National Park Service
U.S. Department of the Interior

Northeast Region
Boston, Massachusetts

Integrated Pest Management Plan
Marsh-Billings-Rockefeller National Historical Park

Natural Resources Report NPS/NER/NRR–2006/013



Developed by:
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Integrated Pest Management Plan
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Natural Resources Report NPS/NER/NRR–2006/013

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ON THE COVER
Marsh-Billings-Rockefeller Mansion
Photograph by: Jean A. Currie, President, International Pest Management Institute

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INTEGRATED PEST MANAGEMENT PLAN
FOR
MARSH-BILLINGS-ROCKEFELLER NATIONAL HISTORICAL PARK

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MARSH-BILLINGS-ROCKEFELLER NATIONAL HISTORICAL PARK
INTEGRATED PEST MANAGEMENT ACTION PLAN

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EXECUTIVE SUMMARY

INTEGRATED PEST MANAGEMENT PLAN FOR MARSH-BILLINGS-ROCKEFELLER NATIONAL HISTORICAL PARK

This Integrated Pest Management (IPM) Plan for Marsh-Billings-Rockefeller National Historical Park (MABI) in Woodstock, Vermont provides basic pest management guidelines to help preserve the stored cultural museum resources, structures, forests and site grounds, and assist in protecting the health and safety of MABI 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 (Natural Resource Manager) to implement the IPM plan. The IPM Coordinator will work with the Facilities Manager, Curator, Horticulturist, Forester and others in the implementation as outlined in NPS-77 (Natural Resources Management Guidelines).

Any use of pesticides at MABI will be in accordance with Servicewide policies as found in NPS-77. All pesticides used in the site will be applied by or under the direct supervision of a state (Vermont) certified pesticide applicator. All pesticides used in the site 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 MABI in compliance with NPS policy to use low-risk pesticides, if necessary, that will accomplish desired objectives.

At the end of each year, the MABI 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 MABI structures, forests and landscapes are described. There are concerns at the park about many pests such as museum pests (carpet beetles, silverfish), structural pests (mice, carpenter ants, mold, wasps, termites, powderpost beetles, wood rot), gardens and grounds pests (aphids, mealy bugs, rust, grubs, moles, ground hogs, deer), forest pests (cankers, fungi, bronze birch borer, tent caterpillars, leaf miners, hemlock woolly adelgids, gypsy moth) and others, as well as 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 favoring pests will determine the extent of pest presence and direct pest management actions.

The staff of Marsh-Billings-Rockefeller National Historical Park is committed to the implementation of the IPM approach for those pests threatening the site resources and the health and safety of site visitors and staff.

INTRODUCTION

Marsh-Billings-Rockefeller National Historical Park encompasses the historic Marsh-Billings-Rockefeller Mansion, the surrounding grounds, and the Mount Tom Forest in Woodstock Vermont. The park was created by an Act of Congress in 1992 with five key purposes:

- To interpret the history and evolution of conservation stewardship in America
- To recognize and interpret the birthplace and contributions of George Perkins Marsh, pioneering environmentalist; author of Man and Nature, statesman, lawyer, and linguist
- To recognize and interpret the contributions of Frederick Billings, pioneer in reforestation and scientific farm management, lawyer, philanthropist, and railroad builder, who extended the principles of land management introduced by Marsh
- To recognize the significant contributions of Julia Billings, Mary Billings French, Mary French Rockefeller and Laurance Spelman Rockefeller in perpetuating the Marsh-Billings heritage
- To preserve the Marsh-Billings Mansion, which is a National Historic Landmark, and its surrounding lands

The park puts the idea of conservation stewardship in a modern concept interpreting the idea of place and the ways in which humans can balance natural resource conservation with the requirements of our twenty-first century world.

The park consists of 16 historic structures, over 23,000 museum artifacts, five acres of landscaped grounds and formal gardens, and 550 acres of managed forested areas. The park receives over 30,000 visitors per year.

The benefits of an effective IPM plan, fully implemented, provide a system of protection for the structure, collections, gardens, fields and forest health, and can enhance staff and visitor safety. The management of pest species reduces potential damage to museum and other objects, forested and landscaped sites and, therefore, reduces park resources needed to repair or replace objects or modify environmental areas. The IPM approach provides an efficient and environmentally conscious strategy for the preservation of historic collections and landscapes. Low-risk IPM approaches include excluding pests from entering structures, eliminating pests that may already be present in the managed environment, implementing management procedures prior to pest population buildup, and the elimination (or at least minimizing) of placing pesticides in the staff's environment. Such tactics provide a flexible and varied approach to managing the forest and landscaped site and curatorial environment to reduce or eliminate pest populations.

This historical park has an excellent staff, with tremendous experience and intimate knowledge of the park's workings. Park staff has a key role in protecting park resources and providing for visitor safety, and will use this low-risk pest management plan to continue to accomplish these objectives. Maintenance and custodial staffs have already made important contributions toward reducing pest populations. Additional directed efforts by the maintenance and resource management staff will further reduce the potential adverse pest impact upon the protection of the site contents and visitor enjoyment. Additionally, several studies have been conducted on the park's natural and cultural resources, and the recommendations in these reports should serve as a guide for developing IPM management approaches.

LEGAL AUTHORITIES AND REQUIREMENTS

The National Park Service is committed to using 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

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.

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

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.

STATE OF VERMONT POLICY

Vermont Regulations for Control of Pesticides in Accordance with 6 V.S.A. Chapter 87, effective August 2, 1991, State of Vermont, Department of Agriculture, Food and Markets, Montpelier, Vermont 05620-2901.

PARK INTEGRATED PEST MANAGEMENT STRATEGIES

IPM is defined as:

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 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 (early detection, rapid response),
- potential public health issues, and
- the procedures and actions necessary to prevent pest access and methods for their elimination (early detection, rapid response).

This plan will help preserve MABI resources: Cultural resources (structures, landscaped areas, forest and fields) associated values at MABI are protected, restored and maintained in good condition and managed within their cultural context. Display the continuity of stewardship and

conservation practices toward the fields and forest environment practiced by George P. Marsh, Frederick Billings and Laurance S. Rockefeller over more than a century.

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. Pest presence in a forest, field or cultivated environment can also cause damage that has ecological and environmental consequences. IPM is proactive – work must be done to prevent pest activity rather than react to pest damage. Damaged artifacts may NOT be replaceable, and the extent of damage may preclude effective restoration. Prevention is equally as important as response and may preclude having to respond!

Materials such as paper, glues, leather, sinew, fur, hair, wood, cotton, wool, hemp, linen, silk, casein, grass, reed and pine needles are organic materials susceptible to the ravages of insects and other arthropods, rodents, mold, and bacterial pest organisms. The continuity of forest health, field fertility and productiveness can be adversely affected by the activity of pests, particularly non-native invasive plants, insects, and diseases.

In addition to the potential for damage to park resources, some pests pose potential health risks to staff and visitors. Rodents (rats and mice) and deer ticks are known vectors of many disease organisms to humans such as Hantavirus and Lyme disease. 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. Managing all these potential pests is an important consideration in a low-risk integrated pest management plan.

NATIONAL PARK SERVICE LOW-RISK INTEGRATED PEST MANAGEMENT PROCESS

The National Park Service has developed an effective and advanced 11 step process for developing and implementing an IPM strategy for pests on park sites. A brief discussion of these 11 steps follows.

Step 1 Set Site Pest Management Objectives and Priorities

Provide an educational demonstration of forest stewardship and conservation.

Priorities: Carriage Barn Visitor Center, bungalow, greenhouse, Belvedere, Rockefeller mansion and their historic contents, exhibit areas, collections storage areas and workspaces, Mansion grounds, fields and forests.

- Protect historic resources (structures, collections, Mansion grounds, forests and fields) from pests and other hazards
- Provide an educational, safe and pleasing experience for visitors

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. This process may already be implemented to include:

- Occupants: public, visitors, community, site staff (employees)
- Pest managers: IPM Coordinator, resource managers, curatorial staff, maintenance staff, landscape and forestry contractors, NER Exotic Plant Management Team
- Decision makers: Superintendent, Facilities Manager, Natural Resource Manager/IPM Coordinator, Curator

(1) Provide signage and other interpretive information on pest management issues and procedures through interpretive staff, news releases, seminars or conferences.
(2) IPM Coordinator to hold periodic 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 the superintendent two times per year on critical issues, progress and successes.

Step 3 Document Decisions and Maintain Records

This pest management plan provides the basis for IPM decision-making. As the plan is implemented, documentation of implementation actions and monitoring data is critical for adopting management practices to changes in pest conditions. These include:

- Pest sighting logs for critical sites, curatorial storage, structures, fields, forests.
- Records for all data collected, information on remedial actions taken to eliminate pest access, and any pesticide treatment actions.

Step 4 Know The Resource

The MABI maintenance, curatorial and resource management staffs and the IPM Coordinator have intimate knowledge of the site and cultural and natural resources.

- The resource consists of historic artifacts, structure(s), storage areas, offices, public areas, landscaping and public grounds and forest.
- This rural park has a moderate to heavy human occupancy (public) and staff, and pest pressure from the surroundings.
- An exotic weed management plan for invasive plants has been developed for the site and should be implemented.
- Numerous studies and plans have been created that assess site conditions and help guide management decisions.

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 include:

- Museum pests – carpet beetles, clothes moths, silverfish, mold
- Structural pests – eastern subterranean termites (potential), carpenter ants, carpenter bees, wood borers, ants, rodents, earwigs

- Public health pests – bats, mice, flies, 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, Sudden Oak Death, 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. Pheromone trap grids can be set up to monitor pest presence in landscaped and forested areas, physical observation of plant health and degree day information to predict plant pest emergence.

- Continue monitoring regimens and 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. In sustainable forestry or agricultural environments, action thresholds depend on overall management objectives (i.e., species composition, productivity, or ecological integrity/resilience).

- The presence of a single pest (larval dermestidae) in a critical area (artifacts) calls for an immediate remedial action (physical removal, cleaning, trapping, etc.).
- Prevention is a key component: early initiation of 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 require remedial action (see the "Exotic Plant Management Plan")
- Potential sighting of new populations of non-native highly invasive forest insects, such as hemlock woolly adelgid, requires early response. Presence of native forest insects may indicate an environmental condition (e.g., drought, forest crowding).

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 exotic plants. Selective pruning, thinning, harvesting or releasing parasitic or predatory arthropods may reduce losses from field or forest environments.

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. See Legal Authorities and Requirements.

Step 10 Obtain Approval, Define Responsibilities, and Implement Strategies

Responsibilities of the IPM Coordinator, curatorial and resource management 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 MABI IPM Coordinator to the NER IPM Coordinator for approval prior to the performance of any application. NEPA and NHPA issues are the responsibilities of park staff to address; and are not a part of this IPM plan.

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.

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 MABI. 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 preservation and protection of park resources. The integrated pest management (IPM) program has similar responsibilities and should closely interact with all site personnel. Most MABI 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 contractors) 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 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 relates to park resources and activities. Support from the Superintendent includes, as appropriate, designating staff to implement the IPM plan; 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.

RESOURCE MANAGER

The Resource Manager has responsibilities for management of the site's natural resources and cultural landscapes, and oversight, review and support of the pest management program, including this IPM plan. The Manager must also understand the principles and practices of IPM and annually review the IPM plan for any necessary changes or additions. The Manager may serve as the IPM Coordinator, or such duties can be designated to other resource management staff. Additionally, the Resource Manager, and designated resource management staff, will annually inspect the Park's forest and fields for pests and record inspection findings; if inspections show evidence of pest activity of concern, 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. The Resource Manager will provide, as appropriate, training for resource management personnel on pest management strategies.

IPM COORDINATOR

The responsibilities of the site IPM Coordinator are described in NPS-77 Natural Resource Guidelines and in the March 10, 1997 IPM re-engineering Memorandum. The MABI 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 site staff and residents. The IPM Coordinator works with other Park staff to implement IPM activities in this plan, assisting staff with solving pest problems, reviewing pest monitoring reports, and facilitating training of employees with pest management duties. The IPM Coordinator will annually review the IPM plan for necessary changes or additions with the Superintendent and other program managers, and inform the Superintendent on all pest management issues and pesticide use. The IPM Coordinator is also responsible for pesticide use reporting with the Regional IPM Coordinator and ensuring personnel applying restricted-use pesticides work under direct supervision of a certified applicator licensed by the State of Vermont.

CURATOR

The Curator 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 for maintenance will be identified and scheduled with the Facilities Manager and reported to the IPM Coordinator.

FACILITY MANAGER

The Facility Manager has the responsibility of maintaining historic structures and the Mansion grounds. The Facility Manager will oversee and designate staff to identify pest management issues related to structures and grounds. Maintenance staff, in particular, is a valuable part of the IPM preventative program. Keeping structures in good repair and overseeing repairs to buildings to eliminate entryways for pests is a fundamental component of the IPM approach – total exclusion of pests from entry into structures is the first line of defense in this pest management plan. Additionally, assuring 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. The Facility Manager and designated Maintenance staff 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 in consultation with the IPM Coordinator, and assure Park staff is provided the latest information concerning health and safety matters on pests and pesticides. The Facility Manager will provide, as appropriate, training for Maintenance personnel on pest management strategies.

HORTICULTURALIST

Working with the IPM Coordinator and Facility Manager, the Horticulturalist is responsible for assisting with the maintenance of the Mansion grounds. If warranted, the Horticulturalist may apply or oversee the application of pesticides to meet Park IPM management objectives. As such, the Horticulturalist may be required to be licensed by the State of Vermont as a certified pesticide applicator. The Horticulturalist will, as needed and appropriate, maintain the locked pesticide cabinet, pesticide labels and material safety data sheets (MSDS) on all approved pesticides.

DOCUMENTATION

INSPECTIONS

The initial inspection of the site and a written report may be the first official record of a pest presence. 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. Methods of monitoring will vary, depending upon the pest of concern. For example, 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. For flying insects, 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. Talc or diatomaceous earth patches placed in rodent runways can be used to determine rodent population size and if the runways are active by checking tracks in the dust. Monitoring for plants that are undesirable in the park can be conducted by observation, line transects, meter grids and other means. See Inspection and Monitoring for further details on monitoring recommendations.

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, trapping, etc.)
- Record of findings and subsequent management decisions
- Treatment efficacy on target pest (and nontargets)

PESTICIDE USE PROPOSALS (PUPS) AND 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 Vermont may also request to review the pesticide use logs.

Before the pesticide application is made, pesticide use request must be submitted to the Regional IPM Coordinator or the Washington Office IPM Coordinator (depending upon the desired product, pest and site), using the PUPS NPS IPM database. The Park IPM Coordinator manages the PUPS intranet database for the Park. 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.

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 MABI IPM Coordinator's or the Horticulturalist's office. Copies of pesticide use records and pesticide labels will also be kept in the pesticide applicator's notebook or file.

PURCHASING, DI-1s

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. This includes insect repellants as well, even when sold by concessions within the park.

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. The IPM Coordinator should become licensed in Vermont to legally oversee the use of pesticides. Others involved with the use or application of pesticides should be certified applicators under the direction of the licensed IPM Coordinator.

COOPERATIVE AGREEMENTS

The park, 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. Cooperators or contractors providing pest management services must follow NPS rules, guidelines and other requirements when providing services on park sites. Pesticide use must be approved and pesticide use data must be provided to the Regional IPM Coordinator via the PUPS.

INSPECTION FINDINGS AND RECOMMENDATIONS

Marsh-Billings-Rockefeller National Historical Park had inspections of the structures and grounds on November 11-16, 2004 and June 20-21, 2005 conducted by William E. and Jean A. Currie of IPMI. The weather during the first inspection was clear and cool; and the second inspection weather was clear and warm. November 12, 2004 was spent in a meeting with the IPM Coordinator and several staff discussing some history and IPM concerns.

THE MANSION



The Mansion

The mansion was originally built in 1805 for a growing Marsh family. The federal style brick house was sold to Frederick Billings in 1869. An 1869 renovation transformed the house into a "fashionable stick style" mansion. In 1885, the Billings family updated the home again. In 1954, Laurance and Mary F. Rockefeller inherited the house and updated it with new wallpapers, paints and upholsteries.

It was stated that photographs are generally not allowed to be taken inside the mansion. However, photographs of specific pest situations were allowed.

Mansion Basement: There is evidence of earwigs, mice, bats and red squirrels in the basement area. The hole in the wall by the pipes on the east side allows pest access and should be filled with Stuf-Fit and sealed. The basements are damp and mold is present. Dehumidifiers should be installed. The dehumidifiers must be monitored and the water reservoir emptied periodically.

The pipe races throughout the basement should have the holes where the pipes go through the walls filled and sealed to prevent easy pest transit. There is sign of entry activity through the holes in the wall/ceiling junction on the wall toward the rear of the house. Boxes on shelves in 015 have been chewed and should be removed or replaced. There is a hole in the south side wall above the shelves in 015 that should be repaired (sealed). Where wires penetrate the south wall, there are signs of rodent chewing the area around the wires. There are nests in boxes and food caches on shelves which are indications of squirrel activity. Holes in pipe room 013 on the northwest side and in shelf room 015 need to be filled. The room that can only be entered via a ladder (014) can have the holes filled around pipe entries. Otherwise it looks relatively secure here from pests. The pipe tunnel has lots of pipes, and the holes in the walls may be able to be filled by using a pointing trowel.

The computer storage room (016A) has only a few small holes that should be filled. Fill the holes around pipes in the room where wicker is stored (001). The generator room (012) has holes in the ceiling around pipes that need to be filled. There are also missing ceiling tiles on both ends of the room and front wall that need to be replaced. The restroom (009) has holes at the wall/ceiling junction big enough for mouse entry. There are holes over the Unigrid shelves in the hallway (008). THE KEY is to secure the perimeter of the mansion so that insect and rodent pests cannot enter.

