperature treatment:**

- Freezing is the method of choice for treating most active infestations of objects.
- However, certain materials can be significantly damaged by freezing. Consult a conservator to determine what materials are appropriate for freezing.
- See [COG 3/6: “An Insect Pest Control Procedure: The Freezing Process”](#) for procedures and further information.

– **Anoxic Treatment:**

- Replacing the oxygen with a gas (nitrogen, argon, carbon dioxide) or using an oxygen scavenger/absorber in a closed space can kill insects and their eggs.
- Consult a conservator to determine if the anoxic treatment is appropriate.
- See [COG 3/8: “Controlling Insect Pests: Alternatives to Pesticides”](#), and [COG 3/9: “Anoxic Microenvironments: A Treatment for Pest Control”](#) for more information.

– **Fumigation/Pesticides:**

- **Consult with the regional curator, the park IPM and a conservator when considering any fumigation or pesticide options.**
- **All pesticide use must be approved PUPS.**
- Conventional chemical fumigation is only appropriate if objects cannot be treated by other means, and is rarely recommended.
- In the event fumigation is needed, work a professional applicator. Do not use space fumigants such as naphthalene, paradichlorobenzene, dichlorvos (Vapona, DDVP, No Pest strips), or thymol.
- **Do not use pesticides directly on museum objects.** Persistent pesticides may leave residuals on objects and cause damage, and/or be a health risk.
- Document any pesticide use through PUPS.

### I. Evaluating the Museum IPM Plan

- Evaluate the effectiveness of the IPM plan through ongoing monitoring and evaluation of all documentation, including comparison of year-to-year and month- to-month inspection, monitoring, and trapping records.
- Review the environmental monitoring data to see if the control actions have successfully changed the environment.
- Evaluate implemented control actions on an ongoing basis to determine if they have been effective. For example, review exclusion actions and determine if the building envelope is adequately sealed by determining if pests are still entering the structure. If so, reevaluate and improve your exclusion methods to ensure that no pests will enter the structure.
- Determine if you have met the objectives stated in the IPM plan. Use this information to guide future pest management measures.
- Modify the IPM plan as necessary, based on the evaluation results.

### J. Action Plans

Include an action plan for each relevant pest. Pest photographs or drawings may be included.

**Figure 5.2 Sample Museum IPM Plan (continued)**

**National Park Service  
Sample Object Pest Incident Report**

Object: \_\_\_\_\_  
 Catalog Number: \_\_\_\_\_  
 Materials: \_\_\_\_\_  
 Affected area of object: \_\_\_\_\_  
 Object Location: \_\_\_\_\_  
 Building Number: \_\_\_\_\_  
 Date: \_\_\_\_\_  
 Responsible Individual: \_\_\_\_\_

**Pest Observation**

Number of pests observed: \_\_\_\_\_  
     Living: \_\_\_\_\_  
     Dead: \_\_\_\_\_

Identification source: \_\_\_\_\_

ant	fungus/mold	springtail
cigarette beetle	mouse	termite
clothes moth	powderpost beetle	other:
cockroach	psocid	other:
cricket	rat	unidentified
dermestid beetle	silverfish	unidentified
fly	spider	unidentified

**Evidence Observation**

chewing	exit holes	missing rug piles	other:
carcasses	flyspecks	odor	other:
casings	frass	pest body parts	other:
cast skins	grazed surfaces	staining	other:
droppings	live insect/larvae	tunnels	other:
eggs	losses	webbing	other:

**Control Action Taken**

Control action	Description
anoxic treatment	
follow-up inspection (list frequency)	
freezer treatment	
isolation	
mechanical cleaning	
other:	

**Description/Comments**

\_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

Figure 5.3 Sample Pest Incident Report (blank)

**National Park Service  
Sample Object Pest Incident Report**

Object: Hat  
 Catalog Number: PARK2014  
 Materials: Wool  
 Affected area of object: Interior, brim  
 Object Location: Collections Storage, Cabinet 3, drawer 5  
 Building Number: 1  
 Date: 9/1/2014  
 Responsible Individual: Jane Smith, Curator

**Pest Observation**

Number of pests observed: 1  
 Living: 0  
 Dead: 1

Identification source: Park reference collection

	ant		fungus/mold		springtail
	cigarette beetle		mouse		termite
	clothes moth		powderpost beetle		other:
	cockroach		psocid		other:
	cricket		rat		unidentified
X	dermestid beetle		silverfish		unidentified
	fly		spider		unidentified

**Evidence Observation**

	chewing		exit holes		missing rug piles		other:
X	carcasses		flyspecks		odor		other:
	casings	X	frass		pest body parts		other:
	cast skins	X	grazed surfaces		staining		other:
	droppings		live insect/larvae		tunnels		other:
	eggs		losses		webbing		other:

**Control Action Taken**

	Control action	Description
	anoxic treatment	
X	follow-up inspection (list frequency)	Inspect in 3 months
X	freezer treatment	One week at -4°F, 9/1/14-9/7/14
X	isolation	9/7/2014-10/7/2014
X	mechanical cleaning	Insect was removed, object was vacuumed
	other:	

**Description/Comments**

Carcass of a black carpet beetle discovered in interior of hat brim, hat has grazing damage and frass present. Object was bagged and moved to isolation room, conservator was consulted and determined that object should be given freezer treatment. Object was isolated in isolation room for one month following freezer treatment. Inspection following the isolation period revealed no further pests.

**Figure 5.4 Sample Pest Incident Report (completed)**

**National Park Service  
Sample Freezer Treatment Record**

Object: \_\_\_\_\_  
 Catalog Number: \_\_\_\_\_  
 Materials: \_\_\_\_\_  
 Pest: \_\_\_\_\_  
 Object Location: \_\_\_\_\_  
 Building Number: \_\_\_\_\_  
 Date: \_\_\_\_\_  
 Responsible Individual: \_\_\_\_\_

**Freezer**

Brand name of freezer: \_\_\_\_\_  
 Temperature reached during treatment: \_\_\_\_\_  
 Time in freezer (calculate based on freezer temperature, object size, materials, and packaging): \_\_\_\_\_

**Procedures**

**1. Freezing Process**

Wrapped in tissue paper and bagged?	
Date/time in	
Date/time freezer temperature reached	
Date/time out	
Total hours in	

**2. Thawing Process**

Object left in packaging?	
Temperature of isolation room	
Total time warmed to room temperature (minimum 24 hours)	

**3. Isolation/Observation**

Dates object isolated for	
Object inspected	
Additional pests observed?	

