National Park Service
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Northeast Region
Boston, Massachusetts

Integrated Pest Management Plan
Weir Farm National Historic Site

Natural Resources Report NPS/NER/NRR—2006/008

Developed by:
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Management Institute

August 2006

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ON THE COVER
Burlingham House
Photograph by: Jean A. Currie, President, International Pest Management Institute

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WEIR FARM NATIONAL HISTORIC SITE
INTEGRATED PEST MANAGEMENT PLAN

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WEIR FARM NATIONAL HISTORIC SITE
INTEGRATED PEST MANAGEMENT MUSEUM ACTION PLAN

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Perma-Guard Commercial Insecticide Label
Perma-Guard Fossil Shell Flour Label & MSDS
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EXECUTIVE SUMMARY

INTEGRATED PEST MANAGEMENT PLAN FOR WEIR FARM NATIONAL HISTORIC SITE

This Integrated Pest Management (IPM) Plan for Weir Farm National Historic Site (WEFA) in Ridgefield and Wilton, Connecticut provides basic pest management guidelines to help preserve the stored cultural museum resources, structures and park grounds, and assist in protecting the health and safety of park staff and visitors. As new information and IPM methods will develop over time, this plan should be reviewed and updated periodically.

The Superintendent is responsible for pest management at the site and designates a site IPM coordinator to implement the IPM plan. The IPM Coordinator will work with the Chief of Maintenance, Chief of Cultural Resources and others in the implementation as outlined in NPS-77 (Natural Resources Management Guidelines).

Any use of pesticides at WEFA will be in accordance with Servicewide policies as found in NPS-77. All pesticides used in the park will be applied by or under the direct supervision of a state (Connecticut) certified pesticide applicator. All pesticides used in the park by residents, contractors, special use permittees, agricultural issues, or non-NPS personnel will conform to NPS policies and guidelines, and will be approved before use. It is the goal of WEFA in compliance with NPS policy to use low-risk pesticides, if necessary, that will accomplish desired objectives.

At the end of each year, the WEFA IPM Coordinator is to compile a list of the pesticides applied at the site (on NPS IPM software PUPS) and forward a copy of that report to the Northeast Regional Support Office.

Descriptions and low-risk pest management methods of museum and other pests potentially present in WEFA structures, displays and landscapes are described. The site has pest concerns about museum pests, bats, wasps, carpenter bees, mice, rats, spiders, camel (cave) crickets, voles, wood-destroying organisms, powderpost beetles, carpenter ants and exotic invasive plants. Preventive methods such as exclusion, sanitation and habitat modification are described, as well as direct actions such as trapping and the use of directed pesticide applications. Inspections and monitoring of pest populations and conducive conditions will determine the extent of pest presence and direct pest management actions.

The staff of Weir Farm National Historic Site are committed to the implementation of the IPM approach for those pests threatening the site resources and the health and safety of park visitors and staff.

INTRODUCTION

Weir Farm (WEFA) became a national historic site in 1990 by an act of Congress to protect and preserve one of the last intact landscapes associated with American impressionism. Weir Farm National Historic Site, located in the towns of Wilton and Ridgefield in southwestern Connecticut, is the first National Park Service unit to honor an American painter. The farm includes successional old fields, hardwood forests, wetland areas, streams and two farmsteads. J. Alden Weir, an American impressionist painter, used the farm and its environs as inspiration for capturing light and motion in landscapes on canvas. After Mr. Weir's death in 1919, the next two generations of occupants were also noted artists. WEFA continues the artistic tradition through its partnership with the Weir Farm Trust in providing a resident artist's program for continued inspiration for an artistic future.

The area encompassing Ridgefield and Wilton, Connecticut is rural with small farms and woodland estates, and has some potential for pest pressure from rodents, insects and other pest organisms. The site receives about 12,000 visitors annually, which places additional pressure on park resources.

This low-risk, integrated pest management (IPM) plan attempts to provide insight into the continued protection and preservation of the historic site and its artistic ambiance from the potential adverse effects caused by the presence of pests. Risk is a result of toxicity (hazard) times exposure. This low-risk pest management plan reduces pest presence reducing their hazard to the park site and humans. It also suggests low-toxicity pesticides or other non-toxic methods for managing pests, resulting in the low-risk pest management approach. Integrated pest management is a process that utilizes knowledge of the biology and behavior of the pest(s) in managing pest presence through exclusion, sanitation and habit modification; and minimal use of pesticides.

LEGAL AUTHORITIES AND REQUIREMENTS

The National Park Service has decided to use integrated pest management (IPM) methods as the preferred means for managing pests based on federal laws, regulations, executive orders, presidential memorandum, NPS policies and guidelines, and state regulations on pesticide use.

FEDERAL LAWS AND REGULATIONS

Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) of 1947; amended by P.L. 92 516 (82 Stat. 973) and P.L. 94-140 (89 Stat. 751)
Federal Environmental Pesticide Control Act of 1972 (7 U.S.C. 135 et.seq.)
President Carter's 1979 Executive Order requiring all Federal Agencies to use integrated pest management technology for pest control and to reduce use of toxic pesticides
President Clinton's April 26, 1994, Memorandum concerning economically beneficial practices on Federal landscaped grounds
Secretary Babbitt's July 12, 1994, Memorandum concerning the Department of Interior and the Federal Insecticide, Fungicide, and Rodenticide Act
Executive Order 11870 concerning Animal Damage Control
Executive Order 11987 concerning Exotic Organisms
Executive Order 12088 concerning Pollution Control
Resource Conservation and Recovery Act (40 CFR 165) dealing with pesticide disposal
Migratory Bird Treaty Act of 1918 implemented the 1916 Convention between the United States and Great Britain (for Canada) for the protection of migratory birds
Endangered Species Act of 1973 which provides broad protection for species of fish, wildlife and plants that are listed as threatened or endangered in the United States or elsewhere
Occupational Health and Safety (OSHA) Hazard Communication Standard (29 CFR 1910.1200) and Respiratory Program Standard (29 CFR 1910.134)

NPS POLICIES AND GUIDELINES

Guide for Pesticide Use in the National Park Service, WASO, and Director's Order 77-7:

NPS Management Policies 2001

> *The decision to incorporate a chemical, biological or bio-engineered pesticide into a management strategy will be based on a determination by a designated IPM specialist that it is necessary, and that all other available options are either not acceptable or not feasible.*

NPS Natural Resources Management Guidelines (NPS-77), Chapters 2, 4 and 5

Additional guidelines relating to the park's IPM program appear in other chapters of NPS-77:

Chapter 2: Vegetation Management; Native Animal Management; Freshwater Resources Management; Endangered, Threatened, and Rare Species Management; Exotic Species Management; Hazardous Waste Management; and Public Health and Safety.

Chapter 3: Agricultural Use, Right-of-Way and Easements, and Backcountry Recreation Management.

Chapter 4: Environmental Compliance

Chapter 5: Special Use Permits and Collections.

The NPS Museum Handbook, Parts I and III, Museum Collections, affords guidance on instituting a museum IPM program, identification of museum pests, and proper actions to take if pests are discovered in a museum.

PARK MANAGEMENT STRATEGIES

LOW-RISK PEST MANAGEMENT ACTION PLAN OBJECTIVES

Plan Objectives: A low-risk integrated pest management (IPM) action plan is designed to provide guidance to staff in the care and protection of the historic site, the important historical materials within, and the surrounding environment from pest presence and subsequent damage.

This plan describes:

- observed evidence of pest activity (and damage),
- potential pest species that may interfere with the site's objectives,
- potential public health issues, and
- most importantly the procedures and actions necessary to prevent pest access and methods for their elimination.

This plan will help meet goals to preserve WEFA resources: Cultural resources and associated values at WEFA are protected, restored and maintained in good condition and managed within their cultural context.

Many facilities deal with pests in a reactive sense, treating for the pest after the infestation has occurred or with routine monthly sprays. Pests in a museum, library or archive environment can cause serious damage to highly valuable, and many times, irreplaceable materials or artifacts. IPM is proactive – work must be done to prevent pest activity rather than react to pest damage to artifacts. Damaged artifacts may NOT be replaceable, and the extent of damage may preclude effective restoration.

IPM is proactive – how long does a pest presence take to damage a historic artifact (feeding, fecal droppings, nesting, etc.)? Prevention is equally as important as response and may preclude having to respond!

Museum, library and archival collections contain many materials, including composites of various organic and inorganic substances. Materials such as paper, glues, leather, sinew, fur, hair, wood, cotton, wool, hemp, linen, silk, casein, grass, reed, pine needles, or fabrics contaminated with sweat, blood, urine, feces and so on, are organic materials susceptible to the ravages of insects and other arthropods, rodents, mold, and bacterial pest organisms.

The benefits of an effective IPM plan, fully implemented, provide a system of protection for the structure, collections, and staff from close encounters with pest species. The absence of pest species reduces potential damage to museum objects and, therefore, reduces park resources needed to repair and replace museum objects. Benefits of implementing a low-risk IPM approach include excluding pests from entering the structure, eliminating pests that may already be present, implementing management procedures prior to pest population buildup, and the elimination (or at least minimizing) of placing pesticides in the staff's environment. Additionally, it provides an opportunity to provide a flexible and varied approach to managing

the museum and curatorial environment so the pest does not want to be there. The IPM approach provides an efficient and environmentally conscious preservation of historic collections.

In addition to the potential for actual damage to materials in the displays and collections, some pests pose potential health risks to staff and visitors. Rodents (rats and mice) are known vectors of many disease organisms to humans, including the deadly Hantavirus. Cockroaches produce fine exuviae and pheromones which may trigger asthma attacks in sensitive individuals. The cast skins of dermestid beetle larvae also contain fine barbed hairs that can be very irritating. Ants, bees, wasps, spiders, dust mites, and other insect pests and molds, both inside and outside, may cause some health risks to the general public. Deer ticks (and other species) can transmit Lyme disease and other maladies to staff and visitors. Managing all these potential pest issues where the public has access, as well as staff-accessed areas, is an important consideration in a low-risk integrated pest management plan.

Curatorial staff has a key role in protecting the historic fabric present in displays and storage areas, and will use this low-risk pest management plan to accomplish this objective. Maintenance and custodial staff have already made important contributions toward reducing pest populations. Additional directed efforts by the maintenance and custodial staff will further reduce the potential adverse pest impact upon the protection of the site contents and visitor enjoyment.

IPM is defined as follows:

Integrated Pest Management (IPM) is the coordinated use of pest and environmental information with available pest management methods to prevent unacceptable levels of pest damage by the most economical means, and with the least possible hazard to people and the environment. The goal of the IPM approach is to manage pests and the environment so as to balance costs, benefits, human health and environmental quality. IPM systems utilize a high quantity and quality of technical information on the pest and its interaction with the environment (site). Because IPM programs apply a holistic approach to pest management decision-making, they take advantage of all low-risk pest management options, emphasizing natural biological methods, and the appropriate use of selective pesticides. IPM strategies incorporate environmental considerations by emphasizing pest management measures that minimize intrusion on natural bio-diversity ecosystems. Thus, IPM is:

- A system utilizing multiple methods
- A decision-making process
- A risk reduction system
- Information intensive
- Biologically based
- Cost effective, and
- Site specific

A short definition is:

IPM is risk reduction: reduction of the risks from the presence of the pest, as well as the risks from the means used to manage the pests.

Low-risk IPM considers the acute and chronic toxicity of the pesticide that may be employed as well as the potential exposure from the treatment to staff and visitors (especially more vulnerable children).

NATIONAL PARK SERVICE LOW-RISK INTEGRATED PEST MANAGEMENT PROCESS

The National Park Service has developed an effective and advanced process for developing and implementing an IPM strategy for pests on park sites. An 11-step process has evolved since 1979 to its current form. A brief discussion of these 11 steps as they relate to Weir Farm National Historic Site follows.

Step 1 Set Site Pest Management Objectives and Priorities

The mission of Weir Farm National Historic Site is to preserve, conserve, protect, and maintain those resources within its charge for the enjoyment of this and future generations.

Priorities: Weir House and Barn, Burlingham House and Barn and the historical artifacts within, the Caretaker's House, Weir Studio, Young Studio, and the pastoral scene and enclosing rock walls; the Westervelt House, the water tower and lean-to, the shop, collections storage areas and workspaces.

- Protect historic resources from pests and other hazards
- Protect structural integrity to maintain historic ambiance and form
- Provide an educational, safe and pleasing experience for visitors
- Maintain an aesthetic (and historic) landscape on the park grounds
- Protect the cultural landscape from damaging pests
- Implement the "Invasive Species Management Plan for Weir Farm National Historic Site"

Step 2 Build Consensus

Establish communication links between interested or concerned parties (occupants, pest managers, decision makers) and agree on mutual pest management approaches, methods and priorities.

- Occupants: public, visitors, community, site staff
- Pest managers: IPM Coordinator, custodians, curatorial staff, maintenance staff, Exotic Plant Management Team
- Decision makers: Superintendent, Cultural Resources Manager, Chief of Maintenance, IPM Coordinator

(1) Provide signage and other interpretive information on pest management issues and procedures through interpreter staff, news releases, seminars or conferences.

(2) IPM Coordinator to hold periodic monthly meetings (short) to discuss findings by staff, track progress toward goals and provide praise for jobs well done.

(3) IPM Coordinator to provide briefing for supervisors and/or superintendent, two times per year on critical issues, progress and successes.

Step 3 Document Decisions and Maintain Records

This pest management plan will help with pest management decision making and will become part of the park's IPM records.

- Installation of environmental (temperature/humidity) sensors in artifact displays and storage areas are required to gain environmental information of a specific room.
- Collect monitoring data from all pheromone or sticky traps and record findings (pest ID and numbers).
- Placement of traps can be indicators of access routes into the sites by pests.
- Provide pest sighting logs for critical sites, museums, curatorial storage, displays, break rooms, etc.
- Record all data collected, information on remedial actions taken to eliminate pest access, and any pesticide treatment actions.

Step 4 Know The Resource

The WEFA maintenance, curatorial and custodial staffs and the IPM Coordinator have intimate knowledge of the site and its contained historic and exhibited materials.

- The resource consists of historic artifacts, structure(s), storage areas, offices, public areas, landscaping and public grounds and forest.
- This rural site has a moderate to heavy human occupancy (public) and staff, and pest pressure from the surroundings.
- A weed management plan for invasive plants has been developed for the site and should be implemented.

Step 5 Know The Pests

This pest management plan provides detailed information on the pests, their biology and behavior, and low-risk pest management measures.

Potential and known pests:

- Museum pests – carpet beetles, clothes moths, silverfish, mold
- Structural pests – termites (eastern subterranean), carpenter ants, carpenter bees, wood borers
- Public health pests – bats, rats, mice, flies, cockroaches, spiders, wasps, ticks, Lyme disease, mosquitoes, West Nile virus

- Landscape and forest pests – aphids, mealy bugs, rust, white grubs, weeds, moles, voles, groundhogs, deer, Hemlock wooly adelgid, invasive exotic plants.

Step 6 Monitor Pests and Environmental Conditions

Monitoring for pest presence will be done through several methods: observation or sighting logs, sticky trap captures, observation of damage, tracks, droppings, etc.; indoor environmental conditions are monitored with temperature/humidity recorders, and housekeeping sanitation measures. Line transects and grids can be set up to monitor pest presence in landscaped and forested areas, etc.

- Set up monitoring regimens to inspect regularly and record and report findings.

Step 7 Establish Action Thresholds

In a museum or curatorial storage setting, "Action Thresholds" are set very low to prevent pest activity from damaging artifacts.

- The presence of a single pest in a critical area (artifacts) calls for an immediate remedial action (physical removal, cleaning, trapping, etc.).
- Prevention is a key component: one larval dermestidae in historic artifacts needs immediate action (exclusion, sanitation, habitat modification).
- Non-invasive weeds in turf may not require any action other than routine mowing and appropriate fertilization. Invasive weeds (exotic) may need remedial action (see the "Invasive Species Management Plan").

Step 8 Review Available Tools and Best Management Practices

Exclusion, sanitation and habitat modification are effective tools to manage museum, structural and public health pests. Some low-risk pesticides and traps may be necessary in some instances. The Exotic Invasive Plant Management Team will assist with invasive plants.

Step 9 Select Effective, Low-Risk IPM Strategies within Laws, Regulations and Policies

This IPM Plan addresses IPM strategies taking into account Federal and State laws, and National Park Service regulations and policy.

Step 10 Obtain Approval, Define Responsibilities, and Implement Strategies

Responsibilities of the IPM Coordinator, curatorial and custodial staffs are included in this IPM plan. Action threshold levels will determine management strategies to be implemented and responsibilities of different divisions will determine the staff involved. Information provided to the public through signs and interpretive staff can also make visitors aware of how their actions can help in preventing pest presence. When pesticide applications are deemed necessary, proposed use plans will be submitted by the WEFA IPM Coordinator to the NER IPM Coordinator for approval prior to the performance of any application.

Step 11 Evaluate Results, Follow-up and Adjust Strategy if Needed

Observation, monitoring, exclusion, sanitation and habitat modification utilized in appropriate strengths make this plan easily adjustable to manage most pests likely to be encountered. Following pest management actions, the affected resource will be monitored for continuing presence of the pest. The conditions found will be evaluated to determine the success of management actions. In the event a pest remains above an action threshold level, additional or alternate strategies may be selected and implemented following the appropriate approval and use procedures. Pesticides or other pest lethal force may be necessary.

INTERPRETATION AND IPM

The site interpretive staff has a great responsibility in providing the visiting public with information on the historic events that occurred at WEFA during the period of American Impressionism. In addition to all this, it is useful to inform the public about how the site preserves and protects the structures, artifacts, landscapes and forests from pests and their potential damage. The public can use IPM information in their homes, and become aware of how their actions can help prevent the presence of pests in the park.

The interpretive staff can provide information on some of the specific pests that have been encountered at the site, pest's basic needs (air, water, food, shelter, adequate temperature), and how the IPM approach manages pests through exclusion, sanitation and habitat modification. A discussion of the influence of pests on the cultural and natural resources, how pests interfere with natural processes, and how exotic invasive plant species may displace native species should be included. A display can be developed to identify pest species and exotic invasive plant species, including how people have a role in providing or preventing pests.

ROLES AND RESPONSIBILITIES

It is essential for all park operations to support staff and visitor health and safety, as well as preserve and protect park resources. The integrated pest management (IPM) program has similar responsibilities and should closely interact with all park personnel. Most WEFA site staff will be involved in pest management activities at one time or another. To make the IPM program most effective, the entire staff (and several non-NPS persons) should participate as members of the pest problem-solving team.

SUPERINTENDENT

The Superintendent has overall responsibility for park functions, including the IPM program. The Superintendent may delegate the IPM program implementation to the IPM Coordinator and other site divisions. The Superintendent may also make reasonable attempts to provide adequate staffing and funding to implement and sustain the IPM program and provide for monitoring, exclusion and pest management needs.

The Superintendent must understand the principles and practices of IPM and realize how the broad scope of IPM tactics relate to park resources and activities; designate and train a curator to oversee historic artifacts and their preservation; inform employees, through memos, of the need for vigilance and to practice IPM functions; annually review with the IPM Coordinator the low-risk IPM plan for necessary changes or additions; provide for proper and necessary training for the IPM Coordinator and other staff; and ensure that all pesticide applications are done by certified pesticide applicators who meet both state and federal requirements.

HORTICULTURIST/NATURAL RESOURCE MANAGER

The Horticulturist/Natural Resource Manager has responsibilities for management of the site natural resources and oversight, review and support of the pest management program, including this IPM plan. The Chief must also understand the principles and practices of IPM and annually review the IPM plan for any necessary changes or additions.

CHIEF OF COLLECTIONS

The Chief of Collections has pest management roles that are important to the preservation of historic artifacts and displays, pest monitoring within the collections, and performing an effective museum cleaning program. The curator has the responsibility to inspect, at least semiannually in early spring and late summer (preferably monthly) museum areas, storage and curatorial areas, collections, and the interior and exterior of all buildings containing collections or stored museum artifacts. Inspections will record pest presence and conditions conducive to supporting pests. Needed repairs or maintenance will be identified and scheduled with the Chief of Maintenance and reported to the IPM Coordinator.

CHIEF OF MAINTENANCE

The Maintenance Division staff has very important roles in WEFA pest management. The Maintenance staff provides all the repairs to buildings to ensure there are NO entryways for pests to have access to the inside spaces. Total exclusion of pests from entry into structures is the first line of defense in this pest management plan. Maintaining screens on windows and chimneys, tight door sweeps, closing cracks and crevices, repairing leaks, cleaning offices and other spaces, and generally keeping structures in good repair; reporting observations of pests or their activity to the IPM Coordinator for action is also important as maintenance staff may work in areas not frequented by the IPM Coordinator or other pest management personnel; will train maintenance staff to be alert to conducive conditions and signs of pests and pest damage and report findings; assure good sanitation procedures (the second line of defense in this pest management plan) are carried out to eliminate food, water and shelter conditions that encourage pests; and punctually schedule repairs to structures, utilities or vegetation that support pest infestations.