Furnace Room 007: There are holes in the northeast wall over the two doors and holes around the pipe in the west end above the tank. There is also a crack in the ceiling above the furnace. All of these openings can allow insect and/or rodent pest access to the mansion and must be screened and/or sealed.

Cistern Room 010: The inside window in back of the cistern room is broken and should be repaired (replaced). There is a hole that should be sealed in the floor/wall junction below the broken window.

There is a hole in the hall stairs from the basement that needs to be filled.

The first floor of the Mansion was not thoroughly inspected; the rooms were viewed from the hallway during both inspections.

Second and Third Floors: Bats have been found in the house in hot, humid weather. Some have been found and captured in wastebaskets sitting on the floor. Find bat entry points and seal.

A project to restore textiles with exact replicas is being funded. Carpet beetle damage to carpets on the 2nd and 3rd floor has occurred. There is substantial damage from carpet beetle larvae on the carpet edges by upright beams. Live dermestid larvae were found in carpeting on the 2nd floor on the east side in Rooms 201 and 202. Dead black carpet beetle and varied carpet beetle adults were found on the 3rd floor in the southwest bedroom (306) window. Additionally, dead *Harmonia sp.* adult beetles were found in all south windows and the bath. Remove all dead



Carpet Beetle Larvae Damage



Carpet Beetle Larvae Damage

insects. If live dermestid larvae or carpet beetle adults are present, treat the affected carpeting with food grade diatomaceous earth (DE), Perma-Guard Commercial Insecticide or TimBor Pro.

Master Bedroom 207: Dead moths and cluster flies were found here. Clothes moths have been seen in the mansion apartment. Remove all dead insects and install clothes moth pheromone traps.

3rd Floor, Southwest Bedroom 306: There were many cluster flies (alive and dead), dead paper wasps, many dead *Harmonia sp.* lady beetles and dead clothes moths throughout the room. There is evidence of chewing on the edges of the carpet and chewing damage to the felt on the desk. The rug by the fireplace has been an insect infestation point in the past. Eggs, larvae and



Carpet Beetles & *Harmonia sp.*

adult beetles may be present beneath the carpet and/or in other hidden areas of the room. The Rockefeller staff used to fumigate and use "Raid" in the rooms before the Rockefellers would be in residence. Remove all dead insects. Treat damaged areas with diatomaceous earth, Perma-Guard Commercial Insecticide or TimBor Pro dust when monitoring traps indicate the presence of dermestid beetle adults or larvae.

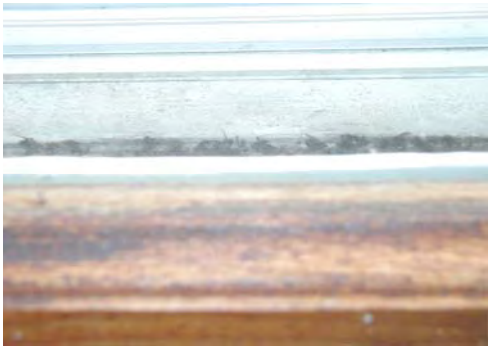
3rd Floor, Southeast Bedroom 303: Dead wasps, *Harmonia sp.*, little house fly and live and dead cluster flies were present here. Remove all dead insects and clean thoroughly.

Billiard Room 314: Moths were found flying in the billiard room. The felt on the billiard table appeared to be undamaged. Sticky traps and pheromone traps for clothes moths should be placed in several places (in a grid pattern) to determine the source of the moths. Monitor these sticky traps frequently (weekly) to determine moth focal point and treat.

The Attic



The Mansion Attic



Cluster Flies & *Harmonia sp.* in Window

There are mouse droppings on the shelf by the east windows (area 402). Dead leaf legged plant bug and green lacewing adults were observed. There are several spider webs present. A sugar-like substance was observed on the south shelves toward the front. Mouse droppings are behind the electric panel in the southwest room (area 404) and in the south side sprinkler head room (area 401). There is a hole which needs to be filled in the floor next to the standpipe on the west side under the windows (area 401), and large holes need to be filled by pipes on the lower attic level where the wicker is stored (area 406). Use Stuf-Fit on holes around pipes.



Insect Frass

Dead carpet beetle adults, cluster flies, *Harmonia sp.* lady beetles and spider webs were found in the attic. The attic needs to be thoroughly cleaned to remove dead insects (dermestid beetle larvae food), and thoroughly inspected to identify small holes, cracks, crevices and other areas where insects can enter or hide. These hiding places should be treated with TimBor Pro or Perma-Guard Commercial Insecticide, and then sealed to prevent pest access.

Crawl Space 405: There is evidence of rodent tunnels in the insulation with several holes that go down below the level of the floor next to the roof line. There are pine cone remains present. This could be evidence of squirrels or mice. Close holes at outer wall and roof line junction to exclude rodents. There is a room off the crawl space to the southwest about 1.22 m (4 ft) high by 2.44 m (8 ft) wide which has difficult access. There is evidence of squirrel activity and mice (droppings) under the eaves near the overhang.



Tree Too Close To Structure

Outside, a vine on the rear (west) side of the mansion can provide access by rodents to upper portions of the structure. The plantings are too close to the building and should be pruned back at least 45.72 cm (18 in) away from the structure, if possible without an adverse effect on the historic landscape character. Allowing open space between plant material and the structure reduces moisture intrusion and deters insect and rodent access to the mansion. There is also evidence of water damage, probably from ice damming on gutters. A permanent solution could be to install a berm or swale uphill from the Mansion to redirect the runoff from a rain event around or away from the structure.



Insect Frass beside Post

Chipmunks are present around the back entry porch and in the kitchen area. A quality (rubber or neoprene) door sweep on the back door to the mansion can prevent rodent and insect intrusion.

Carpenter ants were seen on the porch. A front porch post has frass at the base. There is some wood rot present. Treat the wood with BoraCare or TimBor Pro. When the first treatment is dry to the touch (next day), apply another treatment to push the first borate material the rest of the way through the wood material.

CARRIAGE BARN CURATORIAL STORAGE 002, Assisted by Janet Houghton, Curator



The Carriage Barn

In addition to the Mansion, this storage area houses the highest level artifacts. Here the oxygen depleters can be used for the bagged carpets. There were millipedes and cluster flies on the floor and in the fluorescent lights. There was an earwig on the floor by the portrait storage. A sticky trap by the entrance door has mites, and the sticky trap in the northeast corner has midges and a beetle. Sticky traps at the floor/wall junction set in February had captured midges, millipedes, ants, spiders, psocids, black and varied carpet beetle adults, cluster flies and *Harmonia sp*. lady beetles. The sticky trap behind the compact shelving captured a cricket and a clothes moth adult. There

were also dermestid larvae cast skins and frass in books in Carriage 4, Bays A-F. The outside door sweeps on the entrance doors should be checked to make sure there are NO gaps. Replace the brush type with a heavy rubber or neoprene sweep (the brush type is not very effective). The shelves, artifacts and floors are clean. Sticky traps need to be monitored frequently (weekly) to know what pest pressures are present. Keep records of captures in a log to be able to predict when pests will appear. When traps become dry (not sticky to the touch), replace with new ones.



Dermestid Cast Skin on Shelf

THE CARRIAGE BARN has several staff offices and very clean restrooms. The structure is in good repair and clean. Remove trash at the close of business every day. Staff must be careful about the development of clutter in offices that provides harborage for pests, and eating at desks may provide them food.

BELVEDERE

The Belvedere was built in the 1860s. There is condensation on the windows, mold, and wood rot on the window sills, and the stairwell has old water damage. Increase air flow to reduce moisture. Treat wood rot and mold with BoraCare or TimBor Pro.

Upstairs Office 201: There is condensation on the windows which can lead to mold and wood rot. There are cluster flies in the 2nd floor windows (dead and alive). The main north/south laminated beam is coming apart, perhaps from high humidity. There is mold on the terrace doors on the east side and apparently moth damage on the rug. Clean thoroughly and treat mold with BoraCare or TimBor Pro.



The Belvedere

Bowling Alley 103: There is mold and condensation on the windows; some windows need to be caulked. There is also old water damage on the west end by the mechanical area (104) of the bowling alley. There have been bats resting behind paintings. One bat was removed from behind a wood picture; there is a pipe hole and dropping on the wall in back of this picture. There are dermestid cast skins on the 1776-1976 wall hanging. Mouse droppings were found on the soda fountain counter by the ice cream scoop, under the soda fountain refrigerator, and on the counter above the refrigerator by the snap traps. Suggest fine tuning mouse snap traps and resetting several to reduce the mouse population. Clean up the mouse droppings and monitor daily until all mice have been removed.

There is a bird nest outside under the eave of the 2nd floor office on the north side. If no eggs or young are present, it should be removed to prevent bird mites from entering the building. Install a 45° angle to prevent future nests.

BUNGALOW

The bungalow was built in 1916 - 1979 and a new roof was installed in 1998-99. It has white cedar siding. The bungalow was used as a guest house, and is now used as a conference area.



The Bungalow

The window frames have been painted. There is a crawl space under the bungalow and a partial basement where the furnace is located. The inside is untreated cedar paneling. There are two baths, four bedrooms, kitchen and great room. The timbers underneath are sound. If desired, these timbers could be treated with TimBor or BoraCare to prevent mold, wood rot and insect borer damage.

Basement 001: There are areas with rodent chewing around holes by the furnace which should be filled with Stuf-Fit, as well as the hole behind the stairs.

Ground Floor: The hole underneath the dishwasher (107) should be filled with Stuf-Fit and sealed. The east bath (105) needs the grout replaced around the tub. The hole between the shower tile and wood should be filled. The wall panel in the east bath behind the toilet needs to be fastened (nail, screw?). The built-in chest in the southeast bedroom (106) has frass, which could indicate beetle or carpenter ant activity. There is a hole in the ceiling by the cabinet that should be filled. The northwest bedroom (108) has mice droppings in both closets. There is also rodent gnawing on the closet door in the northwest bedroom. There are holes in the wall and floor behind the chest in the great room (101).

GREENHOUSE

The top windows against the bowling alley are rotting with mold and mushrooms growing from the frames. The lower windows on the south side are fine. The wood materials may need to be scraped to bare wood, treated with TimBor or BoraCare, then repainted.



The Greenhouse

DUAL (STAFF) APARTMENTS

Mice droppings were observed in the stove, outside closet and in the basement. Millipedes are also found in the basement. Clean up the mouse droppings. Set mouse snap traps in the basement and daily check for captures, remove dead mice and reset until there are no more captures and no more droppings are observed.

PONY SHED

This structure is now used as a storage area for tools and deer fencing. There are occasional mice, woodchucks and porcupines. The woodchuck porcupine should be able to be excluded with .64 cm (1/4 in) hardware cloth down the side of the structure to 30.48 cm (12 in) below grade and bent out 15.24 cm (6 in) in an L shape to prevent burrowing under the structure.

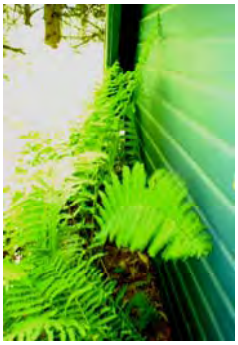
Inside, close all holes with Stuf-Fit and seal to prevent mice access. The sliding doors (hung from tracks above) can be modified by installing a rubber or neoprene "door sweep" on the bottom. Although a determined mouse could eventually chew through the rubber sweep, most will be deterred by the physical barrier. Be sure there are no gaps on the ends. Use Victor-brand snap traps which have been fine tuned for hair trigger and trap until there are no mice inside. Check and remove captured mice every day and reset traps. Woodpeckers have damaged portions of the wood outside, feeding on carpenter bees or other wood borers. Treat raw wood with TimBor or BoraCare and paint with quality paint.



Gnawing on Siding

SPRING HOUSE

The spring house is a wooden structure with a large concrete tank inside which used to serve as the water source for the estate. This water source is no longer used. The open tank is covered with tarps inside the structure. Outside, there are ferns and other vegetation very close to the building, which should be removed to 45.72 cm (18 in) from the structure. A 15.24 cm (6 in) deep by 45.72 cm (18 in) wide gravel strip should be placed around the building to become a barrier for rodents, to prevent vegetation and reduce moisture against the structure.



Ferns too close to Building

GROUNDS, TURF AND ORNAMENTALS

Trees near the "official" vehicle entrance are exhibiting poor health due to a combination of stresses such as soil compaction, presence of sand, snow removal chemicals and salt. Compaction can be alleviated by periodic aeration, which may also help dilute the adverse effects of the chemicals. The birch leafminer (*Fenusa pusilla*) presence on birches may cause premature leaf drop. Merit (imidichloprid), a systemic insecticide, had been applied as a preventive treatment.

The turf appears to be healthy except along the driveway where there is considerable compaction from foot traffic. The benefit of using a plug aerator along this area will enhance turf health.

The lilacs no longer get full sun where they are planted, and are not healthy. Powdery mildew present on leaves and buds may not be a problem late in the season. Remove and destroy infected leaves. Provide ample space between plants for good air circulation. Leaves tunneled by leafminers can be hand-picked and destroyed. Replace declining lilacs with more shade-tolerant viburnam.

Creeping Charlie or ground ivy (*Glechoma hederacea*) prefers rich soils and is shade tolerant. This shallow rooted broadleaf vine can be hand pulled from turf. Laurels have evidence of black spot and black vine weevil (*Otiorhynchus solcatus* [Fabricus]). The black vine weevil is active

at night. All adults are female and during midsummer, alternatively feed and lay eggs. The larvae feed on roots. Larvae pupate in the soil. Adult weevils emerge about mid-June in the northeast. The parasitic nematodes, *Heterorhabditis heliothidis* and *Steinernema feltiae*, have been successful in managing larvae and pupae.

Arborvitae Leafminer (*Argyresthia thuiella* [Packard]) is found from Canada down through the Mid-Atlantic States and west to Missouri. The adult moths appear from mid-June to mid-July to lay their eggs in the green tips of host species. Trees may lose up to 80% of their leaves. 27 parasites of the larvae and pupae have been discovered, but *Pentacnemus bucculatricis* Howard, a wasp parasite, is the most abundant and important in natural control.

The rhododendron bed (an understory plant) should do great under the hemlocks. The turf is a combination of bluegrass, fescue and rye. Mealy bugs on ornamental plantings can be managed by periodic releases of the mealy bug destroyer (*Cryptolaemus montrouzieri*). The adult beetle is .3 cm (1/8 in) long, orange and black, and the larvae resemble mealy bugs except the white waxy coating is thicker and longer than mealy bugs. Both adult and larvae are voracious feeders on mealy bugs. White fly in the greenhouse can be managed by releasing the white fly parasite, *Encarsia Formosa*, a very tiny parasitic wasp. A tiny (.15 cm [1/16 in]) brown/black lady beetle, *Delphastus pusillas*, as both adults and larvae, feed on all stages of many species of white fly.

White grubs in lawns previously treated with milky spore disease (*Bacillus popillae*) may be better managed by the entopathogenic nematodes *Steinema carpocapsae, S. feltiae*. These nematodes get better control of white grubs when turf is irrigated. *Metarhizium anisopliae* is also effective on grubs in turf.

Euonymus caterpillar (*Yponommeuta cagnagella*) feed in colonies on plant foliage within webs. Adult moths appear in July and lay eggs in the bud axils which hatch in mid-August. Larvae feed for a short time, and then overwinter beneath the egg shells. In the following spring, the larvae feed on new foliage as they make webs. Over the winter, check susceptible plants for larvae under egg masses, and prune and destroy. In early spring (May), prune infested foliage or treat young caterpillars with *BtK* (*Bacillus thuringiensis kurstaki*).

Japanese beetles (*Popillia japonica* Newman) feed on roots of turf as larvae and on about 300 plant species as adults. Managing the grubs in turf with a combination of the bacterium, *Bacillis popilliae*, and the parasitic nematodes, *Heterorhabdtitis bacteriophora*, is most effective. Apply the nematodes during a rain event to achieve good penetration. Bait traps with a food lure attracts both sexes of the beetle and should be placed near turf but away from landscape plants. Check and empty traps daily.

Black spot on roses is a fungus that overwinters on fallen leaves and diseased canes. Fungal spores are splashed onto new leaves, and with adequate temperature and leaf wetness, can germinate to infect the rose plant. Remove all fallen leaves and infected canes over the winter, along with the infected leaves on the plant. Spores are spread by wind currents.

Lace bug damage occurs from feeding on lower surfaces of leaves. Black droplets of excrement are signs of feeding. Azalea and rhododendrons are more susceptible to lace bug damage if

planted in full sun. Green lacewing larvae and assassin bugs are predaceous on the young nymphs. Insecticidal soaps sprayed on the underside of infested leaves can help manage the lace bug nymphs.

Snow mold fungus becomes active under snow cover in turf. Rake the infected areas of turf early in the spring to enhance drying. Do not apply nitrogen fertilizers in the fall and mow turf short before the first snowfall. Remove fallen leaves and use snow fencing to prevent snow piles on turf.

Aphids and sooty mold are present when ants are protecting the aphids, or when aphid predators are not present. If ants are present, install Drax Liquidator ant bait stations near the ant colony or in affected plant beds. In the absence of ants, release aphid predators such as lady beetle larvae, green lacewing larvae, or parasitic wasps that parasitize aphids.

Earwigs can be predators, feeding on aphids and other soft-bodied insects; and on flowers, fruit or leaves. Earwigs need high moisture situations and can be found at night under mulch, boards or around foundations. Prevent entry inside structures by installing door sweeps, caulking cracks and crevices, or using other exclusion methods.