**4. Follow Up**

Pest Incident Report completed?	
Object Cleaning	

**Comments**

\_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

**Figure 5.5 Sample Freezer Treatment Record (blank)**

**National Park Service  
Sample Freezer Treatment Record**

Object: Hat  
 Catalog Number: PARK2014  
 Materials: Wool  
 Pest: Black carpet beetle  
 Object Location: Collections Storage, Cabinet 3, drawer 5  
 Building Number: 1

Date: 9/1/2014  
 Responsible Individual: Jane Smith, Curator

**Freezer**

Brand name of freezer: X Brand chest freezer  
 Temperature reached during treatment: - 4°F  
 Time in freezer (calculate based on freezer temperature, object size, materials, and packaging): 7 days

**Procedures**

**1. Freezing Process**

Wrapped in tissue paper and bagged?	Yes
Date/time in	9/1/2014, 9:00 AM
Time freezer temperature reached	9/1/2014, 11:00 AM
Date/Time out	9/7/2014, 11:00 AM
Total hours in	168 (7 days)

**2. Thawing Process**

Object left in packaging?	Yes
Temperature of isolation room	70°F
Total time warmed to room temperature (minimum 24 hrs)	24 hours

**3. Isolation/Observation**

Dates object isolated for	9/7/2014 – 10/7/2014
Object inspected	Yes, weekly
Additional pests observed?	No

**4. Follow Up**

Pest Incident Report completed?	Yes
Object Cleaning	Insect removed, object vacuumed

**Comments**

Carcass of a black carpet beetle discovered in interior of hat brim, object was bagged and moved to isolation room. Conservator was consulted and determined that object should be given freezer treatment. Object was placed in X Brand freezer at - 4°F for one week. Object was isolated in isolation room for one month following freezer treatment. Inspection following the isolation period revealed no further pests.

**Figure 5.6 Sample Freezer Treatment Record (completed)**  
**National Park Service**  
**Sample Pest Trap and Evidence Monitoring Log**

Date Traps Set: \_\_\_\_\_ Date Traps Inspected: \_\_\_\_\_

Space Housing Museum Collections: \_\_\_\_\_

Building Number: \_\_\_\_\_ Exhibit Space: \_\_\_\_\_ Storage Space: \_\_\_\_\_

Name and Title of Inspector: \_\_\_\_\_

List number of each type of pest present in the trap.

<b>Trap number:</b>	#	#	#	#	#	#	#	#
<b>Location:</b>								
ant								
cigarette beetle								
clothes moth								
cockroach								
cricket								
dermestid beetle								
fly								
fungus/mold								
mouse								
powderpost beetle								
psocid								
rat								
silverfish								
spider								
springtail								
termite								
other:								
other:								
unidentified								
<b>Total pests:</b>								

**Pest Evidence Observation**

	<b>Evidence</b>	<b>Location</b>		<b>Evidence</b>	<b>Location</b>
	bait consumption			live insect/larvae	
	carcasses			nests/burrows	
	casings			odor	
	cast skins			pest body parts	
	droppings			rodent smudges	
	food caches			sounds	
	frass			webbing	
	infested food			other:	

**Comments**

\_\_\_\_\_

\_\_\_\_\_

**Figure 5.7 Sample Pest Trap and Evidence Monitoring Log (blank)**  
**National Park Service**  
**Sample Pest Trap and Evidence Monitoring Log**

Date Traps Set: 8/26/2014 Date Traps Inspected: 9/1/2014

Space Housing Museum Collections: Collections storage room in Collections Storage Facility

Building Number: 1 Exhibit Space:        Storage Space: X

Name and Title of Inspector: Jane Smith, Curator

List number of each type of pest present in the trap.

Trap number:	#34	#35	#36	#37	#38	#41	#42
Location:	W. door	W. wall	NW corner	WIF door	CDS door	NE corner	E. wall
ant							
cigarette beetle							
clothes moth							
cockroach							
cricket							
dermestid beetle						1	1
fly							
fungus/mold							
mouse							
powderpost beetle							
psocid							
rat							
silverfish							
spider	2						
springtail							
termite							
other:							
other:							
unidentified							
<b>Total pests:</b>	2					1	1

**Pest Evidence Observation**

	Evidence	Location		Evidence	Location
	bait consumption			live insect/larvae	
X	carcasses	Cabinet 3, drawer 5		nests/burrows	
	casings			odor	
	cast skins			pest body parts	
	droppings			rodent smudges	
	food caches			sounds	
X	frass	Cabinet 3, drawer 5	X	webbing	By #34, W. door
	infested food			other:	

**Comments**

Two spiders found in trap 34 and webbing found by trap 34. One dermestid larva found in trap 41 and one dermestid larva found in trap 42. Infested hat, PARK2014, found in Cabinet 3, drawer 5 on East wall. Infested object was bagged and removed to isolation room. All surrounding cabinets were searched for infested objects.

**Figure 5.8 Sample Pest Trap and Evidence Monitoring Log (completed)**



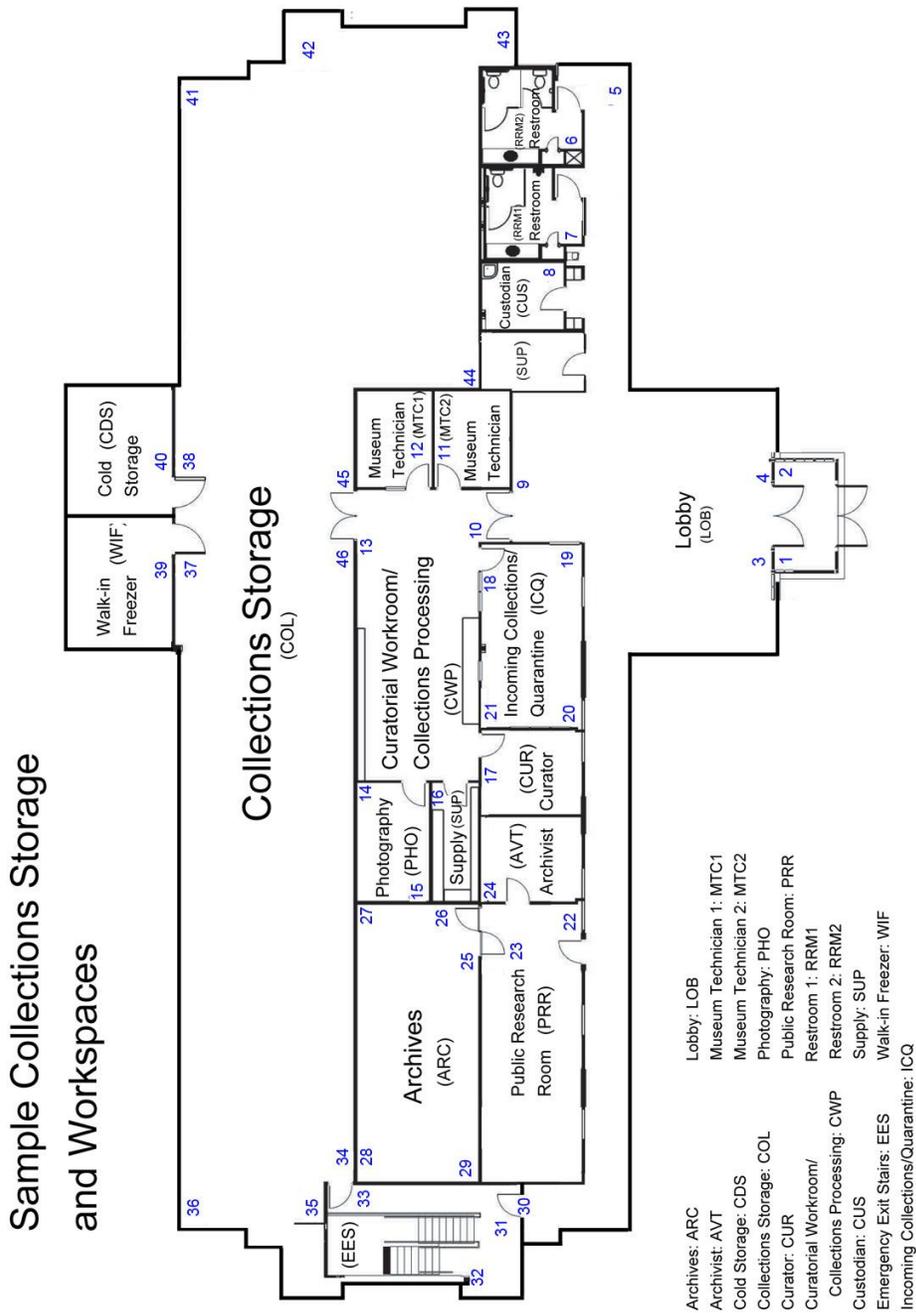
National Park Service  
Sample Pest Database Report