IPM COORDINATOR

The responsibilities of the park IPM Coordinator are described in NPS-77 Natural Resource Guidelines and in the March 10, 1997 IPM re-engineering Memorandum. The WEFA IPM Coordinator serves as the focal point of all activities that directly (or indirectly) relate to pest management, including maintenance, resource management, interpretation, planning and design, and other park responsibilities. The IPM Coordinator is responsible for compiling IPM related information and continuing education on IPM techniques, methods and pesticide safety to park staff and residents; will be responsible for performing IPM activities in this plan, assisting staff with solving pest problems, reviewing pest monitoring reports, and training employees with pest management duties; will prepare monitoring forms and conduct inspections, and document needed repairs and structural deficiencies for action by maintenance staff; will with the Superintendent and other program managers, annually review the IPM plan for necessary changes or additions; ensure personnel applying restricted-use pesticides work under direct supervision of a certified applicator; ensure all reports, requests, and pesticide use logs are accurate, complete and submitted in a timely manner; will maintain the locked pesticide cabinet, pesticide labels and material safety data sheets (MSDS) on all approved pesticides; informs the Superintendent on all pest management issues and pesticide use; will semiannually (early spring and late summer) inspect the exterior and interior of all buildings in the park and record inspection findings; if inspections show evidence of pest activity, will increase monitoring actions, and if action thresholds for the site are met, will initiate further pest management actions, and assure park staff is provided the latest information concerning health and safety matters on pests and pesticides.

DOCUMENTATION

INSPECTIONS

The initial inspection of the site and a written report may be the first official record of a pest problem. The inspection report (with photos if possible) should identify conditions conducive to supporting pest presence, as well as ID of pests that are present. The inspection report should document the findings, and include the key location and potential distribution of the pest or pests, the resources (water, food, shelter) available to the pest(s), and the remedial actions necessary to manage the situation. The inspection provides a snapshot of pest activity at that time.

MONITORING

Monitoring provides information on pest activity over a specified period of time while no one is watching. Methods of monitoring will vary, depending upon the pest of concern. Crawling insect activity can be monitored by placing sticky traps and bait in a strategic location and checking them for captures after a specified time period. If the crawling insect population is suspected to be large, sticky traps should be checked each day to obtain species identification and relative numbers. If the population is small, traps can be checked weekly or at least monthly. A series of sticky traps may be placed near all possible sources of water, food, entry access or shelter to delineate population size, extent of location and whether the population is growing or declining. Monitoring for flying insect pests may require special sticky traps with an appropriate pheromone that is attractive to the male, female (or both) of the flying insect pest(s) of concern (Insects Limited, Inc. is a source). The flying insect pest pheromone traps can be placed in a grid pattern to pinpoint the area of the pest harborage or food source, and thus limit the area and amount of treatment necessary to manage the pest. Monitoring devices should be placed during the inspection in areas where evidence of pest activity is observed.

Talc or diatomaceous earth patches placed in rodent runways can be used to determine rodent population size and if the runways are active. Rodents tend to dribble urine as they run along, which can be detected by using a UV light showing urine as a bluish-green fluorescence. Rodents also run next to vertical surfaces and leave a mark of body oils and dirt where they rub. You can determine if the rub marks are fresh (soft) or old (brittle). Food material, usually a block, can be monitored periodically to determine the amount of food taken by weighing it or by measuring the actual remaining dimensions. Knowing the amount of food the target rodent species takes in a day (or other time frame) can give you an idea of the size of the population.

Monitoring for plants that are undesirable in the site can be conducted by observation, line transects, meter grids and other means. Identification of the species and its location can be placed on a map of the site. Observations over a period of time or seasons can determine the plant’s rate of spread or population increase. If an action threshold has been determined, the monitoring record can show when the action threshold has been reached, and remedial action for removal can be taken. Some exotic invasive species may require the presence of even a single plant to be removed. Hazard trees may require pruning or removal as well.

Good records of all monitoring results are important for a successful IPM program. Comparing monitoring data from before treatment actions and after can provide evaluations of the relative success or lack thereof for the treatment. If treatment action (exclusion, sanitation, habitat modification, physical trapping or pesticide application) are effective or only partially effective in managing the pest, re-evaluation of the approach may be necessary. Recording the results of monitoring data should include the following:

- Location or site
- Purpose for monitoring
- Target pest population being monitored
- Frequency of monitoring (daily, weekly, monthly)
- Number and description of monitoring locations
- Monitoring procedures (counting, weighing, identification, etc.)
- Record of findings and subsequent management decisions
- Treatment efficacy on target pest (and nontargets)

PESTICIDE USE PROPOSALS (PUPS)

Pesticide use under this low-risk IPM plan must go through an approval process by the Regional IPM coordinator or the Washington Office IPM Coordinator, depending upon the desired product, pest and site. The PUPS NPS IPM software must be used. The proposed pesticide use approval must be obtained before the pesticide application can be made. The park IPM Coordinator has a password to enter the PUPS intranet database. The Director's Order 77-7 (DO 77-7) provides information on the allowed use of pesticides, approval process and restrictions. The Regional IPM Coordinator can approve most PUPS. Aerial applications, water applications, restricted use pesticides, and areas with threatened and endangered species must be approved by the Washington Office IPM Coordinator.

PESTICIDE USE LOGS

The park will keep records on all pesticides; amount used during the year, and will submit pesticide use reports (PUPS) on NPS pesticide management software to the regional IPM coordinator at the end of the year. The State of Connecticut does require end of year submittal of what pesticides were used.

LABELS AND MATERIAL SAFETY DATA SHEETS

Copies of all pesticide labels and MSDS of pesticide products used or stored in the park will be kept in the park MSDS book. Copies of pesticide use records and pesticide labels will also be kept in the pesticide applicator's notebook or file.

PEST MANAGEMENT ACTIONS TAKEN

The National Park Service has instituted a nationwide IPM software program to facilitate recordkeeping and tracking pest management actions. Pesticide applications are entered into the software at the end of each year.

PURCHASING, DI-1s

Regular staff and visitors should NOT purchase pesticides for use in the park. The IPM Coordinator, after approval from the Regional or Washington office IPM Coordinators, can request the purchasing officer to obtain pesticides or contracts. Any product that has a U.S. EPA registration number must go through the approval process.

IPM POLICY

The site should establish a procedure and incorporate the pest management approach into any agreement (written or oral) with any outside party who wishes to conduct any activity within the jurisdiction of the site. It should be made clear that NO pesticides are to be used while on park premises. The participant must take appropriate action to avoid providing water, food or shelter for any pest. These factors must be included (preferably in writing) in any agreement, special use permits, concession contract, right-of-way instruments, leases, contracts and any other document which allows an activity to occur on park jurisdiction which may attract pests (of any kind) or effect the IPM program. It must also indicate the user's responsibility to exclude pests, eliminate water, food and shelter from pest access, and to immediately remediate any such adverse conditions that may occur.

COOPERATIVE AGREEMENTS

The site, through the IPM Coordinator, may elect to develop a cooperative agreement or contract to engage the assistance of a local expert in the management of pests that may be problematic for some portion of the site. Candidates could be experts from the cooperative extension office, university, independent consultant, agricultural crop advisor, landscaper, tree service, orchardist, archivist, curator, structural pest management company or other pest management expertise critical to the park. The agreement or contract must state that no pesticides will be utilized without the full approval process being completed. Selection criteria should encourage the ability to think outside the pesticide box; and use exclusion, sanitation and habitat modification as the focus.

ANNUAL WORK PLAN

January

- Monitor Artifact Curatorial Storage Rooms for insect or other pest activity. Treat cracks and crevices with diatomaceous earth if necessary.
- Prepare and submit PUPS anticipated (known) pesticides projected to be used on the site properties to the Regional IPM Coordinator for approval.
- Set and monitor rodent snap traps daily.
- Conduct maintenance and cleaning daily.

February

- Monitor Artifact Curatorial Storage for insect or other pest activity. Treat cracks and crevices with diatomaceous earth if necessary.
- Set and monitor rodent snap traps daily.
- Conduct maintenance and cleaning daily.

March

- Monitor Artifact Curatorial Storage for insect or other pest activity. Treat cracks and crevices with diatomaceous earth if necessary.
- Set and monitor rodent snap traps daily.
- Conduct maintenance and cleaning daily.
- Maintain vegetation-free zone around buildings.

April

- Vacuum hibernating insects (beetles, flies, moths, dermestid larvae) and bat droppings from attics, cracks and crevices, roof joists, corners and beams in all structures.
- Set and monitor rodent snap traps daily.
- Monitor Curatorial Storage for pest insect activity.
- Inspect all wood in each structure for bees, wood borers, mold, algae, and lichens or other wood-destroying organisms and wasp nests; and spot-treat wood with borates if necessary (spring and fall).
- Conduct maintenance and cleaning daily.
- Maintain vegetation-free zone around buildings.

May

- Monitor Curatorial Storage for pest insect activity.
- Conduct thorough inspections of all structures for insect, spider and rodent activity.
- Conduct exclusion actions to prevent rodent (mice, squirrel, wood rat) and insect entry into all structures.
- Set and monitor rodent snap traps daily.
- Maintain vegetation-free zone around buildings.
- Conduct maintenance and cleaning daily.

June

- Monitor all structures for pest insect and rodent activity.
- Search for emergence of carpenter bees, wood beetles, etc. and treat infested wood beams.
- Monitor Curatorial Storage areas, etc. for pest activity.
- Maintain vegetation-free zone around buildings.
- Conduct maintenance and cleaning daily.
- Monitor and reset rodent snap traps daily.

July

- Monitor Curatorial Storage areas, etc. for pest insect activity.
- Monitor and reset rodent snap traps daily.
- Conduct a thorough structure inspection and maintenance of structural integrity, repairing holes providing insect or rodent access.
- Conduct maintenance and cleaning daily.
- Maintain vegetation-free zone around buildings.

August

- Monitor Curatorial Storage areas, etc. for pest insect activity.
- Monitor and reset rodent snap traps daily.
- Conduct maintenance and cleaning daily.
- Maintain vegetation-free zone around buildings.

September

- When bats migrate south, seal exit holes in attics of structures.
- Thoroughly clean inside structures, especially upstairs, to remove hibernating insects (beetles, flies, moths).
- Maintain vegetation-free zone around buildings.
- Inspect the wood in all structures for wood borers, mold, algae, lichens or other wood-destroying organisms, and spot-treat if necessary.
- Conduct maintenance and cleaning daily.
- Monitor Curatorial Storage areas, etc. for pest activity.

October

- Monitor Curatorial Storage areas, etc. for pest activity.
- Monitor and reset rodent traps daily.
- Ensure door sweeps are sealed to prevent rodent entry into structures.
- Clean interpretive historic or period clothing.
- Conduct maintenance and cleaning daily.
- Maintain vegetation-free zone around buildings

November

- Monitor for insect pests in Artifact Curatorial Storage areas. Treat cracks and crevices with diatomaceous earth if necessary.
- Conduct maintenance and cleaning daily.

December

- Prepare and submit the past year pesticide use amounts and other data to the NPS Regional IPM Coordinator via PUPS.
- Monitor for pest activity in Curatorial Storage areas. Treat with diatomaceous earth if necessary.
- Conduct maintenance and cleaning daily.
- Check set rodent (mice, rats, etc.) snap traps each morning, remove captures and reset.

Daily Activities

- Check set rodent (mice, rats) snap traps each morning, remove captures and reset.
- Thorough cleaning of floors, restrooms, break rooms and entryways, etc.
- Remove all trash and organic material from the structures at the close of business.
- Interpretive staff includes IPM information in presentations.
- Eliminate clutter.
- Empty all outside trash containers at close of business.

Weekly Activities

- Check all insect sticky traps and pheromone traps and record findings. Replace those traps that contain numerous captures.
- Clean all trash containers (and dumpsters) as needed (weekly).
- Inspect for insect or rodent damage (holes, gnawing, rub marks, nests) and clean or repair as necessary.
- Inspect structures for pest access, food, moisture and harborage, and modify habitat.

Monthly Activities

- Download data loggers for all museum and artifact storage sites, and analyze data for anomalies (high temperature or humidity). Adjust air conditioning equipment as necessary.
- Remove dust from all exposed displays.
- Check animal mounts and furs for insect activity or other damage and thoroughly clean.
- Inspect and clean all natural hides and organic material (cloth, etc.) in displays.

Seasonal Activities (when time and labor are available)

- Train staff in important roles in implementing IPM practices.
- Prepare for insect and/or rodent invasion of structures.
- Seal and/or repair the holes in all structures.
- Seal all openings, cracks and crevices in the upper floors and attics of all structures to exclude bats. This should be accomplished in the winter when bats have migrated south.
- Clean floor/wall junctions and corners of wax, dirt and grime in all structures.
- Inspect and clean all storage cabinets.
- Inspect and unfold/unroll all organic material in displays and clean, brush or vacuum to remove contaminants, eggs, larvae or insects (preferably spring and fall).

TIME AND BUDGET REQUIREMENTS

Responsibilities for implementing the Integrated Pest Management Action Plan for Weir Farm National Historic Site reside in all divisions of the park unit. Some tasks are pest management specific, while others are part of routine maintenance, public health and safety, and hazardous material handling activities. As such, estimating the financial support necessary for full implementation of this plan has some inaccuracies. A conservative estimate based on the current response to pest management within the site (Table 1) is 1740 man hours of effort among all divisions. Although this amounts to 0.83 FTE, it is distributed among several divisions.

Table 1. Estimated annual work hours and FTE equivalents of Weir Farm National Historic Site staff for performing Integrated Pest Management related tasks:

Resource management division		
Museum collection management		
Monitoring; daily, monthly, seasonal tasks		120 hrs
Artifact cleaning, inspection and storage		80 hrs
Historic site pest management		
PUP plan oversight		20 hrs
Seasonal and ad hoc inspections		80 hrs
Orchard vole and deer exclusion		80 hrs
Resource management and interpretive division		
Public health and other pest management		
Insect management activities		60 hrs
Rodent trap monitoring and exclusion		80 hrs
Interpretive, goods handling		
Seasonal cleaning		80 hrs
Daily/weekly cleaning and inspections		80 hrs
Historic orchard and garden IPM		
Daily monitoring for pests		80 hrs
Maintenance division		
Routine activities		
Refuse handling		180 hrs
Custodial services in buildings		360 hrs
Seasonal activities		
Buildings maintenance		360 hrs
Orchard mowing		80 hrs
	Total	1740 hrs

0.18 FTE	Resource management division	
		IPM program oversight and monitoring
		Museum collection IPM management
0.18 FTE	Interpretive division	
		Museum collection and interpretive goods
		Historic orchard and garden pest management
0.47 FTE	Maintenance division	
		Routine cleaning and refuse management
		Buildings and grounds maintenance

FUNDING

Current routine Integrated Pest Management activities are supported under base funding for the site. Unusual or periodic treatments, such as wood preservative treatment of building exteriors, must be supported by additional funding. This may be solicited as cyclical maintenance funds through the PMIS system, as based on needs identified in FMSS and related NPS service-wide fiscal management systems.

Full implementation of this IPM Action Plan and additional needs related to protecting structural integrity and landscape quality may require additional base funds to support additional staffing. Although this is unlikely to be the addition of a full or partial position, it would provide additional funding for the divisions already performing related actions in order to better address pest management needs.

INSPECTION FINDINGS AND RECOMMENDATIONS

The information and photos were obtained during two visits to Weir Farm National Historic Site on April 11-13, 2005 and June 12-14, 2005.

BURLINGHAM HOUSE

Live carpenter ants were observed on the porch. Follow ants to pest site and drill and treat with Borid or TimBor Pro dust. Small holes surrounded by small dirt mounds between patio stones are ground bee nesting sites. These bees are tan and about 1.27 cm (1/2 in) long. Treat only if they become a problem for visitors. Use diatomaceous earth (DE) or a fine borate dust into the holes.

Basement

There was evidence of mouse activity with numerous mouse droppings. Greg Waters, IPM Coordinator, begins mouse trapping in November as mice invade every fall. Check for openings into the basement which may be accessible to mice and close them using Stuf-Fit and caulk, spackle or cement. The many spider webs present indicate some air flow (most spiders capture flying insects). Find and close all openings through the walls in the basement, then remove the spiders with a vacuum. Beams in the basement have damage from powderpost beetles. All wood beams should be treated with TimBor or BoraCare. Use a sprayer to get good coverage of the beams. After the surfaces have dried to the touch (next day), treat the beams again. The second treatment pushes the first borate/water gradient on through the beam to reach toward the center.

East Crawl Space

The dirt floor under the fireplace outlet base does not show any burrows for rodents. However, there is a cache of acorns in the corner which may have been stashed by a squirrel or mouse. Use snap traps to capture and remove mice, rats or squirrels. There is evidence of wood rot in the beams which means a moisture source may be present. The crawl space goes under the porch to the south. If it is possible to gain access to the beams with a sprayer, they should be treated (twice – a day apart) with TimBor or BoraCare to prevent further damage. The moisture source also needs to be eliminated.

Sentricon System Bait Station

Subterranean termites swarmed near the back door. Staff started using the Sentricon system and to date have not had any more termite swarms.

The first floor contains a gathering room, a break room, the bookstore and a small office. The second floor contains office space and a restroom. These floors were not inspected. If there are pests present, eliminating clutter and food should be the first step. Monitor for crawling insects

with sticky traps (such as Lo-Line Crawling Insect Traps) placed near entryways, under desks and bookcases; and at the floor/wall junctions.

BURLINGHAM BARN

Carpenter ants had been seen in the barn prior to the site inspections. Drione was dusted around the perimeter and in the wall behind the white board. Ants were observed on the east side near the floor. Dead carpenter ants were observed in the closet behind the restrooms. Moisture meter readings from wood planks and beams registered 9 – 14 %, an overhead board at 17%, and a floor beam at 11%. Wood rot and wood-infesting insects can adversely affect wood at moisture levels of 14% and above. The space between the inner and outer walls is inaccessible for inspection. Suggest the use of Drax Liquidator bait stations as a supplement to the Drione treatment. The bait is slow-acting and will last long enough to be fed to ant larvae and the queen, thus eliminating the colony.

BURLINGHAM LANDSCAPE

Japanese beetles and white grubs have been noticed in the lawns. Milky spore disease applied to the turf areas will manage the beetle grubs over time. *Bacillis popillae* can be obtained from Biocontrol Network at www.biconet.com. Trails on the property and through the woods down to the pond have poison ivy along the edges. This has been treated with Round-up as needed. The meadow is reverting back to grassy turf (it was formerly a victory garden) with a few leftover plants here and there.

Weir Farm Landscape

Poison Ivy along Trail

Invasive species include bittersweet, multiflora rose, garlic mustard, Virginia creeper and others. The Weir Farm Invasive Species Management Plan developed in 2002 is quite comprehensive. As with any plan, the implementation is the tough part. At this point, IPMI would not add to the quality of the plan.

WEIR BARN (behind Weir House)

Carpenter bees are boring holes and galleries in the wood. Live bees were observed. Treat the holes with a DE or borate dust (i.e. Perma-Guard Fossil Shell Flour or TimBor Pro). These dusts abrade the insect cuticle or are ingested in grooming to achieve kill. The

Weir Barn

emerging bees will be killed. The adult female making the nest can be killed with a fly swatter. After dusting the hole and galleries, seal the hole with a dowel, wood putty or other wood repair material. A good coat of oil-based paint will prevent carpenter bees from drilling gallery holes. The Weir House is painted and has no carpenter bees.

Carpenter Bee Damage

Evidence of bats roosting inside the barn behind roof beams was observed. Bat droppings are evident just inside the door and on the middle half-wall. These piles of droppings are aligned with the overhead beams. Bats can be managed after they migrate south in the fall. Exclusion is the best way. Seal structures so they can't enter to roost. Roosting areas can be covered with .63 cm (1/4 in) hardware cloth, or all access points into the structure can be sealed. Bats are beneficial as they eat half their weight in flying insects every night, reducing mosquitoes, moths, and other pesky night fliers. Install a bat house nearby to house a bat colony that will continue to consume night-flying insects.

Bat Droppings under Beam

Curatorial Storage

There are no moisture or environmental controls in the curatorial storage room in the back of the barn. The storage area is monitored for crawling insects. Carpenter ant frass was observed. There is a black widow spider and web in a corner near the floor which may provide some flying insect control. This spider may be removed with a vacuum or "Webster" (a specialized web-removing brush). This room contains furniture, easels and other materials. Place Lo-Line sticky traps to monitor for crawling insects at the floor/wall junction and check them weekly. The presence of dermestid beetle adults or larvae in the traps is an indication that stored material may be damaged. Examine stored materials monthly for damage. This is NOT a secure storage for valued curatorial objects that are susceptible to pest damage.

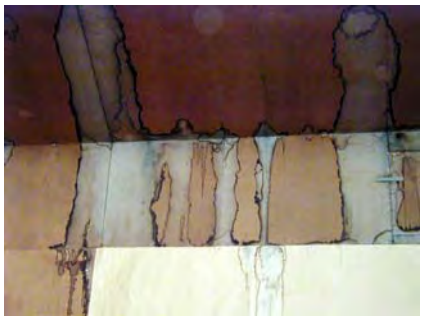
The tool room, its contents, and another storage room in the barn belong to the Andrews family. There are many dead insects captured in the spider webs.