INTEGRATED PEST MANAGEMENT METHODS

This section provides a general overview of Integrated Pest Management methods that can be considered for addressing some of the Park's pest populations, particularly as related to the Park's collections and structures. Pest exclusion, sanitation and habitat modification are the most effective treatment practices. Additional practices for IPM methods related to the management of the forest and fields is outside the scope of IPMI expertise and should be developed in consultation with forestry and agricultural professionals.

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 .64 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 or roosts with 45º angle surfaces as a preventative.

Note: Screening chimneys and stove pipes may cause soot to build up on the screen. 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.

Exclusion of pests from outside landscaped areas may be much more difficult. Voles or other rodents that may damage orchard trees by gnawing the bark can be excluded from individual trees by installing ¼ inch hardware cloth around the trunk (10.16 cm [4 in] out from the trunk) and at least 10.16 cm (4 in) deep below soil level. Weeds or turf can be excluded from around fence lines by installing mowing strips 15.24 cm (6 in) out from center on each side of wire or wooden fences or from walls. Rodent repellents such as coyote or cougar urine can be used to keep rodents away from attractive plantings. Weeds can be discouraged from entering some areas by modifying soil to encourage healthy turf (aeration and nutrient mix) or by shading out broadleaf weeds by covering with black plastic. Physical removal of larger weeds can be done with a weed wrench or chain saw. Insects are much more mobile but can be excluded with reflective foil around the base of ornamental plants, or repelled temporarily (1 – 2 days without wind) with Garlic Barrier sprayed around a small area (1 – 3 acres) for a special event. The introduction of pest-specific predators or parasites can also reduce or eliminate landscape and ornamental plantings pests.

The IPM Coordinator should perform periodic inspections 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. The IPM Coordinator should also consider innovative approaches for excluding pests from landscaped areas.

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 resource management 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).

Housing

Employees 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 cannot use them to move onto the building. If possible, establish a .91 m (3 ft) wide vegetation management zone around buildings. 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. Forest management practices, such as thinning, can improve tree growth and forest health, thereby reducing impacts from native insects and diseases.

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. 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

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 (see Appendix).

There are important tools that support the inspector and assist in gathering information. One of the most important tools for the art of inspection in structures and collection areas 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.

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

"inspection" refers to the <u>initial discovery</u> of pests or conditions supporting them and is a snapshot in time, and

"monitoring" refers to <u>watching or measuring changing conditions over time</u> 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.

INSPECTING AND MONITORING MABI STRUCTURES

Exterior Inspections

Thorough inspections of the exterior portions of MABI 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 not 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 ft) or more 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 45.72 cm (18 in) from the building so pests can not use them to move onto the building. If possible, establish a one-half meter (18 in) 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 they are 15 m (50 ft) or more from the building, raised on platforms off the ground, trash is being promptly removed, interiors are being cleaned, lids fit tightly, and exteriors are clean.

Identify and schedule the removal of stinging insect (honey bees, paper wasps, yellow jackets, etc.) and bird nests (barn swallow, robin and phoebe) 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, 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.

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 although it may not affect rodents. 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 (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 (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. 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, the value of protected materials, 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 and insects 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 .64 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 12% 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 all 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 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.

Exclusion Study: 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.

INSPECTION AND MONITORING IN LANDSCAPED AREAS

Monitoring techniques for landscaped and forest areas differ considerably from those used for structures and buildings. They can include the use of traps (pitfall, sticky or pheromone), site surveys (e.g. using line transects, grids, random area sampling, etc.), repeat photo documentation, and reporting on site variables (e.g. moisture, soil nutrients, tree growth rates, etc.). This section provides a brief overview of factors that MABI staff can consider when inspecting and monitoring landscape and forest areas. However, additional monitoring approaches for the grounds and the forest and fields should be developed further in consultation with the park's horticulturalist,

forester, extension agent, and other disciplinary experts with more experience in the northeast than can be provided by IPMI at this time.

Inspections of landscaped areas usually rely upon visual and close examination of foliage, stems, flowers and fruit of plants. Healthy plants tend not to have pest problems if provided proper watering and necessary nutrients. Stressed plants are much more susceptible (and attractive) to pest arthropods and diseases. Inspections should be looking for the healthy appearance of the landscape. Plant stress can be caused by too much or too little available moisture, too much sun or shade, inadequate aeration of soil, soil compaction or other physical factors. Other physical characteristics of plants can manifest the presence of pest arthropods. Look for notched leaves, scars on branches and trunks, honeydew on leaves, mottled or spotted foliage, dead leaves, curled leaves, and other abnormalities. Noticing changes over time between inspections can provide indications of pest activity. The presence of predators such as lady beetles, green lacewing larvae and others indicate the presence of pests on plants.

Turf can also have insect damage by white grubs feeding underground, foliar damage by chinch bugs, bill bugs and sod webworms; and damage by fungal pathogens. Weeds in turf can also crowd out grass or detract from its aesthetic beauty. Some turf cultivars are being marketed with endophytic properties that are resistant to some pests. Entomopathogenic nematodes such as *Steinernema carpocapsae* may be used for managing some turf insect larvae. Thick vigorous turf may be resistant to weed invasion. Mowing practices also have an effect on turf health. Higher mowing levels conserve moisture and help turf outcompete weeds. Mowing frequency should remove no more than one-third of the turf blade length. Aerate turf with a plugger that pulls a core of soil out of the ground and drops it on the surface. Aeration allows moisture and air to penetrate deeper into the soil promoting turf health. Monitor the turf for compaction to determine when aeration is beneficial.

Inspection and monitoring for turf pests can be as simple as making observations of conditions attractive or supportive of the pest. Rodent or other vertebrate activity may be manifested by holes or dirt mounds in the turf, long lines of raised turf or soil, or scratched digging areas in the turf. Dirt mounds, holes or raised turf may indicate the presence of groundhogs, moles or squirrels. Scratched dug out areas may be skunks, opossums or raccoons searching for grubs. Mechanical traps for groundhogs, moles or squirrels can be set and checked daily for captures. Clipped runways in turf can be caused by voles. Monitor for activity by placing diatomaceous earth tracking patches in the runways to determine activity levels. Monitoring for turf feeding insects may be done by a sweep net to capture adults. Root feeding grubs may result in loose turf or other visible damage.

Pitfall traps (cups or cans) set in the turf with the open top lip at ground level can be used to monitor for bill bug adults, crickets or other crawling insects. Pheromone traps can be placed at strategic locations to detect adult (usually male) insects such as some Lepidoptera pests of turf. Black light traps can be used to monitor for night-flying insects. Check monitoring traps often to determine when adults are present so management methods can be initiated before mating and egg laying occurs.

Degree day accumulations are another good monitoring method for insect pests.

INTRODUCTION TO MUSEUM PESTS

CHARACTERISTICS AND RECOGNITION

Major museum pests include 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. Cigarette and drugstore beetles are also found to attack and damage organic museum artifacts, although they may not be present in the collection at this time. 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. Other important museum pests included in this IPM plan are psocids, booklice, silverfish, firebrats, Asian lady beetle and crickets.

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
Floor cracks, baseboards and vents for lint, debris, and hair accumulations
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
Old books where insects are attracted to the glue in bindings

Other locations where museum 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; 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:

- 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 to remove infestation sources

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 woolen fabrics. Once a month, brush hidden areas (pockets, reverse cuffs, collars, etc.) on those garments which are infrequently used 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 can be 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 moth larvae damage clothing and rugs.

Although the following pests were not observed during inspections, they are commonly found in museum collections. Be aware that they may infest new additions to the collection. For further information on these pests, contact IPMI for Pest Profiles:

Indian Meal Moth
Saw-Toothed Grain Beetle
Warehouse Beetle
Rice and Granary Weevil
Cigarette and Drugstore Beetle
Red and Confused Flour Beetle

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, mice and squirrels. Although bats, birds, 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. 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.

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 and mice 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 (45.72 cm [18 in]) 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 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., 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 (90º 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

Rodents are occasional structural pests. Some species present in the eastern United States are the house mouse, native deer and white-footed mouse, voles and grey squirrels; and 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. Deer mice range from Hudson Bay, Canada to Pennsylvania and the southern Appalachian Mountains. White-footed mice range from mid-Maine south to northern South Carolina. 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.

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.

The only rodents actually observed during inspections at MABI were grey squirrels. However, mouse droppings were observed in structures. The three species of mice mentioned have home ranges that include the area occupied by the park. All mentioned rodent species may be found at MABI. It is also possible for Norway and roof rats to be present at MABI, although no evidence was observed. See Pest Profiles for additional information.

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 has been responsible for a number of deaths. 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. 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 produce about 70 droppings per day and the native mice will produce similar numbers. 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.

<u>Sanitation</u>: 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.

<u>Rodent-Proofing</u>: 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

MABI 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 .64 cm (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 fleas, wasps and bees, spiders, ticks, mosquitoes and poison ivy.

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 MABI.

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 MABI 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 MABI. 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 MABI are *Aedes albopictus, Aedes vexans* and *Culex pipiens*.

Poison ivy (*Toxicodendron radicans* or *Rhus toxicodendron*) is a woody vine that is well-known for its ability to produce urushiol, a skin irritant that causes an itching rash for most people, technically known as urushiol-induced contact dermatitis.

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. MABI staff 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 maintained turf and mowed fields have insect and weed pests. Several park resource studies have been developed to assess current pest population levels, including an invasive plant inventory (2004), hemlock woolly adelgid risk assessment report (2005), and proposal to develop a silviculture inventory system (2006). While these studies provide a basis for assessing current pest population levels, additional monitoring guidelines and treatment approaches should be developed. This IPM Plan serves as a basic overview for these approaches, but further monitoring and treatment details should be developed in association with the park's horticulturalist, forester, and other disciplinary experts.

INSPECTION AND MONITORING

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 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. 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. Two informative websites are http://tncweeds.ucdavis.edu/index.html and http://science.nature.nps.gov/.

Booklets of Suppliers of Beneficial Organisms in North America have been included in the back of this binder. Check for beneficial organisms to manage pests of landscape areas, forest, orchard and turf. A quality source for beneficial organisms to assist in managing pests is IPM Laboratories, Inc., Main Street, Locke, New York 13092; telephone 315-497-2063; email ipmlabs@baldcom.net.

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. 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 (i.e., Glyphosate or Triclopyr). See Pest Profiles.

INTRODUCTION TO TURF MANAGEMENT

GENERAL

Introduction: The continuous planting, maintenance, and replacement of plants is essential to maintaining a high-quality landscape. Over time, landscape development should provide a sense of permanence and a historic 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 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.

This is the cool-season region that includes Vermont where there is abundant rainfall and acid soils. Upright growing grasses (Kentucky bluegrass *[Poa pratensis]*, fine fescue *[Festuca rubra]*, and perennial ryegrass *[Lolium perenne]*) 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 spring. During the fall season, temperatures are moderate, rainfall is plentiful, and there is less weed competition.

FERTILIZATION

Soil Sampling and Testing: Obtain a soil test kit from the Vermont Cooperative Extension. 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

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 to 7.62 – 10.16 cm (3 – 4 in), 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. High mowing to shade out weeds should be considered. Low mowing will stress 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. Contact the NPS Regional Exotic Plant Management Team.

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, 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.

APPENDICES

Appendix I

PEST PROFILES

MUSEUM PESTS

CLOTHES MOTH (*Tineola bissolliella)*



Webbing Clothes Moth

Webbing clothes moth adults are yellowish or golden colored, 1.27 cm (1/2 in) long or less, with narrow wings of about 1.27 cm (1/2 in) wingspan, and are distinguished by a tuft of fluffy, fine bronze to reddish-gold colored hairs (pompadour) on a bronze head. The wings do not have spots. Adults do not feed, but they fly to find food materials on which they lay 40 to 150 eggs, which hatch in seven to ten days. Clothing moth larvae are about 1.27 cm (1/2 in) long, light cream-colored, with a dark brown head. The larvae do not form a protective case around themselves.

BIOLOGY

The life cycle ranges from two to six months, depending upon environmental conditions. Although the adult moths are weak flyers, they are known to move over 91 m (300 ft) in distance. The males fly to find and mate with females, who generally remain in dark and dimly lit areas. Females produce eggs that are glued to potential food materials in closets or other sites where clothes or other natural fiber or animal pelts may be stored. From two to four generations per year are possible in warm, heated areas.

CASEMAKING MOTH (*Tinea pellionella)*

Adults are small; light brown to tan colored moths with a wing span of about 1.27 cm (1/2 in) The front wings have three dark spots and both wings have trailing edges of soft fringe. Larvae are about .94 cm (3/8 in) long and form a slightly smaller protective case (about .79 cm [5/16 in] long) around them which is made from the same material as that which they eat. They carry the case with them while feeding. Casemaking moths are general feeders on dried animal and plant proteins, dead insects and nests, animal carcasses, feathers, hair, etc.

BIOLOGY

Although adult moths prefer relatively dry conditions, 75% humidity is the most favorable condition for development of larvae. This moth prefers darkness and seeks out folds of fabric or secluded places to hide when disturbed. Rug lint and hair accumulations behind baseboards or in heating units are favored hiding places. The life cycle is about three to four months with one to two generations per year.



Casemaking Moth

DAMAGE

Clothes moths and casemaking moth adults do not feed but tend to remain close to the materials on which they developed. The adults are very attracted to and lay eggs on soiled materials of vegetable origin. The larvae are general feeders on hair, wool, fur, feathers, upholstered furnishings, piano felts and insect specimens. During feeding, the larvae leave distinctive silken trails on materials and produce round fecal pellets colored like the material being eaten. Any visual evidence of moths usually indicates a major infestation.

DERMESTID BEETLES (Carpet Beetles)

There are a many different kinds of carpet beetles in the United States, and all have greatly varying life cycles and habits. Therefore, it is best to request pest identification by an insect specialist before considering management. In nature carpet beetles are scavengers that infest bird, mouse, rodent, tent caterpillar, old bee or wasp nests, and spider webs. In general, adult carpet beetles are broadly oval in shape, .15 - .3 cm (1/16 – 1/8 in) long, and calico, brown, or grayish in color. The round shape and mottled color distinguishes fabric beetles from such other stored-product pests as flour and grain beetles. Female carpet beetles lay up to 100 eggs, which hatch in about two weeks. Carpet beetle larvae are brownish or yellowish, about .64 – 1.27 cm (1/4 – 1/2 in) long, with slender bodies that taper towards a tail bearing tufts of hair on the upper surface. The larvae are covered with fine barbed hairs (an effective protection against insect predators). Larvae are generally found on products of animal origin. Adults are attracted to the light at windows. Below are examples of several pests of fabrics, furs and animal origin products.



Black Carpet Beetle
Attagenus megatoma



Dermestid Larvae



Anthrenus verbasci



Varied Carpet Beetle Larvae



Furniture Beetle Larvae



Hide Beetle
Dermestes frischi



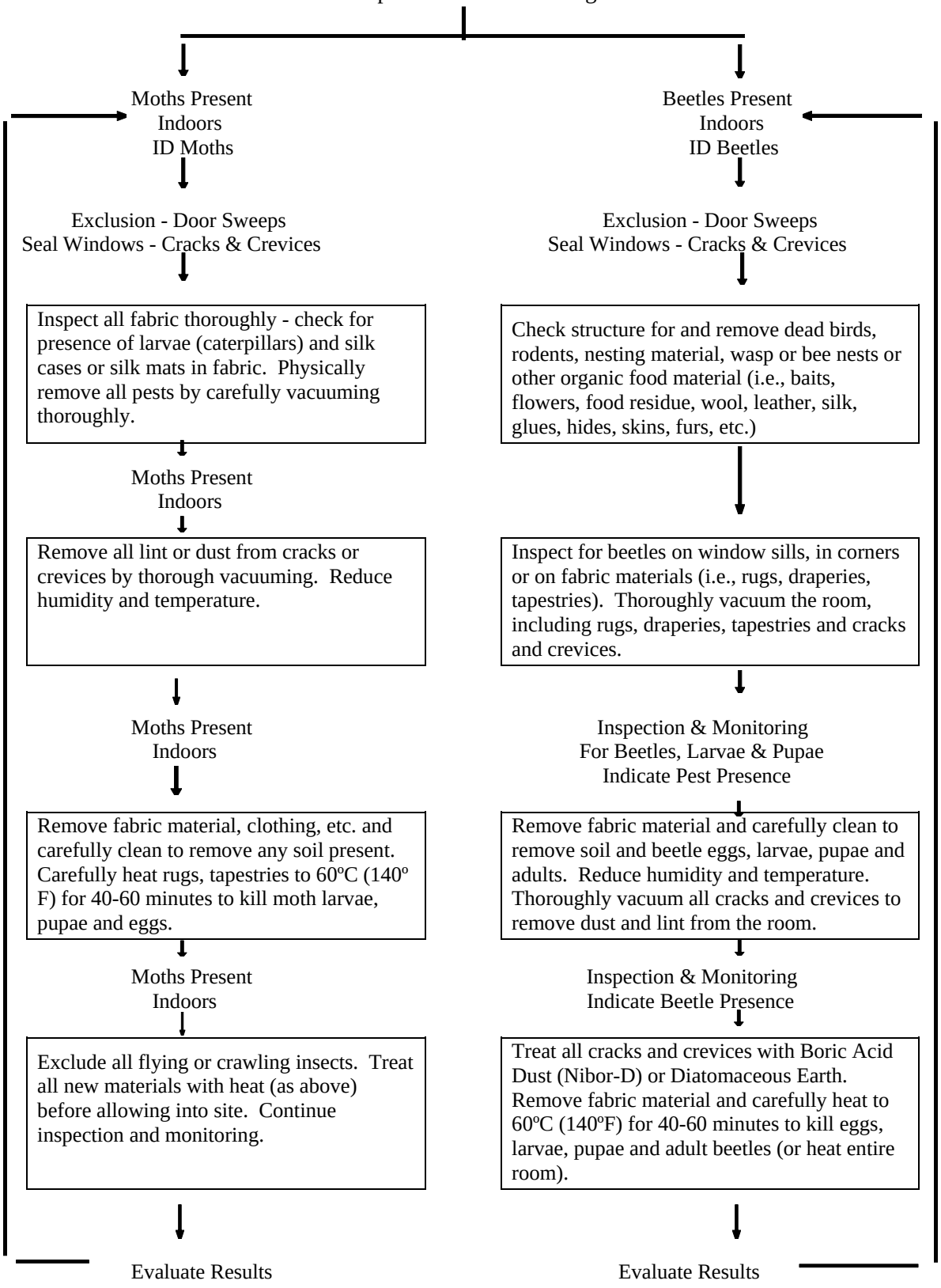
Spider Beetles
Mezium americanum (laporte)



Larder Beetle
Dermestes lardarius L.