Building name/number: Collections Storage/1

Catch report for dates: 8/26/2014 to 9/1/2014

Room	Location	Date	Pest Name	Type Description	Trap Number	Quantity	Comments
Lobby	West wall by interior door	9/1/2014	Odd beetle	Museum pest	1	1	
Restroom 1	South wall	9/1/2014	Springtail	Miscellaneous	7	1	
Curatorial Workroom	South wall behind door	9/1/2014	Black carpet beetle	Museum pest	10	1	
Museum Technician 1	South wall behind door	9/1/2014	Silverfish	Museum pest	12	1	
Curatorial Workroom	North wall behind door	9/1/2014	Spider	Predator	13	1	
Curator's Office	North wall behind door	9/1/2014	Spider	Predator	17	2	
Collections Storage	South wall behind door	9/1/2014	Spider	Predator	34	2	Webbing found nearby
Collections Storage	South wall behind door	9/1/2014	Dermeestid larva	Museum pest	41	1	
Collections Storage	East wall by cabinet, 3	9/1/2014	Dermeestid larva	Museum pest	42	1	Black carpet beetle found on PARK2014, in cabinet 3, shelf 5
						<b>Total:</b> 11	

**Figure 5.10 Sample Pest Monitoring Database Report (completed)**



**Figure 5.11 Sample Floor Plan with Trap Locations**

**National Park Service  
Sample Pest Identification Request Letter**

[Date]

[Name]  
[Organization]  
[Address]  
[City, State Zip Code]

Dear [Name]:

The enclosed insect samples were found during monthly pest monitoring at [Park]. We would appreciate it if you would identify the insects circled in red in the enclosed sticky traps as specifically as possible. We are particularly interested in potential pests to museum objects. Please return the specimens to me so that I can refer to them in the future.

My address is:            [Name, Title]  
                                 National Park Service  
                                 [Park]  
                                 [Address]  
                                 [City, State Zip Code]

Thank you very much for your help.

Sincerely,

[Name]  
[Title]

**Figure 5.12 Sample Pest Identification Request Letter** (blank)

**National Park Service  
Sample Action Plan  
Pest Type: Pest Name**

**Pest Description/Biology**

*Species*

**Damage**

**Monitoring and Inspection**

**Action Threshold**

**Control Actions**

*Non-chemical control*

Prevention:

Management:

*Chemical control*

**Pest Activity On-site**

*Known history of pest with date and locations of past infestations*

*Past control actions: freezer treatment*

**Figure 5.13 Sample Action Plan: Pest Name (blank)**

**National Park Service  
Action Plan  
Fabric Pest: Dermestid Beetles**

**Pest Description/Biology**

Dermestid beetles cause the most damage to museum collections as larvae. Dermestid larvae hide in crevices, find nourishment by eating components of dust and other dead insects, and avoid light by burrowing deep into objects. Adults are attracted to light, come out of hiding to mate, and may collect along windowsills. See *MH-I*, Ch. 5, Biological Infestations, Section G.3, for more information.

*Species:* black carpet beetle, common carpet beetle, varied carpet beetle, furniture carpet beetle, hide beetle, larder beetle, black larder beetle, odd beetle, cabinet beetle, larger cabinet beetle, warehouse beetle

**Damage**

Dermestid larvae feed on a wide variety of materials including fur, feathers, wool and silk cloth, wool felt, wool or silk carpets, study skins, and taxidermy mounts. Dermestids also eat hair and horn, as they can digest keratin. Beetle larvae burrow into or graze the surfaces of their food.

**Monitoring and Inspection**

Ongoing, systematic monitoring is essential to determining if you have an infestation, including inspecting spaces and objects for pests and establishing a pest trapping program. Inspect for feeding damage, such as grazing or raised burrowing lines. Use insect sticky traps to monitor for presence of dermestid beetles. Place traps by windowsills to monitor for adult carpet beetles. Regularly inspect all sticky traps, as dermestid larvae will eat other pests caught in the traps, and they have proven to be among the few insects that can escape from traps. Adult dermestids lay their eggs on or near dead insects as a food source for their young. Look for dermestid frass on sticky traps around other dead insects, which indicates that dermestid larvae are eating the other insects.

**Action Threshold**

The action threshold is the sighting of one larva or adult insect or any traces of the insect or damage to objects in spaces holding collections.

**Control Actions**

*Non-chemical control*

**Prevention**

Improve sanitation to control dermestids. Regularly vacuum the collections area with HEPA filters, especially in cracks and crevices. Inspect the structure for possible sources of the infestation, such as bird nests or mouse carcasses, and remove them.

**Management**

Use freezer or anoxic treatments to kill the pests.

**Figure 5.14 Sample Action Plan: Dermestid Beetles**

### *Chemical control*

If continued monitoring indicates an ongoing infestation after non-chemical controls have been applied, request use of a low-risk pesticide dust as a crack and crevice treatment. Consult with the IPM Coordinator and a conservator and seek approval through PUPS before proceeding with this treatment. See Section F.6 for more information. **Do not apply pesticides directly to museum objects.**

### **Pest Activity On-site**

#### *Known history of pest with date and locations of past infestations*

6/15/2010, one adult black carpet beetle was discovered on windowsill of second floor guest bedroom in historic structure. Inspection of guest bedroom led to the discovery of infested deer taxidermy mount. 9/1/2014, black carpet beetle larvae discovered on traps 41 and 42 and dermestid beetle damage and adult black carpet beetle carcass discovered in Collections Storage Cabinet 3 drawer 5 on PARK2014 (hat). Inspection of other objects in cabinet led to discovery of 3 other infested objects.

#### *Past control actions*

6/15/2010, infested object was successfully given freezer treatment. Increased inspection and vacuuming of guest bedroom was implemented. 9/1/2014, all infested objects were successfully given freezer treatment. Increased inspection and vacuuming of collections storage was implemented.

**Figure 5.14 Sample Action Plan: Dermestid Beetles (continued)**

**National Park Service  
Action Plan  
Fabric Pests: Clothes Moths**

**Pest Description/Biology**

The webbing clothes moth and the casemaking clothes moth are the two most common clothes moths found in museums. They are small, silvery-beige moths with a wingspan of less than 1/2". The larvae, small white caterpillars with brown heads, feed on the surface of the infested material. Casemaking clothes moth larvae are rarely seen since they construct a cylindrical case of fabric which they carry around to hide and feed in. The color of the larval case will match the material on which it's feeding. Adult moths avoid light. See *MH-I*, Ch. 5, Biological Infestations, Section G.3, for more information.