YOUNG STUDIO

This building stores many of the Sperry Andrews paintings and other works. There are mice droppings and other indications of mice presence, such as nesting material. Any hole in the structure larger than .63 cm (1/4 in) can allow mouse entry. Seal all such holes to exclude mice, and then use snap traps to remove any that remain inside. There are moisture leaks to the left of the storage room door, and powdery mildew above the leaks. Roof leaks and other moisture sources must be eliminated to protect the historic structure and its contents. The wood cabinet has damage to the upper left side.

Young Studio

Monitoring in this building (and others) consists of different approaches. The first, and easiest, is observing the conditions that are present at the time you are there, and taking notes of the observations. Rodents and insects tend to move along lines such as the floor/wall junction, along beams or a seam in the wall or floor. Look for grease marks where rodents rub against the wall, joists, etc. Look for runways that are not dusty, and check window sills for flying insects. Spider webs also will capture flying insects for you to observe. Wood beams and other wood structures provide food for several species of pest beetle larvae and termites. Exit holes in wood indicate that the beetle adults have emerged. Some beetle larvae leave a very fine powdered frass (waste product) that may fall out of the holes. Carpenter ants make very smooth galleries in wood, but the frass they kick out of the wood may be coarse wood shavings and may include insect parts (their prey). Pest droppings can also provide information about the pest. Bats produce thin droppings with insect parts included. Mice droppings are larger and may have hair imbedded in them. Rat droppings are larger (olive pit shape). Rodents tend to dribble urine as they travel which fluoresces when viewed with a black light. Sticky traps of different types will also capture insects that wander into them. Some sticky traps can be fitted with a specific pheromone to capture a specific species (such as Clothes Moth or Indian Meal Moth). Temperature/ humidity loggers are another monitoring technique that provides data on the structure's environment. As a structure is periodically monitored, the data obtained can be tracked and patterns will emerge that will tell when eggs hatch, where the moisture leaks are, and the conditions that cause population increases. Good tight exclusion of structures results in fewer pest problems. Good sanitation (eliminating food and water) will keep the carrying capacity for pests to a minimum. The elimination of clutter reduces the harborage for insects and rodents. Sometimes a sense of smell can be developed so different rodent species, bats, and even three or four common species of cockroach can be discerned. All of the monitoring data for structural pests will, over time, give a sense of what can be found when you enter a structure.



Old Water Damage Stain

WATER TOWER

Dead Carpenter Ants

There are many dead carpenter ants on the floor inside the door and on top of the beams. The bottom of the water tower has a woodchuck hole in the floor. Woodchucks have been seen coming out from under the front steps. There is no sign of moisture damage. There are woodpecker holes in the side of the building.

LEAN-TO

There is woodpecker damage in the siding of the lean-to. There is also evidence of woodchucks under the building. The foundation appears to be sound. Repairs are needed to the foundation to eliminate woodchuck access. Install .63 cm (1/4 in) hardware cloth from the edge of the foundation down underground 45.72 – 60.96 cm (18 – 24 in) and out 15.24 cm (6 in) in an L shape to prevent woodchucks digging under the foundation. Care is needed to make sure there are no young woodchucks under the structure when the modification is done to prevent them being trapped underneath.

Woodpecker Damage

WEIR STUDIO

Weir Studio

There are water leaks from upper areas. During the rainy season, determine water leak sources to focus on where repairs need to be made. Visible moisture areas may also have accompanying unseen moisture damage that may be more extensive and a greater hazard. There is powderpost beetle damage along the edges of beams in the etching room. There is old mouse evidence, droppings and nesting, that must be removed. This old material provides food and harborage for dermestid beetle larvae and other critters. There have also been carpenter ants swarming around the door that indicate the presence of a mature colony. There is evidence of silverfish damage on several corners and in boxes, and also on a paper document tacked into the wall. On the upper floor, silverfish have also damaged old issues (collection items) of National Geographic and other periodicals stored on shelves. Apply Dekko Silverfish Pak bait stations that contain borates to manage the silverfish population. There are also mouse droppings on the second floor area. Find and fill any holes .63 cm (1/4 in) or larger to exclude mice, and then use snap traps to remove those left inside. Dead cluster flies are in the upstairs windows which can also be a food source for dermestid beetle larvae and mice. Remove them with a vacuum.

Rodent Urine Damage to Canvas

Silverfish Damage on Wall

Silverfish Damage to Magazines

WESTERVELT HOUSE

Westervelt House

This house is vacant except for when occasional meetings are held here. There are few pests present that pose a risk to the building or occupants. There were dead centipedes in the basement. Centipedes are predators on insects and prefer a humid environment. Their presence indicates there may be insect prey in the house, and that there may also be a moisture source. These factors were not apparent. There were black widow spiders present which also indicates the possibility of air flow and flying insect prey. Remove spiders with a vacuum or Webster and seal all holes found.

Basement View

Clothes moths and carpenter ants were observed in the master bath on the second floor. Vacuum these insects up and set out crawling insect and flying insect pheromone monitoring traps. The building needs a good thorough cleaning, including carpet shampooing. Set out monitoring traps in critical areas such as the kitchen, laundry room and bathrooms, and inspect periodically (weekly). The outside of the structure needs painting. Quality paint prevents structural pests and moisture damage. There is mildew damage above the garage doors which should be removed. The lawn should be monitored periodically to locate and identify turf damaging insects, moles, voles and pest weeds so management actions can be initiated. Healthy turf, mowed properly, has fewer pests.

THE SHOP

The Shop

The shop is remote from the Weir Farm and contains offices, a workshop and collections storage. This is an open area with temporary walls to divide office space from the open shop, and to enclose three locked collection storage rooms. The offices had sufficient clutter to harbor pests, however, there were none observed and no one mentioned having pests present. It would be a good idea to reduce or eliminate the clutter and monitor for crawling insects with Lo-Line Crawling Insect Traps, and rodents occasionally with snap traps or tracking dust.

Shop Collection Room 3

Humidity in this area was 66% read and recorded. There is no control of humidity in the storage rooms except to turn on fans and open the doors. The artifacts stored have fabric and wood materials. The collections are very clean with no evidence of pest activity. If silverfish appear, place Dekko Silverfish Pak bait stations near. There is a need to close or tighten up openings around pipe races and where the beam goes through the room. Use Stuf-Fit and/or closed cell expanding foam to reduce insect and rodent access into the storage room. Install a rubber or neoprene door sweep on the entry door.

Shop Collection Room 2

The humidity was 65% read and recorded here. Collections have fabric and wood artifacts which are very clean. There was no evidence of pest activity in this collection room. Install a rubber or neoprene door sweep on the entry door.

Shop Collection Room 1

The humidity was 71% read and recorded. Collections have fabric, wood and paper. The collections are very well done and very clean. If silverfish should appear, place Dekko Silverfish Pak bait stations near where silverfish are seen.

When total exclusion has been accomplished, then museum pest pheromone traps can be placed in the collection rooms to monitor for any museum pests that had not been seen. Pheromone traps can be obtained from Insects Limited (see Vendors). Use pheromone traps for casemaking and webbing clothes moths, black and varied carpet beetles which are the greatest risk to the collection.

The Shop Itself

The shop area is very clean, and the equipment has been cleaned and is ready to use. An occasional bird may fly in, but there are no mice or rats. The two pesticide cabinets were NOT locked. Greg Waters locked them while we were there. Pesticides, no matter how benign, must be kept under lock, except when in use; and then under direct supervision.

Maria Abonnel provided some comments for our use. “Sanitation of the offices and curatorial areas needs to be a high priority, with attention to details. There should be NO eating in historic

structures at all. Break room or kitchen sanitation should be better so there is NO food available to any pest that might be present. People should thoroughly clean up after themselves." She mentioned that her office is on the first floor in the Burlingham House. She sees carpenter ants in her office, maybe four or five at a time. Carpenter ants can be traced back to the nest and treated. Drax Liquidator is an attractive, slow-acting bait for carpenter ants. There are also dead insects between file cabinets, which should be vacuumed out. A knot hole in the floor goes through to the basement, and can be filled with wood putty or other impervious material.

CARETAKER'S HOUSE

Caretaker's House

This historical building is being occupied by resident artists who are studying and practicing here. There are dead carpenter ants in the living room and bedroom. The building had been treated by Orkin recently using Cypermethrin or Cyfluthrin in a floor/wall junction spray. **It is not a good idea to use pyrethroids to treat the inside living spaces of a structure that is occupied**, as many people react to these products.

There was a dead spider on the floor in the bedroom. Dead carpenter ants, workers and reproductives, were found behind a shelf on the north wall. Dead flying insect parts were also found. The upstairs studio has one window with a .63 cm (1/4 in) space between the frame and the screen. → This leaves an open gap for critters (insects) to fly or crawl into the studio. There were mice droppings on the west bedroom floor by the window. Mice droppings were also found in the kitchen in the stove and behind the refrigerator. Find and seal all holes .63 cm (1/4 in) or larger to exclude rodents. Use snap traps to remove those left in the structure. A higher level of sanitation is needed in the caretaker's house so pests are not fed. Elimination of clutter reduces pest harborage areas.

Window Gap

If there is further evidence of carpenter ant activity (sightings), a thorough inspection of the structure, inside and out, should be done to determine the exact location of the colony. It may be underneath in structural beams or in the roof rafters. Check for "kick out" holes with rough wood frass to verify the presence of ant galleries. Once the ant galleries in the wood are determined, drill a small hole into them and inject a borate dust such as TimBor Pro or Borid to kill the colony. The colony may be located away from the structure in a stump or log nearby. If so, treat the stump, etc. Follow the ant trail to determine how and where they enter the structure and seal the gap.

2nd Floor Studio

There is loose plaster around the chimney which may be pest access or harborage. This needs to be repaired. The beams in the studio appear to be intact. Around the outside, bushes and other vegetation should be removed to .91 m (3 ft) from the building and a 15.24 cm (6 in) deep gravel barrier installed to reduce moisture and deter pest access to the building. Some cracks on the outside of the building have been filled with foam substance (which is unsightly). Trim and paint the material or remove it and use an historic material such as oakum or other caulking.

WEIR HOUSE

Weir House

The Weir house is still occupied by Sperry Andrews, who is very ill, and his caregiver Dave. Dave has seen mice in the kitchen and by the front door. There have also been problems with mold and carpenter ants in the past. Mousetraps should be set at the floor/wall junctions near the front door and in the kitchen, and Dave can monitor them for captures. Greg Waters can then remove the captures and reset the traps.

Basement

There are cracks in the outer basement wall next to the stair where moisture has come through. The wall needs to be waterproofed and the cracks sealed to prevent moisture intrusion. This area is very clean and the ceiling beams do not appear to be damaged. In the closet behind the stairway, the wall plaster has broken away about 30.48 cm (12 in) above the floor, exposing the wood lath. Wood rot or insect damage is not evident. The walls and beams have been whitewashed, and all beams are solid without evidence of mold or insect damage. The brick alcove behind the black door is clean. The 1.27 cm (1/2 in) hardware cloth around the locked space will not exclude mice and other small rodents. Replace it with .63 cm (1/4 in) hardware cloth and set snap traps around the perimeter about 1.83 – 3.05 m (6 – 10 ft) apart. The enclosure (not entered) appears to be very clean. Roots of the sassafras tree outside have pushed in part of the block basement wall (near the floor) on the front of the house. The basement wall here needs to be repaired. There is powderpost beetle damage above the green painted cabinets. There was fly pupae found on the floor in the left closet. The right closet has mouse droppings on the upper shelf (only). Find where the mouse has entry and repair to exclude them; then set Victor snap traps to remove those still inside. There is a hole by the pipe above the outside door. In the tool and garden storage there are mouse droppings on a shelf to the left of the doorway. There is also a hole in the window to the next room. There is a hole by the outside window with tail tracks in the loose dust below. The outer outside door has a chewed hole at the bottom (the inner door was intact). The laundry/furnace room has unstable floor boards (beneath the plywood) which should be replaced or at least stabilized. There is moisture damage in the window by the clothes dryer. The crawl space looks clean without evidence of pest presence.

First Floor

The kitchen does not have evidence of mice; however, there is trash and other debris under the radiator. The dining room had two dead carpenter ants (workers) on the floor. The bookcases in the hall are very clean, and there is no evidence of psocids or silverfish in the books. The library is also very clean with no evidence of psocids or silverfish in the books.

Second Floor

There is general clutter throughout this floor as family are going through and cataloging the contents. There was no visible evidence of pest presence except a spider web in the nursery. The northwest bedroom, the southeast bedroom suite and the bath were all OK. The southwest bedroom where Sperry Andrews' daughter stays when visiting was locked and not entered.

INTEGRATED PEST MANAGEMENT METHODS

Pest exclusion, sanitation and habitat modification are the most effective treatment practices.

EXCLUSION

Exclusion is the first line of defense in a good IPM program. Exclusion means making the structures physically unavailable to pests so that they cannot enter the structure to take up residence or detrimental activity inside. Some pests, especially in the larval stages, are very small and may be able to penetrate our tightest defenses. Exclusion procedures include keeping the external structure intact, by repairing all cracks, holes or other entry points into the structure that could allow insects, mites, spiders or rodents inside. Roosting, nesting or loafing sites for bats or birds must be modified to prevent these pests (spikes and glues don't work for long). Ledges and other level sites must be refitted with a 45º to 60º angled surface to prevent bird occupation. This can be accomplished on historic structures without ugly, distracting devices. Exterior doors can be fitted with "brass kick plates" and tight-fitting door sweeps to close the gaps between the door and the threshold to exclude crawling insects and rodents. Unused chimneys, air vents and other entry points into a structure should also be screened with 16 mesh or finer to prevent pest intrusion.

Exclusion is defined as finding and eliminating all possible entryways (points of access) pests use to enter a structure or room. Those entryways may be as small as a hairline crack in a wall or as large as a gap under a door, openings around pipe and wire traces, or the absence of screens on windows. Exclusion is more important and effective for the management of most pests than even increased sanitation (availability of food). Pests simply cannot be present in a building or display case if they do not have an entryway. All possible routes of pest entry or attraction must be found and eliminated. Periodic inspection and monitoring will guarantee the prompt discovery and correction of any newly appearing entry points.

Correcting exclusion deficiencies is site-specific but is usually done by sealing them (i.e., caulking, carpentry repairs, installing door sweeps, netting, installing filters on air vents and hot air registers, etc.). Identify and seal all holes that could potentially allow insects (small cracks) or rodents (holes or cracks .63 cm (1/4 in) in diameter or larger) to enter the structure or room. In storage areas, sequester sensitive items in metal, glass, or durable plastic containers and periodically monitor them.

Assure that pests are not inadvertently imported into the building in or along with infested products or supplies (i.e., museum items or displays, firewood, outdoor furniture, employee clothing, lumber, books that have been on loan, etc.). This should occur in the receiving quarantine area.

Bird netting is an effective measure to exclude birds from alcoves, porches, and attics. Fit all ledges or level areas that are attractive for bird nests with 45º angle surfaces as a preventative.

Note: Screening chimneys and stove pipes may cause soot to build up on the screen. Install proper chimney caps for bat and bird exclusion. Periodic scrubbing of screening with a nylon brush will clear the screen and restore fireplace or wood stove performance. Various commercial chimney caps are available which exclude rodents, bats, larger mammals, and birds.

Moisture in contact with untreated wood is an opportunity for wood decay fungi to become established and destroy the structural strength of the wood. Wood kept dry will never decay. Wood in contact with soil, cement or masonry is more susceptible to moisture and, thus, very susceptible to wood decay fungi. The local weather (snow, rain, humidity) also exposes the exterior wood to moisture. Any leaks may also expose interior wood to moisture.

The IPM Coordinator should perform an inspection to identify specific areas to close and direct maintenance efforts to accomplish this. Routine maintenance to repair roofs, siding, windows, doors or other portions of the structure should be accomplished with pest exclusion in mind.

SANITATION

The second line of defense is sanitation; eliminating pest access to food, moisture and shelter. Food and moisture are basic biological needs for any living organism, and life cannot be sustained without them. Eliminating food and moisture from access by pests will cause them to either leave or die. Reducing the access to food and moisture will reduce the carrying capacity of the site for living organisms. Reducing the carrying capacity of a site to zero may not be realistically accomplished with today's technology. However, reducing resources for pests will limit population size and growth. Reducing or eliminating clutter may be a more realistic goal. The combined efforts of Curatorial, Maintenance and Custodial staff can make great strides toward eliminating clutter in critical portions of the structures.

Identify and remove all potential food sources (rotten wood, food, fabrics, organic artifacts, mold, mildew, fungus, lichens, plants, etc.) and all possible harborage sites (openings, cracks, crevices, stacked firewood, clutter, etc.) available to pests. Verify that employees (or visitors) are not accidentally or willfully feeding animals (birds, squirrels, etc.) around the building(s). Verify that any animal wastes are regularly removed from around the exterior of the building.

Eliminating most food sources available to pests is a responsibility of site staff who work in or otherwise occupy the buildings. Food can be eaten elsewhere out of the buildings, or any (all) food residues cleaned up immediately when noticed. Food stored in the structures must be in metal or glass containers with tight-fitting lids (rodents and some chewing insects can easily cut through plastic containers). Elimination of all food sources that are accessible to insects or rodents is required. Moisture sources (leaks, condensation) can be identified and requested to be remediated by the Maintenance staff. Drink spills must be cleaned up immediately by the responsible staff member.

Many pests can go for great lengths of time without feeding or are able to survive on lint, fabric fibers, mold, and other uncommon food sources. Verify that museum and curatorial storage areas are thoroughly vacuumed (floors, cabinets, windows, and walls; in, under, and around equipment

and furniture; and all cracks and crevices) at least twice a month, and more frequently if possible, to remove accumulated lint and dirt. Cleaning denies pests food and harborage and reduces insect survival rates.

Be sure visitors or employees are not providing food and water sources to animals, and that the grounds around buildings are free from debris or stacks of stored items.

Museum Collection Storage

Preventive placement of sticky traps at the floor/wall junction on both sides of the entry doors will reduce access by crawling insects. The inside bottom surface of the enclosed cabinets (below the bottom drawer) can be dusted with diatomaceous earth as a deterrent for dermestid beetle larvae and adults. DO NOT overtreat – a very light layer of diatomaceous earth dust is sufficient. The installation of museum pest-specific pheromone traps in upper corners of the rooms for flying adult moths and beetles can provide monitoring information and is a management method. Periodic vacuuming within the rooms will eliminate dust and other organic materials that can support pests.

Administrative Offices

Trash and other organic refuse must be removed at close of business each day. Thorough cleaning of each office and the break room must be conducted at least once a week. A periodic (unannounced) “white glove” inspection by the IPM coordinator is helpful to point out clutter and sanitation deficiencies. Occupants (staff) can be made aware of how their own actions (and care) are important to prevent conditions conducive to pests being present (while staff are gone or in the office).

Resident Artist Program

Resident artists should be provided information on the role they have in managing pests by eliminating clutter, sanitation and assuring food or other organic material is not available to rodent or arthropod pests. Keeping their quarters clean, neat and orderly is their own responsibility.

HABITAT MODIFICATION

The third line of defense is habitat modification, which may include changing the behavior and activities of the humans that work and visit these historic sites. Habitat modification is a term used to describe changes made to a site in order to reduce the number of pests the site can support. Living organisms need to have air, water or moisture, food or nutrients, adequate temperature, secure hiding or resting areas, and light for plant growth. These things make up the habitat of a site. By manipulating the access or availability of these necessities, the "habitat" can be modified to such an extent that the site is no longer attractive to the pest, or the site no longer supports the pest's life. Habitat modification can take many forms and is usually directed toward the "life style" of a specific pest to be managed.

If possible (to keep insects from being attracted to lights near entryways), mount outside lights on poles located at least 9.14 m (30 ft) from the building and shine the light back onto the building.

High pressure sodium vapor lamps that attract fewer insects and are more energy efficient can be used for exterior lighting.

Controlling temperature and humidity in structures can be very important in reducing insect populations. Humidity and temperature in museums and curatorial areas should be kept as cool and dry (below 45% humidity) as practical. The closer temperatures approach 10ºC (50ºF) and below, the slower insect activity becomes, which lessens feeding and reproduction. Reducing humidity lessens survival of humidity-dependent pests like silverfish or psocids.

Exclusion and sanitation measures cited previously are important parts of habitat modification. An additional measure to make habitat modification effective is the elimination of clutter. Clutter provides shelter and hiding places for insect and rodent pests. The elimination of clutter creates open areas where pests prefer to avoid. Material (boxes, boards, etc.) stacked against walls or on the floor create hiding areas and pathways where insects and rodents can live undisturbed and unseen. Every person visiting or occupying the site is responsible for eliminating clutter. The introduction of predators or parasites into an area can also modify the habitat so that insects, rodents or other pests cannot easily propagate or survive.

Verify that all plants overhanging or touching the building are trimmed back at least .91 m (3 ft) from the building so pests can not use them to move onto the building. If possible, establish a .91 m (3 ft) wide vegetation-free zone around buildings. Use 1.91 – 2.54 cm (3/4 – 1 in) rock gravel mulch (at least 2.54 cm [4 in] deep) next to the structure. If a vegetation-free zone is not possible, keep grass, bushes, and trees next to buildings cut short.