MUSEUM PESTS

Inspection and Monitoring



PSOCIDS - BOOKLICE (Worldwide)

(Liposcelis corrodons) but also many other species. Cosmopolitan distribution.

DESCRIPTION

Psocids or Booklice are small (.1 - .3 cm [1/25 – 1/8 in] long), opaque to white in color, soft-bodied insects with four wings, or only wing buds in adults.



Psocids

BIOLOGY

Outdoors, booklice live under tree bark and feed on fungi; they lay eggs during fall and spring. Indoors, booklice feed on mold and mildew and under proper conditions breeding and development can continue indefinitely. Booklice are most commonly found in dark cracks and crevices. Females of at least one species can reproduce parthenogenetically and produce from 120 to 450 eggs per season in clutches that average about 20 to 50 eggs each, depending on temperature conditions. The insects can over winter in the egg stage. After eggs hatch through gradual metamorphosis, booklice attain maturity in around one to two months and can live up to three months. Moist conditions enhance growth and longevity and booklice are most common in structures during spring and summer. Large populations can suddenly appear under high humidity or moisture conditions. Psocids may also be found in bird or mammal nests, moist grain or other starchy plant material.



Winged Psocid

DAMAGE

Booklice damage paper products, bindings and eat paste, glue or anything supporting mildew. Psocids generally feed upon microscopic molds. They often infest damp, moldy books, feeding on both the mold and starch in glues. They also will infest dried plants in herbaria, insect collections, and furniture stuffed with flax, hemp, jute or Spanish moss. The presence of booklice is an indicator of moisture problems.

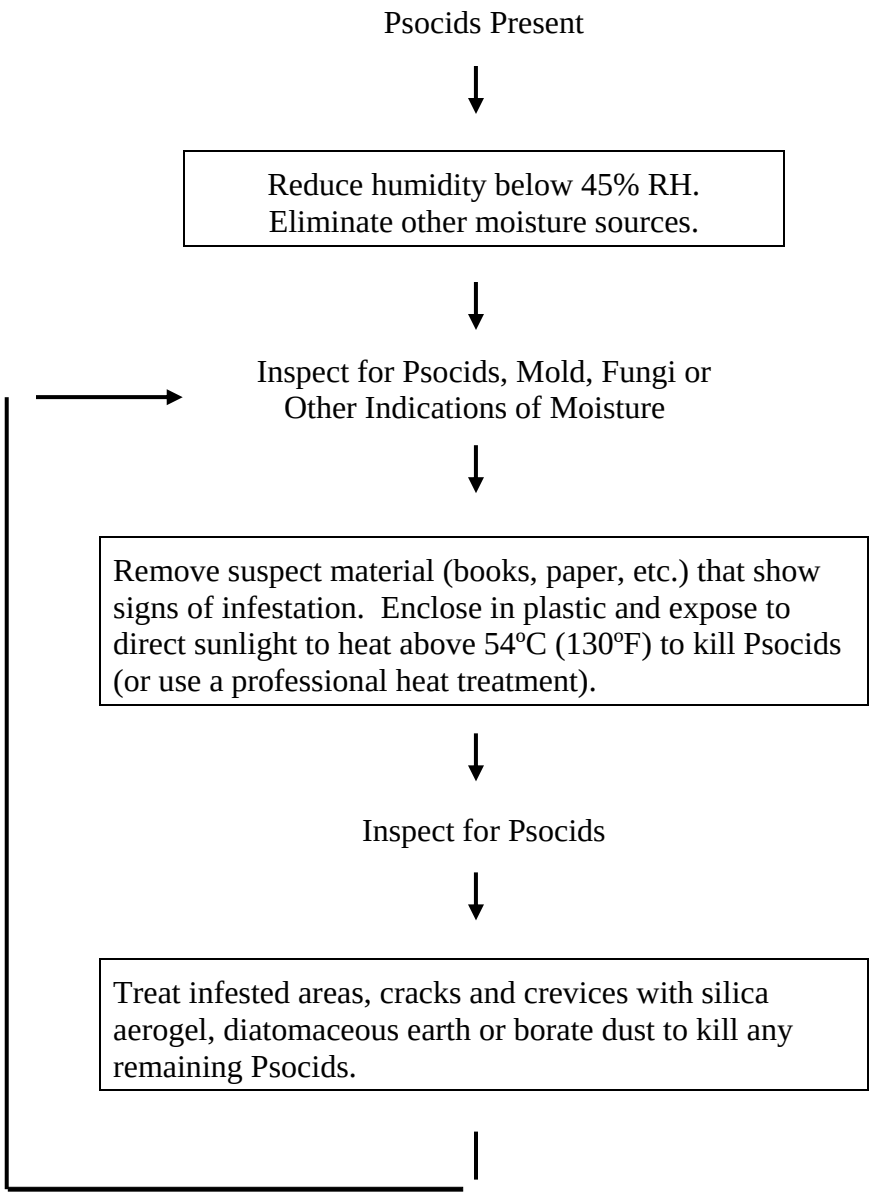
MONITORING

Sticky traps may not be attractive to Psocids except in large populations. Direct observation of susceptible materials may be necessary. The presence of mold, fungi or other indications of high humidity or moisture are clues to conditions favorable to psocids. If mold is present, look for psocids!

MANAGEMENT

Psocids are best managed by reducing the humidity below 45%. This may take some time, but eventually all psocids will desiccate and die. Removing other moisture sources will also help. For infested books or other materials, placing them in a clear plastic bag and exposing them to direct sunlight to heat the interior about 54ºC (130ºF) will kill localized infestations. Diatomaceous earth, silica aerogel or borate dusts will manage psocids.

PSOCIDS - BOOKLICE



SILVERFISH AND FIREBRATS (Worldwide)



Silverfish

Silverfish (*Lepisma saccharina L),* are wingless, flat and carrot-shaped insects, about 1.27 cm (1/2 in) long, and covered with a sheen of silvery scales. They have two long antennae and possess three long, slender filaments that project rearward from the abdomen. Silverfish prefer temperatures between 21 - 27ºC (70 – 81 ºF), and high humidity. Adults may live from two to eight years, and can survive as long as a year without food. Silverfish feed on starches like flour, glue, paste, and textile and paper sizing, but they can also digest cellulose.

Silverfish populations build up around materials upon which they feed, such as corrugated cardboard boxes in damp basements, and on insulation, glue, and stored books. Silverfish lay eggs in cracks over an extended period of time, which hatch in about 30 days. Immatures reach maturity in three to four months. Their feeding leaves irregular, yellow-stained holes in textiles and paper, damaged surfaces on corrugated cardboard, and irregular chewed areas on cloth-bound books. Damaged materials often have dark fungus growing on them supported by humidity and insect fecal pellets. Large populations of silverfish spread into other humid areas within the building from basements and wall voids penetrated by pipe ducts and electrical conduits.



Firebrat

Firebrats (*Thermobia domestica [Packard])* are similar insects but not silver-colored, rather mottled dark gray and dull yellow. Their size, shape, and appendages very much resemble silverfish, but firebrats prefer decidedly higher temperatures and surroundings, to 32ºC (90ºF) or above. Firebrats are commonly found in furnace rooms, steam-pipe tunnels, hot bathrooms, and partition walls of water-heater rooms. The firebrat female lays one to three batches of average 50 eggs per batch depositing them in cracks. It takes two to four months from egg to adult under optimum conditions (32 - 38ºC [90 – 100ºF] with 76 – 85% relative humidity). Firebrats feed on carbohydrates and proteins such as bond paper, linen, cotton, silk, dried beef, etc.

HAZARDS OF INFESTATION

Silverfish and firebrats are destructive to books, paper, fabrics, and may contaminate foods. These insects are often found in libraries, book shelves and areas where old books and papers are stored.

INSPECTION AND MONITORING

In a quarantine area, thoroughly inspect incoming goods, furniture, books and other materials for the presence of silverfish or firebrats. Remove or treat any items that are infested.

Conduct a thorough inspection for the presence of pests, moisture, food sources, clutter, cracks, crevices and other openings. Inspect water heater closets, utility rooms and areas of high humidity and temperature. Bookcases and books are especially attractive to these pests.

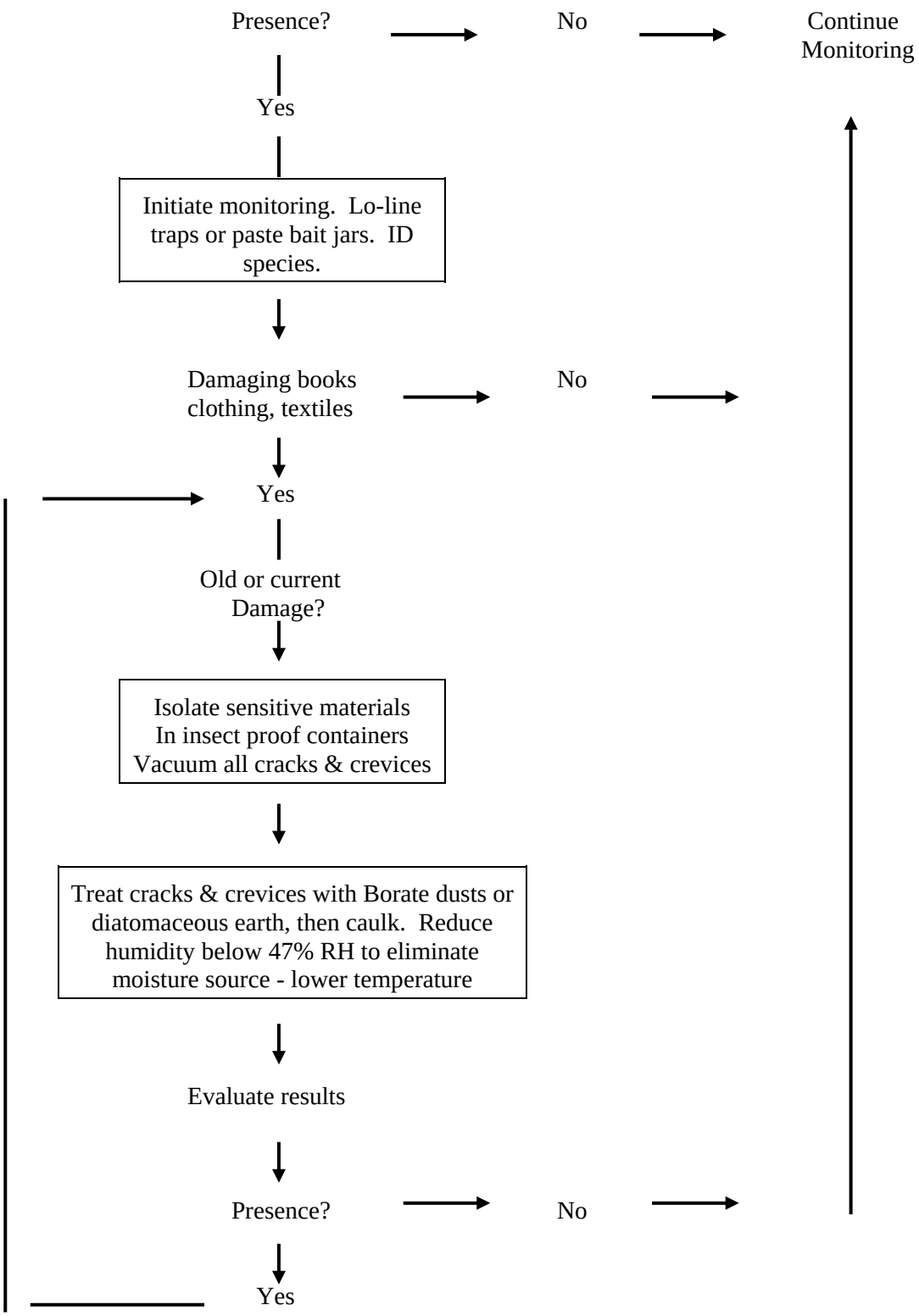
MANAGEMENT

Exclusion: For pests the size of silverfish or firebrats to be excluded, use caulk, Stuf-Fit, oakum, weather stripping, door sweeps, screens and other repair approaches. Once done, excluding silverfish and firebrats is usually passive and permanent.

Sanitation: It doesn't take much organic material to feed silverfish or firebrats. Water in any form, condensation, leaks or moisture in potted plants, etc., should be eliminated. Silverfish and firebrats like to be in an area where they feel safe – in between things. Clutter that builds up in corners, on cabinets, shelves or on the floor becomes harborage for firebrats, silverfish that can attack and ruin irreplaceable historic artifacts. Sanitation is active and must be conducted on a daily basis.

Habitat modification: Eliminate food, water and shelter. Other means are raising or lowering temperatures or reducing humidity to levels intolerable by pests, and increasing lighting. Habitat modification is relatively passive and semi-permanent.

SILVERFISH AND FIREBRATS



ASIAN LADY BEETLE *Harmonia axyridis* (Pallas)

The Asian lady beetle, *Harmonia axyridis* (Pallas) was introduced into the United States between 1910 and 1970 unsuccessfully (no survival). After years without a sighting, the beetle was seen in Louisiana in 1988, apparently from an accidental introduction in a freighter from Asia to New Orleans. Since that time, the Asian lady beetle has spread throughout the northeast from Florida to Quebec, and west to Missouri and Texas. It has also been reported in Colorado, Oregon, Washington, and British Columbia, Canada.



Asian Lady Beetles

The Asian lady beetle is a voracious feeder on aphids, scale and other soft-bodied insect pests. Both the adult and larval forms of the beetle are predators on soft-bodied prey. In its native habitat (most of Asia), it tends to overwinter in larger congregations in white cliffs, cracks, crevices and other voids. Here in the United States, the Asian lady beetle tends to aggregate in large numbers in homes, structures and other human-constructed or occupied sites. When they overwinter in a historic structure which contains valuable artifacts, their presence may pose a hazard. Large numbers of beetles in structures over a harsh winter causes a number of the beetles to die. It could be a few or many. The dead beetles can become a food source for dermestid beetle larvae. Dermestid beetle larvae or adults in a historic site may become a major threat for organic material in the collection, including furs, woolens, sinew, cotton, silk or other material on display.



Dead Harmonia & Dermestid Larvae

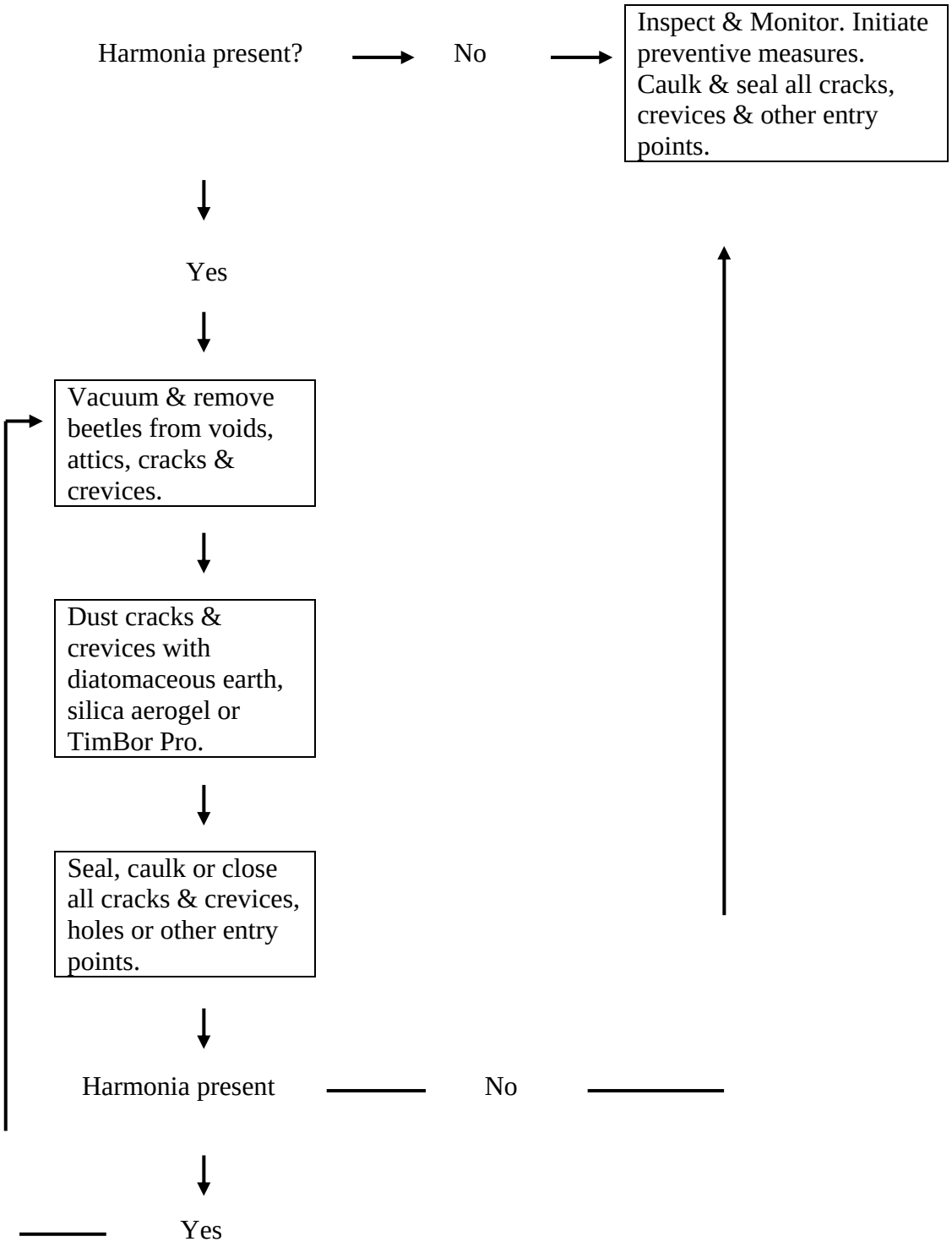
The first line of defense against the beetle is to fill all cracks, crevices, holes or other entry points into the structure. A hole as small as .53 cm (7/32 in) wide can allow beetle access to the inside of the structure.