*Species:* webbing clothes moth, casemaking clothes moth, carpet (tapestry) moth

**Damage**

Larvae cause the most damage to museum collections, as the adults do not feed on collections. The larvae feed on wool, silk, felt, fur, hair, and feathers, upholstered furnishings, piano felts, tapestries, carpets, leather and skin products, taxidermy specimens, felt, hats, horsehair padding or fabric, insect collections, dead insects and nests. Soiled materials are particularly vulnerable. During feeding, larvae produce feeding holes, feeding tunnels of silk and patches of silken webbing on the fabric's surface. Damage can occur quickly.

**Monitoring and Inspection**

Ongoing, systematic monitoring is essential to determining if there is an infestation, including inspecting spaces and objects for pests and establishing a pest trapping program. Inspect the collections areas for evidence of a clothes moth infestation. Search dark areas such as corners, closets, in fabric folds, in rug lint and hair accumulations behind baseboards and in heating units. Inspect textiles for signs of damage. Any visual evidence of clothes moths, such as the sighting of adults or larvae, silken tubes, or feeding damage, usually indicates a major infestation.

**Action Threshold**

The action threshold is the sighting of one larva or adult moth or any traces of the insect or damage to objects in spaces holding collections, such as cases from casemaking clothes moth larvae/pupae.

**Control Actions**

*Non-Chemical Control*

Prevention

Regularly vacuum rugs and textiles, including furnishings.

Management

Clean infested objects by vacuuming with a HEPA filter and removing webbing and cases. Bag and seal objects in polyethylene and use the freezer treatment to kill clothes moths, larvae and eggs. Objects going into storage should remain sealed to prevent re-infestation.

*Chemical Control*

Chemical treatments are not appropriate for a clothes moth infestation.

**Figure 5.15 Sample Action Plan: Clothes Moths**

## **Pest Activity On-site**

### *Known history of pest with date and locations of past infestations:*

2/26/2013, one adult clothes moth was discovered in Collections Storage, Cabinet 4, drawer 2 on PARK2012 (cotton tablecloth) during object spot check. Surrounding objects were inspected and 4 in Cabinet 4 were found to be infested with clothes moth larvae.

### *Past control actions:*

2/26/2013, all infested objects were successfully given freezer treatment. Increased inspection of cloth objects and increased vacuuming were implemented.

**Figure 5.15 Sample Action Plan: Clothes Moths (continued)**

**National Park Service  
Action Plan  
Wood Pest: Powderpost Beetles**

**Pest Description/Biology**

Powderpost beetles are a group of woodboring beetles. The term "powderpost" comes from the fact that the larvae of these beetles feed on wood and, given enough time, can reduce it to a mass of fine powder. See *MH-I*, Ch. 5, Biological Infestations, Section G.4, for more information.

*Species:* Powderpost "furniture" beetle, anobiid beetle, deathwatch beetle, true powderpost beetle, false powderpost beetle bamboo powderpost beetle

**Damage**

Powderpost beetle larvae damage wooden objects, frames, furniture, tool handles, gun stocks, books, toys, bamboo, flooring, and structural timbers, creating narrow, meandering tunnels in wood as they feed. They also damage spices, grains, tobacco, and dried fruits and vegetables. The lower the wood moisture content, the longer the larvae live in the wood. Infestations are often not apparent until adult beetles, attracted to light, emerge from the wood, leaving exit holes behind. They will re-infest wood year after year.

**Monitoring and Inspection**

Ongoing, systematic monitoring is essential to determining if you have an infestation, including inspecting spaces and objects for pests and establishing a pest trapping program. Inspect the collections for wood objects with small round exit holes, the indicator of powderpost beetles. If you discover objects with exit holes, immediately wrap the object in plastic and place it in the isolation room. Inspect windowsills for adult insects.

**Action Threshold**

The action threshold is the sighting of one larva or adult insect or any traces of the insect or damage to objects in spaces holding collections.

**Control Actions**

*Non-chemical control*

Prevention:

Control RH to prevent powderpost beetle infestations. Powderpost beetles prefer infesting wood with moisture content of 12-15% or greater, and wood with lower moisture content than 12% is not often re-infested. Test wood moisture content with a moisture meter. Lowering high moisture levels in the wood through fixing leaks and/or dehumidification may prevent re-infestation.

Management:

For suspected infestations, bag, remove and isolate objects in the isolation room. Place white paper under the object and monitor for frass appearing below the object for 12 weeks. If frass appears on the paper or the exit holes are light colored, the infestation may be active and you should proceed with further treatments. If possible, isolate the object in the isolation room for a period of one year. If this is not possible and if no frass has appeared after 12 weeks, you may remove the object from the isolation room but double bag it or wrap it in two layers of plastic on white paper. Inspect it regularly for frass and holes in the plastic for a minimum of one year. Holes indicate that the object is still infested. Use the freezer treatment for infested objects, after consulting with a conservator.

**Figure 5.16 Sample Action Plan: Powderpost Beetles**

### *Chemical Control*

For widespread infestations, large objects that cannot be frozen, or where it is not possible to remove infested items (such as ceiling beams in structures), request approval to use a pesticide surface treatment or injection. The affected wood (if unfinished) can be treated with localized applications of approved pesticides. You must get approval through PUPS to use this treatment. See Section F.6 for more information.

### **Pest Activity On-site**

#### *Known history of pest with date and locations of past infestations:*

6/3/2012, fresh, light colored exit holes and frass were discovered during isolation period of incoming object, PARK2008 (wooden box).

#### *Past control actions:*

6/3/2012, PARK2008 was effectively given freezer treatment and was isolated for one year in Incoming Collections Quarantine room before being placed in Collections Storage.

**Figure 5.16 Sample Action Plan: Powderpost Beetles (continued)**

**National Park Service  
Action Plan  
Stored Product Pests**

**Pest Description/Biology**

Stored product pests or "pantry pests" infest objects containing seeds, nuts, grains, spices, dried fruits and vegetables, and other foods. They are also common pests of cellulose materials, such as herbaria, paper, and baskets. The cigarette beetle and the drugstore beetle are the most common museum pests of this type. See *MH-I*, Ch. 5, Biological Infestations, Section G.5, for more information.

*Species:* Cigarette beetle, drugstore beetle, saw-toothed grain beetle, lesser grain borer, red flour beetle, confused flour beetle, foreign grain beetle, cadelle beetle, spider beetles, red-legged ham beetle

**Damage**

Stored product pests attack a wide variety of food materials, such as grain, seeds, nuts, corn, tobacco, flour, spices, chocolate, dried fruit, dried and smoked meats and beans. They also infest other materials, including paper, fabrics, books, wood, baskets, herbarium specimens, vegetal matter, upholstered furniture, grain-based rodent bait, leather, hides, bone, hair, feathers, mummies, freeze dried animal specimens, dry pharmaceuticals, medicines, poisons, cellophanes, plastic and cardboard. Many stored product pests can easily penetrate packaging materials. They leave visible feeding damage, shot holes, emergence holes and fine dust around their food sources.

**Monitoring and Inspection**

Ongoing, systematic monitoring is essential to determining if there is an infestation, including inspecting spaces and objects for pests and establishing a pest trapping program. Thoroughly inspect the objects, cases, and structure for signs of an infestation. Focus inspections on objects that contain food products. Look for feeding damage, shot holes, emergence holes and fine dust around these types of objects. Also inspect for rodent nests, which attract stored product pests. Use sticky traps to monitor for these pests.