Verify that all sources of moisture around the building are corrected. Eliminate any low spots in the ground that accumulate water run-off and all other water-holding sources (i.e., old tires, cans, refuse, and hollow trees).

BoraCare, a borate product with glycol to enhance penetration, is mixed with water to be applied to wood to protect from termites, wood boring beetles and all wood decay fungi, and is a fire retardant. Apply BoraCare as a spray to clean exterior wood. Apply a second treatment (the next day) to push the first moisture gradient totally throughout the wood beam. This makes all of the wood cells toxic to insects, fungi and molds. A moisture barrier can then be applied to further protect from moisture presence. WOODguard can be applied when wood moisture is 18% or below so it will penetrate to provide a transparent moisture barrier. Reapplication of the moisture barrier may be required every two or four years.

MAINTENANCE

Good maintenance practices should include habitat modification. Maintaining the structural integrity of a building is excluding pests from entering the building. The maintenance activities that repair leaks and other moisture management activities are modifying pest habitats that are reliant upon water. Temperature control can slow or increase the growth of insects, fungi and molds. A good example is interior humidity control. The lower the humidity, the fewer pests can live in a site. Good cleaning or sanitation practices will also reduce the carrying capacity of a site for pests.

Exclusion is another habitat modification that will reduce the capacity of a site for pests. Keeping food stored in pest proof containers such as glass or metal containers with tight fitting lids prevents pest access to food. Tight door sweeps keep crawling insects and rodents from entering. Similarly, repair of masonry and holes in walls and floors prevents potential pest access. The most effective way to manage rodents inside a structure is to keep them from entering the structure in the first place.

Changing the behavior of personnel who occupy the site is another means of habitat modification. Getting people to use trash receptacles, and removing trash at the close of business is necessary. Inspect trash cans to verify that the cans are 15.24 m (50 ft) or more from the building, raised on platforms off the ground, trash is being promptly removed, can interiors are being cleaned (use can liners), lids fit tightly, and can exteriors are clean. Removing or rearranging clutter can improve the habitat to make it less desirable for pests. Convincing occupants to clean up after themselves has great benefits. Habitat modification may also include behavior such as better cleaning practices, more frequent inspections and monitoring, and removing infested or contaminated materials from the structures.

Modification of the landscape can also prevent or reduce pest presence. Keeping turf properly mowed to 2.54 cm (4 in) reduces habitat for broadleaf weeds and ticks. Planting pest resistant varieties of turf and ornamental trees and plants also reduces pest presence and makes pest management easier. Proper watering regimens, fertilizing, and aeration of turf prevent insect, disease and weed pests on the site. Decorative rock mulch next to the building reduces suitable habitat for rodents, insects and other pests, and also helps manage moisture around the building.

Biological changes of the habitat can include interplanting to repel pests, encouraging the presence of bats or purple martins, introduction of lady bugs, lace wings, preying mantis, predator mites, parasites, other predators, diseases and entomophagus fungi.

Physical controls can be instituted to manage pest populations, such as: installing screens, air doors, light traps, fencing, proper pruning of foliage, netting or tension wires to exclude birds, sticky traps, lethal snap traps, chimney screens, metal flashing, weather stripping, caulking cracks and crevices, and mosquito nets. Other habitat modifications include moving stored firewood outside away from the building and moving lights away from doors or the building.

Identify and schedule the removal of stinging insect (honey bees, paper wasps, yellow jackets, etc.) and bird nests (English sparrow, swallows, etc.) from the structure as early in the spring as possible. Remove all organic debris (i.e., feathers, dead insects, excrement, etc.) from building ledges, gutters, and openings. Remove any spike or sticky glues used to deter birds and replace with a 45º ledge barrier to eliminate nesting and roosting.

Identify and remove the mammals from all burrows leading under the building foundation. Verify that crawlspace access doors and crawlspace ventilation ports are tight and screened to exclude mammals and arthropods. Verify that holes, cracks, or gaps do not occur (or are sealed) in the foundation.

If animals are using burrows, trap out the animals and securely close the burrow entrances. DO NOT USE TOXIC BAITS. If animal nests are inside or under buildings and can be reached, it may be necessary to treat the nests for fleas, mites, and other parasites.

Rodent Traps

When managing rodents inside buildings, be sure to place a sufficient number of snap traps along all rodent travel routes and in all probable harborage areas. Place two traps 30.48 cm (12 in) apart at each trapping station and locate stations every 3.05 – 6.10 m (10 – 20 ft) along walls in suspected rodent harborage areas. Place traps with the triggers pointing toward the wall. Fewer traps can be used when larger rodents are present but there should be no less than two traps at each trapping station and at least one trapping station per room. Vary the baits used on traps by using food materials on some and cotton on others. Cotton balls are used by females to line the nest.

Snap traps: Because of Hantavirus and other disease concerns, the Center for Disease Control recommends only using snap traps (not live-capture type traps) for rodents because:

- snap traps prevent the possible spread of Hantavirus into unaffected rodent populations.
- snap traps limit the spread of rodent urine, saliva, and feces around trap sites.
- snap traps prevent human contact with disease organisms which may occur from bites or other physical contact with rodents.
- snap traps prevent human contact with disease-contaminated aerosols during trap handling.
- snap traps must be checked daily.

Glue Boards: Glue board traps are flat boards or trays coated with glue. Rodents become stuck to them and cannot escape. Glue board traps are not humane and must NOT be used.

Insect Traps: Low-Line, Mister Sticky and other crawling insect capturing traps can be placed at the floor/wall junction to remove (and monitor) insects from inside the buildings. Place them inside cabinets, shelving, under sinks and other dark areas where insect pests may seek food, moisture or shelter. Pheromone traps to capture adult (flying) moths and beetles that may attack historic fabrics, furs and other organic materials, can be placed near the ceilings or in corners away from critical or susceptible materials. Check blunder or pheromone traps at least weekly to monitor for the presence of pest insects that may have invaded the site.

Replace sticky traps or pheromone traps when they start getting full. Pheromone traps are most used in a museum setting to attract and capture carpet beetles, cigarette beetles, dermestid beetles, drug store beetles, Indian meal moths, clothing moths, and warehouse beetles (but other pheromones are being developed). Contact Insects Limited, Inc. for newly available pheromone traps.

There are many means to modify the habitat to make the site less attractive to pests, and to deny them the necessities for life.

PESTICIDES

Specific low-risk pesticides may be suggested to preserve and restore certain elements of the structures and historic contents from further damage by pests. Proposed pesticide use must be reviewed and approved by the IPM coordinators at the regional and perhaps national level before application. Any suggested and approved pesticide applications must be conducted very carefully so as to not contact non-target surfaces. Any pesticides used should first be used on a like "test" surface to avoid any potential "mishap" to "historic fabric" such as wood, tile or plaster. Approved pesticide applications must be documented and kept in the site IPM Coordinator's file.

INSPECTION AND MONITORING

Successful low-risk integrated pest management (IPM) depends on "inspections and monitoring" more than anything else. These activities provide pest management alternatives because they identify the presence and changes in conditions that support pest populations.

Inspection is an action taken by a person (usually the IPM Coordinator) looking for (and seeing) evidence of pest activity in a structure, its surrounding environment, turf, landscape or other areas. Anyone can conduct an inspection; however, it will achieve better results if the same person performs the inspection periodically, thereby noticing changes that may occur. Other staff can make observations and report them on a Pest Sighting Log.

There are important tools that support the inspector and assist in gathering information. One of the most important tools for the art of inspection is a powerful flashlight. Outdoors, a pocket mirror (on sunny days) can take the place of the flashlight. The flashlight (and mirror) illuminates a relatively small area and helps the inspector to focus the vision in that small area to see more detail. Use a moisture meter to detect the level of moisture in structural media such as wood members, carpeting, plaster, shelving, cabinets, etc., to help detect conditions supporting Wood Destroying Organisms (WDOs) and mold. Be sure to record moisture readings and the media being tested. A UV light (black light) is useful for detecting rodent urine stains (they fluoresce) in runways, corners and other active sites. A notepad and pen, or working tape recorder and camera are also useful tools. Hand lenses, killing jars, plastic Zip Loc bags or envelopes for collecting specimens are also useful.

Consequently, non-chemical methods of pest control become very important. When inspecting and monitoring for pests, information obtained will indicate effective non-chemical means for preventing, reducing, or eliminating pest infestations.

In some cases, "inspecting" and "monitoring" may seem to relate to similar activities; however:

> "inspection" refers to the initial discovery of pests or conditions supporting them and is a snapshot in time, and
>
> "monitoring" refers to watching or measuring changing conditions over time to quantify whether pest populations or the conducive conditions supporting pests are static, decreasing and improving, or increasing and worsening. The need for continual monitoring and prompt discovery of pests, especially arthropods and rodents, is urgent because populations are able to rapidly increase in a short period of time and, when numerous, management requires significantly more effort, time, and expense.

Even though inspecting and monitoring may have different purposes, both activities examine similar things in similar ways. This describes a large number of things to look for and document on inspection and monitoring forms.

To be effective, low-risk pest management should never begin by applying a pesticide, but rather with an inspection that shows how the pest(s) entered, identifies the pest, and estimates the extent or seriousness of the infestation. There are always good (and usually apparent) reasons for every infestation and these must be discovered. Inspections (and monitoring) for pests and pest damage should always concentrate on obtaining information on:

- how pests entered (or, could enter)
- the location of harborage, food, and water available to the pest
- the existence, extent, and severity of the pest problem
- reproductive, life history, and behavioral information on the pest
- the safest and most appropriate management strategies, based on site limitations

INSPECTING AND MONITORING WEIR FARM STRUCTURES

Exterior Inspections

Thorough inspections of the exterior portions of WEFA structures should be conducted at least twice a year – in early spring (April) and fall (October) when weather patterns change. Good exterior sanitation, exclusion, elimination of pest harborage and moisture, and management of exterior lighting will do much to keep pests away from and being able to enter the building. Use a bright flashlight (or mirror) to carefully look for pests, evidence of pests, equipment deficiencies, and exterior cultural practices (clutter) that could potentially encourage or support pests. Carefully examine the building exterior from the ground to the roof, watching for locations where pests could enter the building (pest management efforts inside the building will never be effective until all exterior holes are closed). Locations sometimes overlooked include openings in and under equipment and inside electrical equipment and motors, openings in soffits, roof dormers, and in or around pipes and ducts (particularly those on the roof). Inspect cracks and voids by applying a flushing agent such as compressed air that forces insects out of hiding.

Inspect locations of outside lighting for attracted insect pests. If possible (to keep insects from being attracted to porches and entryways), mount outside lights on poles located 9.15 m (30 or more ft) from the building and shine the light back onto the building. High pressure sodium vapor lamps that attract fewer insects and are more energy efficient can also be used for exterior lighting.

Look for, identify and remove all potential food sources (rotten wood, food, fabrics, organic artifacts, mold, mildew, fungus, lichens, plants, etc.) and find all possible harborage sites (openings, cracks, crevices, stacked firewood, clutter, etc.) available to pests. Request that employees (or visitors) are not accidentally or willfully feeding animals (birds, squirrels, etc.) around the building. Verify that animal wastes are regularly removed from around the exterior of the building. Check for animal burrows under structures and determine if they are active (occupied).

Ensure that all plants overhanging or touching the building are trimmed back at least .91 m (3 ft) from the building so pests can not use them to move onto the building. If possible, establish a one meter (3 ft) wide vegetation-free zone around buildings. Use 1.89 cm (3/4 in) to 2.54 cm (1 in) rock gravel mulch (at least 10.16 cm [4 in] deep) next to the structure. If a vegetation-free zone is not possible, keep grass, bushes, and trees next to buildings cut short.

Check that all sources of moisture around the building are corrected. Eliminate any low spots in the ground that accumulate water run-off and remove all other water-holding sources (i.e., old tires, cans, refuse, and hollow trees).

Inspect trash containers to verify that the cans are 15 m (50 ft) or more from the building, raised on platforms off the ground, trash is being promptly removed, can interiors are being cleaned, lids fit tightly, and can exteriors are clean.

Identify and schedule the removal of stinging insect (honey bees, paper wasps, yellow jackets, etc.) and bird nests (English sparrow, starling and pigeon) from the structure as early in the spring as possible (Fish and Wildlife permits may be required to remove the nests of migratory birds). Remove all organic debris (i.e., feathers, dead insects, excrement, etc.) from building ledges, gutters, and openings. Remove any spike or sticky glues to deter birds and replace with a 45º ledge barrier to eliminate nesting and roosting.

Identify and remove the mammals from all mammal burrows under the building foundation. Verify that crawlspace access doors and crawlspace ventilation ports are tight and screened to exclude mammals and arthropods. Ensure that holes, cracks, or gaps do not occur (or are sealed) in the foundation.

Outside Bird and Bat Inspections

Birds and bats enter buildings (usually, attics) for nesting or roosting or when outside conditions become too harsh. Preventing birds and bats from being attracted to or using buildings can be very difficult but such actions are important for preventing accumulations of bird- or bat-associated debris and feces and to keep their ectoparasites from becoming established in buildings. Although bats are beneficial for reducing night-flying insects such as mosquitoes, they should not be allowed to roost inside structures. Provide a bat house for their benefit.

Thoroughly inspect the eaves, roofs, gables, and other structural building elements for the presence of birds, bats, bird nests, and bird and bat roosting sites. Verify that chimneys have bat-proof caps and roof vents are screened with woven hardware cloth (.64 cm [1/4 in] mesh). Look for and close small (.64 cm [1/4 in] diameter) holes around soffits, eaves, and attics to keep birds, bats, or other animals out of attics and the void spaces between walls. Be sure that exterior garbage containers are in good condition, kept clean, lids are tight, and disposal practices are appropriate. Be sure water sources are not available to animals, and grounds around buildings are free from debris or stacks of stored items. Bird netting is an effective measure to exclude birds from alcoves, porches, and attics. Fit all ledges or level areas that are attractive for bird nests with 45º angle surfaces as a preventative.

Note: Screening active chimneys and stove pipes may cause soot to build up on the screen. This could reduce the draft and cause smoke-filled rooms or other safety hazards. Periodic scrubbing of screening with a nylon brush will clear the screen and restore fireplace or wood stove performance. Various commercial chimney caps are also available which exclude rodents, bats, larger mammals, and birds.

Outside Inspection for Large Mammals

The presence of larger vertebrate pests (i.e., skunks, raccoons, rabbits, porcupines, ringtail cats, foxes, feral dogs and cats, etc.) in a structure can allow for various other common pest problems and possible damage. Inspecting buildings for larger animals is easier than for insects or mice because the holes and trails are larger and the animals create more sign.

Carefully inspect building exteriors and perimeters for burrows leading under foundations, large rocks, or tree bases; see that crawlspace openings are tightly closed. If animals are using burrows, trap the animals and securely close the burrow entrances. If animal nests are inside or under buildings and can be reached, it may be necessary to treat the nests for fleas, mites, and other parasites. Record observations of larger animals and damage to grounds and structures.

Some methods for determining if an animal burrow is active are to: (1) place wadded newspaper in it, (2) sprinkle talc or dust on the ground around the opening, or (3) kick in or collapse the burrow. Look for evidence of activity (newspaper moved, tracks in the dust, or the burrow reopened) on your next visit. Active skunk dens usually have a strong odor associated with them.

INSPECTING FOR RODENTS

The most effective way to manage rodents inside a structure is to keep them from entering the structure in the first place. Rodent inspections and monitoring must find and close the points of entry. A Center for Disease Control (CDC) study (Glass, et al) found rodents in rural cabins and mobile homes commonly move from outside habitats into the structure then back outside again. Interior rodent infestations were reduced by more than 90% by simply increasing the standards of construction methods and maintenance. Rodent management will only be effective where inspections uncover and correct structural deficiencies that support rodent infestations, such as: open points of access for movement into the building or between rooms, careless sanitation and garbage management practices, and inappropriate storage conditions which create harborage. Pre-management inspection and monitoring data can be used as a base-line against which post-treatment results are compared to record the effectiveness of management efforts.

Outside Rodent Inspection and Monitoring

The long-term management of rodents in outside areas (i.e., burrowing rodents around structures, rodents that enter parked vehicles, etc.) can only be had through habitat and ecosystem management which determines and, if possible, removes resources attracting pests and/or effectively excludes the animals from the resources. The ability to identify such conditions requires knowledge of the pests, their biology, abilities, and habitats.

Similar to an interior inspection, begin at an identifiable point outside the building and methodically progress around the building to find any evidence of pests or locations where pests could enter the building. Key rodent signs or deficiencies that should be watched for in outdoor inspections are many. Look for fresh burrowing activity, the presence of runways, or damaged plants, etc. Record any structural foundations that are in poor condition or vents, subfloor crawlspace vents and doors, door sweeps, porches, and windows that allow rodents access into buildings. Look for rodent activity around garbage disposal areas. Holes around utility service boxes and pipe or wire chases leading through walls allow rodents access into structures. Be sure

structural roofs, chimneys, and roof vents are rodent-proofed with .64 cm (1/4 in) mesh hardware cloth or similar exclusion device. Note any standing water, leaking pipes/hydrants, or poor grade conditions around buildings. Look for "vegetation ladders" that allow rodents to gain access to buildings.

The best methods to monitor population densities of outdoor rodents are through documented visual counts of individuals; counts and locations of active rodent burrows and/or access points into structures; damage to rock or structural walls, foundations, sheds, etc.; and other such observations. Over time, such data will indicate the relative numbers of rodents present in different seasons and in different years. Information obtained from observational study will provide information for effective management approaches.

Monitoring for rodents in outside locations requires:

- regular documented analysis of rodent activity and sign by means of visual observations, trapping and open burrow surveys.
- maintaining weather records (i.e., weather results – not forecasts, water content in winter snowfall, precipitation, etc.) as early-warnings for climatic conditions favoring unusual plant growth that influences the occurrence of larger or smaller rodent populations.
- recording the numbers and kinds of dead rodents found. This information acts as an early warning for possible diseases in wild populations. Where feasible, all discovered freshly-dead rodents should be sent to public health agencies for analysis.
- monitoring the storage, transportation, and disposal of garbage and general area sanitation.
- request assistance from the State Department of Health or NPS Public Health officer for monitoring of possible plague-carrying fleas in rodent burrows.

Interior Inspections

Conduct thorough inspections of the interior of structures at least twice a year – in early spring (April) and fall (October), usually in conjunction with exterior inspections. Inspect critical sites (displays of organic historic fabric, archive storage, etc.) up to twice a month if necessary. Once insects invade a structure, museum or archival storage area, management can be very difficult, expensive, and require considerable time because small, residual populations are able to survive under even the most sanitary of conditions. Given the opportunity, such latent populations can suddenly explode into major problems.

It is important to find pest infestations as early as possible because most pests are highly adaptable to conditions and very prolific. Inspections that discover the early stages of an insect infestation and concentrate corrective measures on good exclusion, increased sanitation, and reducing pest habitat will generally manage most insect problems.

Serious pest problems in one part of a building usually means the entire building will need to have management action because all the rooms usually share an adjoining attic and crawlspace as well as pipes, electrical wiring, and ducts. If pests survive in an untreated room, it is possible for them to quickly spread to all other rooms. Thus, pest inspections should also encompass the entire building containing the historic material or museum.

Use a bright flashlight to examine all portions of the building (all floor, walls, ceilings, and furniture or equipment) for any potential sources of food (crumbs, fabrics, lint, organic artifacts, etc.), water, or harborage (cracks, crevices, clutter, dark corners, etc.) available to pests. Also watch for pests, evidence of pests, and structural deficiencies or cultural practices (sanitation) that could support pests.

Controlling temperature and humidity in structures can be very important in reducing insect populations. Humidity and temperature in museums and curatorial areas should be kept as cool and dry (below 45% humidity) as practical. The closer temperatures approach 10ºC (50ºF), the slower insect activity becomes, which lessens feeding and reproduction. Reducing humidity lessens survival of humidity-dependent pests like silverfish or psocids.

Locations often overlooked include areas inside and under drawers, cabinets, and furniture; attics and store rooms (where rodents or other animals may have food caches), inaccessible wall voids (that may hold dead insect or animal carcasses); and inside electrical equipment and motors (especially computers). Because there are so many different kinds of pests that have different biology and living requirements, museum inspections must be extremely thorough and the inspector must be familiar with the various species and their preferred habitats.

The signs of a pest infestation can include: shed insect skins, feeding debris (or, frass) around or below specimens, hair falling from fur or pelts, mats of fibers, silken tubes or cases, live or dead adults, larvae, or pupae, living or dead insects near windows, damage to or exit or feeding holes in organic objects (i.e., wood, fabrics, hide, fur, feathers, horn, silk, etc.), infested or damaged food or food packaging, pests captured in pheromone or sticky traps, pests captured in ceiling light fixtures or pests or pest debris found in vacuum bags. A hand lens may be necessary to examine for small insect parts or to find eggs.

Carefully examine window sills and ledges, insides of light fixtures and areas behind or under display cases, baseboards and moldings, picture frames, rug edges, furniture, radiators and areas inside air conditioning and heating ducts, etc.