The second line of defense is sanitation. The beetles like to use clutter in which to overwinter. Elimination of clutter will reduce the areas where the overwintering beetles congregate.

The third means of managing the beetles once they are in the structure is to use a vacuum to remove them in large numbers. Black light (ultraviolet) traps with a sticky glue board to collect the beetles attracted to the light are also useful. The traps should be checked periodically and the glue boards replaced when full.

Vacuum the joists, beams and other accessible voids in the attics each spring and late fall.

ASIAN LADY BEETLE CHART



HOUSE CRICKET *(Acheta domesticus [Linnaeus])* (Worldwide)

House cricket adults are 1.91 – 2.54 cm (3/4 – 1 in) long and have a light-colored head marked with three dark cross bands, yellowish-brown to straw-colored body, long and thin antennae, and heavy mandibles. House crickets fly but also have large rear jumping legs like a grasshopper. Crickets are nocturnal insects that enter structures in spring or before winter. They are attracted to shelter, light, moisture, and warmth. House crickets are mainly attracted to warm areas around stoves, fireplaces, and furnaces, but they can also be found throughout the structure.



Nymph & Adult House Crickets

Incessant nocturnal chirping by the male makes this a nuisance pest. Outside, house crickets live in compost piles, debris, and garbage dumps. Usually there is one generation per year. Eggs laid in sandy soil during fall hatch in late spring. Nymphs often enter structures under doors or through cracks and voids and complete their life cycle indoors, where they develop all year and lay eggs in cracks. Nymphs mature in mid- to late-summer.

Outside, house crickets feed on plants and other insects. Inside, their diet is more diverse: they feed in early evening on bread crumbs, fruits, vegetables, liquids, paper (such as soiled news-print), clothing, rubber, silk, wool, linen, rayon, fur, feathers, meat and meat products, dead insects, and leather. House crickets contaminate food by walking over it.

INSPECTION AND MONITORING

Outside: Inspect for the presence of house crickets near the structure. Also check for moisture near the building, and for organic material (mulch, leaves, etc.) that provides harborage and food. Look for cracks, crevices and other openings (drains, pipes, vents) into the structure that provide entry for house crickets.

Inside: Conduct an inspection for the presence of moisture, food sources, clutter, cracks, crevices and other openings. Place and check WEEKLY sticky trap monitoring devices at floor/wall junctions and other likely or critical areas where house crickets may occur.

FIELD CRICKETS *(Gryllus spp.)* (North America)

Field crickets are common pests attracted indoors by light; however, once inside, they die before early winter because they cannot adapt to indoor conditions. Adults are 1.27 – 2.54 cm (1/2 to 1 in) long and look very similar to house crickets, except that field crickets are usually black to dark brown in color, and have brown wings, a shiny head, and antennae much longer than the body. Males have two spear-like appendages at the tip of the abdomen. Females have three similar appendages.



Field Cricket

The field cricket also flies and jumps. In northern parts of the United States, eggs deposited in the ground are the overwintering stage for most field crickets. The small remainder pass the winter as half-grown nymphs under leaves, trash, and debris. There is only one generation per year. Females lay 150 to 400 eggs about .64 – 2.54 cm (1/4 – 1 in) deep in the soil in late August to September. Eggs hatch in May to June and nymphs develop in nine to 15 weeks. Adults are only found outside from late July until the first hard freeze. Field crickets migrate into structures during fall, when populations are large, or as vegetation dries up.

Indoors, field crickets are attracted to such warm, dark areas as water-heater closets and large appliances. They are usually found in basements and ground-floor levels where they feed on human food, debris, and clothing. Field crickets do not live long indoors. However, they can cause damage to cotton, wool, linen, silk, synthetics, and leather and fur items.

INSPECTION AND MONITORING

Outside: Inspect for the presence of field crickets near the structure. Also check for moisture near the building and for organic material (mulch, leaves, etc.) that provides harborage and food.

Inside: Conduct a thorough inspection for the presence of crickets, moisture, food sources, clutter, cracks, crevices and other openings. Place and check WEEKLY sticky trap monitoring devices at floor/wall junctions and other likely or critical areas where field crickets may occur. Inspect water heater closets, utility rooms and areas of high humidity and temperature.

CAVE OR CAMEL CRICKET *(Ceuthophilus spp.)* (Worldwide)

Cave or camel cricket populations build up indoors during fall, when large numbers of these insects move under doors and through cracks, seeking dark, cool, damp areas in crawlspaces, basements, utility rooms, garages, and outdoor sheds. They are rarely found in occupied spaces. Their natural habitat is outside, where camel crickets live under stones and logs or in animal burrows. Camel crickets have a rounded, hump-backed appearance with a head bent downwards. They are light brown in color with darker brown bands and markings. Camel crickets are easily identified by their long antennae and long and large jumping hind legs. They are wingless, don't chirp, and are not attracted to light. Most importantly, camel crickets serve as a warning or indicator of excessive moisture problems. Camel crickets can feed on cotton, linen or other cloth material.



Cave or Camel Cricket

INSPECTION AND MONITORING

Outside: Inspect for the presence of cave crickets near the structure. Also check for moisture near the building and for organic material (mulch, leaves, etc.) that provides harborage and food. Look for cracks, crevices and other openings (drains, pipes, vents) into the structure that provide entry for pests.

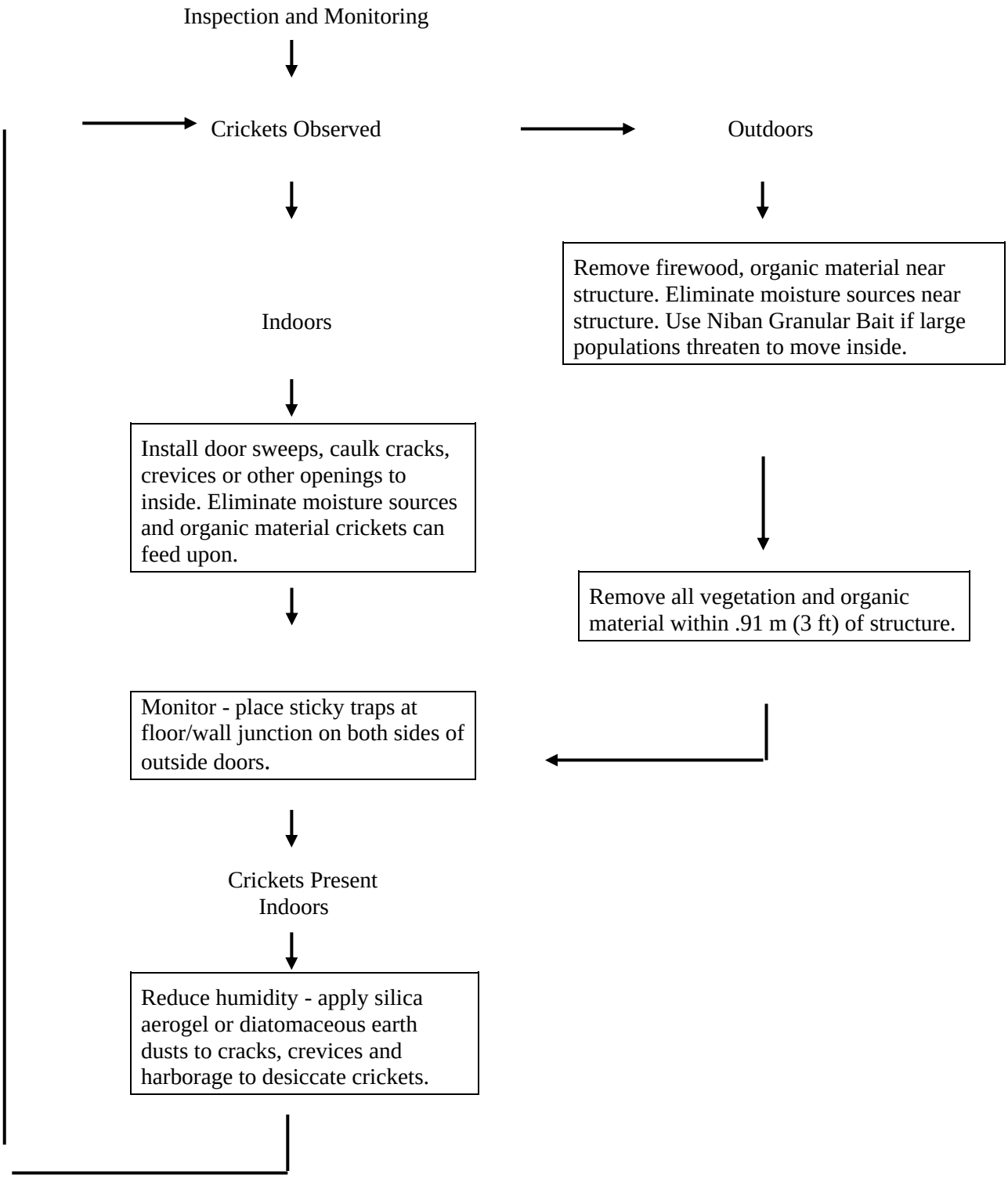
Inside: Conduct a thorough inspection for the presence of crickets, moisture, food sources, clutter, cracks, crevices and other openings. Place and check WEEKLY sticky trap monitoring devices at floor/wall junctions and other likely or critical areas where cave crickets may occur. Inspect water heater closets, utility rooms and areas of high humidity.

MANAGEMENT

Outside: Remove all organic material (mulch, leaves, etc.) from within .91 m (3 ft) of the structure (replace with a 1.91 – 2.54 cm [3/4 – 1 in] mulch or gravel) and eliminate moisture and standing water in this area. Install effective door sweeps on all outside doors and eliminate other entry points into the structure.

Inside: Reduce humidity levels and eliminate leaks and other water sources. Keep corridors, offices, exhibits and storage spaces clean (no organic material available to the pest). Eliminate clutter, caulk cracks, crevices and close hiding places. Dust cricket harborage with diatomaceous earth (DE) or borate insecticide.

CRICKETS


Inspection and Monitoring
Crickets Observed
Outdoors
Remove firewood, organic material near structure. Eliminate moisture sources near structure. Use Niban Granular Bait if large populations threaten to move inside.
Indoors
Install door sweeps, caulk cracks, crevices or other openings to inside. Eliminate moisture sources and organic material crickets can feed upon.
Remove all vegetation and organic material within .91 m (3 ft) of structure.
Monitor - place sticky traps at floor/wall junction on both sides of outside doors.
Crickets Present Indoors
Reduce humidity - apply silica aerogel or diatomaceous earth dusts to cracks, crevices and harborage to desiccate crickets.

STRUCTURAL PESTS

TERMITES AND THEIR MANAGEMENT

INTRODUCTION

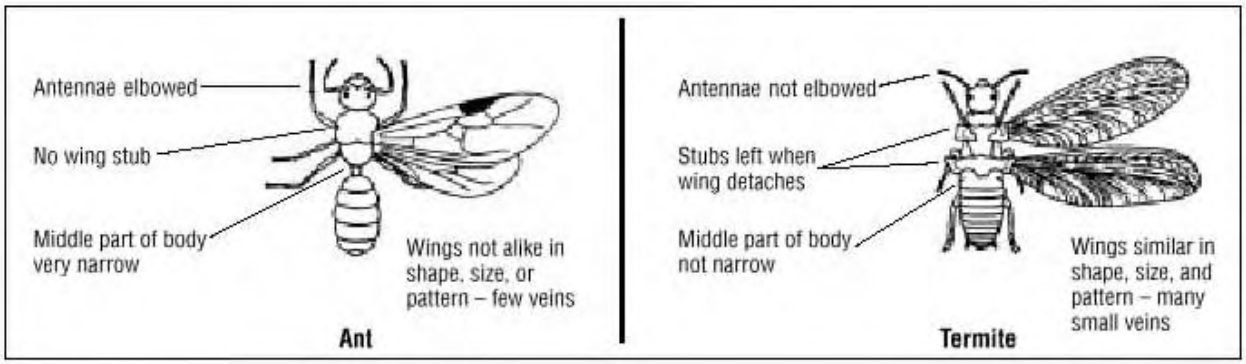
Termites are the most destructive wood-destroying insects in the U.S., costing hundreds of millions of dollars each year in prevention efforts, direct damage to structures and trees, and corrective costs. In older structures, about one of every ten is infested to some degree, while in newer structures; perhaps one in 20 is infested.

Termites are social insects belonging to the order *Isoptera* (meaning equal wings) and, like the cockroaches to which they are closely related, have been around for hundreds of millions of years. As inhabitants of forests, they serve a valuable function in the ecosystem by consuming dead and decaying wood. When people began to build wood structures, these structures became additional food sources and habitat for termites. Termites sometimes endanger the structural integrity of buildings.

Termites are classified according to their primary habitats subterranean, dampwood, and drywood termites. Only eastern subterranean termites are likely to be found at MABI. By far, the subterranean termites are the most widely distributed. They occur throughout most of the 48 contiguous states, Hawaii, lower Alaska along the pacific coast, and the Caribbean territories. Because of the ever-present threat to housing and other wooden structures, vigilance is necessary to prevent, mitigate, and eliminate termites.

CHARACTERISTICS AND RECOGNITION

Usually, the first experience with termites is when they swarm around structures by the thousands during spring. For the termites, this is a dispersal flight as they begin spreading to new areas. People usually report "flying ants" and immediately call their exterminator. The pest management supervisor identifies these flying insects as termites, and points out the differences between true flying ants, which have two pair of unequal wings, elbowed antennae, and a narrow waist, and termites, which have two pair of nearly equal wings, straight antennae, and a thick-waist.



Typically, the subterranean termites swarm in the early spring on a warm day after a rain.

Warmth, sunlight and moisture are the three elements necessary for the survival of this species, and the reproductive termites sense that these conditions will enhance their chance of survival. Close inspection of the building may show piles of detached termite wings, the small (less than .63 cm [1/4 in]) white worker termites in wood below ground, and their galleries in wood structures.

BIOLOGY OF SUBTERRANEAN TERMITES

Subterranean termites, the most widespread and destructive termites in the U.S., have their nests underground and within easy access of wood which is their only food. They are social insects with a complex division of functions including a queen, king, soldiers, supplementary reproductives and workers.



King & Queen


Reproductive


Workers


Soldier

The life of the colony depends on the queen, which is a greatly enlarged, light brown, winged termite about 1.27 cm (1/2 in) long. The queen can lay millions of eggs over her lifetime of over 25 years. Her egg-laying activities are augmented by supplementary wingless reproductives as the queen ages or the colony outgrows its original nest. The king is the same size and color as the queen and also has two pair of wings. It exists only to mate with the queen, and lives, as does the queen, entirely within the subterranean nest once it is established.

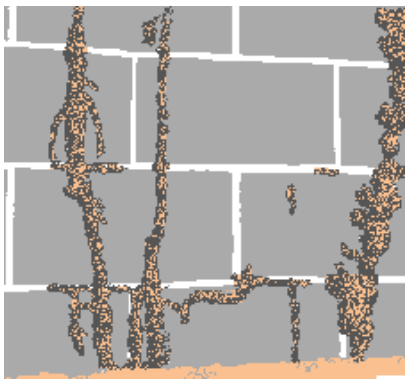
The supplementary reproductives are light in color, about .63 cm (1/4 in) long, and have two pair of wing pads. They also stay entirely within the underground nest. The soldiers are white, except for an enlarged brown head capsule, and are about .79 cm (5/16 in) long. They defend entrances to the nest against enemies, particularly ants which are the primary enemies of termites.

The workers, which are actually nymphs, are entirely white, about .46 cm (3/16 in) long, and do all of the foraging and feeding activity of the colony. They may live up to five years, and are the ones that venture above-ground into structures, construct the galleries, bring wood back to the nest, and build the mud tubes that connect the nest to the galleries and the structure. They also feed the young nymphs and other castes which cannot feed themselves.

Since the termites' ability to digest cellulose is totally dependent upon the protozoans living within their midgut, it is imperative that workers exchange anal fluid containing these organisms

so that young termites can digest their food. This is accomplished by grooming among workers, a process that is important in selecting a pest management strategy.

The conditions that termite colonies need to flourish are rather basic, but critical. They include relatively high moisture content in their living and feeding areas, adequate shelter and temperature, and a plentiful food source. The colony will not flourish if any of these is lacking. The high moisture content need is met by the soil in most parts of the country. Even coastal beaches, deep in the sand, provide ample moisture for termite colonies. The soil also provides termites the necessary protection from desiccation, since their cuticle is rather permeable and they can easily die from exposure in air. It has been theorized that the connecting mud tubes from above ground food sources to nests (built from mud, digested wood, and termite secretions and excretions) protect termites against dehydration along the journey from the nest to the food source and back.