**Action Threshold**

The action threshold is the sighting of one larva or adult insect or any traces of the insect or damage to objects in spaces holding collections.

**Control Actions**

*Non-chemical control*

**Prevention**

Practice good sanitation to prevent any future infestations by vacuuming the collections area with a HEPA filter. Ensure that any food source for these pests is well sealed. Do not store food in structures housing collections. If food must be kept in the structure, store it in a container with a tight fitting lid.

**Management**

If you suspect that an object or food source may be infested, isolate it in a sealed plastic bag in the isolation room and observe for any signs of infestation. Inspect the structure to find and eliminate the source of the infestation. Eliminate moisture sources and control RH, as humid conditions encourage stored pantry pests, particularly foreign grain beetles. Use the freezer treatment to kill an active or suspected infestation.

**Figure 5.17 Sample Action Plan: Stored Product Pests**

### *Chemical control*

If continued monitoring indicates an ongoing infestation after non-chemical controls have been applied, request use of a low-risk pesticide dust as a crack and crevice treatment. Consult with the IPM Coordinator and a conservator and seek approval through PUPS before proceeding with this treatment. See Section F.6 for more information. **Do not use any pesticides on museum objects.**

### **Pest Activity On-site**

#### *Known history of pest with date and locations of past infestations*

3/1/2006, Cigarette beetle damage discovered by maintenance staff on new object (dried tobacco) in exhibit case 3 in Visitors Center/Museum building. Cigarette beetles and larvae found on two other objects in case

#### *Past control actions*

3/1/2006, all infested objects were successfully given freezer treatment. A new policy was enacted to isolate all incoming objects before placing them in collections storage or on exhibit.

**Figure 5.17 Sample Action Plan: Stored Product Pests** (continued)

**National Park Service  
Action Plan  
General Pests: Silverfish**

**Pest Description/Biology**

Silverfish are one of the major museum pests of starch and paper. Their enzymes and cellulose-digesting bacteria in the gut break down cellulose in paper or other wood products. Silverfish can live for nearly a year without feeding. Due to their small size and reclusive nature, silverfish are seldom seen. If they are seen, populations are probably high and damage can be significant. See *MH-I*, Ch. 5, Biological Infestations, Section G.6, for more information.

*Species:* (Thysanura sp.) fourlined silverfish, gray silverfish, firebrat

**Damage**

Silverfish are chewing insects that primarily feed on paper products, including books, stored papers, writing papers, newspaper, wrapping paper, and cardboard. They also eat herbarium specimens, wallpaper or the paste behind it, and starchy human foods. Book bindings show minute scrapings. Typically, paper sizing is removed irregularly (“grazing”), and paper edges appear notched. In cases of high populations, irregular holes will be eaten directly through paper. Feeding habits of various silverfish species are similar.

**Monitoring and Inspection**

Ongoing, systematic monitoring is essential to determining if there is an infestation, including inspecting spaces and objects for pests and establishing a pest trapping program. Thoroughly inspect for silverfish and signs of damage, focusing on paper collections and possible sources of moisture. As silverfish are thigmotactic and like to wedge their bodies in small spaces, look in small cracks and crevices, such as in baseboards and in corrugations of corrugated cardboard boxes. Look for small dark feces, small yellow stains, scales and signs of feeding on paper objects. Use insect sticky traps along baseboards to confirm their presence. Once a source of food is located, silverfish remain in the vicinity.

**Action Threshold**

The action threshold is the sighting of one insect or any traces of the insect or damage to objects in spaces holding collections.

**Control Actions**

*Non-Chemical control*

**Prevention**

Silverfish are an indicator species for moisture problems. Control RH and temperature to reduce silverfish. Use air conditioners or dehumidifiers in rooms where documents and books are stored to reduce RH and temperature. Repair any water leaks promptly. Practice good sanitation through vacuum cleaning with HEPA filters, especially around crevices and baseboards. Store paper products, books, and documents in tightly sealed containers and cabinets.

**Management**

Use the freezer treatment to kill silverfish and their eggs on boxes, books, archival paper, herbarium sheets, textiles, and other similar materials.

**Figure 5.18 Action Plan: Silverfish**

### *Chemical control*

If continued monitoring indicates an ongoing infestation after non-chemical controls have been used, request use of a low-risk pesticide dust, such as boric acid, silica aerogel, or diatomaceous earth, as a crack and crevice treatment. Consult with the IPM coordinator and a conservator and seek approval through PUPS before proceeding with this treatment. See Section F.6 for more information. **Do not use any pesticides directly on museum objects.**

### **Pest Activity On-site**

#### *Known history of pest with date and locations of past infestations*

4/19/2010, three silverfish were discovered in the Archives Room on Shelf 6 on a book, PARK 2009. Inspection of surrounding objects led to discovery of 4 additional infested books.

#### *Past control actions*

4/19/2010, all infested objects were successfully given freezer treatment. A portable dehumidifier was used to decrease RH in Archives and environmental conditions were monitored more frequently.

**Figure 5.18 Action Plan: Silverfish** (continued)

**National Park Service  
Action Plan  
Moisture Pests: Springtails**

**Pest Description/Biology**

Springtails are minute, wingless insects, varying in color, that get their name from the ability to leap through the air three to four inches. Springtails occur in most climates and are attracted to moist conditions. They enter buildings through doorways, screens, or other openings and may also breed indoors with high levels of humidity that occur near leaks and cracks to the exterior. They can easily climb the sides of houses, are attracted to lights and can be brought into homes in the soil of potted plants. See *MH-I*, Ch. 5, Biological Infestations, Section G.6, for more information.

*Species:* Collembola; Entomobrya spp.; Lepidocyrtus spp.; Heteromurus spp; Orchesella spp.; Sira spp.

**Damage**

Springtails feed on microscopic mold and usually target damp or moldy materials, wallpaper, and new plaster. They do not feed on collections objects but their presence indicates a moisture problem and the likely presence of mold. They are not museum pests and are seldom found on artifacts.

**Monitoring and Inspection**

Ongoing, systematic monitoring is essential to determining if you have an infestation, including inspecting spaces and objects for pests and establishing a pest trapping program. Search for springtails where dampness occurs, such as in basements, cellars, bathrooms, and kitchens, especially near drains, leaking water pipes, sinks, and in the soil of over-watered house plants. Use humidity meters around the structure to help identify problem locations. Use sticky traps to monitor for springtails. Place sticky traps near doors and window, where springtails are often found. Due to their very small size, examine sticky traps with a magnifying glass to identify springtails.

**Action Threshold**

The action threshold is the sighting of one insect or any traces of the insect or damage to objects in spaces holding collections.

**Control Actions**

*Non-chemical control*

**Prevention**

Seal cracks and crevices with caulk and weather-strip around doors and windows to exclude springtails and help control RH. Do not allow live plants in areas with museum collections. If large numbers of springtails are found near doors or windows, check outside to see if there is moisture gathering in the area from poor grading or vegetation or mulch that should be removed.

**Management**

Springtails are highly sensitive to desiccation. Lower the RH to control springtails. Use a fan or dehumidifier to dry the structure and repair any plumbing leaks and dripping pipes. Vacuum any microscopic mold and springtails using a HEPA filter vacuum cleaner.