Traps

Even if an inspection has not identified the presence of pests, place light, electrocuter or pheromone traps throughout a building where they will attract and capture flying pests (follow manufacturer's recommendations for placement). Also place sticky insect traps in hidden areas throughout a building, as well as inside specimen cases. Place mouse-sized snap traps near or under furniture and shelving. Check all the insect traps on each visit (at least every two weeks). Check all rodent traps every day. Identify all captured pests. Replace sticky traps and re-set rodent traps, as necessary. Record all information on identity, numbers and location of pest presence found in monitoring traps and their surroundings.

Pheromone traps are an excellent means for the early detection of certain kinds of museum pests since the traps only capture pests that are specifically attracted to the given chemical odors (i.e., pheromone). Pheromone traps are most used in a museum setting to attract and capture carpet beetles, cigarette beetles, Dermestid beetles, drug store beetles, Indian meal moths, clothing moths,

and warehouse beetles (but other pheromones are being developed). Contact manufacturers (Insects Limited, Inc.) for newly available pheromone traps.

Pheromone traps, however, should not be considered as "control traps". Sticky, light, and electrocuter traps are not selective for species caught and are not principally used for control purposes either. These traps are used to verify the presence of insects, give information as to major areas of infestation or entry, obtain specimens for identification, determine if insects are coming in from outside, monitor approximate changes in numbers or types present, and evaluate the effectiveness of management measures.

Sticky traps are used for both inspecting and monitoring and are not selective of the species caught. They are not so much used to manage pests but rather to verify the presence of pests, obtain specimens for identification, determine if pests are coming in from outside, monitor for approximate changes in numbers or types of pests present, and to evaluate the effectiveness of management measures. Record the direction from which pests enter sticky traps and the location on the trap where pests are captured to help indicate possible focal sources of infestations. One innovative method for using insect sticky traps for difficult-to-catch insects is to place the sticky side of the trap down on <1 cm (1/16 in) spacers (such as small coins) to keep the trap just barely suspended over the floor. Traps set in this manner often are more effective in capturing crawling insects that seek refuge in small cracks.

Insect electrocuter and light traps are useful for detecting flying insects. Some of these traps emit ultraviolet light (black light) that attracts flying insects, particularly flies and moths. The insects attracted to the trap are electrocuted or become stuck on a glue board. These traps, as well as insect sticky traps, must be frequently checked and emptied or replaced or the dead insects can become an attraction for dermestid beetles and other scavengers. Place traps in areas of suspected pest activity, against walls, near doorways, under fixtures and appliances but not directly in air currents, out in the open, or where they will become wet. Pheromone traps, however, sometimes become more effective when placed in air currents (follow the manufacturer's recommendations).

Reposition traps that do not catch pests after a week or two. The number of traps required in a room varies greatly depending on the kinds of pests present and severity and location of infestations. Increase the numbers and locations of traps when suspected infestations can not be found or managed.

Use snap traps to monitor for rodent activity. Check the traps daily for captured animals. Place two snap traps at each trapping location and place the traps against walls (triggers against the wall), in corners, under furniture, and in other areas where rodents may be active. For general building monitoring, place at least two trap stations in each room. Individually number traps and record their locations on a floor plan diagram. Record on the floor plan diagram the numbers, locations, dates, and species of animals caught. Record all findings from inspections, pest reports from residents or employees, track-dusting results, night time surveys with a night-vision scope or red or yellow lights, etc. This information can be used in locating major pest harborage and entrance sites, identifying seasonal risk factors, showing changes in pest numbers over time, providing information on the results of pest management methods, providing information on trap vandalism or unexplained trap losses, noting predation on trapped animals by rodents or other animals, making treatment recommendations, or helping establish new action thresholds.

Exclusion

Exclusion is defined as finding and eliminating all possible entryways (points of access) pests use to enter a structure or room. Those entryways may be as small as a hairline crack in a wall or as large as a gap under a door, openings around pipe and wire traces, or the absence of screens on windows. Exclusion is more important and effective for the management of most pests than even increased sanitation (availability of food). Pests simply can not be present in a building or display case if they do not have an entryway. All possible routes of pest entry or attraction must be found and eliminated. Periodic inspection and monitoring will provide the prompt discovery and correction of any newly appearing entry points.

Correcting exclusion deficiencies is site-specific but is usually done by sealing them (i.e., caulking, carpentry repairs, installing door sweeps, netting, installing filters on air vents and hot air registers, etc.). Identify and seal all holes that could potentially allow insects (small cracks) or rodents (holes or cracks .63 cm [1/4 in] in diameter or larger) to enter the structure or room. In storage areas, sequester sensitive items in metal, glass, or durable plastic containers and periodically monitor them.

Assure that pests are not inadvertently imported into the building in or along with infested products or supplies (i.e., museum items or displays, firewood, outdoor furniture, employee clothing, lumber, books that have been on loan, etc.). This should occur in the receiving quarantine area.

Pest Harborage

Use a bright flashlight to find and examine all pest harborage in the building. As necessary, inspect cracks or voids with a flushing agent such as compressed air, which forces pests out of hiding and shows the focal points of pest activity.

Sources of Moisture Available to Pests

It is very important to find and remove all possible sources of moisture available to pests. Look for any sources of dampness or wet food (especially, slime, lint, and organic matter in open drain receptacles) that could attract fungus-feeding beetles, flies, mites, psocids, silverfish, and other pests. During inspections, watch for spilled or condensate water around water coolers and fountains, dehumidifiers and humidifiers, hot water pipes (condensation), potted plants, and aquaria. Check toilets, kitchens or laboratories (sinks), boiler rooms, mop closets, floors, ceilings, crawlspaces, attics for water leaks.

Use a moisture meter to inspect walls and floors for suspected moisture content or to identify leaking pipes. Watch for mold or fungus on walls. If possible, keep the moisture content of wooden structural elements in buildings below 20% to discourage termite and carpenter ant activity, and reduce the incidence of mold.

It is best to not have live, potted plants or fresh flowers (adult dermestids and other museum pests feed on pollen and nectar) in offices, museums, or curatorial areas. If plants must remain inside, assure they are not over-watered and carefully inspect the soil, along the edges of pots, and under supporting catch plates for arthropods, particularly fungus gnats.

Insects are often found under rugs close to water coolers and in motors and condenser housings of water coolers. Inspect areas where water bottles are stored; some bottles may leak or are brought into the building in wooden crates that import pests or provide moisture or harborage to insects.

Verify that condensation does not form, run off, or puddle under windows in cold weather. In winter, check for residual moisture or puddles of water near boots and overshoes and for water puddles near entryways and in closets. Cover fish tanks and other open water sources tightly and do not locate them where they will attract insects. Check to see that rest rooms, sinks, drinking fountains, and coffee rooms do not show condensed moisture on cold water lines. Verify that there are no moisture problems in the crawlspace (if so, increase ventilation or install moisture barriers).

Food Available to Pests

Many pests can go for great lengths of time without feeding or are able to survive on lint, fabric fibers, mold, and other uncommon food sources. Verify that museum and curatorial storage areas are thoroughly vacuumed (floors, cabinets, windows, and walls; in, under, and around equipment and furniture; and all cracks and crevices) at least twice a month, and more frequently if possible, to remove accumulated lint and dirt. Cleaning denies pests food and harborage and reduces insect survival rates.

When inspecting buildings containing museum items, be very alert to all possible sources of food available to pests. Check for candy, sugar, fresh fruit, snacks, etc. stored by the staff in office desks, cabinets, or at visitor contact stations (there should be no human foods at all in curatorial areas and museums); empty aluminum cans or food containers destined for recycling (do not store empty aluminum cans indoors before they are moved to recycling stations); fresh flowers or potted plants in offices; spilled food materials or dirty dishes in break rooms; dead insects or rodents on sticky traps; etc. All food kept in the building in employee lounges should be kept in refrigerators or in tightly sealed glass or metal containers. Verify that birdseed, rodent poison, and other animal food materials are not stored in the building housing the museum or curatorial storage area (if such materials *must* be kept in the building, be sure they are kept in tightly sealed containers). Check to see that lint and all other organic materials are regularly cleaned out of stoves, refrigerator coils, microwave ovens, and other equipment used in the employee break room. Check to see that interior floors are thoroughly vacuumed every day and that custodians notify supervisors, IPM coordinator, and museum curator where moisture, pests or evidence of pests, or food scraps are found. Check to see that fabrics in the museum have been dry cleaned to remove pest attracting stains (i.e., sweat, food, etc.) and kill insect larvae and eggs. Woolens should be frequently brushed and cleaned (or, dry cleaned) or hung in the sun to remove larvae and destroy eggs.

Importation of Pests

Carefully inspect all boxes, supplies, equipment, wooden pallets, specimens for acquisition, etc. that come into the structure for possible pest infestations. Verify that all incoming goods are carefully checked for possible pests and, if infested, are rejected or quarantined (tightly sealed in a labeled polyethylene bag kept well separated from collections and supplies until it is determined to be pest-free) or sterilized (deep-freeze, heat, fumigated, or by other means). This activity should be conducted in the quarantine area.

Storage Conditions

Verify that all items prone to insect infestation or that could supply harborage to pests (boxes and articles stored on floors) are placed on shelves or platforms (15.24 cm [6 in] or more off the floor; the accepted standard for museum storage). This eliminates harborage beneath the items on the floor, moves items up and away from sites of major insect activity, allows for cleaning and inspection of floors, and allows for placement of monitoring traps.

Infested museum items. Verify that all items in the structure or collections showing signs of active pest infestations are immediately removed from display or storage and are isolated and treated. Following removal of infested items, the area surrounding the infestation should be carefully inspected and treated by appropriate means.

Occasional insect invaders. It is important to note that finding outdoor insect pests inside a building ("accidental pests") clearly demonstrates the inadequacy of exclusion and should initiate a thorough inspection to find and close the entrance holes. Verify that all doors to the outside have tight-fitting door sweeps and that there are no openings around window and door frames.

Interior Rodent Inspection and Monitoring

Begin at an identifiable point in one of the rooms and methodically progress along a wall and through all rooms to completely search out all possible points of rodent entry or elements supporting their presence. A data sheet for recording inspection data can be used to list such inspection findings.

Sign. The presence of rodents produces a variety of signs that can be used for a subjective determination of the size or occurrence of a population. Signs are often found throughout a building in or around such places as fireplaces and mantles, floors and ceilings, edges of electrical and plumbing traces, attics, hollow walls and structural voids, decorative moldings, wooden and upholstered furniture, inside water heater and furnace cabinets, and in kitchen and bathroom areas. It is always important to consider the physical abilities and behavior of rodents, especially their tendency to seek shelter and warmth behind, under, or in appliances, sink cabinets, drawers, stored goods, wall voids, false ceilings, and other undisturbed areas. Several of the common signs of rodents to look for during an inspection include:

Food Damage: Food packages that rodents have gnawed into, rodent feces or hair in open food containers, food scattered on the floor, etc.

Sounds: Sounds coming from inside walls or under ceilings of rodents gnawing, scratching, squeaking, or running.

Droppings: The number of rodent fecal pellets found relates to the number and type of rodents present and how long they have frequented a location. Periodically vacuuming rodent debris from an area will allow for information to be developed on relative pest use during an elapsed time interval. Prior to vacuuming, disinfect an area to prevent exposure to Hantavirus.

Urine: Rodent urine stains are visible under ultraviolet light (UV) and fluoresce yellowish, bluish-white, or yellowish-white. Since many other items in a building also fluoresce, it is important to be able to recognize stain patterns when using UV light. Urine patterns appear as lines of fine drops or streaks while chemical and food spills tend to be larger, patchy areas or uniformly spread out. Test kits are available to validate the presence of rodent urine.

Rodent Feeding stations: Many rodents carry food to what they consider to be a safe place to eat it, usually in a protected corner. A greater abundance of rodent feces and urine deposits are seen in those areas. Also, remnants of foods (candy wrappers, nut shells, etc.) the animals have carried there are often seen and suggest what food sources should be inspected for rodent damage. Rodent feeding stations are good places to trap rodents.

Smudge marks: Dirt and oil on a rodent's fur leave smudge marks where the animals rub against pipes, beams, and openings. Once the marks are cleaned off the areas, the next monitoring will show if rodents are still using the trails.

Runs/trails: Rodent trails are often found in sheltered areas where rodents feel secure to travel; these appear as dust-free pathways both within and outside of buildings.

Tracks: Rodent footprints and tail drag marks are sometimes seen in outdoor and indoor mud or dusts. Patches of non-toxic tracking powder (chalk, Diatomaceous Earth [DE] or talc) can be used on floors inside buildings to verify the presence, activity routes, and relative abundance of rodents. Tracking patches have been shown to be up to 150 percent more effective for monitoring rodent activity than are snap traps.

Odor: Musky rodent odors can be detected when infestations are large and well-established, especially when ventilation is poor.

Gnawing: Rodent gnawing leaves small piles of chips around doors, baseboards, and windows. Gnaw marks may also be found on stored goods and food containers; electrical wire insulation; and as enlarged areas of pipe and wire traces.

Burrows: Holes and enlarged openings in walls and under foundations are often entrances to rodent burrows.

Nests and food caches: Rodent nests and food caches are found in undisturbed locations in structures including storage areas, computer and water cooler cabinets, attics, crawlspaces, and around refrigerator or freezer motors. Nests are also found outside beneath rocks or boards, in pipes, etc.

Pet reactions: Pet cats and dogs may show unusually strong interest in a specific wall or floor area when rodents are present; this is especially true when rodent invasion is recent.

Traps

When monitoring or controlling rodents inside buildings, be sure to place a sufficient number of snap traps along all rodent travel routes and in all probable harborage areas. Place two traps at

each trapping station and locate stations every ten to twenty lineal feet along walls in suspected rodent harborage areas. Place traps adjacent to one another with the triggers pointing toward the wall. Fewer traps can be used when larger rodents are present but there should be no less than two traps at each trapping station and at least one trapping station per room. Vary the baits used on traps by using food materials on some and cotton on others. Cotton balls are used by rodent females to line the nest. Snap traps must be monitored for captures daily.

Snap traps:

Because of Hantavirus and other disease concerns, the Center for Disease Control recommends only using snap traps (not live-capture type traps) for rodents because:

snap-traps prevent the possible spread of Hantavirus into unaffected rodent populations
snap-traps limit the spread of rodent urine, saliva, and feces around trap sites
snap-traps prevent human contact with disease organisms which may occur from bites or other physical contact with rodents.
snap-traps prevent human contact with disease-contaminated aerosols during trap handling or animal release.

Multiple capture traps: Multiple capture traps are available for both mice (one-way-entry and wind-up models) and larger rodents and may catch rodents that can not be caught in snap traps. Rodents, seeking shelter or food, enter traps but are unable to leave. Multiple capture traps are best used in runways where rodent activity is high or in locations difficult to monitor with snap traps. Multiple capture traps must be monitored daily.

Sticky traps: Sticky traps are flat boards or trays coated with glue. Rodents become stuck to them and cannot escape. Sticky traps are inhumane and are NOT to be used at NPS sites.

INTRODUCTION TO MUSEUM PESTS

CHARACTERISTICS AND RECOGNITION

Museum pests are represented by two species of clothes moths and an array of different, although similar-appearing, small, variously colored beetles, which are grouped under the generic name of carpet beetles. These carpet beetles include black and varied carpet beetles, hide beetles, spider beetles, larder beetles, etc. Indian meal moth, cigarette and drugstore beetles, rice and granary weevils, red and confused flour beetles, and saw-toothed grain beetles are also found to attack and damage organic museum artifacts. Carpet beetles are among the most difficult of all insects to manage. Pesticides are rarely effective for very long. Regardless of the treatment used, the best management for museum pests is thorough and very careful inspections, exclusion, good sanitation, and habitat modification.

Textiles infested and damaged by pests are usually wool-based items such as clothing, carpets, and tapestries. However, both carpet beetles and clothes moths feed on a broader diet than just wool, including items containing cotton, silk, hair, mohair, bristles, fur, feathers, and leather, as well as dead insects, pollen, grains, seeds, and many stored foods. Inside, infestations frequently occur when museum pests develop on dead animal carcasses (birds and rodents) or nests located in or adjacent to buildings, on dead insects (wasps, bees, cluster flies, Asian lady beetle, etc.) and molted insect skins, or in spilled foods. Clothing that has food, sweat, or urine stains is especially attractive to clothes moths.

Female moths and carpet beetles lay soft white eggs on materials that will later serve as a larval food source (including lint and organic debris in concealed cracks). Larvae hatch and feed until mature, at which time they may move away from the food source into secluded spots where they pupate. Upon emerging as adults they mate and fly around; the females looking for egg-laying locations. Since larvae and adults often avoid light, finding a random cast skin, larva, pupae, or adult museum pest in a structure may be the only signal of an impending infestation.

Proper identification of pests is a critical part in this IPM program because it provides information on possible effective management alternatives. However, identification of museum pests is an entire field unto itself. This plan does not attempt to provide enough information for complete or scientific identification of museum pests, which would take volumes of information. Refer to pest profiles for a number of the major pests which might be expected in museums along with very brief sketches of their life histories. Museum curators and IPM coordinators should refer to taxonomic tests and other sources (universities, reputable researchers, etc.) for pest identification.

INSPECTION AND MONITORING

There is a reason for pest infestation. The intent of inspection is to determine the kind and extent of infestations, how the pest got into the space and what factors contribute to its survival.

Any occurrence of moths or carpet beetles (adults, eggs, larvae, or pupal cases) is ample reason to initiate management measures. Museum pests feed on a wide variety of items, and inspection should be carefully and thoroughly performed in order to identify the food source. Populations can expand rapidly from the presence of only a few adults. Since museum pests are transported into buildings with infested products, management cannot be complete until all infested material is found and removed. This can be a sizeable undertaking, based on the variety of places where museum pests may be found. Inspect the following:

Stored woolen clothing and bedding
Down pillows and comforters
Silk, fur, mohair objects
Wool or silk carpets, rugs and blankets
Stuffed dolls and furniture padding
Upholstered furniture, animal hides and trophies, stuffed animals, light fixtures, dried flower arrangements, pet foods
Floor cracks, baseboards and vents for lint, debris, and hair accumulations
Indian corn decorations and popcorn packing
Spices in metal containers that have been kept for years
Eaves, attics, wall voids, and crawlspaces for wasp and bee nests, bird nests, bat roosts and dead or live animals
Fireplaces, chimneys, and vents for dead animals
Cereal, meal, and flour goods; bird seed or feed
Bean bags or candy that has been hidden away
Old books where insects are attracted to the glue in bindings
Ornamental artwork using foods and grains in printers' boxes, apothecary jars, picture frames and jewelry
Table centerpieces containing nuts, beans, seeds or other food products such as macaroni
Old rodent bait

Other locations where stored-product pests may be found are cork boards and backings; dead animal carcasses in voids, attics, or crawl spaces; objects containing fur, skins, horn, hair, feathers, and bristles; lint in cracks, picture frames, decorations; stored leather goods; old drugs; organic fertilizers and bone meal; garden seeds and bulbs; insect displays and collections; bird, rodent, wasp, bee, and bat nests; and smoked or dried meats.

To inspect carpets, pull back the edges from the tack strip and look under edges. Use sticky traps around walls and make careful visual observations. Insects do not infest the entire rug, only those parts not exposed to light and traffic. Closely examine compressed fibers under rugs and under furniture legs. Also inspect carpet edges under the quarter round.

Monitor pheromone and sticky traps for museum pest infestations at least twice a year (monthly preferred), using a hand lens and flashlight to search for eggs, adults, larvae, granular feces, and cast larval skins. Check window sills, under windows, window runners, behind baseboards, in cracks, crevices, radiators, and air ducts.

Critical Site Pest Sighting Logs

From the pest sighting log, request that the occupants mark on a floor plan of the site where pests have been seen, and then carefully examine those areas.

MANAGEMENT

Major Mistakes in Museum Pest Management Programs

The following are some of the major mistakes made in museum pest management programs:

- Failing to find and manage or remove sources of infestation
- Allowing museum pest infestations from the outside through poor exclusion or importing by infested artifacts, clothing, containers, and contaminated foods
- Failing to periodically monitor for museum pests and allowing infestations to become severe before initiating prevention or management actions

The presence of museum pests generally indicates inadequate sanitation practices; management requires that sources of infestation be found and discarded and the storage area be meticulously cleaned. If the source of infestation is not removed, pest management programs will not be effective.

Physical, Mechanical, and Cultural Measures

Regularly and carefully inspect clothing for insects and evidence of damage; do not import insect eggs or larvae on unprotected or uncleaned articles. Inspect new articles for possible infestation and damage (especially antique upholstered furnishings) before mixing them with articles already in the building. This function should be performed in a quarantine receiving area.

Moths normally only damage seldom-used clothing and blankets; frequently rotate or use woolen fabrics. Once a month, brush hidden areas (pockets, reverse cuffs, collars, etc.) on those garments which are infrequently worn and then shake, brush, comb, beat, and air them out in bright sun. Beating, brushing, and vacuuming dislodge and crush eggs and young larvae. Sunning and dry-cleaning removes both moths and larvae.

Brush or comb fur skins with a fine-toothed comb close to the skin where larvae spin cocoons.

Heat susceptible flour and cereal goods and hold internal temperature at 54ºC (130ºF) for an hour or more to kill most stored-product pests.

Sterilization

Storing fabrics in atmospheres containing more than 50% carbon dioxide or inert gas suffocates insects. Removing the oxygen from a storage area will also kill pests.