Subterranean Termite Mud Tubes

These tubes may also provide protection against enemies, primarily ants. The minimum tolerable temperature for termites is -30°C (-22ºF). This does not mean that termites can flourish at this temperature, but rather that they can withdraw deep enough into the ground to survive that outside air temperature for a short period, usually a matter of weeks. If they have to stay too deep for too long, however, they are deprived of their primary food source, decaying wood.

Human habitats are ideal for termites. They provide the cellulose needed for food and the temperatures beside and underneath the building allow year-round activity by the colony. It does not take much wood to attract a mated pair of termites to set up housekeeping; a piece of a discarded 5.08 x 10.16 cm (2 x 4 in) in a foundation void will do it. Of course, once that food source is exhausted, termites will move on through cracks in the foundation to find another food source, usually in the interior of the structure.

Damage

The damage done to wooden structures may take years to reach the point when any evidence is visible. Often the area of damage is inaccessible, such as behind basement walls, in crawl spaces, or where floor joists meet the wall studs. Termites prefer to eat the softer portions (the spring sapwood) of beams, joists, studs, door jambs, window sills, or wood paneling, leaving behind enough of the harder summer sapwood to keep the structure intact.



Termite Damage

Termites will also eat through plastic sheathing, foam insulation, and any other soft obstacles on their path to their foraging sites. If there is moisture in the wood, the destructive process is accelerated by fungi carried on termites' bodies. Their activities also tend to increase the

moisture content in the wood they forage in. Termites deposit their frass (droppings) inside the galleries or use it together with earth and decayed wood to construct mud tubes. The mixture of feces, frass, and decaying wood gives the galleries a dirty appearance.

Over a period of years, the wood may become so thin that literally only paint is holding it together and just touching it can cause the wood to give way. Ultimately, the building may become structurally unsound, and major supporting members may require replacement.

INSPECTION AND MONITORING

Foundations

In order to inspect and monitor for termites, it is important to understand structures and the structural defects that lead to termite infestation.

For subterranean termites, the most common routes of infestation are the basement or ground floors of structures including:

- Poured-concrete slab foundations,
- Raised concrete foundations and footings,
- Vertical void concrete masonry block foundations,
- Brick foundations, and
- Stone and rubble foundations.

Other than solid poured concrete basements, the floor slab is usually supported by footings underneath and at the perimeter, and walls rest on top of the slab.

The slab usually has underlying gravel. Caps at the tops of foundations can be solid block caps, poured-concrete caps, top course of hollow blocks filled with concrete, or brick caps.



Subterranean Termite Entry Points

Sometimes supporting posts or stairs extend through the concrete slab to the soil below. Wherever there is a joint between the wall and floor, or the wall and cap, there is opportunity for cracks to develop which become entry points for termites. Similarly, cracks in the wall, mortar between blocks, bricks, or masonry provide entry points for termites. Faults in the blocks may also provide access for termites to the joists.

Poured concrete wall and pier construction, brick, hollow block, masonry walls, or wooden piers, are all used in buildings constructed on raised foundations. Piers constructed of poured concrete, concrete blocks, bricks or treated wood provide support for the girders and floor joists. Termites gain access through cracks or voids that occur.

Access through piers or directly from the crawl space itself are easy portals of termite entry, since the distance is short and mud tubes may escape notice. Subterranean termites commonly gain access to structures by building shelter tubes from the ground to the wood over concrete piers, foundation walls, and from underneath exterior soil-filled porches and patio slabs.

Slab-on-grade construction has become very common in the last 30 years. The monolithic slab, consisting of a solid, unitized pad and footing, offers protection against termite infestation. The supported slab is another type, which is tied at its ends to the foundation wall. The floating slab is the third type, which is structurally independent from the foundation wall. It "floats" over a gravel layer.

All three types of slabs provide access for termites once cracks develop in the slab or foundation wall. This scenario is most likely to occur at the expansion joint of the floating slab. Once in the building, termites have ready access to the wooden studs, joists, floor sheathing, and finished interior wood.

Site History

The pest manager should be familiar with the history of the site. Sites that were once heavily wooded areas, particularly with softwood trees, often have dense populations of termites. Sources of moisture in structures may also be areas where termites are attracted, and need careful scrutiny. Utility pipes and electrical conduits that run under a structure or up from the ground are natural paths for termites to invade. These termite highways should be checked carefully for mud tubes.

Tools

The tools of inspection are a flashlight, awl or ice pick, small hammer, moisture meter, hacksaw blade, measuring tape, and electronic stethoscope or other sound-listening device. In addition, an inspector needs coveralls, knee pads and bump hat to safely get into tight areas under the structure and graph paper to diagram termite entry points and damage. A stepladder is needed to gain access to the attic and to high areas of the exterior.

THE INSPECTION

Before starting the inspection, always interview the occupants. Often they have some knowledge of previous termite problems, where moisture occurs, and possible hidden joints or voids. Next, size up the exterior of the structure and draw a diagram on graph paper, noting dimensions, grading, drainage, garages, decks, any structural wood in contact with soil, and location of wood piles. The graph also should account for hidden joints, voids in porches, and moisture-laden areas.

Note any exterior wood that shows excessive moisture or decay. Inspect the interior areas adjacent to this decay for further evidence of damage or infestation. Also, observe any possible roof leaks either under the shingles, around chimneys, or toward the structure after exiting downspouts. Blistered paint, insect or woodpecker attack areas, and evidence of insect exit

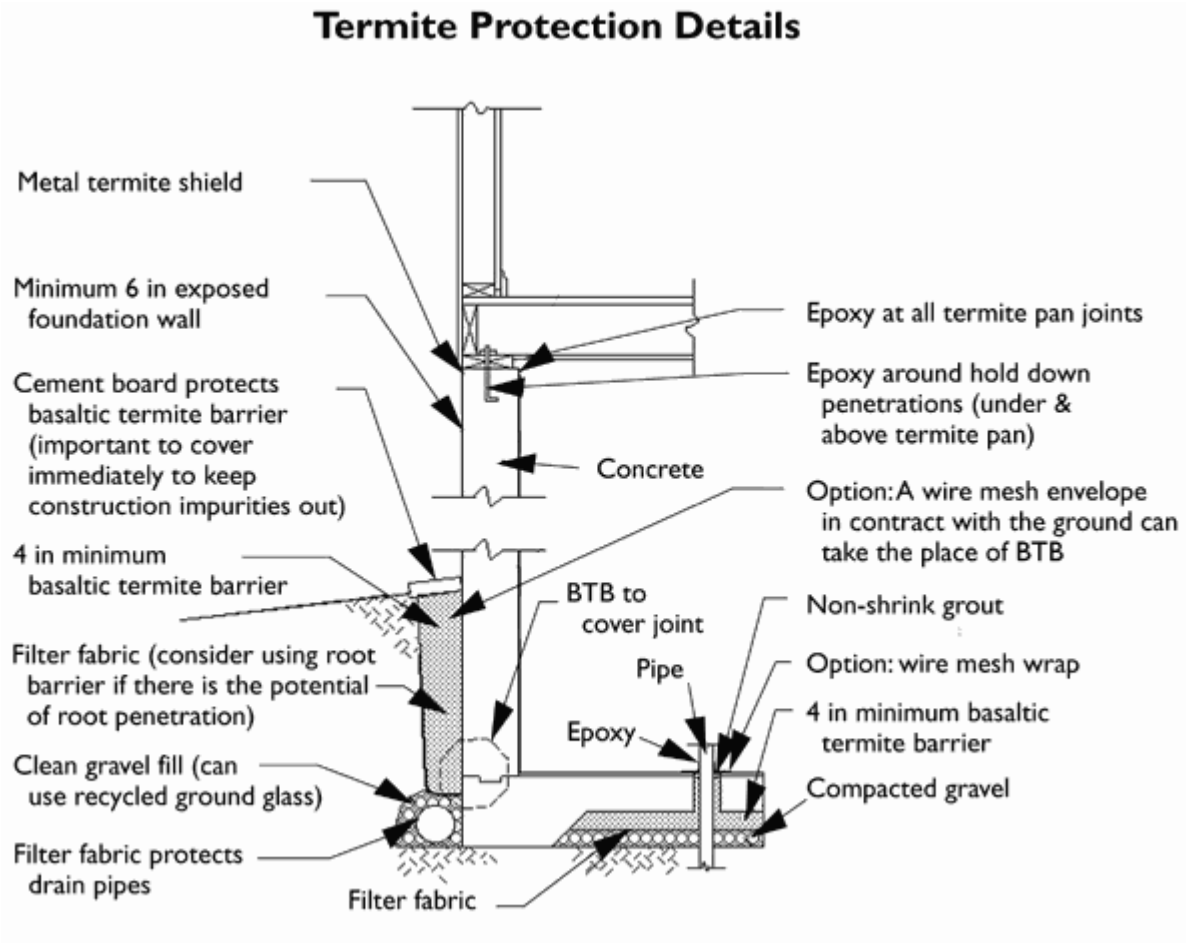
holes, feces, or sawdust are additional points of concern. Outside, in areas where there are planters or earth-filled porches, use a hacksaw blade to insert under window and door sills. The blade should not penetrate beyond the sills or headers. Note any areas where the outside grade is higher than the top of the foundation or slab. This “faulty grade” condition will allow direct access for termites to the wall studs and will contribute to excessive moisture and decay.

In the interior, examine every room systematically. Look for possible signs of decay, damage, and moisture in all wooden structures. For example, if there is a drip or leak under the sink, fill up the sink and examine underneath after it empties to see if water appears at the bottom of the cabinet. If water is leaking from any area, "sound" (tap and listen for a hollow sound) the nearby wood with a hammer, then look for possible mud tubes in adjacent areas. In walking through a structure, notice whether or not floors seem to sag or buckle in places. Sagging members may indicate termite damage . Similarly, water stains, buckling paint, or bulging plaster are indicative of moisture-laden areas which bear further scrutiny. Stained walls may occur where subterranean termites have been depositing mud on inside surfaces of walls. Sound baseboards as well since these are primary areas of attack. Examine cracks occurring around door or window frames since these may be portals of entry.

Inspect bathrooms carefully. Pay particular attention to shower pans and shower or bathtub enclosures as these areas often leak, causing decay and contributing to dry rot and termite infestation. Toilet leaks are common at the point of contact with the floor. Decay or rot is also common at the floor area around the toilet.

In the basement, carefully examine areas around the base of stairs and support posts which may extend through the floor slab. Also, examine the floor joists at the juncture of basement wall for signs of sawdust, feces and spider webs. Probing suspect timbers with an ice pick or sounding, using a small ball peen hammer, may yield a positive finding. Inspect plumbing accesses throughout the structure, as these often will reveal frass, mud tubes, or feces if termites are present. Carefully inspect the underside of stall showers and toilets for leakage, dry rot or termite infestation. Stall showers should be water tested for 15 minutes and inspected for leakage from the basement or substructure if these areas are accessible.

In slab-on-grade construction, look carefully at the expansion joints when these joints are visible for inspection. Occasionally subterranean termite infestations will extend into moist attic areas. Inspect bracing and rafters carefully for evidence of damage or mud tubes. Note any inaccessible areas in the report. Pay particular attention to evidence of leaking water, especially around chimneys, vent pipes, and roof sheathing.



Carefully inspect every part of the crawlspace by using a flashlight, since it is a likely area for hidden termite mud tubes because of the proximity of ground and the first floor wood substructure. Also check the storage sheds and temporary buildings which usually give termites easy access to the structure, if attached or nearby. Pay close attention to areas in which infestation, damage, excessive moisture or faulty grade conditions were noticed from interior or exterior inspection. Signs of infestation or damage may also exist in the substructure. Inspect the areas adjacent to earth-filled porches for evidence of subterranean termites entering from the earth fill. Finally, review carefully any unseen areas and voids, and record such data on the inspection diagram.

Regardless of the type of termite infestation, it is imperative to describe as thoroughly as possible the origin of infestation as well as its extent. In addition to the diagram, a descriptive report must be prepared for future reference, whether or not there is an actual infestation. A list of areas to inspect when performing a termite inspection can be found at the end of this chapter.

PREVENTIVE MEASURES

The implementation of preventive measures discussed in this section can minimize costly repairs of termite damage.

Subterranean Termites

Subterranean termites cannot thrive without ample moisture in the wood of structures, in the adjoining soil, or both. Therefore, repairing defects and correcting patterns that allow water or excess moisture into any part of the structure, will help minimize termite damage. For example, if the ground slopes toward a structure, it should be regraded to redirect the runoff. It is also necessary to ensure that the water from roof, downspouts, porches, driveways, patios, and slabs runs away from the structure, and that leaky drains, baths, toilets, and plumbing are repaired inside the building. If crawl spaces have no ventilation, installation of vents will prevent moisture accumulation. Gutters should be clear of debris so that water does not pour over the top during rainstorms. Roof flashing must not allow water to flow under the membranes and shingles. Flashing around chimneys and vents should be tight and sealed so that water cannot run down into the structure. Tree branches which are moist and close to the structure should be cut back.

It is also necessary to remove wood debris from under the building or near the foundation, firewood that is closer than three feet to the building, and wooden planters next to the building. Modify untreated wooden structural members so that they are more than 45.72 cm (18 in) away from the soil. This may involve regrading if siding or joists are too close to the soil, or installing metal termite shields or a concrete barrier beneath the wood. If decay is evident but slight, treat unpainted wood with a suitable wood preservative such as BoraCare or TimBor. Treat exposed untreated wood. Replace supporting posts, stairs, and fences made of untreated wood with pressure-treated wood. Caulk areas where moisture can enter around windows, door frames, or sills. Remove bark or wood chip mulches next to the structure and replace with decorative rock mulch.

Foam insulation has become a concern in recent years since termites, while not digesting foam, easily tunnel through it to reach wood. Where foam insulation is in close contact with the ground, it might mask termite tunnels and hide structural damage. Therefore, it is essential to ensure that it does not extend closer than 45.72 cm (18 in) from the soil. Even with this precaution, most termite-control companies will not guarantee against termite infestation if a building has foam insulation, because of the high risk of non-detection.

LOW RISK MANAGEMENT METHODS

Termi-Barrier: An innovative, non-toxic treatment, first suggested by Dr. Walter Ebeling in 1957, has been in use by Live Oak Structural, Inc. since 1989 in the San Francisco Bay area to prevent subterranean termites from entering structures. The "Termi-Barrier" is a layer of untreated sand that the termites cannot penetrate because the small particles are too big for the termite to grasp and move with its mandibles, yet the largest particles are not big enough to allow

the termites to crawl between. The sand particles, ranging in size from 2.5 to 1.6 mm (.1 to .06 in), form a barrier that prevents termite penetration; however, particles larger or smaller than the narrow size range may allow termites to tunnel through. Sand barriers can be installed before concrete slabs are poured over them, or in crawl spaces around the foundation perimeter and under pier foundations.

The sand is placed 6.62 to 15.24 cm (3 to 6 in) deep next to foundation walls and tapered down to 2.54 cm (1 in) deep over a 25.4 cm (20 in) or more lateral distance from the wall. Occasionally the entire crawl space must be covered if termite activity is intense. Barriers outside the foundation must be capped with concrete or asphalt to prevent movement away from the wall by rain or other means. Periodic inspection of the integrity of the barrier is an integral part of this approach.

Termite Shields: Sheet-metal strips called termite shields have been installed historically during construction, ostensibly to prevent hidden termite entry through masonry walls. In actuality, termite shields are seldom properly installed, and once installed are rarely maintained. They are intended to force termites to build mud tubes over the metal so that they may be observed and treated. However, they are easily damaged and may hide termite activity if frequent observations are not made on the inside, as well as the outside, of the masonry wall. In this situation, termite entry is unimpeded.

Steel Mesh: Efforts are underway to evaluate a stainless steel mesh barrier, developed by Termi-Mesh, Ltd., and to make it commercially available in the U.S.

Diatomaceous Earth: Diatomaceous earth (DE) can be used as a termite barrier by applying it in strategic places. Natural DE is sold under the brand name Perma-Guard, which is available with or without pyrethrins.

THE FUTURE

Termites have been an economic burden to owners of homes and other structures that contain wood, paper or cellulose products for many years. A great deal of research has been, and is being conducted, to develop better and safer means to manage this costly structural pest.

The Sentricon System is now available by DowElanco to selected companies in the commercial pest control industry. Since 1988, Dr. Nan-Yao Su has worked on developing the method, which utilizes a monitoring system for subterranean termites and the biology and behavior of the termite to achieve management. According to Dr. Su, if no termites, keep monitoring. If termites show up in the monitoring device, then a bait tube is provided for the termites in a recruiting chamber. The bait material contains a chitin inhibitor (the juvenile growth hormones hexaflumuron or noviflumeron), which is passed throughout the colony by the termites' normal recruiting and feeding behavior, and eventually leads to the demise of the colony.

Beneficial nematodes have been marketed for subterranean termite control with mixed results. When research with nematodes yields consistently effective results for most sites and soil conditions, it will be considered a "low risk" method.

CHEMICAL PREVENTIVE BARRIERS

When deemed necessary, pesticide applications shall be performed by licensed applicators only. Applications shall be made according to the National Park Service Integrated Pest Management policy and procedures guidelines, according to pesticide label directions, and following applicable laws and regulations.

Since few buildings are termite-proof, a preventive chemical-barrier treatment around buildings located in high risk infestation areas is a traditional precaution. Preconstruction treatment of structural wood can be accomplished with a dip-diffusion method, with a 10% disodium octaborate tetrahydrate solution. Such "TimBorized" lumber is available in many areas commercially. Additionally, sodium borate solutions can be applied to exposed structural wood during construction ("dry in" stage) or after construction is completed, which is also suitable for all wood that is not in contact with the ground and not exposed to rain. Applications can be made to wood in attics, walls, around windows, floors and sub floors, joists, and sill plates.