*Chemical control*

**Figure 5.19 Sample Action Plan: Springtails**

Chemical treatments are not appropriate for a springtail infestation.

**Pest Activity On-site**

*Known history of pest with date and locations of past infestations*

1/7/2014, three springtails were discovered on trap 7 in kitchen of historic structure (near window).

*Past control actions*

1/7/2014, inspection of kitchen led to discovery of improperly sealed kitchen window, resulting in increased RH and water leak. The window was properly sealed and a portable dehumidifier was used to decrease RH.

**Figure 5.19 Sample Action Plan: Springtails** (continued)

**National Park Service  
Action Plan  
Moisture Pests: Psocids**

**Pest Description/Biology**

Psocids, commonly called booklice, are very small (less than 1/8" long), clear gray to light brown or white in color, semi-transparent and soft-bodied wingless insects. They feed on mold, mildew and a variety of both plant- and animal-based foods such as dried fruit, flour, and grains. Moist conditions enhance growth and longevity and they are most common in structures during spring and summer. See *MH-I*, Ch. 5, Biological Infestations, Section G.6, for more information.

*Species:* Liposcelis corrodens

**Damage**

Psocids are also called booklice because they often infest damp, moldy books. They damage paper products and bindings by eating paste, glue or anything supporting mildew. Psocids also infest herbaria, insect collections, manuscripts, cardboard boxes, and furniture stuffed with flax, hemp, jute, or Spanish moss. They damage objects by grazing on the surfaces of paper or plants, and they can leave stains on papers if they are crushed. Their damage is less severe than that of silverfish. Their presence indicates a moisture problem and likely presence of damaging molds.

**Monitoring and Inspection**

Ongoing, systematic monitoring is essential to determining if you have an infestation, including inspecting spaces and objects for pests and establishing a pest trapping program. Psocids are most commonly found in dark cracks and crevices, and proliferate under damp conditions. They are often found on houseplants and flowers. Inspect books, archives and herbarium sheets with a flashlight using raking light and a magnifying glass. Use insect sticky traps to monitor for psocids. Due to the very small size of psocids, examine sticky traps with a magnifying glass to identify them.

**Action Threshold**

The action threshold is the sighting of one insect or any traces of the insect or damage to objects in spaces holding collections.

**Control Actions**

*Non-chemical controls*

**Prevention**

Lower the RH or moisture content of objects to control psocids. Do not allow live plants in areas with museum collections.

**Management**

Vacuum the microscopic mold from objects using a HEPA filter vacuum cleaner at low suction. Use the freezer treatment for infested objects.

*Chemical control*

Chemical treatments are not appropriate for a psocid infestation.

**Figure 5.20 Sample Action Plan: Psocids**

## **Pest Activity On-site**

### *Known history of pest with date and locations of past infestations*

1/7/2014, ten psocids were discovered on PARK 2009 (cookbook) on a table next to the window in kitchen of historic structure. Inspection of surrounding area found no other pests.

### *Past control actions*

1/7/2014, discovery of 3 springtails on trap 7 in kitchen led to inspection of kitchen. An improperly sealed kitchen window, which resulted in increased RH and water leak, was discovered. A cookbook, PARK 2009 was nearby was found to be moldy and infested with psocids. The window was properly sealed and a portable dehumidifier was used to decrease RH. PARK 2009 was isolated, mold was vacuumed off after it dried and object was successfully given freezer treatment.

**Figure 5.20 Sample Action Plan: Psocids (continued)**

**National Park Service**  
**Action Plan- Moisture Pests: Molds and Fungi**

**Pest Description/Biology**

Molds are primitive plants supported by excessive moisture. They are found in indoor and outdoor air, soils, food and on plant matter. Airborne fungal spores are practically everywhere and act like seeds, which spread easily and form new mold growth. Presence of mold indicates high RH above 65% or high moisture content in objects. Other contributing conditions are high temperature, darkness, and lack of ventilation. See *MH-I*, Ch. 5, Biological Infestations, Section G.6, for more information.

**Damage**

Mold damages all organic objects, including cellulose-based materials such as cotton, linen, paper and wood, and proteinacious materials like leather, parchment, freeze-dried animals, and adhesives, through odor, staining, digestion, and structural weakening to complete destruction. Mold also causes odor and stains on inorganic objects. Fungi can produce organic acids that corrode and etch metal and stone. Soiled objects are most at risk.

**Monitoring and Inspection**

Inspect the collections for signs of microorganisms, including characteristic mildewy odor, irregular stains, color change, fuzzy growths on surfaces, and round colonies of conidia. Mold-feeding insects such as psocids or springtails are indicators of mold. Consult a conservator to determine if microorganisms are present.

**Action Threshold**

The action threshold is any evidence of active or inactive mold on surfaces, as mold grows extremely quickly under high RH.

**Control Action**

*Non-chemical control*

**Prevention**

Modifying climatic conditions, such as lowering the RH, can inhibit or solve mold problems. Monitor and control temperature and RH. Keep RH below 65% and dehumidify if the RH exceeds this level. Practice good housekeeping and keep museum objects clean, as mold grows on dust. Vacuum spaces and objects with HEPA filter vacuum. Containerize objects in storage to prevent dust and mold spores settling on objects and slow moisture absorption from short RH fluctuations. Maintain air ducts by placing filters over openings and regularly cleaning with a vacuum. Eliminate sources of microorganisms (food, plants) from storage or exhibit areas.

**Management**

Microorganisms can be a human health hazard, particularly to persons with respiratory conditions, sensitivities (allergies, asthma) or weakened immune systems. Use personal protective clothing while handling mold infested objects including nitrile gloves, HEPA filter dust mask or respirator and disposable or washable over-clothing. If mold is suspected, place object in a covered cardboard box immediately and isolate box in a cool and ventilated space. Do not use a plastic bag and do not reuse the box. Label boxes: "Mold Damaged Objects; Biohazard; Potential respiratory hazard; Protective clothing required." Move objects as little as possible to avoid spreading mold spores and enforce careful and minimal handling of objects. Locate the humidity source, such as water pipes, roof leaks, leaky windows, floor drains, or air ducts. Reduce RH by eliminating the water source, dehumidifying the space and drying the object. Vacuum object with HEPA filter vacuum after mold dries out and becomes dormant

### **Figure 5.21 Sample Action Plan: Molds and Fungi**

(can be done by a conservator or trained staff). A conservator may need to clean object with a biocide or solvent. Freezing will not kill mold but will slow down its growth. Consult experts according to the severity of the mold outbreak, including the park IPM coordinator, regional curator, and a conservator, remediation specialists, industrial hygienists, mycologist, public health or medical personnel.

#### *Chemical control*

Chemical controls are not appropriate for molds and fungi.

#### **Pest Activity On-site**

##### *Known history of pest with date and locations of past infestations*

1/7/2014, mold was discovered on PARK 2009 (cookbook) on table next to window in kitchen of historic structure. Inspection of surrounding area found no other pests

##### *Past control actions*

1/7/2014, discovery of 3 springtails on trap 7 in kitchen led to inspection of kitchen. An improperly sealed kitchen window, which resulted in increased RH and water leak, was discovered. PARK 2009 (cookbook) was discovered on table by window to be moldy and infested with psocids. The window was properly sealed and a portable dehumidifier was used to decrease RH. PARK 2009 was isolated and the mold was vacuumed off after it dried.