Freeze objects 23ºC (-10ºF) for several days to kill larvae and moths, warm them to 4ºC (40ºF) to encourage any eggs that survived to hatch, and then freeze again to kill any newly emerged larvae.

Subject infested objects to a temperature of 54ºC (130ºF) or more in a microwave, in a plastic bag placed in the sun, or for extended period of time in temperatures greater than 34ºC (93ºF) museum pests have very low resistance to heat. An infested structure can be heated to 71ºC (160ºF) to kill most pests, including drywood termites and mold spores.

HAZARDS OF INFESTATION

Small barbed hairs on larval carpet beetles, when ingested or inhaled, may cause dermatitis and irritations to nasal passages and sinuses. Food containing carpet beetle larvae has sometimes been responsible for enteric irritation in infants, or intestinal disturbances or allergenic conditions (urticaria, conjunctivitis, nausea, respiratory tract irritations) in adults. Further, these insect pests feed upon and damage museum objects.

Although fabric pests are not known to transmit diseases, feeding larvae do considerable damage to organic materials. Clothes moths damage clothing and rugs.

INTRODUCTION TO STRUCTURAL PESTS

CHARACTERISTICS AND RECOGNITION

Structural pests are characterized by those organisms that live, eat, bore and/or lay eggs in the wood that makes up the structure; and those that take up shelter or forage in structures. The former group are the wood destroying insects (powderpost beetles, other beetles and carpenter ants) and molds and fungi. The second group includes several species of ants, bats, birds, rats, mice and squirrels. Although bats, birds, rats and mice do carry and/or transmit disease organisms to humans and could be included with public health pests, they MUST be excluded from structures. Thus, they are included here with other structural pests.

These various pests can be managed through the application of the basic principles of IPM – thorough inspection and monitoring for conditions conducive to pests as well as the pests themselves, exclusion, sanitation and habitat modification. Structural wood can become the food and shelter for several beetles and fungi, which causes the wood to lose its structural strength and its aesthetic appeal. Reconstructed historical structures may require non-historic methods and materials to protect from damage by these pests. Protecting the structure from the presence of water may be the basic concept necessary to manage most structural pests.

Identification of the pests, sometimes by their left-behind signs or behaviors, is very important to management or prevention of damage by the pest(s). Specific identification of all the structural pests may be beyond the scope of this effort, but general information on several major structural pests is provided in the pest profiles. Insect specimens can be identified by your local extension agent.

INSPECTION AND MONITORING

A thorough inspection of all wood members of the structure should be done at least twice a year in late spring and early fall. Look for small round or oval holes in the wood and fine powdery wood frass from wood-boring beetles, or coarse wood shavings with insect parts intermingled from carpenter ants. Use a moisture meter to monitor wood moisture as most wood pests need a wood-moisture content of 12% or higher. Carpenter bees prefer to bore entry holes and galleries in outdoor beams or fascia to lay eggs and provisions for next year’s generation.

Ants infest structures in the search for food, shelter and moisture. Ants may form trails or randomly search inside. Outside ants are usually considered to be beneficial; inside they are a nuisance, but also a sign of poor sanitation. Follow trailing ants to find the entry point into the structure to perform exclusion action.

Molds and fungi can live or colonize on most organic substrates that have 12% or more moisture present. A moisture meter is a necessary tool. Many molds and fungi can be detected by a moldy odor or by visual signs of growth or fruiting bodies. The elimination of moisture or a treatment of the substrate may be necessary.

Rodents prefer to run next to vertical surfaces at the floor/wall junction, and leave grease marks from their fur which are visible with a powerful flashlight. Rats and mice tend to dribble urine as they travel these runways and in protected corners where they eat. Use a black light (UV) to detect the fluorescence of rodent urine. Rodents must constantly gnaw on wood or other firm materials to keep their teeth worn down as they constantly grow. Fresh gnawing on wood is light-colored which darkens as it ages. Proper exclusion of rodents is the most effective management method.

Bats in a structure are usually noticed by their droppings beneath roosting areas. At dusk, they can be seen exiting the structure. Birds like to build nests under the protective eaves. Prevention of these pests is best accomplished by exclusion techniques or a 45 - 60º angle on ledges.

Norway and roof rats are notorious for being moved from place to place by shipping. These exotic rodents are common in many urban cities. Exclusion and snap traps are the most effective management practices.

HAZARDS OF INFESTATION

Structural pests occupy areas in buildings that also contain people, thereby placing pests and people in close proximity. Although most of the structural pests do not carry diseases, bats, birds, mice and rats do. Wood-destroying beetles, carpenter ants and molds and fungi can adversely affect the structural strength and aesthetic appearance of wood structures. Structural pests must be managed for safety and aesthetic reasons.

INTRODUCTION TO WOOD-DESTROYING INSECTS

INTRODUCTION

There are several hundred species of beetles, ants and wasps that attack the wood in structures; however, most of the damage is minor except those caused by powderpost beetles, carpenter ants and old house borer. For more information on groups not covered here, please refer to Moore's "Wood-Inhabiting Insects in Houses." There are several groups of powderpost beetles. It is critical to know which type of beetle is present in order to determine the necessary management methods, or if management is necessary at all. More than fifteen kinds of carpenter ants are serious structural pests in this country, some being more common in or restricted to certain geographic areas than others. All carpenter ants show good cold tolerance.

INSPECTION FOR WOOD-BORING BEETLES

Careful inspection is the key to determining what species is causing damage and worth treating. It is essential to note the appearance of wood, moisture conditions, location of infestation, type of frass, beetles found, fecal pellet presence and appearance, appearance of galleries, and size and shape of exit holes. It is advisable to collect as many specimens as possible and, if necessary, give them to an expert for identification. This means that the pest manager will have to work not only with a flashlight, but also with sample-collection vials, a knife, forceps and a hand lens.

PREVENTION AND MANAGEMENT MEASURES

Prevention and management require thorough knowledge of beetles, their life cycles and damage potential on which a meaningful inspection can be based. Using kiln-dried lumber or pressure-treated wood is one of the available preventive measures. Another is keeping moisture out by painting the wood and ensuring good ventilation as most wood-infesting beetles do not flourish below a moisture content of 10 – 12%, depending upon species. Another method for prevention and treatment is pre-treating wood members by painting or spraying wood with sodium isoborate products. This reduced-risk compound can be applied to wood either before or after installation, so remedial treatment as well as prevention is possible in existing structures.

If there is reason to suspect that beetles are present in finish or trim wood to be installed in areas which will be difficult to treat or replace later, heat sterilization or treatment with disodium octaborate tetrahydrate (DOT) may be advisable. Required wood temperatures for heat treatment of infested wood are 49ºC (120ºF) for four hours and up to 60ºC (140ºF) for two hours, with wood temperature measured in the center of the wood member. If bostrichid beetles are involved, the higher temperature range should be used.

INTRODUCTION TO ANTS

CHARACTERISTICS AND RECOGNITION

General

Of the 750 different kinds of ants found in almost every North American habitat, only about 30 species cause problems in structures. Because their small size permits ants to enter tiny holes, ant problems may be common. This section will describe methods for managing ants frequently found in kitchens, pantries, and food storage areas. Structure-damaging carpenter ants are covered in Structural Pest Profiles.

Ants are attracted to a wide variety of foods, including other insects, seeds, nectar, meat, grease, sugar, and honeydew (a sweet liquid produced by plant-sucking insects). Some ant species seem to wander randomly while others form trails from the colony to a food source. Most ants bite when disturbed and many species sting.

HAZARDS OF INFESTATION

Regardless of damages, ants are generally considered beneficial. Like spiders, ants kill and eat many insects including flea and fly larvae, and bedbugs. Ants are important in soil aeration and recycling of dead animal and vegetable materials. However, their management in structures is necessary because they contaminate food, damage structures, and some (pharaohs) transmit disease organisms. Several ant species, including pavement ants, are annoying because of their painful stings.

INSPECTION AND MONITORING

The target for exterior inspections is to find and correct breaches (which may be quite small) where ants are entering the structure from outside. The following are offered to assist in interior ant inspections:

- Study ant trails and identify where they are entering the space.
- Inspect behind baseboards, inside heat registers and ducts.
- Carefully inspect foundations and under grass, mulch, rocks, and logs for possible nest sites and trails.

MANAGEMENT

Major Mistakes

Major mistakes usually made in ant management are:

- Failure to accurately identify the ant so that its biology can be used to manage it.

- Failure to exclude ants through caulking and sealing and removing vegetation "ladders."
- A failure to thoroughly inspect the building, find nests and sterilize or kill the queen or queens.
- Failure to manage contributing conditions such as damp wood, bad sanitation, poor crawl space ventilation.

PREVENTION OF ANT INFESTATIONS

Established ant infestations can be difficult to manage. The best management is good sanitation practices, which eliminates the conditions attracting ants, and exclusion. The following practices are very important to follow:

- Clean up all food particles and frequently sweep, vacuum or mop up all scraps, lint or dead insects.
- Store all food in pest-proof plastic or glass containers.
- Use garbage receptacles with tight-fitting lids and remove the wet garbage every night.
- Trim back (.91 m [3 ft]) vegetation and trees that are next to buildings as these will harbor ants or aphids.
- Eliminate all sources of water for ants.
- Remove all old and decomposing wood debris, shrubs, or tree trunks that could provide nesting possibility for ants; control honey-dew-producing insects with beneficial predator insects.

MANAGEMENT OF ANT INFESTATIONS

Action Thresholds

Because ants readily communicate the location of food and water sources to other members of the colony, it is imperative that ant management begin immediately upon identifying them in the structure. The initial response may be to follow the line of ants and seal the point of entry to the structure. Remove the food attraction. The presence of swarming or winged ants should always suggest the presence of nests indoors. Determine the ant species and possible nest location.

Physical, Mechanical, Cultural Measures

Limiting Entry: The basic Rule of Thumb in ant management is exclusion <u>not</u> eradication. Simply killing worker ants seldom manages a colony and may, indeed, result in colony multiplication. The following exclusions are suggested:

- Caulk all interior and exterior cracks and crevices and install tight fitting door sweeps on exterior doors; ants will stop coming into the structure when the distance from the nest to food becomes too long.
- As an additional precaution, cracks may be treated with an inert dust before caulking.

Physical and Mechanical Measures

- Sponge mop with soapy water or vacuum to remove trailing ants. Soapy water washes away trailing odors and forces ants to find other food sources.

Heat Sterilization

If the affected items can tolerate it, equipment, rooms, and furniture infested with ants can be sterilized by steam cleaning or dry heat (54ºC [130ºF] for 30 minutes).

Pesticide Treatments

Pesticides generally provide only temporary relief from pests in buildings. When chemicals dissipate, ants often reinvade structures. Exterior sanitation should be used in combination with interior sanitation. Treatment should be aimed at destroying the nest or sterilizing the ant queen.

Before any pesticide is applied, it is vital to know the kind of ants present, what they are feeding on, and whether their nests are located indoors. Borate based dusts and baits applied into harborage cracks and crevices of ants and other pests are very effective treatments.

Various types of solid, semi-solid, gel and liquid ant-bait stations are commercially available. Many contain low-risk chemicals including borates, abamectin, or hydramethylnon that are readily taken into the nest and to the queen. Ants feed each other so ant baits must be slow acting as several ants may be fed before the bait is passed through to the queen. These baits are attractive to ants, and help to manage ant populations. Place stations along ant trails where ants quickly find them. However, where sanitation is poor, bait performance will also be poor because of the availability of alternative food sources.

INTRODUCTION TO MOLDS AND FUNGI (Worldwide)

CHARACTERISTICS AND RECOGNITION

Molds and fungi are similar kinds of primitive organisms supported when excessive moisture and proper temperature are present. These organisms can physically damage many kinds of organic objects and create/support conditions that attract pests which may feed on them (i.e., dampwood and subterranean termites, wood-destroying beetles, carpenter ants, springtails, silverfish, mites, millipedes, fungus gnats, booklice and sow bugs). Molds, mildew and fungus are often an important cause of various human allergenic diseases (asthma, hay fever, allergic rhinitis, eczema and hives). Optimum conditions for fungal growth occur in temperatures between 10 and 35ºC (50 and 95ºF) when substrata (usually wood or paper) have 12% or greater moisture content (caused by various problems including moisture in the crawl space, improper drainage, etc.). The growth of mold is inhibited by strong light and dry conditions. Various kinds of fungus-caused rot are sometimes mistaken for insect damage. The presence of indicator moisture-loving insects (booklice for one) points out the need to correct conditions supporting or causing moisture.

There are several types of decay fungi. Decay fungi will occur in any (including redwood and cedar) untreated wood in contact with the ground, cement, masonry or other source of moisture. Other water sources can be plumbing leaks, rain leaks, condensation, poor drainage or broken or inadequate rain gutters.

Brown rot fungi feed on the cellulose in wood. As the cellulose is removed, the brown lignin is left behind (thus brown rot). With only lignin left (which holds wood cells together), the wood structure is weakened. When the moisture is removed or "dried out," it is referred to as "dry rot," a misnomer as wood does NOT decay when dry. Wood with brown rot tends to crack across the grain. This characteristic can be tested with a probe during inspections.

White rot breaks down both the cellulose and the lignin holding the cells together, which causes the wood to look whiter than normal. Wood infested with white rot does not usually crack across the grain. However, the wood will shrink and collapse if severely infected, eventually becoming spongy and weak.

The water conducting fungus, *Poria incrassata,* will attack wood that might not be used by brown or white rot fungi. *Poria* can transport water several feet through rhizomorphs, which look like roots. These fungi may start in damp, dirt-filled porches, crawl spaces and basements, conducting moisture from the soil to the wood. The rhizomorphs transporting water may be dirty white (when young) to dark brown to black as they age. The older the rhizomorphs are, the larger they become (.63 cm [1/4 in] up to 2.54 cm [1 in] or more). *Poria* can damage a substantial amount of wood in a short time.

Molds or stains may be found on wood; however, they do not cause structural damage to the wood. The presence of molds may indicate conducive conditions (moisture) for decay fungi. . The elimination or remediation of the moisture source is indicated.

Lichens are a symbiosis between a fungus and an alga – a relationship where the two organisms benefit from each other. The fungus delivers water and minerals to the alga; the alga supplies photosynthesis and delivers sugars to the fungus. This enables the lichen to survive extreme conditions, living on many surfaces (wood, rocks) and surviving freezing, wet and dry conditions. These amazing organisms can be a problem when living on a wood substrate as they are flammable under dry conditions.

HAZARDS OF INFESTATION

Molds and fungi are usually associated with wood or wood products (i.e., paper). As these plants do not have chlorophyll, they must obtain their energy from carbohydrate sources such as starches from wood or paper. Wood infesting fungi may cause brown rot, white rot or blue stain in wood which compromises the structural strength of the wood. Other fungi may cause surface stains from molds and mildew. These molds, mildew and fungi become food sources for wood wasps (in living wood), fungus gnats, mold or plaster beetles, springtails and psocids (booklice).

INSPECTION AND MONITORING

To detect the presence of conditions that are conducive to molds, mildew and fungi, a moisture meter is useful. If the area smells moldy, then these fungi are present. Decayed wood will break when probed (90^{o} angle) with an ice pick or awl, whereas sound wood will splinter.

Any wood material containing more than 12% moisture (use a moisture meter) can be damaged by these various fungi. Preventing wood contact with moisture is a necessary preventive measure. Inspect thoroughly to find all possible moisture sources that contact wood. Repairs or remediation (including redirecting the water) to remove the moisture and dry out the wood is necessary to prevent decay fungi damage. Check rain gutters, downspouts, eaves, roof leaks, condensation, roof valleys and other areas where water flows or stands. The presence of fungi indicates the wood material had or has 12% moisture or more.

MANAGEMENT METHODS

To manage molds and fungi, reduce humidity and moisture sources. A 3% sodium hypochlorite solution (bleach) will kill most molds or fungi. Molds and fungi do not do well in bright direct light. Dry heat can also kill these fungi.

Wood that is in contact with moisture must be protected from decay fungi. A few products are available that, when properly applied, will penetrate throughout the wood beam, log, plank, shingle, post, etc., and protect it from decay fungi. The borates are one of these products. BoraCare, TimBor Pro, Permachink and other borate products, when mixed with water and applied to the surface, will move on the moisture gradient and penetrate each cell of the wood. A second application will push the first through to the center of the wood. This will kill any fungus, wood-boring beetle or other wood-infesting organism present. Following the borate treatment with a water repellent such as WOODguard (Copper 8-quinolinolate) will seal in the protection. WOODguard will need to be reapplied every two to four years as it weathers. The borates do not need to be reapplied after proper treatment and a water repellent sealer. Wood in contact with soil, concrete or masonry may need to be injected with Jecta or Impel rods to prevent further damage by moisture and decay fungi before sealing with WOODguard.

INTRODUCTION TO RODENTS

Rats and mice are occasional structural pests consisting of the exotic Norway rat, roof rat and house mouse; and the native deer mouse. Other native rodents such as the white-footed mouse, voles and grey squirrels can also be pests in the Park. These rodents can cause structural damage as well as posing health risks to Park staff and visitors.

CHARACTERISTICS AND RECOGNITION

Mice are small rodents that have very wide distribution. House mice are found throughout the world, and the deer mice and white-footed mice have populations in North America. The house mouse prefers to live in structures, whereas deer mice and white-footed mice prefer to nest in woodland habitats. The deer mice are known to carry Hantavirus, and will inhabit structures if they are available. These rodents usually have small territories and fast reproduction rates, so populations can build rapidly.

Norway and roof rats are not native to North America; however, they were brought from Europe with the early explorers and colonists. Both exotic rats prefer urban environments, but can easily expand into rural meadows, fields and woodlands. Most large cities have relatively large populations of Norway rats although they are not usually seen. Norway rats have been found to carry Hantavirus in some eastern cities, and also may carry a large number of other human diseases. The roof rat is more often found in suburban areas and also carries many human diseases. Both rats can have large territories if resources are abundant (water, food, harborage). The Norway rat is dominant if the two rats' territories coincide. Norway rats prefer to burrow underground whereas the roof rat prefers to nest up high in trees or attics.

Grey squirrels may be common in areas with woodlands or large trees. Squirrels can be a nuisance pest if they invade structures. Their teeth are quite hard and strong; and their gnawing can damage historic beams and other wood portions of structures. Nests in attics can harbor fleas and other parasites. Exclusion is the most effective management approach.

Voles, sometimes called "meadow mice," can be major pests in crops and orchards. They prefer heavy grass ground cover. Voles forage on grasses, forbs, snails, insects and roots. They construct extensive tunnels and runways with many burrow openings. Voles are active day and night throughout the year. Two species may be present at Weir Farm National Historic Site: the meadow vole and the pine vole.

HAZARDS OF INFESTATION

When rodents infest structures, stored food may be consumed and contaminated by urine and fecal droppings, making it unfit for human consumption. Several diseases can be transmitted by rodents or their ectoparasites, such as Salmonellosis, Rickettsial pox, meningitis, Leptospirosis, dermatitis, rat-bite fever, Ray fungus, ringworm and the deadly Hantavirus.

Hantaviruses are a worldwide occurring family of viruses that were first identified as human disease causing agents in the mid-1970's. One of these viruses, recently identified, causes acute and sudden respiratory illness and was responsible for a number of deaths in the Four Corners area of Arizona, Utah, Colorado and New Mexico during the summer of 1993. Now, additional cases of this Hantavirus strain caused a disease called Hantavirus-Associated Respiratory Distress Syndrome (HARDS), and have been confirmed in over a dozen states. Although there is reason to believe individual human resistance varies, records show this Hantavirus is lethal in about 60 to 70% of the clinically confirmed cases.

Hantavirus, naturally found in many rodents, is believed to be primarily carried by the very adaptable and widely distributed deer mice throughout the United States. The Norway rat has also been found to carry Hantavirus. Infected rodents do not show apparent effects of illness and may carry the disease during an entire lifetime, continually shedding virus in urine, saliva and feces. Humans may contract the disease with exposure to infected rodent excreta, especially when the virus is inhaled on contaminated dust particles. However, human transmission may also occur from rodent bites or when dried materials contaminated with rodent excreta are disturbed, directly introduced into broken skin or the eye, or possibly ingested in contaminated food and water.

Before inside rodent elimination work is begun, ventilate closed buildings or areas inside buildings by opening doors and windows for at least 30 minutes. Use an exhaust fan or cross ventilation if possible. Leave the area until the airing-out period is finished. This airing may help remove any aerosolized virus inside the closed-in structure.

INSPECTION AND MONITORING

Rodents may be more active at night and make their presence known by sounds of scrambling, gnawing and squeaks. Such sounds can be more easily pinpointed with the use of an electronic or regular stethoscope. The most easily noticed evidence of rodent activity in structures is fecal droppings. The house mouse will product about 70 droppings per day and the native mice will produce similar numbers. Rats produce fewer droppings. Rodent droppings become quite hard within a few days; fresh ones will be firm. Droppings will be along runways, in protected areas, near food sources and nests. Rodents dribble urine as they travel along runways and in protected areas. Look for many small drops of urine fluorescence using a black light. Rodents also produce greasy smears where dirt and oil from their fur mark pipes, beams and baseboards. Look for footprints and tail marks on dusty surfaces or in mud. Light-colored gnawing on wood corners, enlarged cracks or holes in woodwork, doors, cabinets and baseboards is evidence of recent rodent activity.