Sodium borate solutions penetrate into the wood, treating more than just the surface, and protect and preserve the wood permanently. Sodium borate functions as a slow-acting stomach poison in insects and decay fungi. Termites accumulate the active ingredients while they feed. These slow-acting poisons allow the termites to move throughout the colony to spread the insecticide by the feeding of nymphs, soldiers, and reproductives. Sodium borate solutions can be brushed or sprayed onto bare wood or drilled and pressure treated into known infestations.

A soil pre-treatment performed during construction usually provides an effective barrier for a specified time. The principle is to provide a pesticide barrier in the soil that will be in contact with the foundation and slab. Apply termiticide according to the label at the recommended rate. Before pouring concrete pads, a moisture barrier of polyethylene sheeting should be in place.

Soil treatment termiticides shall be applied in strict accordance with the recommended rates of the manufacturer which are shown on the container label.

Post-Construction Treatments for Subterranean Termites

If a structure has had termites in the past, or if there are conditions conducive to termites (evidence of infested wood around the foundation along with cracks in the foundation or porch voids), it is reasonable to assume that a chemical barrier is necessary to protect against future infestation. When an infestation occurs, the *entire* barrier requires re-establishment. Treating just the area of infestation often fails to prevent termite entry, and results in costly callbacks.

Unpainted or unsealed termite-infested wood can be remedied by painting (brushing) or spraying sodium borate solution on it. At the same time, eliminate moisture problems that may have led to and sustained the moisture needs of the colony. Wood with known infestations or galleries should be drilled and pressure-injected wherever possible.

Slab construction requires that pesticide not only provide a barrier around the outside, but also underneath the slab so that any possible cracks are protected.

If the infested areas are mainly structural, extensive, and inaccessible, fumigation may be selected. This is an expensive and highly technical procedure that should be undertaken only by licensed fumigators. It, however, offers no protection against future infestations. The basic procedure is to wrap the entire building in gas-tight tarps made of nylon, rubber, neoprene, or plastic. Seams between sheets of the tarps are rolled together and joined with metal clamps or heat-sealed. The bottoms of the tarps are anchored to the ground with "sand snakes" (sand in bags). It is essential that the entire structure is airtight for fumigation, so careful attention to each detail is necessary. The building is fumigated with sulfuryl fluoride, or other registered fumigant. Fumigation exposure with sulfuryl fluoride is usually a 24-hour process. Additional time will be required for the aeration process.

In some states, the aeration period for Vikane (sulfuryl fluoride) gas is 24 hours. After the aeration period, the structure is reopened and the fumigator measures gas residues with a fumiscope. When the structure contains less than 5 ppm of Vikane, the fumigator can certify the structure for reoccupancy. Warning signs must be posted and maintained from the time the fumigant is introduced until the fumigator clears the building, prohibiting entrance into the building treated. During the fumigation and aeration process, secondary locks remain on the structure to guard against access until the building is safe to occupy.

Infested, stand-alone items such as furniture, construction timbers, or crates can be treated in a fumigation chamber or with heat in similar fashion as buildings.

AREAS TO INSPECT WHEN PERFORMING A TERMITE INSPECTION

Substructure
- Foundations
- Porches
- Sub floor
- Plumbing
- Pier posts, pier pads
- Heating ducts (high humidity)
- Mudsill, floor joists and header joists
- Ventilation
- Shower drains and sub floor adjacent to the shower
- Toilet drains and sub floor adjacent to the toilet
- Inaccessible areas

Exterior
- Foundations
- Porches
- Patios
- Eaves, fascia boards and rafter tails
- Exterior grade level
- Drainage
- Ventilation
- Exterior siding
- Exterior stucco

- Columns and abutments
- Attached fences, sheds, wood decks
- Visually inspect the roof
- Window sills
- Porte cochere
- Carports

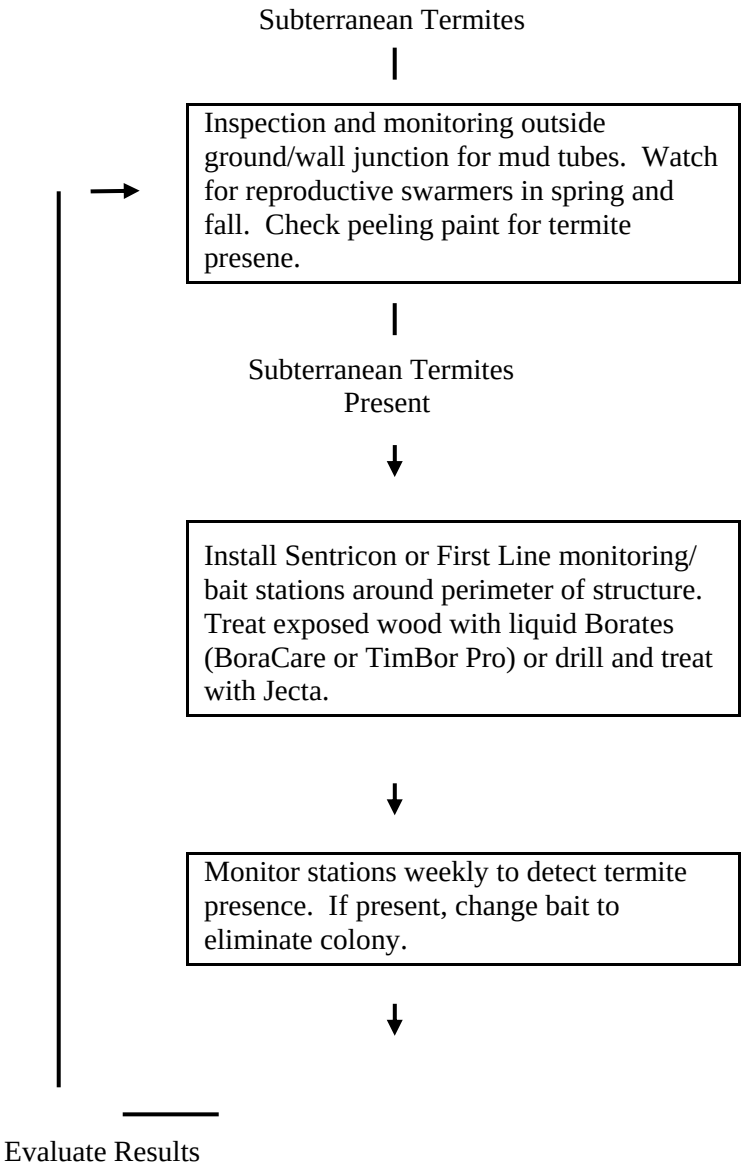
Interior

- Baseboards
- Window ledges, sills and frames
- Floors
- Paneling, plaster board and other wall covering
- Ceilings
- Cabinets
- Plumbing fixtures
- Shower and bath tub enclosures
- Toilet areas
- Fireplace
- Door jambs
- Hollow doors
- Door sills, thresholds
- Inaccessible areas

Attic

- All framing (joists, rafters and sheathing)
- Ventilation
- Heating and air conditioning system
- Roof
- Inaccessible areas

TERMITES


Subterranean Termites
Inspection and monitoring outside ground/wall junction for mud tubes. Watch for reproductive swarmers in spring and fall. Check peeling paint for termite presene.
Subterranean Termites Present
Install Sentricon or First Line monitoring/ bait stations around perimeter of structure. Treat exposed wood with liquid Borates (BoraCare or TimBor Pro) or drill and treat with Jecta.
Monitor stations weekly to detect termite presence. If present, change bait to eliminate colony.
Evaluate Results

POWDERPOST BEETLES



Powderpost Beetle



Powderpost Beetle Damage



Powderpost Beetle Larvae

The first group is known as lyctid powderpost beetles. Lyctids are small, reddish-brown to black beetles about .3 - .64 cm (1/8 - 1/4 in) long, whose life cycle requires about a year or less and takes place entirely within wood, except for mating. They only attack the sapwood of hardwoods having large pores, such as oak, hickory, ash, walnut, pecan and many tropical hardwoods. They attack both new and seasoned wood, so they may occur either in structural members or in paneling, furniture and flooring.

Their damage appears when larvae construct numerous galleries, about .15 cm (1/16 in) in diameter, throughout the wood. Exit holes of .08 - .15 cm (1/32 - 1/16 in) in diameter on the wood surface (made as newly-emerged adult beetles escape from the wood), coupled with fine sawdust-like frass, may be the only evidence that lyctid beetles are at work. The frass may collect below the infested wood on spider webs, or it may fall out when slightly tapping the wood. The interior of wood may be so riddled with galleries that the remaining structure is only a veneer of surface wood. Replacement or removal of panels may be the best method if the infestation is not structural. However, if structural members are involved, the treatment depends on the extent of the infestation. If only exposed timbers are involved, a Borate insecticide may be the best treatment. However, if the extent of the infestation is uncertain, one should carefully examine and probe-delineate the infestation for treatment. Heat may then be the treatment of choice.

Anobiid beetles, also known as death-watch or furniture beetles, belong to the powderpost beetle group. The adult beetles are also .3 - .64 cm (1/8 - 1/4 in) in length and reddish-brown to black in color. However, the adult beetles are rarely seen, and it is the fine frass, pellets and exit holes (.15 - .3 cm [1/16 - 1/8 in] in diameter) which indicate their presence. Their damage includes boring in the sapwood of both hardwoods and softwoods, and reinfestation of seasoned wood if conditions are favorable. Attacks often begin in attics or in poorly ventilated crawl spaces and then spread to other parts of the structures.



Death-watch Beetle & Damage

If the frass is yellowed or partially caked on the surface where it lies, the infestation is probably old or already managed. It may take ten years or more for infestations to become significant enough to be noticed. At this point, both large numbers of exit holes and large quantities of whitish frass are observable. Once the infestation is noticed, management, as with lyctids, depends on the extent of the infestation. The options are essentially the same as those listed for management of lyctid beetles.

BOSTRICHID (false) POWDERPOST BEETLES

The size of various species ranges from .64 cm (1/4 in) (most common species) to 5.08 cm (2 in) (uncommon species). All of the species are elongated, cylindrical, compact beetles with a flat-headed appearance in profile. The larvae are whitish, similar to other powderpost beetle larvae. Their life cycle is relatively short (about a year).



Bostrichid Beetles

There are several species in this group. Among the well-known species are the bamboo borer, the red-shouldered shot-hole borer, the oriental wood borer, the black polycaon, and the lead cable borer. Some of the species are pests of stored products such as grains.

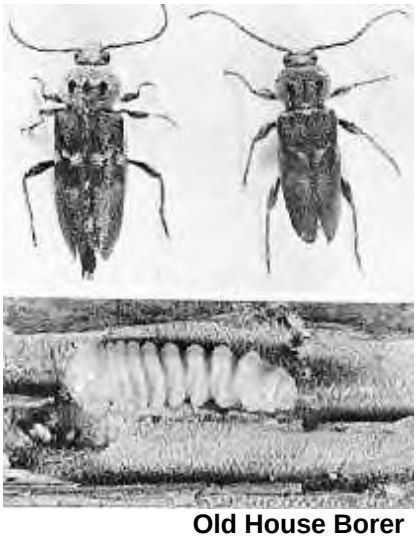
Although this group reinfests wood, it rarely does severe economic damage. Most damage noticed in construction timbers occurs before curing while moisture content of the wood is high. An exception is bamboo and weakened (from moisture or other damage) structural timber, in which considerable damage may occur. The appearance of frass is similar to that of lyctids, except that it often forms small cakes or clumps. However, unlike the lyctid powderpost beetles, exit holes are free of frass and are .08 - .94 cm (1/32 - 3/8 in) in diameter, depending upon species.

OLD HOUSE BORERS

This pest, a native of northern Africa, spread to the U.S. through Europe, and is now ranked second to termites as a pest of seasoned wood in structures. Its distribution is primarily along the east coast, with occasional findings in the other states east of the Mississippi River. The old house borer, *Hylotrupes bajulus,* is a large brownish-black, slightly flattened beetle that ranges from 1.57 – 2.54 cm (5/8 – 1 in) in length. It is a long-horned beetle and has two prominent bumps on the prothorax. The larvae are also large (up to 3.18 cm [1 1/4 in] long) and homeowners may hear them making gnawing sounds (clicking). Unfortunately, evidence of their presence, bulging of the surface wood, only occurs when larvae are near maturity. Eggs are placed in small cracks or in the joints between floor joists and other structures.

The life cycle in the northeastern states may take six to eight years or longer to complete, while in the southeast, the life cycle takes only three to five years. Adults may remain in galleries for up to ten months before emerging. Once emerged, usually in June or July, they live just a matter of weeks before they mate, lay eggs and die.

The old-house borer usually occurs in new, not old wood, as the name implies. However, it usually escapes notice until years after the completion of the structure. Infestation by a second generation of borers occurs rarely in well-ventilated, centrally heated structures. When such reinfestation occurs, there may be overlapping generations of borers in the structure for many years.



Old House Borer

Favorite attack sites include attic framing, floor joists and wood studs. The larvae may reduce the sapwood area of these timbers to mere powdery frass. Luckily, the damage is localized. The fecal pellets are rod-like and crumble easily. The most characteristic feature of infestation is the damage, which is striking because of the size (up to .94 cm [3/8 in] in diameter), shape (oval) and rippled appearance in the galleries. Just prior to emergence, larvae may create bulging in the wood. Exit holes are also oval in shape and surrounded by frass and feces.

MISCELLANEOUS BORERS

There are many other borers that live in wood; most do not survive to reinfest seasoned wood. One of the exceptions is the flat oak borer *(Smodicum cucujiforme)*. This species infests seasoned dry oak heartwood from New York to Florida and west to Texas. Adults are medium-sized (.79 – 1.09 cm [5/16 – 7/16 in] long), brownish, elongated, and slightly flattened as typical long-horned borers. They have an extended life cycle of one to two years in the south, with longer life cycles in northern regions. The damage they cause in the gulf coast states can be severe in stored lumber.



Flat-headed Borer

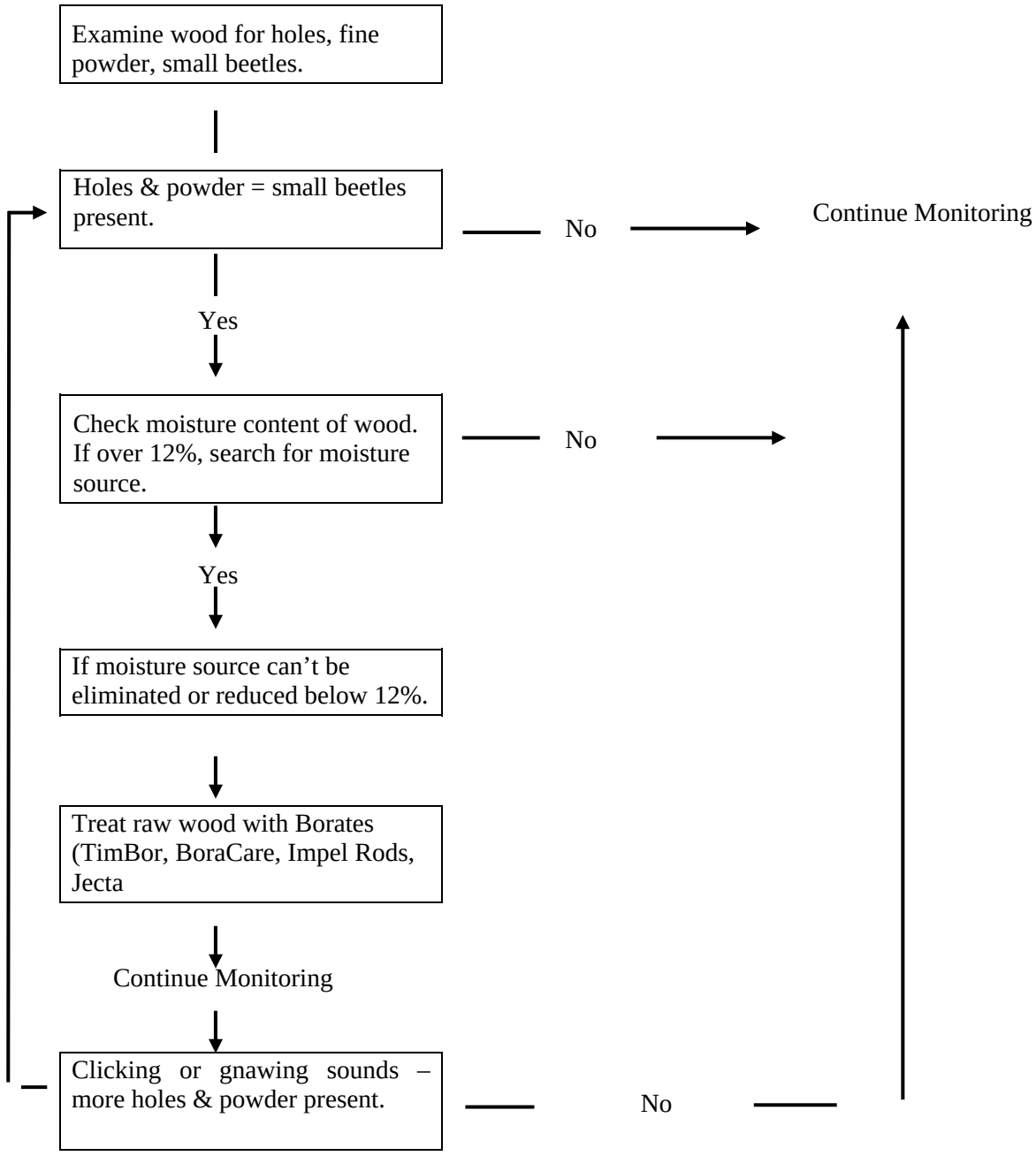
Other long-horned beetles and metallic wood-boring beetles may cause concern by their appearance, which is somewhat iridescent and readily attracts attention. These beetles come into the structure in already-infested wood and, once emerged, do not reinfest.