**Figure 5.21 Sample Action Plan: Molds and Fungi** (continued)  
**National Park Service**  
**Action Plan**  
**Rodents: Mice and Rats**

**Pest Description/Biology**

Mice and rats are prolific museum pests with a high potential for causing contamination, damage to historical resources, and disease. They are exceptionally agile. Mice can jump one foot high and can fit through spaces 1/4" in diameter. Rats can jump three feet high and fit through spaces 1/2" in diameter. Because of the known potential for causing damage and disease, an aggressive rodent management program is a high management priority. See *MH-I*, Ch. 5, Biological Infestations, Section G.7, for more information.

*Species:* house mouse, deer mouse, white-footed mouse, Norway rat, roof rat, rice rat, cotton rat

**Damage**

Rodents cause damage through feeding and gnawing on objects or structural elements, contaminating collections with feces/urine, damaging electrical wires (sometimes causing fires or malfunction of electrical equipment), rubbing grease marks on objects or structural elements, and contaminating human foods with disease organisms. They also accumulate nesting and food materials inside hollow walls, voids, holes, and cracks that attract other pests.

**Monitoring and Inspection**

Ongoing, systematic monitoring is essential to determine if there is an infestation. This includes inspecting spaces and objects for pests and establishing a pest trapping program. Routinely inspect structures to identify rodent infestations. Rodent sounds, droppings, burrows, urine stains, smudge marks, runways, tracks, gnawing damage, nests, food caches, and odors are all signs of rodent activity. Place snap traps in strategic locations and document all catches. Sprinkling talc on the floor in non-public areas can help detect presence and runways.

**Action Threshold**

The action threshold for any rodent is the sighting of one rodent or any traces of rodents or damage to objects in spaces holding collections.

**Control Actions**

*Non-Chemical Control*

**Prevention**

Exclude mice and rats from all structures housing museum collections. Repair any gaps in the structure larger than 1/4". Improve sanitation by ensuring that rodents have no available food sources within the structure. Reduce clutter within and around the structure to reduce harborage.

**Management**

Use rodent snap traps to kill mice and rats. Rodent glue boards, live traps, and electronic traps are not recommended. Snap trapping is now the primary management tool available to the NPS aside from preventive measures, and it is effective as a control measure especially when many baited snap traps are put out at a time of a known infestation. Use peanut butter or cotton as bait when rodents are known to be present. Note that snap traps are also effective without bait. Follow appropriate protocols for minimizing risk of exposure to hantavirus.

***Chemical Control***

Rodenticides are not recommended for use inside NPS structures. Mice and rats dying in inaccessible locations in

**Figure 5.22 Sample Action Plan: Mice and Rats**

museums are likely to cause odor and secondary infestations of museum pests like dermestids. Rodenticides are not recommended for use outside NPS structures. Poisoned rodents can be eaten by predators causing secondary poisoning to non-target animals, or non-target animals can access the poison directly in their outside environment.

**Pest Activity On-site**

*Known history of pest with date and locations of past infestations*

11/19/2012, a house mouse was trapped in snap trap 5 in garage of historic structure. Inspection of the garage led to discovery of a mouse nest in a cardboard box in the NW corner.

*Past control actions*

11/19/2012, the nest and all mice were removed. Increased rodent snap trapping was implemented. The exterior of the structure was inspected and a small gap underneath the exterior door leading to the garden was sealed.

**Figure 5.22 Sample Action Plan: Mice and Rats (blank)**

## J. Index

---

- Action plan 5:1, 14, 15, 24, 26, 33, 35, 36-40, 46, 48, 54, 57, 68-86
- Action threshold 5:10, 13, 14, 25, 26, 35, 37-41, 43, 48, 49, 54, 68, 69, 71, 73, 75, 77, 79, 81, 83, 85
- Active infestation 5:2, 14, 25, 36, 37, 38-41, 43, 54, 57
- Anoxic treatment  
*See* treatment; anoxic treatment
- Building envelope 5:5, 10, 16, 27, 57
- Cabinets 5:2, 3, 16, 18, 20, 22, 24, 27, 28, 31, 49, 51-53, 55, 70, 72, 77
- Cleaning 5:3, 4, 14, 15, 18, 24, 27-29, 31, 48, 49, 50, 53, 54, 56, 58, 59, 60, 61, 71, 77, 83
- Control action 5:1, 12, 14-17, 26, 36, 38, 48, 49, 54, 57, 58, 59, 68, 69, 70-87  
Chemical control 5:1, 14, 26, 31, 32, 44, 58, 68, 69, 70, 71, 74, 76, 78, 79  
Cultural control 5:1, 14, 26, 27, 49, 55  
Exclusion 5:1, 5, 9, 10, 14, 16, 17, 26, 27, 30, 40-43, 48, 54, 57  
Harborage 5:2, 14, 22, 29, 41, 48, 49, 51, 54, 55, 85  
Hot zone or sanitary barrier 5:28  
Mechanical control 5:1, 26, 27, 28, 54  
Sanitation 5:2, 9, 14, 26, 28, 41, 42, 43, 69, 75, 77, 85
- Dermeestid beetles 5:14, 15, 17, 33, 34, 46, 58, 59, 61-63, 69, 70
- Documentation 5:2, 5, 7, 11, 13, 15, 18, 48, 53, 54, 57
- Environmental conditions 5:2, 4, 10, 17, 39, 49, 54, 78  
*See also* relative humidity (RH)  
*See also* temperature
- Environmental controls 5:4, 55  
HVAC 5:4, 20, 28  
Portable dehumidifier 5:4, 16, 78, 80, 82, 84
- Environmental monitoring 5:11, 13-15, 17, 48, 53, 54, 57
- Evidence/signs of pests 5:1-4, 12, 14, 15, 17, 18, 21, 22-25, 26, 28, 36, 37, 38, 39-43, 49-53, 56, 62, 63, 69, 71, 73, 75, 77, 79, 81, 83, 85  
Burrows 5:22, 51, 56, 62, 63, 85  
Casings 5:22, 58, 59, 62, 63  
Chewing 5:22, 24, 25, 37, 39, 40, 41, 51, 58, 59, 77  
Eggs 5:2-5, 7, 21, 24, 36, 52, 56, 57, 58, 59, 69, 71, 77  
Flayspecks 5:22, 51, 58, 59  
Food caches 5:22, 51, 52, 62-64, 85  
Frass 5:3, 15, 18, 21, 22, 25, 33, 36-38, 51, 52, 58, 59, 62, 63, 69, 73, 74  
Gnawing 5:1, 22, 25, 32, 39, 40, 51, 85  
Grazed surfaces 5:22, 36, 51, 58, 59, 69, 77, 81  
Nests 5:4, 19, 22, 31-33, 35, 39-42, 51, 55, 56, 62, 63, 69, 71, 75, 85  
Odors 5:22, 30, 41, 42, 51, 58, 59, 62, 63, 83, 85  
Pupae 5:3-6, 22, 34, 36, 51, 71  
Rodent smudge/grease marks 5:1, 3, 22, 40, 51, 52, 62, 63, 85  
Shed/cast skins 5:3, 22, 51, 58, 59, 62, 63  
Sounds 5:22, 51, 62, 63, 85  
Webbing 5:1, 15, 21, 22, 24, 35, 36, 51, 58, 59, 62, 63, 71
- Exclusion  
*See* control action; exclusion
- Floor plan 5:1, 15, 20, 30, 46, 53, 66
- Freezer treatment  
*See* treatments, freezer treatment
- Freezer Treatment Record 5:1, 7, 46, 53, 60, 61
- Fumigation 5:8
- Hantavirus 5:2, 4, 31, 43, 44, 52, 56, 57, 85