MANAGEMENT

Management and prevention of rodents is a three-part process: exclusion (rodent-proofing), sanitation (elimination of <u>all</u> food sources), and population reduction indoors with snap traps. The first two are useful preventive measures. When a rodent population already exists, lethal

management is necessary. Otherwise, the reproductive capability of the rodents, and their remarkable ability to find food in almost any habitat, will keep their populations up or increase.

Sanitation

Good sanitation makes it easier to detect signs of infestation since it also increases the effectiveness of baits and traps, which represent the only food supply. However, even the best sanitation may not eliminate mice, since they require very little space to get into the building and small amounts of food to flourish.

Rodent-Proofing

It is a challenge to completely rodent-proof a building, since mice are able to squeeze through an opening a bit larger than .64 cm (1/4 in). Seal all holes to limit the movement of rodents into and through a building. Plug holes in foundation walls with 64 cm (1/4 in) hardware cloth or copper mesh. Caulk and fit doors and windows tightly. Seal holes around pipes, utility lines, and vents, to make it difficult for rodents to move in and out of wall and ceiling voids. This confines them to a smaller area and will make snap traps more effective.

Trapping

Snap Traps

If used correctly, snap traps are very effective in managing rodents. The territory of mice rarely extends further than 9.14m (30 ft) from the nest, and usually is about 3.05 m (10 ft). Rats have larger territories. If rodents are sighted throughout a building it means that there are numerous locations where you will have to set traps. Place snap traps not only wherever you see obvious signs, but look for good trap locations in a three-dimensional sphere about 3.05 m (10 ft) in diameter around those signs. Place traps every .91 – 1.83 m (3 – 6 ft) in prime mouse habitat, and every 3.05 – 6.10 m (10 – 20 ft) in rat infested areas at the floor/wall junction with the trigger against and perpendicular to the wall. Check traps daily.

Rodents can be living above their main food supply in suspended ceilings, attics, inside vertical pipe runs, and on top of walk-in coolers. Or they can be below, in floor voids or crawlspaces. The best trapping sites are those with large numbers of droppings, since that indicates that rodents are spending a lot of time there. Other good sites are along walls, behind objects, and in dark corners, particularly where runways narrow down, funneling rodents into a limited area.

Good baits increase the effectiveness of traps. Peanut butter, bacon, cereal, and nuts are traditional, but another is a cotton ball, which the female rodents like to use for nest material. It should be tied securely to the trigger. Food baits should be fresh to be effective. Mice are attracted to sweet baits, so a gumdrop tied to the bait pan may be effective. Probably the biggest mistake made in rodent trapping is not using enough traps. Use enough to make the trapping campaign short and productive.

Remove killed rodents from the traps. Wear rubber or plastic gloves while handling dead rodents. Place the carcasses in a plastic bag containing a sufficient amount of a general-purpose household disinfectant to thoroughly wet the carcasses. Seal and properly dispose of the bag. Rebait and reset all sprung traps, or discard with the rodent. Before removing the gloves, wash gloved hands in a general household disinfectant and then in soap and water. A hypochlorite solution prepared by mixing three tablespoons of household bleach in one gallon of water may be used in place of a commercial disinfectant. Thoroughly wash hands with soap and water after removing the gloves.

Rat Zapper 2000

Rat Zapper 2000 is an electronic trap that humanely kills rodents. The trap is a battery-powered plastic tunnel that is attractive to rodents, and provides a bait placement inside. When the rodent enters the tunnel for the bait and steps on a sensor, the rodent is given a lethal shock. A blinking red light then alerts you to the dead rodent in the trap. Empty the trap by turning it upside down, allowing the dead rodent to slide out. Remote sensing is also available for multiple traps.

Glue Boards

Glue boards are effective against mice. However, glue boards are not humane and are NOT suggested for use on NPS sites.

Rodenticides

The use of toxic baits and tracking powders is discouraged in occupied structures, museums or historic sites. Rodents are nibblers and may not get a large enough dose to achieve a kill. This leads to bait shyness. Rodents that are killed usually die in hidden areas that may be inaccessible. Dead rodents will have a bad odor for a while, another disadvantage to toxic baits. Dead rodents that are not removed immediately become attractive to blowflies and dermestid beetles that feed upon the carcass. These insects then may become the source of insect infestations in other areas of buildings.

CLEAN-UP OF RODENT CONTAMINATED AREAS

Hantaviruses have lipid envelopes that are susceptible to most disinfectants (e.g., dilute hypochlorite solutions, detergents, ethyl alcohol [70%], or most general purpose household disinfectants), or exposure to strong, direct sunlight.

Areas with evidence of rodent activity (e.g., dead rodents, rodent excreta) should be thoroughly cleaned to reduce the likelihood of exposure to Hantavirus infected materials. Clean-up procedures must be performed in a manner that limits the potential for dirt or dust to become airborne from all potentially contaminated surfaces and goods.

A baseline serum sample, preferably drawn at the time these activities are initiated, should be available for all persons conducting the clean-up of buildings with heavy rodent infestation.

Persons involved in the clean-up should wear coveralls (disposable if possible), rubber boots or disposable shoe covers, rubber or plastic gloves, protective goggles, and an appropriate respiratory protection device, such as a half-mask air-purifying (or negative-pressure) respirator with a high-efficiency particulate air (HEPA) filter or a powered air-purifying respirator (PAPR) with HEPA filters.

Spray dead rodents, rodent nests, droppings, or foods and other items that have been tainted by rodents with a general-purpose household disinfectant. Soak the material thoroughly, and place in a plastic bag. When clean-up is complete (or when the bag is full), seal the bag, then place it into a second plastic bag and seal. Dispose of the bagged material by burning.

After the above items have been removed, mop floors with a solution of water, detergent, and disinfectant. A second mopping or spraying of floors with a general-purpose household disinfectant is optional. To avoid generating potential infectious aerosols, do not vacuum or sweep dry surfaces before mopping. Disinfect countertops, cabinets, drawers and other durable surfaces by washing them with a solution of detergent, water and disinfectant, followed by wiping them down with a general-purpose household disinfectant.

Rugs and upholstered furniture should be steam cleaned or shampooed. If rodents have nested inside furniture and the nests are not accessible for decontamination, the furniture should be removed and destroyed to avoid reuse. Launder potentially contaminated bedding and clothing with hot water and detergent. Use rubber or plastic gloves when handling the dirty laundry; then wash and disinfect gloves as described earlier. Machine-dry laundry on a high setting or hang it to air dry in the sun.

Personal protective gear should be decontaminated upon removal at the end of the day. If the coveralls are not disposable, they should be laundered on site. If no laundry facilities are available, the coveralls should be immersed in liquid disinfectant until they can be washed.

All potentially infective waste material (including respirator filters) from clean-up operations should be double bagged in appropriate plastic bags. The bagged material should then be labeled as infectious (if it is to be transported) and disposed of in accordance with local requirements for infectious waste.

Workers who develop a febrile or respiratory illness within 45 days of the last potential exposure should immediately seek medical attention and inform the attending physician of the potential occupational risk of Hantavirus infection. The physician should contact local health authorities promptly if Hantavirus-associated illness is suspected. A blood sample should be obtained and forwarded with the baseline serum through the state health department to CDC for Hantavirus antibody testing.

INTRODUCTION TO BATS

CHARACTERISTICS AND RECOGNITION

Bats are unique in the animal kingdom in that they are the only true flying mammals. A thin membrane of skin stretches from their long front legs to the back legs and then to the tail. The bones in their "fingers" are elongated and support the wings.

Bats are usually beneficial, since they feed on insects. They can consume up to half of their body weight in insects in one feeding. Occasionally, bats may become a nuisance when they move into buildings and cause a public-health problem. They become a problem when they live in colonies or groups and defecate inside attic areas or in secluded areas of structures.

Bat Droppings

Weir Farm bat species may include little brown bats and big brown bats. These species sometimes hibernate or roost inside buildings in attics, wall and ceiling voids and chimneys. Bat droppings and urine can cause a foul odor and stains on walls and ceilings. Their squeaking and scrambling noises can be intolerable to some people.

HABITS

During warm weather, bats feed on flying insects in late afternoon, evening, and early morning. They are not active in bright daylight. If you see a bat at this time, it has either been disturbed from its daytime resting place or is sick. When not in flight, they rest in dark hiding and roosting sites including caves, buildings, and hollow trees. Bats are able to enter these places of refuge through holes as small as .94 cm (3/8 in).

Bats capture flying insects by "echo-location." They emit high-frequency sound, inaudible to human beings, similar to sonar. They also make audible squeaking sounds for communication. In much of the country, bats migrate south or hibernate when the weather turns cold, sometimes in hanging clusters inside buildings. Depending on the species and geographic location, they breed from late spring to midsummer. Young bats grow rapidly and can fly in three to seven weeks.

HAZARDS OF INFESTATION

Bats and Disease

Bats are associated with a few diseases that affect people. Rabies and Histoplasmosis are the most serious. Rabies is a dangerous disease, fatal if not treated in time. However, the bat's role in transmission has been greatly exaggerated. Although bats are confirmed carriers of the

disease, only a few human fatalities have been attributed to bat bites. Nevertheless, use care when handling bats. Bat bites should be considered as potential rabies exposure. Because most bats will try to bite when handled, they should be picked up with heavy gloves, forceps, or a stick. If a bat has bitten someone, it should be captured without crushing its head. Refrigerate it (don't freeze it). Then take it to the local Health Department for rabies testing. The incidence of Histoplasmosis transmission from bat droppings to humans is not thought to be high. However, when working in a bat roosting site with lots of accumulated droppings, wear a respirator and protective clothing, and follow the safety procedures

INSPECTION AND MONITORING

Inspection for Bats

When inspecting a structure for bats, look for two things: entry and exit points of bats, and the location of the roost. The roost area may be marked by the bats' body oils and fecal droppings beneath.

Entry and exit points

A building in poor repair will have seemingly unlimited entry points. Look for loose flashing, poorly screened vents, loose shingles, or gaps around siding that bats can squeeze through. Look for damage and openings under eaves and soffits, at cornices, louvers, and doors, by chimneys and windows, and anywhere pipes or wiring enter the structure. Notice droppings under openings, smudges around holes, and odors associated with bats.

Bats can be observed at twilight as they leave the building to feed. The best time to observe the bats and pinpoint major exit and entry points is usually from just before sundown to an hour after sunset. Station one or more observers at different sides of the building, looking up toward the roof. Listen for squeaking at the exits just prior to the flight. If the night is chilly or rainy, the bats may not come out.

Location of Roost

Locate the roost in the following way:

- Look inside attics and unused rooms during daylight;
- Check inside the chimney and vents;
- Bang on the walls and listen for squeaks and scratches as roosting bats are disturbed;
- Check behind shutters;
- Look for bat droppings. They will be found below roosting bats. Their droppings differ from mouse droppings because bat droppings contain wings, legs, and other body parts of insects. Bat droppings often accumulate to a depth of several inches or more.
- In large roosts, smell for bats. They have a very pungent and penetrating odor, musky and sweet, that comes from rotting droppings and bat urine.

PEST MANAGEMENT METHODS

The best way to eliminate bats roosting in a building is through "bat-proofing."

Exclusion

BAT-PROOFING: Making a building "bat-proof" means sealing or screening all of the openings used by the bats to enter a building. It can be a challenging job because, in many cases, all upper openings 1/4 in. and larger must be sealed. This is the only permanent method of ridding a building of bats. Bats should not be entombed when the building is sealed. Otherwise, trapped bats can be a problem. Make the necessary building repairs during winter months when bats are not present in the structures.

June and July are the peak months for bat complaints in much of the country. Unfortunately, this is the worst time for management, since bats are rearing young in their colonies, and young bats cannot fly. Bat-proofing during this period would trap the young bats, and they would die, rot, and become an odor problem. Bats may also crawl and flutter into occupied areas.

The best time of year to bat-proof a building is either in late fall, after bats have left for hibernation, or in late winter and early spring before the bats return. If bat-proofing must be done in summer, it should be done after mid-August when young are flying.

Bat-proofing while bats are present should be carried out as follows: seal all but one or two principal openings. Allow three to four days for the bats to adjust to using the remaining openings, and then seal those openings some evening just after the bats have left for their nightly feeding. "Bat valves" can also be used. These are placed over the remaining openings and allow the bats to leave but not to return.

Standard bat-proofing materials include 1/4 in. hardware cloth, screening, sheet metal, caulking, closed cell expanding polyurethane foam, stainless steel wool, copper mesh, Stuf-Fit, and oakum - the same materials used for rodent-proofing. When old deteriorated buildings have many openings, and can't be sealed economically, large plastic bird nets (1/4 in. mesh) can be draped over the roofs to keep bats out.

During the winter, if big brown bats have left and little brown bats have migrated south, is the best time to clean up the bat droppings and repair the entry holes that allow bats inside. On a sunny day, enter the area (without lights) and look for light leaks in the eaves, where the roof meets the walls, and around the chimney/wall junctions. Fill all holes found with oakum, Stuf-Fit or other compressible material and/or caulk. If, in the spring, the bats have been able to return into the attic, then make observations of the bats leaving to forage in the evenings to locate additional entry/exit sites. Mark those sites for installation of bat valves in summer or repair after bats have left in late fall.

BAT REPELLENTS: Bright lights have been used with some success in repelling bats. Floodlights can be aimed at the bats' entry points to keep them from entering. However, the

bright lights may attract insects too, which the bats eat. Attics can be illuminated with four or more bulbs. If this method is used, ensure that all corners of the attic are illuminated. Drafts of cool air from fans and air conditioners may keep bats from roosting in a poorly sealed attic. Ultrasonic devices do not repel bats.

A SINGLE BAT: When a single bat finds its way into a building's occupied area, it will usually find its way out again. When it does not find its way out, capture the bat with an insect net, a coffee can, or even with a gloved hand. The bat can then be released or destroyed.

When bats have been excluded from the Park structures, the benefits of their presence may be lost. Providing an appropriate bat house for bats is useful for reducing flying insects in the area. Visit the Bat Conservation International website (www.batcon.org) for information and plans for large bat houses.

INTRODUCTION TO PUBLIC HEALTH PESTS

Public health pests are those that have an adverse effect upon human health through the transmission of disease organisms, or through the injection of toxic material into the skin of humans. Many public health pests actually pose a health threat to people; however, some are merely nuisance pests such as cluster flies (*Pollenia rudis* [Fabricius]) and "friendly flies" (*Sarcophaga aldrichi* [Parker]). Other public health pests include cockroaches, fleas, wasps and bees, spiders, ticks, and mosquitoes.

CHARACTERISTICS AND RECOGNITION

Flies make up one of the largest groups of insect pests and are carriers and/or transmitters of many health-related diseases. Some species of filth flies and biting flies may be present at WEFA.

Cockroaches may pose health issues because of the habitats they occupy, such as sewers and other poorly cleaned sites. The presence of cockroaches in kitchens or other portions of structures requires management action.

Fleas are common indoor pests, but are also present in outdoor areas: lawns, transition areas and woodlands. There are several species of fleas that may be present at Weir Farm that have wild hosts such as opossum, fox, coyotes, badgers, skunks, deer, ground squirrels, rats, mice and other rodents. Several flea species can transmit plague, murine typhus and other diseases.

There are only about 50 species of stinging wasps and bees that are troublesome to people. These are generally divided into two groups: the social wasps and bees (including hornets, yellow jackets, umbrella wasps and honey bees); and the solitary wasps and bees which include mud dauber wasps and cicada killer wasps. Social wasps and honeybees build nests in and around structures, beneath eaves, on porches, behind blinds, in trees, shrubbery and vines, in stone walls and in the ground. Solitary wasps prey on insects or spiders they paralyze and place, along with eggs, into individual nests. After the eggs hatch, the larvae feed on those paralyzed arthropods until they can emerge from the nest.

Only a few species of spiders live in structures. Since they feed on insects, they are rarely problems in buildings that do not have an insect food source. They are objectionable pests to people fearful of them, even though most are harmless. There are only two spiders considered dangerous to human beings in the United States: the black widow and the brown recluse, which may be present at WEFA. Funnel web spiders or grass spiders are common throughout the United States and form webs with a funnel the spider hides in. The web is usually in bushes or grass, but may be found in corners of dark rooms inside structures.

Ticks feed on the blood of mammals, birds, reptiles and amphibians. There are two types of ticks: soft and hard. Soft ticks feed on hosts that return periodically to a nest, shelter, cave or coop. Hard ticks are found on pets, cattle, wildlife and people.

Mosquitoes are usually incidental pests in and around buildings since their normal breeding habitats are outdoors. Mosquitoes are generally outdoor pests and may invade buildings during the warmer months from March to October. Some mosquitoes that are of concern at WEFA are *Aedes albopictus, Aedes vexans* and *Culex pipiens*.

See the Pest Profiles for more information.

INSPECTION AND MONITORING

Public health pests are usually detected by a thorough inspection of buildings and grounds or from complaints from staff or visitors. Flies, fleas, ticks, wasps or bees, spiders and mosquitoes are quite likely to be complained about by visitors. WEFA can inspect and monitor for these pests, and use signs to suggest personal protection from bites. Monitoring for flies can be done by using sticky fly tapes, Lure Sticks or sticky strings. Inspect ceilings and edges of structural members inside for flies resting at night or fly speck droppings during the day. Ticks can be monitored by using a tick drag (white flannel cloth) in the transition zone between lawn (meadow) and wooded area. Self-monitoring by each person should also be conducted daily. A white plastic sheet with a chunk of dry ice in the center will attract ticks in approximately an hour's time. Place this monitoring method where deer or other mammals frequent.

Some social wasps will build nests in porches or sheds. Inspect for the early stages of paper nests in the spring, and physically remove nests found with a spatula or knife; then clean the site with soap and water to remove the queen's pheromone which she uses to find the nest. Solitary wasp nests can also be physically removed from structures in the same way. Funnel web spiders can be removed with routine cleaning or a Webster brush can be used. Outdoors these spiders are beneficial.

Inspect and monitor for larval mosquitoes in standing water pools or ponds. Larval mosquitoes and pupae are confined to the water environment where they develop and are most easily managed. When the mosquito adults emerge, they become much more difficult to monitor and manage. The Mosquito Magnet (www.mosquitomagnet.com) will monitor (and remove) adult mosquitoes. Adult bite counts can be made (volunteers) and posted on a Mosquito Meter to inform visitors to wear protective clothing or repellents.

MANAGEMENT

The most important major management mistake is the tendency to minimize the potential health risks from exposure to the disease organisms transmitted or carried by mice and ticks.

Flies can best be managed by exclusion from buildings with screens on doors and windows. Keeping flies from access to food sources can be done by good sanitation practices for waste food material. Personal protection from flies, mosquitoes and ticks can be the wearing of light-colored clothing and the personal application of insect repellents. Garlic Barrier can be sprayed around an area to reduce flying insects for a short time.

Wasp nests can be removed in the spring when only the queen is present before the first brood emerges. Physical removal of the small paper nest can be done with a spatula or pocket knife. Remove the pheromone with soap and water or a spray disinfectant. Mud dauber nests can also be removed before the larvae pupate and the adult solitary wasps emerge. Honey bee swarms must be removed by a professional beekeeper.

Mosquitoes are best managed while in the larval or pupal stage, confined to a pool of standing water. Depressions that hold water in rainy season can be filled, leveled and seeded during the dry season to prevent the puddles. Ponds too large to fill can have mosquito fish released into the pond to feed on the larvae. Vegetable oil or biodegradable mineral oil applied to the surface of the water will prevent mosquito larvae from access to oxygen in the water. This may have adverse effects on other living organisms in the pond as well.

Tick populations can be reduced by mowing pathways short to expose ticks and their eggs to the sun to increase desiccation. Mow up to the wood's edge and along walking or hiking trails.

INTRODUCTION TO LANDSCAPE PESTS

CHARACTERISTICS AND RECOGNITION

Landscape pests can be represented by vertebrates, insects, invasive exotic plants, and bacterial or fungal diseases, all of which are currently a concern at the site. The successional and mature forests have become infested with exotic invasive plants that threaten its historic nature. The orchard has mature and young fruit trees with vertebrate, insect, and disease pests. The maintained turf and mowed fields have insect and weed pests. An Invasive Management Plan has been developed to address these major pest issues. This IPM Plan serves as a supplement to that document.

INSPECTION AND MONITORING

Inspection is essentially a snapshot in time. It tells you the conditions and pests present at that point in time. Monitoring tells you what has happened over a period of time (overnight, the past week or month) or changes that have occurred over time. Both are essential in managing landscape pests. Inspection and monitoring activities should be an essential part of the implementation plans developed for Weir Farm National Historic Site; such as the Invasive Management Plan. Periodic inspection and monitoring will provide feedback on progress toward meeting projected (or professed) management goals.