Harborage  
     *See* control action; harborage  
 Health hazard 5:23, 42, 43, 83  
 Herbarium sheets 5:77, 81  
 Housekeeping 5:1, 2, 9, 10-13, 18, 21, 22, 26, 48, 49, 50, 54, 83  
     *See also* museum housekeeping plan  
 High-efficiency particulate air (HEPA) vacuum 5:3, 4, 24, 28, 29, 49, 50, 53, 56, 69, 71, 75, 77, 79, 81, 83  
 Identification 5:1, 3, 4, 9, 13, 20, 21, 25, 32-43, 46, 48, 49, 54, 58, 59, 67  
     Sources for 5:33  
 Importation of pests  
     *See* incoming objects  
 Incoming objects 5:13, 15, 23, 48, 52, 53, 76  
     Isolation of 5:14, 23, 48, 52, 53  
 Infestation 5:1-5, 8-12, 14-16, 18, 19, 21, 23-26, 31, 32, 36-41, 43, 45, 48, 50-54, 56, 57, 68-86  
     *See also* evidence of pests  
 Infested object 5:2, 3, 5, 15, 18, 23, 24-26, 32, 48, 53, 56, 57, 63, 70-78, 81, 83  
 Injury threshold 5:25  
 Inspection 5:1, 5, 13-18, 21-23, 26, 27, 33, 40, 45, 48-53, 55-61, 68-73, 75, 77-86  
     Of structures 5:21, 51, 52  
     Of objects 5:21, 52  
     Procedures 5:21, 22, 52  
     When to inspect 5:23, 24  
     Where to inspect 5:22, 51-53  
 Integrated pest management (IPM) 5:1, 2, 4, 5, 7-17, 21, 25, 26, 32, 41, 44, 45-57, 70, 76, 78, 84  
     Definition of 5:8  
 IPM plan 5:1, 5, 10, 12-17, 26, 46-57  
     Legal authorities for 5:9, 13, 49  
     Staff involved with 5:12, 50  
     Structure of 5:13, 49  
 Isolation 5:2-5, 13, 14, 23-25, 31, 48, 52, 56, 58, 59, 60, 61, 63, 73-76  
     Isolation room 5:2, 23-25, 52, 56, 59, 60, 61, 63, 73, 75  
     Periods 5:2, 4, 5, 23-25, 31, 52, 59, 61, 74  
     Procedures 5:5, 23-25  
 Low temperature treatment  
     *See* treatments; freezer treatment  
 Mold 5:2, 15, 21-24, 29, 32, 38, 39, 43, 44, 46, 52, 58, 59, 62, 63, 79, 81-84,  
 Monitoring 5:1, 5, 9, 10-21, 25, 26, 29, 31, 46, 48-54, 56, 57, 62-65, 67-71, 73, 75-79, 81, 83-85  
     Tools for 5:23, 51, 52  
     *See also* environmental monitoring  
 Museum housekeeping plan 5:18, 54  
 Museum pest 5:1, 2, 3, 9, 10-12, 15, 17, 21, 23, 25-27, 32, 38, 39, 41-43, 50, 51, 54, 56, 75, 77, 79, 85, 86  
     Definition of 5:1  
 Oxygen scavenger/absorber  
     *See* treatments; anoxic treatment  
 Perimeter invaders  
     *See* pests; general pests  
 Pests  
     Fabric pest 5:32, 33, 35, 69, 71  
     General pest 5:1, 32, 33, 41, 42, 43, 77  
     Moisture pest 5:2, 27, 32, 38, 39, 81, 83  
     Other vertebrates 5:32, 40, 41  
     Rodents 5:2, 3, 19, 21, 22, 23, 27, 30, 31, 32, 39, 40, 51-54, 85, 86  
     Stored product pest 5:15, 32, 37, 38, 46, 75, 76  
     Wood pest 5:32, 36, 37, 73  
 Pest Monitoring Database Report 5:1, 15, 20, 46, 54, 64, 65

Pest Incident Report 5:1, 5, 15, 18, 24, 46, 52, 53, 58-61

Pest traces  
*See* evidence of pests

Pest Trap and Evidence Monitoring Log 5:1, 15, 20, 46, 52-54, 62, 63

Pesticides 5:8, 9, 10-14, 26, 31, 32, 44, 45, 48-50, 53, 54, 57, 70, 74, 76, 78  
 Conventional chemical fumigation 5:8, 57  
 Crack and crevice treatment 5:31, 70, 76, 78  
 Damage by 5:8, 11, 12, 57  
 Pesticide Use Proposal System (PUPS) 5:8, 10, 15, 31, 32, 54, 57, 70, 74, 76, 78  
 Pesticide application: 5:8  
 Vikane 5:8  
 Restrictions on 5:8, 9, 11, 13, 49, 57  
*See also* control actions; chemical control

Personal protective equipment (PPE) 5:31, 39, 83  
 Eyewear 5:21, 23, 52  
 Gloves 5:2, 23, 31, 51, 56, 83  
 Respirator 5:23, 31, 52, 83  
 Respiratory Protection Program 5:23, 52

Potentially infested object 5:2, 23-26, 53

Powderpost beetles  
*See* woodboring beetles

Preventive pest management 5:11, 13, 48, 50

Reference collection 5:32, 54, 59

Relative humidity (RH) 5:2, 4, 8, 16, 17, 27, 39, 49, 54, 55, 73, 75, 77-84  
 Controlling 5:8, 16, 27, 55, 73, 75, 77, 79-84  
 Monitoring 5:16, 17, 49, 54, 83

Rodents 5:1-3, 5, 9, 18, 19, 21-23, 26-28, 30, 31, 32, 39, 40, 43, 44, 49, 51-54, 62, 63, 75, 85, 86

Rodenticides 5:9, 49, 85, 86

Sample Museum IPM Plan 5:1, 5, 10, 14, 46-57

Silverfish 5:2, 15, 38, 46, 54, 55, 58, 59, 62, 63, 77, 78, 81

Temperature 5:1, 2, 4-8, 17, 25, 27, 31, 36, 41, 45, 46, 49, 54, 55, 57, 60, 61, 77, 83

Traps  
 Insect sticky traps 5:5, 18, 19, 20, 21, 32, 33, 51, 53, 67, 69, 75, 77, 79, 81  
 Light traps 5:18, 19, 53  
 Pheromone traps 5:19, 53  
 Rodent snap traps 5:5, 18, 19, 21, 26, 30, 53, 85, 86

Treatments  
 Anoxic treatment 5:5, 7, 8, 10, 14, 15, 24, 25, 48, 54, 57, 58, 59, 69  
 Freezer treatment 5:1, 5-7, 14, 15, 24, 46, 48, 53, 54, 57-61, 68-78, 81, 82  
*See also* pesticides

Woodboring beetles 5:25, 36, 73

Note: *Italicized* page numbers indicate the reference is located within a sample form.