Inspection for vertebrate pests in the landscape may be dependent upon signs of their presence. Such signs may be burrows, runways, clipped grass, droppings or damage to trees, fruit or other potential food sources. Actual sighting of vertebrates gives an excellent opportunity to determine species and perhaps the sex of the critter. Monitoring can be done by placing a tracking dust (flour, chalk or diatomaceous earth) in the runways to determine the numbers using the trail. Weighted baits (non-toxic) can be placed to induce feeding overnight, then weighed to determine feeding activity. A more sophisticated (and expensive) approach would be to place a sensor in the runway that counts the animals that pass by the monitor. Monitoring can help with selecting management methods or determining if management is necessary.

Inspection and monitoring for landscape insect pests may be more challenging as they can be very mobile and have very high reproductive capability. Many are very small (microscopic) and many may be cryptic (hide from human presence). It is sometimes easier to look for the results of insect presence or feeding activity in landscaped areas. Many insects feed on turf, either below ground feeding on roots or above-ground feeding on the grass blades or seed. Insect activity in the Orchard may be feeding on leaves, fruit, roots or stems. Eggs may be placed in or near fruit. Some insects may damage twigs or branches by laying eggs inside. Insects also feed on forest trees and shrubs. Inspect fruit, seeds, leaves, twigs and branches for signs of insect feeding or egg sites. Conduct winter inspections for egg masses on twigs by tent caterpillars (remove them to prevent spring defoliations). Monitoring for insect pests can use pheromone sticky traps for specific insect pests. The pheromone lure is attractive to specific insects (usually males) that get caught in the sticky surface. The glue holds the insect until the trap is monitored

and the insect can be identified. Pheromone lures have been developed and marketed for fruit orchard pests, forest and other insect pests. Insects Limited (see Vendors) has developed several. The USDA Forest Service has also developed monitoring lures for some forest pests.

Inspection and monitoring for exotic invasive plants is complicated by needing to know the various growth stages of plants from other countries or regions. Being able to identify an exotic invasive weed in the seedling or rosette stage is important. Inspection requires an extensive botanical knowledge to be able to differentiate the exotic invasive plant from a native plant (that may even be rare or endangered). Many invasive plants develop quickly and are prolific seed producers. Many also reproduce vegetatively by root suckering or other means. Inspection for weeds is important and should be conducted monthly during the growing season (daily temperatures reach 10ºC [50ºF] or more). Monitoring may involve measuring the infested area and density, rate of growth, seed production and other vegetative measures. Weeds tend to grow where there is bare or disturbed soil, along roads, paths and animal trails.

MANAGEMENT

Vertebrate pest management methods should involve exclusion, sanitation and habitat modification. In landscaped areas, exclusion may be difficult for some situations. To exclude voles from gnawing and girdling orchard trees, building a .64 cm (1/4 in) hardware cloth 46 cm (18 in) cylinder around each tree trunk, 30.48 cm (12 in) high and 15.24 cm (6 in) into the soil can prevent such damage. Fencing deer out of specific areas is difficult as deer can jump rather tall barriers. Predators on rodents such as owls and hawks can be encouraged by placing hawk roosting stands and owl boxes in various parts of the Park where rodent activity is observed. Snap traps placed in trap boxes (to avoid non-targets) can be effective. The deer population can be reduced by a managed hunt, such as black powder only, etc.

If through monitoring it is determined that an insect population has grown to the point where remedial action is necessary, the release of an appropriate predator or parasite will reduce the pest insect population to a low level. Some exotic insect pests have escaped without their natural enemies and can develop large damaging populations. Low-risk insecticides may be necessary. Obtain approval from the Regional IPM Coordinator for the purchase and use of any pesticide on the site.

Exotic invasive plants must be managed by various means such as hand pulling, pulling saplings with a weed wrench or Talon Claw®, pruning or cut stump and the application of Glyphosate or Triclopyr immediately to the stump. Treating the basal portion of a tree (with no skips) from the ground line up to 60 cm (24 in) with an oil formulation of Glyphosate or Triclopyr can also be effective. Check with the Northeastern Exotic Plant Management Team for appropriate species for use of basal treatment. When exotic plants are removed, plant an equivalent desired native plant in its place. Some exotic grasses can be shaded out by staking black plastic over small patches. Areas in full sun can be killed by solarizing the area under two layers of clear plastic. The Exotic Plant Management Team can assist with the management of exotic invasive plants. Implement the Invasive Management Plan for Weir Farm National Historic Park. Two informative websites are http://tncweeds.ucdavis.edu/index.html and http://science.nature.nps.gov/.

HAZARDS OF INFESTATION

Vertebrate pests of landscape areas, forest, orchard and turf can result in degradation of the desired plants through browsing, girdling and feeding on fruit. Populations can expand and reduce the vigor of the desired plants. Some vertebrates also carry diseases hazardous to humans, or harbor insects (ticks) that also feed on humans and transmit Lyme disease.

Insects feed and damage landscaped areas and reduce plant vigor, transmit diseases that have adverse effects on turf, orchards and forests.

Invasive exotic plants have infested the forest and other areas of the site, changing its native aspects. Pests interfere with the Park objectives, changing the historic scene and increasing the costs of management.

INTRODUCTION TO FOREST PESTS

Forest pests have been introduced to the Park over several years. Insect pests have occurred in cycles of high population for a few years, then through starvation, predators or disease, the populations crash for several years. Eventually pest populations build up again. Inspection and monitoring can help anticipate population buildup so preventive measures can be taken. Various cultural and biological actions can be taken to manage pest species to reduce hazards. Exotic plants may need to be removed and the cut stump treated with an herbicide that translocates to the roots (i.e., Glyphosate or Triclopyr). See Pest Profiles.

INTRODUCTION TO ORCHARD PESTS

Orchard pests include several insects, three diseases or fungal pests, and the vertebrate pest. Inspection and monitoring procedures for insect pests can anticipate damaging populations. Pheromone traps can indicate pest presence and degree day calculations can be used to predict damaging population levels. Humidity and temperature monitoring can also predict fungal and disease outbreaks. Exclusion methods can prevent vole damage to tree trunks. See Pest Profiles.

INTRODUCTION TO INVASIVE EXOTIC PLANT PESTS

Invasive exotic plants may be the most troublesome and expensive pest issue in the Park. Exotic plants are numerous, cover large acreage and produce many seeds that are dispersed by birds and other animals. Many exotic plants reproduce vegetatively as well. Some high priority exotic plants may need to be removed (and replaced with desired native plants) and herbicides applied to reduce resprouting. See Pest Profiles.

INTRODUCTION TO TURF MANAGEMENT

GENERAL

Introduction: The continuous planting, maintenance, and replacement of plants is essential to maintaining a high-quality environment landscape. Over time, landscape development should provide a sense of permanence and a regional context. It should also visually reinforce the road network, screen unsightly views or elements, and buffer incompatible land uses.

This unit presents information for effective, economical, and practical landscape and grounds care, and deals with specific landscape problems most frequently encountered. Other sources of information may be obtained from county or state Cooperative Extension Service Agents, Soil Conservation Service staff, university agriculture departments, and city parks department agronomists or horticulturists.

Preventive Maintenance: To control erosion and maintain healthy turf, preventive maintenance can be best conducted by, but is not limited to, the following:

- Analysis of soil conditions through sampling and testing.
- Selection of appropriate grass, seeds, and other plant materials to achieve natural cultural conditions for the given region; to reduce infestation of weeds, encroachment of fungus, and invasion of insects.
- Proper turf care, including seeding, fertilizing, mowing, and watering.
- General cleanliness of grounds, timely attention to aeration, raking, top-dressing, weeding, and the proper preparation of bare spots for reseeding.
- Most desirable frequency and mowing height recommended for the particular type of turf and for a given shade and/or sun environment for each season.
- Resistance of grasses to both drought and excess of rainfall or water in a particular area.
- Need for adequate equipment, tools, and their care.
- Controlling foot traffic and other activities resulting in damage to turf.

Selection by Geographic Areas: For practical purposes, the desirable permanent grasses for each of the following regions can be selected according to their most suitable application to a given climatic environment.

Regions

Cold and Humid: This is the cool-season region that includes the northeastern United States, where there are abundant rainfall and acid soils. Upright growing grasses (Kentucky bluegrass, fine fescue, and bent grass) are adapted to this area. These grasses achieve their best growth during the cool weather of spring and fall, when temperatures are below 27ºC (80ºF). Schedule cultural practices to take advantage of these cooler seasons. The most favorable time to establish turf, or to renovate an existing lawn using these grasses, is during late August or early September. During the fall season, temperatures are moderate, rainfall is plentiful, and there is less weed competition.

Variable: This region, running across the entire country, is where there is an overlap of the warm-season and cool-season grasses. Both types of grass grow in this area, so review species selection with local agronomists. Tall fescue and zoysia grass are most commonly used in this region.

FERTILIZATION

Soil Sampling and Testing: Soil sampling and testing are the foundation of a good fertilization program. To find out the chemical properties present in various types of soils, it is necessary to take soil samples. Soil tests should be done between once a year and once every three years, in the spring. Ranges for acceptable test results are as follows:

pH range	5.8 to 7.0
Organic matter	1.5 to 3.0%
Magnesium - Mg	35 pounds/acre
Phosphorous - P	100 pounds/acre
Potassium – K	85 pounds/acre

Soluble salts not to exceed 500 ppm

The reliability of soil testing depends on the method used for taking soil samples. Grass gets most of its nourishment from the top 10.16 cm (4 in) of soil. Soil test results should be considered an estimate of nutrient availability and pH balance within the soil. It is the base to which additional nutrients are to be added. Soil-testing services for determining the degree of acidity or alkalinity, also the chemical analysis for Nitrogen (N), Phosphate (P_2O_5) or Phosphorus (P) and Potash or Potassium (K) determination, are available. Soil-testing kits for the chemical analysis of pH, N, P, and K, are available commercially. Chemicals used in soil-testing deteriorate with age and must be replaced every year. When test kits are used with care following the instructions, a reliable indication of plant food elements and soil reaction is obtained.

Lime: Some soils are "sour" (acid) and others are "sweet" (alkaline), so called because of their respective positions below or above 7.0, the neutral point on the pH scale. While grasses will grow in soil pH ranging from 5.0 to 7.5, better turf grasses prefer a range between 6.0 and 6.5, or slightly acid on the pH scale. The soil's acidity or alkalinity (pH) is normally controlled by spreading dolomitic lime. The use of ground limestone, with its characteristic trace elements, is preferred to maintain a soil reaction slightly below the pH neutral point. This tends to keep grasses green longer in the fall, ward off the encroachment of snow mold disease, increase drought resistance, and improve resistance to brown patch and dollar-spot disease.

Nitrogen: Nitrogen, the growth-producing nutrient for plants, should be supplied at a constant and uniform rate to keep grass growing and maintain a healthy plant condition. An adequate supply results in dark green foliage and active vegetative growth. However, an oversupply of nitrogen causes too-rapid plant growth, less firm tissues, and weakening of the plant so that it is less resistant to disease, infection, and injury. Excess nitrogen applied at flowering time causes the plant to retard flower and seed formation and to resume active vegetative growth.

Phosphates: Phosphate compounds are needed by all plants, especially plants that produce flowers, seeds, and grain. These compounds promote germination of seed and contribute to general plant health. Phosphate materials include organic phosphates, super-phosphates, and ammonia phosphates. Common sources of organic phosphates are bone meal, sewage sludge, and vegetable meals.

Potassium: The principal sources of potassium are muriate of potash and sulphate of potash, which are completely soluble in water. Other potash carriers are potassium nitrate, cottonseed hulls, hardwood ashes, and tobacco stems. Muriate of potash is the common source of potassium in mixed fertilizers, although the sulphate form is preferable where chloride is a problem, for example, in tobacco fertilizers. Potash is an important food element in the formation and transportation of starch, sugar, and other carbohydrates within the plants. An adequate application of potassium to the soil causes plants to produce disease-resistant, stiff, healthy stems, and improves root growth.

Excessive application of nitrogen (N), or phosphorus (P), or both, often accentuates rust infestation.

Minor Elements: Copper, zinc, iron, manganese, and boron are required by plants in small quantities. Use them with extreme caution, since excess applications may be severely toxic. Animal manures and many natural organic fertilizers contain these trace elements. Copper, zinc, iron, and manganese are usually applied as a sulphate. Recently, however, chelated compounds and insoluble "fritted forms" of these elements have become available.

Slow-Acting Fertilizers: Natural organic and synthetic organic-nitrogen fertilizers are not water-soluble. They depend upon certain soil bacteria and fungi to break down the chemical materials for plant growth. They do not "burn" grass because the bacteria make the nutrients available to the plants. Another reason that natural organic fertilizers do not burn is that they have a low nutrient value.

ESTABLISHING AND MAINTAINING TURF-GRASS

Starting New Turf: Once soil tests have been completed, prepare the site for the application of seed or sod. The preparation of the seed bed determines the long-term success of the turf being planted.

Watering: The need for, and frequency of, watering is dictated by the type of soil, turf, temperature, humidity, and other weather conditions. A water supply of about 76.2 cm (30 in) per year or more is necessary for the establishment of a good turf. This may be from rainfall or a combination of rainfall and irrigation. Artificial watering may be done by fixed or movable sprinklers. Turf should be watered when indicated by their color, lack of resilience to foot printing, or wilting. The need for watering can also be determined by taking a sample core, cut out of turf and soil, 6.35 cm (2 1/2 in) deep, with a 11.43 cm (4 1/2 in) long tapered hollow-tine sampling tool having a 1.27 cm (1/2 in) diameter cutting edge opening.

Mowing: One common reason for turf failure is cutting the grass too close to the ground, which prevents grass from spreading out and developing into a dense turf. The grass' root development

is related to its top growth. To remain healthy and resistant to disease and weed invasion, it must produce, through minimum blade height and surface, enough plant foods for vigorous root development. Low clipping starves the roots, causing them to become shallow.

Also, the turf will thin out and be baked during hot summer temperatures, leaving room for the invasion of low-growing weeds. Low mowing permits sunlight to warm the ground, helping crabgrass seedlings to germinate in late May and June. Grass should not be permitted to grow too high and then cut back so that bleached stems are evident. This is a shock to the plant, which could then be injured by the hot sun. It is also necessary to remove the clippings to avoid smothering the grass with them.

A 7.62 – 10.16 cm (3 – 4 in) mowing height is recommended for all turf grasses to ensure a densely tufted sod, tolerance for long periods of drought, and resistance to heavy traffic. This height also retards the germination of weed seeds lying near the soil surface.

Mowing should be done often enough so that the short clippings can be left on the ground to decompose. This is beneficial to the turf, because clippings under an inch long serve as mulch to the roots and return plant food elements to the soil. Longer clippings tend to mat on top of the grass instead of dropping between the blades to the ground, which smothers the plants. When dried out, long cuttings become an unsightly litter, holding an excessive amount of moisture, and thus weakening the grass. When conditions of humidity and temperature are right, fungi can encroach on the weakened turf.

Aeration: Aeration consists of punching holes and removing soil cores to allow for lateral expansion of the compacted soil into these holes. This loosens the soil beneath the grass without disturbing or damaging the turf surface and root structure. Proper aeration of grass reduces maintenance costs resulting from labor and materials, fertilizer, seed, sod, sprigs, and artificial watering, which would be wasted due to runoff on compacted soils. Also, the turf will be denser, stronger, and better able to withstand traffic. Further, it is less susceptible to disease and hardier through periods of drought. In summary, aeration will do the following:

- Make the soil porous through vertical penetration, permitting air, moisture and fertilizer to reach the grass roots.
- Increase turf growth and density, particularly if plant food is spread and the area dragged while soil cavities are still open.
- Help in preparation of a good seed bed while improving existing turf.

Aeration exposes the ground so it can readily absorb surface water, resulting in less runoff and erosion. When done before fertilization, aeration improves the effectiveness of fertilization. After fertilizing, the turf area should be dragged, raked, or brushed to smooth off any unevenness resulting from the aeration process. This moves the fertilizer from the turf into the soil and grass root system.

WEEDS

General: Webster's dictionary defines a weed as any plant growing in cultivated ground to the detriment of a crop or to the disfigurement of the place. However, weeds may be useful under

special conditions or in specific areas, such as for controlling soil erosion. Weed seeds are transported by birds and wind, and most soil contains dormant seeds that germinate when temperature, moisture, and mowing conditions are favorable. They can reduce a healthy stand of turf by competing with and depriving it of the water, light, and the soil nutrients needed to sustain it.

Weeds become a factor after grasses lose aggressiveness and vigor, and in addition, may serve as host for turf-grass diseases. They frequently provide a haven for vermin and for the over-wintering of plant and turf-attacking insects and diseases. One or a combination of the following conditions encourages weed infestation:

Poor soil type and density
Nutrient starvation
Lack of water
Over-fertilization
Over-watering
Inadequate drainage
Soil compaction
Improper mowing
Insect damage (surface and sub-surface types)
Disease damage
Extreme fluctuations in temperature and natural moisture and/or precipitation

These factors retard both root development and top growth, affect turf color, density, and texture, and impede recovery from injury.

A turf-grass management program should include the planting of permanent grasses and their maintenance through good soil sampling, testing, liming, fertilizing, mowing, and watering practices. Chemical treatment for weeds should be considered only as a last choice.

Characteristics: Various weed seeds remain dormant in the soil for years and germinate when brought to the surface by cultivating, and when other conditions are favorable. Weeds are capable of growing to maturity and setting vast numbers of seed within the short span of 30 – 60 days. When unchecked, their rapid growth enables them to readily overtake and stop turf growth. Certain weeds have extensive root systems and continue to grow new shoots repeatedly, even when the top growth has been destroyed. Clover is a good example of this.

Weeds that are common in turf-grass environments are usually low-growing, prostrate, vine-like forms of undesirable plants. Low mowing, to eradicate weeds, should not be resorted to, since it will also destroy desirable lawn grasses. Weeds may be classed as herbaceous or woody. Most plants regarded as weeds are herbs that are either annuals, biennials, or perennials.

Annuals: Annual herbaceous plants complete their life cycles in one growing season by germinating from seed in the spring or summer, producing seed, and dying in the same year. The seeds of winter annuals germinate in the fall of one growing season. The plants live over winter, produce seed, and die in the spring of the year following germination.

Biennials: Biennials live two years, developing a cluster of leaves fanning out and around the main shoots at ground level during the first year, and a storage root that helps the plant survive the first year's winter. During the second year, leaves, flowers, and seed develop, after which the plant dies. Garlic mustard is an example.

Perennials: Roots and stems of perennials live indefinitely, but their tops die each year and new stems and leaves develop the following year.

Identification and Management: The common names of weeds vary so that a weed may be known by different names in different locations. Conversely, several different weeds may be known by the same common name. Contact your local Cooperative Extension Service for weed I.D. and management methods.

For those interested in learning to identify and control weeds, the following two books are recommended:

Weeds of the North Central States, Circular No. 718, Agriculture Experiment Station, University of Illinois, Urbana, Illinois 61801, 260 pages.

Weed Identification and Control by Duane Isely, Iowa State University Press, Ames, Iowa 50010, 400 pages.

DISEASES

General: More than 100 different diseases have been found on turf grass. However, only about 10 to 15 of them are known to damage the turf.

Diseases are more likely to occur in turf which have been improperly established or maintained. The following conditions contribute to poor turf, and ultimately to disease attack: improper selection of grass mixtures and species, buried debris, compacted soils, improper watering, improper mowing, insect injury, pesticide injury, fertilizer burn, and hydrated-lime burn. Additional causes are foot traffic, children playing on immature and/or wet turf, delivery trucks and automobiles driving over turf or parked on them, and other abuse.

Identification and Management: Some turf diseases can be managed by using chemicals called fungicides, of which many kinds are available. All fungicides are poisonous! On the issue of exposure of workers to pesticides, OSHA defers to the EPA, which enforces pesticide-use laws under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). (OSHA regulations 29 CFR 1910.1200 Scope B.5.A.).

Turf injury from other causes is frequently mistaken for disease symptoms. These include burning with chemical fertilizers, chemical weed killers, drought, dog and insect damage, or fungi damage in combination with other symptoms.

INSECT DAMAGE

General: Turf grass is subject to attack from insects and insect-like pests, which cause it to turn brown and die. These pests can be grouped as follows:

- Soil and root-infesting insects, including Japanese, Oriental, and Asiatic grubs; white-fringed beetles; masked, rose, and European chafers; mole crickets; wireworms; billbugs; and ants.
- Leaf- and stem-damaging insects, including sod webworms, armyworms, cutworms, Lucerne moth, fiery skipper, grasshoppers, and leaf bugs.
- Plant juice-sucking insects, including chinch bugs, aphids, leaf hoppers, mites, scales, and ground pearls.

Inspecting and monitoring the landscaped turf areas should be conducted periodically. Inspections of turf areas can be accomplished during other duties in the turf areas. Healthy turf is generally resistant to pests. Look for good uniform green color, mowing height (10.16 cm [4 in]) and the presence of bare ground patches and weeds. Check the root structure to determine if it is shallow or deep (15.24 cm [6 in] or more). Inspect for the general health of the turf areas at least three times during the season (spring, mid-summer, fall). Dated photo records may be useful.

Monitoring may consist of using line transects to determine the density of turf, presence and identification of weeds, and presence of damage by rodents or insects. Increase the frequency of monitoring if pest damage has been observed. If damage requires remedial action, monitor after the action has been taken to determine results. Pitfall traps can be used in no or low-traffic areas to capture insects or mites for identification. Keep records of observations while monitoring.