Long-horned Beetles

Other species that may appear in structures, but do not reinfest seasoned lumber, include the ambrosia beetles and bark beetles. They are brought into the building with firewood and, when the bark falls off; their intricately carved galleries become visible.

WOOD DESTROYING BEETLES



NOTE: Holes and powdered frass will not disappear. If holes increase in number and jeopardize structural integrity of building, replace damaged wood with borate-treated wood.

CARPENTER ANTS

Carpenter ants *(Camponotus spp.)* are social insects which live in small to occasionally large nests. Unlike other ants found in structures, they excavate wood and build nests in it, but they do not eat the wood. They occur throughout the contiguous 48 states and Hawaii, especially in the Pacific Northwest and the northeastern states. Carpenter ants are nocturnal forest-dwelling insects that, in nature, live in dead and rotting logs and trees, under stones and in leaf litter at elevations up to 9,000 feet.



Carpenter Ant Queen & Workers

Carpenter ant workers are large (.45 – 1.57 cm [3/16 – 5/8 in] long), usually black (although not invariably so) and can inflict painful stings. The waist between the thorax and abdomen, unlike most structure-infesting ants, has a single node, and the overall profile is continuous. The queen is up to 1.42 cm (9/16 in) in length and, as with the male, may bear wings during the swarming season.

The larvae are white and legless and are fed by the workers. Pupae are also white and often are carried about by workers if the colony is disturbed. The foods of adults are sugar and sometimes proteins found in or around a site. Adult ants often feed on aphid honeydew found on plants infested with large populations of aphids. Winged adults emerge from March to July, depending upon location, and establish a nest in moist wood or a cavity adjacent to wood. The colony grows over a three-to-six year period before it matures. Winged swarmers appear in the nest in the late fall, but do not fly to start new colonies until the following spring.



Eggs, Larvae & Pupae

Swarming begins during the first warm or wet days of the year. New housing built on cleared woodlots that previously supported carpenter ants is generally the most troubled. Nests are found in water-rotted wood under shower stalls, under leaking roof-valley downspouts, in window sills where water accumulates, in poorly ventilated areas, and sometimes under insulation in attics. The larger and more long-lived a carpenter ant colony is, the greater is the structural damage.

Outside, carpenter ant workers forage for such foods as honeydew, insects and ripe fruit juices. Ants are not as active during winter. Carpenter ants often move into structures during fall to forage for sweets after plant aphids disappear. Those that have invaded structures seek out sweets, meats, fruit juices and moist kitchen refuse. Since carpenter ants are usually not very active indoors during winter, an occupant's ant complaint during winter is a sure sign of an



Carpenter Ant Galleries

indoor nest. Carpenter ants usually leave structures for the outside during summer. Carpenter ant nests consist of galleries that normally run with the grain of sapwood and have large interconnections which are free of wood shavings, mud and feces, and appear smooth and sanded.

Wood shavings and frass are thrown out of the nest through slit-like exit holes in the surface. Small piles of sawdust-like material may build up below tunnels. During summer months, ants are active at night when chewing sounds are audible.

The nest location may not necessarily be in the building; it may be a hundred feet or more away in a stump or decaying log.

Access to buildings is through ground connection, utility wires or branches touching the building. Since moisture is required to sustain a colony for any length of time, a carpenter ant nest indoors is normally near a moisture-laden area. Indoor nest locations may be in door and window frames, wall voids, roof/ceiling of flat deck porches and hollow porch columns, or behind fascia boards.

Carpenter ants are multi-queened and usually excavate wood previously decayed or damaged by other agents. They generally forage in humid atmospheres (under debris, in damp crawl spaces or in vegetation on building walls) where they find softened wood. Carpenter ants are not thought to be able to start tunnels in wood dryer than 12% moisture content, and some species even have high humidity requirements for the nest.

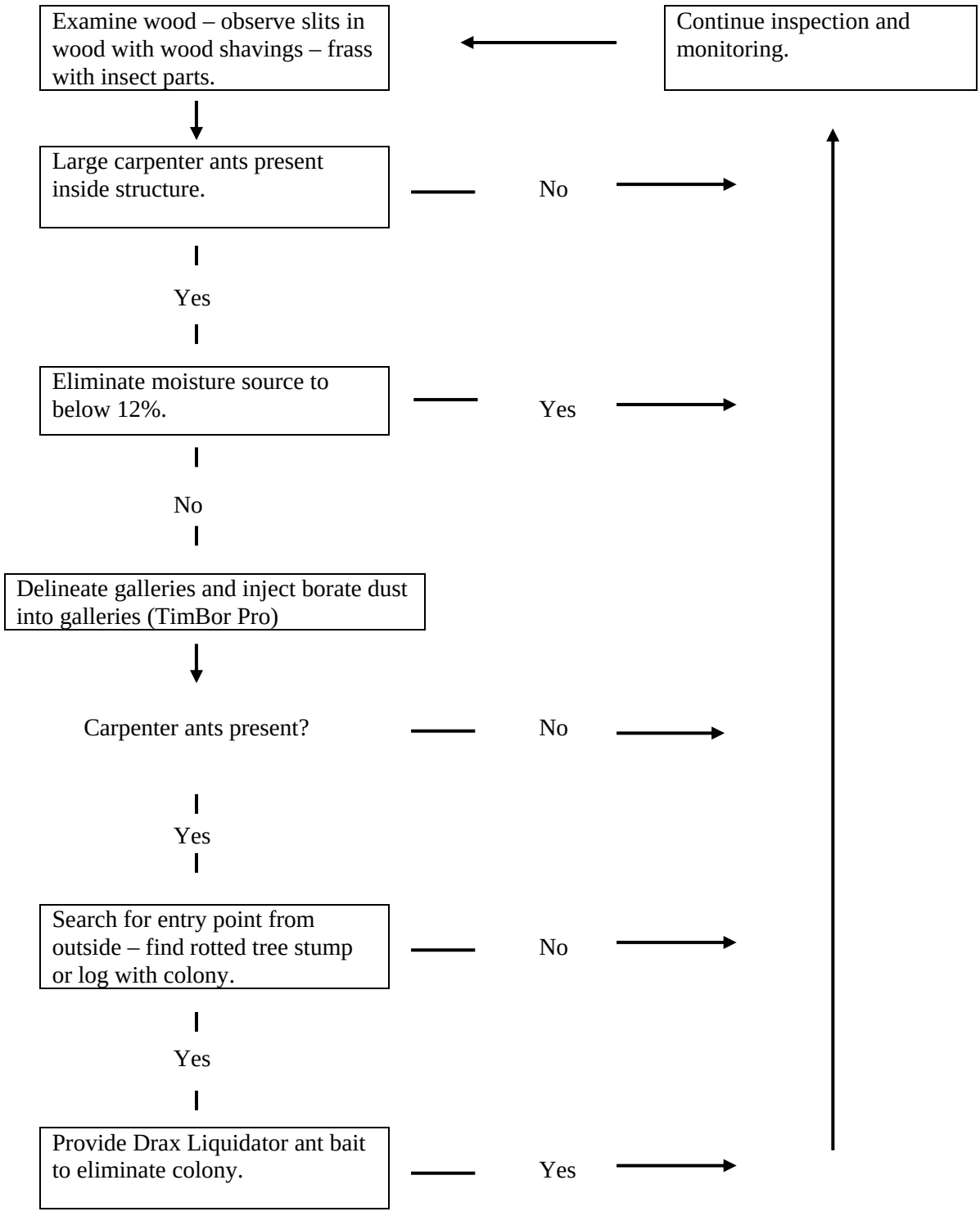
DAMAGE, PREVENTION AND MANAGEMENT

If ignored for many years, structural damage caused by carpenter ants may be extensive and severe. The damage rarely causes structural failure unless the wood is stressed by strong winds or heavy furniture placed on the infested timber.

Prevention methods include eliminating moisture sources in the house, breaking connections to the outside, ensuring good ventilation to crawl spaces, sealing all gaps in wood members, removing wood debris from around the structure, and using borate-treated or pressure-treated lumber in areas subject to moisture.

The most difficult part of treatment is locating the nest, without which the problem cannot be eliminated. If the nest is outside the building, the infested log, stump or other wood item should either be eliminated or removed. Inside the building, the infested areas may be sprayed or dusted with a borate insecticide. In inaccessible areas, wood may require drilling and injection with the pesticide. Chemicals of choice include disodium octaborate tetrahydrate (DOT), silica gel or diatomaceous earth. Some slow-acting baits such as Drax Liquidator may be effective.

CARPENTER ANTS



CARPENTER BEES

Carpenter bees are smooth and shiny solitary bees with a mostly black abdomen. Carpenter bees are similar in appearance to bumble bees, but lack hair on the dorsal side of the abdomen, except on the first segment.



Carpenter Bee

They bore into wood to make a tunnel of cells provisioned with pollen in which they lay eggs and to supply developing young. The tunnel is divided into cells where the individual larvae develop. The tunnels bored by carpenter bees may cause structural damage to buildings where they nest. Typical nesting sites in a structure include fascia, window trim, eave areas, rafters, wood shingles, wood siding, patio furniture and exterior wood trim. Although many different types of wood are selected for nesting sites, softer woods are preferred. Additional damage to the structure can be made by woodpeckers as they bore into the wood to feed on the developing larvae.

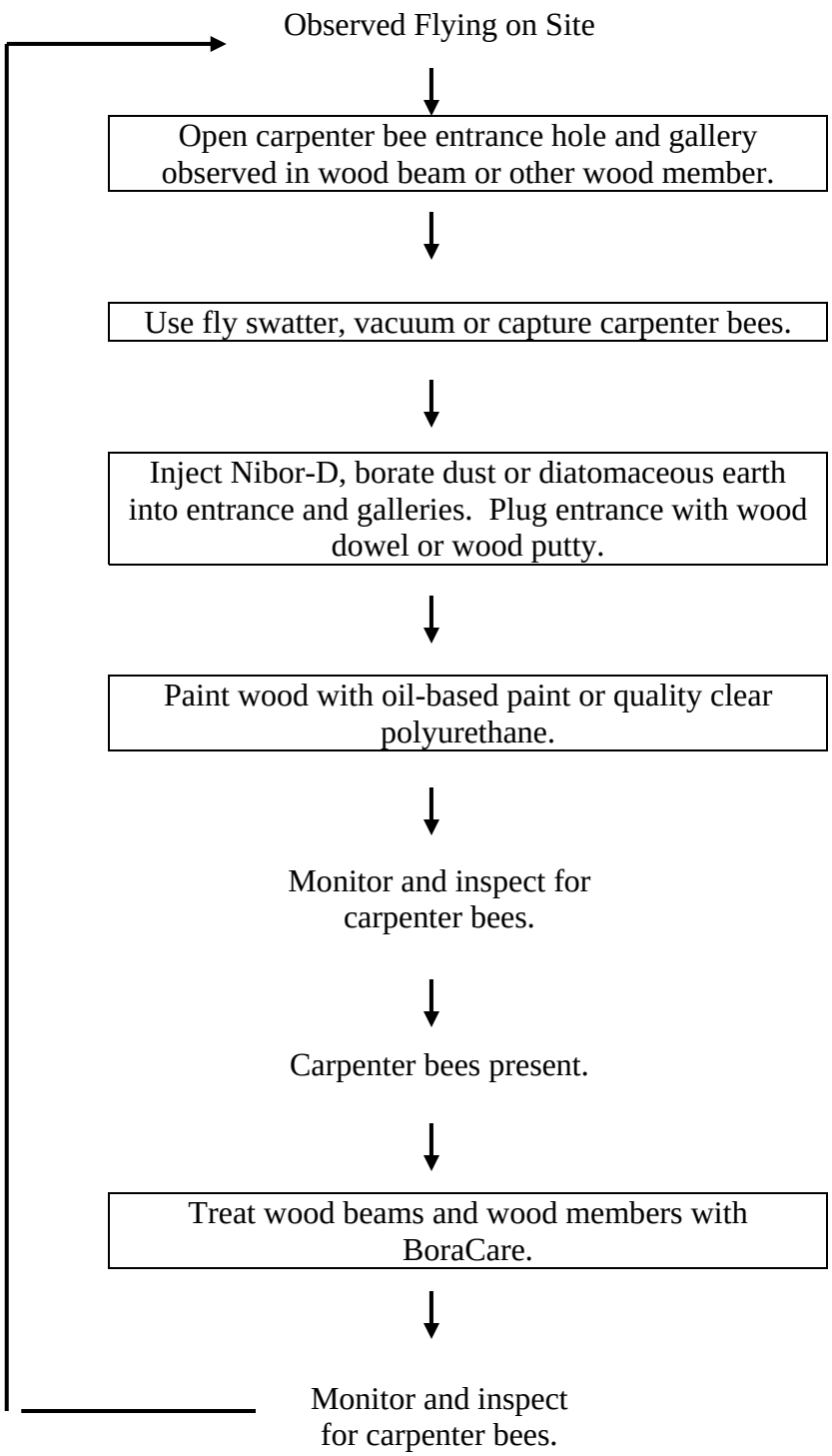
INSPECTION AND MONITORING

Inspect the bottom edges of exterior exposed wood for 1.27 cm (1/2 in) diameter round holes drilled vertically. These are carved by the female carpenter bee forming right angle branches of cells. The male flies aggressively around to protect her while she works. If the hole is sealed, the nest is complete with cells, pollen provisions and eggs or overwintering developing larvae. Adult carpenter bees will emerge in the spring. Only the female carpenter bee can sting. Adult carpenter bees feed on pollen and honey.

MANAGEMENT

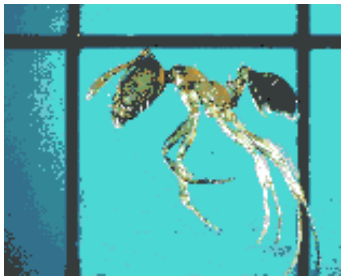
Good quality oil-based paint on the wood (especially bottom edges of exposed beams, fascia, etc.) will prevent and exclude the female bee from constructing the nest. If the nest is in the process of being carved into the wood, dusting inside the hole with diatomaceous earth, TimBor Pro or other low-risk dust pesticide will deter further damage and kill the developing eggs or larvae. Woodpeckers will attack live larvae inside the cells by boring through the wood.

CARPENTER BEES



PHAROAH ANT (*Monomorium pharaonis L.)*

Originally from the African tropics, the pharaoh ant is a trailing species with two nodes on the petiole, twelve segments in the antennae, and a three-segmented antennal club. Its color is yellow-to-red, and the pharaoh ant is .25 – .15 cm (1/10 – 1/16 in) long. This ant forms extremely large colonies (a million or more workers) and is becoming a dominant indoor pest because of its broad diet and habit of colony budding. Infestations may be established months before being recognized. Pharaohs are one of the few North American ants that are active all year.



Pharoah Ant

The pharaoh ant prefers to nest at temperatures between 27 - 30ºC (81 – 86ºF). In the North, pharaoh ants do not nest or survive winter outdoors. Indoors, this species is commonly transferred between buildings in furniture, food packages, laundry, and other items. Indoor nests may be found by examining areas adjoining heating systems and searching for ant trails near hot-water pipes.

Although pharaoh ants forage on many foods (they are especially fond of mint-apple jelly), worker ants need protein and carbohydrates from dead insects, meats, bacon, liver, blood, and honey. A constant food source seems important for pharaoh ants. Removing the food source has sometimes caused pharaohs to leave the building. Pharaoh ants penetrate packaged food and may gnaw holes in silk and rubber. Sources of moisture draw foraging ants to kitchen and bathroom faucets, dishwashers, water coolers and water leaks.

This ant is extremely difficult to manage in structures because colonies tend to multiply (or bud) when treated with chemicals. Since most buildings provide abundant habitat, budding occurs as queens leave the colony accompanied by a number of workers who aid in the establishment of a new colony.

Budding often produces more colonies than the original one that provoked the use of pesticides.

The entire life cycle of workers is complete in 38 to 45 days at room temperature, and life span is about 60 to 70 days. There may be twelve or more pharaoh ant colonies in a building; however, only ten percent of the workers forage for food or water at any given time.

Pharaoh ants prey on bedbugs, and pose significant health threats, especially in hospitals. They may carry more than twelve different pathogenic disease organisms picked up from bedpans, toilets, drains, and washbasins. Once the ants are infected, pathogenic organisms quickly spread through the colony from direct contact as well as through food exchange.

PAVEMENT ANT *Teramorium caespitum (L)*

Pavement ants, originally from Europe and Asia, are distributed mostly in urban areas. They are common along the Atlantic seaboard, less common in the southern states and uncommon inland except in large cities such as Cincinnati and St. Louis. Pavement ants are rarely found in California. Although this ant does not compete well with native ants in rural areas, its range seems to be increasing.



Pavement Ant

The pavement ant is a small, .3 cm (1/8 in) long, blackish-brown species with two nodes on the petiole, a twelve-segmented antenna, a shiny abdomen, dull red-brown head and thorax. This is caused by minute, but easily visible parallel grooves. It has pale legs and antennae. The thorax bears two small spines on the top rear. Most complaints about small ants are caused by annoying pavement ants invading structures throughout the year, especially during summer when they get into everything from food to shoe polish.

Pavement ants nest outside under rocks, next to pavement edges, on door stoops and patios, and also establish colonies inside buildings between foundation and sill plates. This species enter through heating ducts, cracks in the slab and other open areas, and nest in wall voids and bathroom plumbing trap areas. Pavement ants may bite and sting causing an allergic reaction or rash.

Pavement ants store debris including sand, seed coats, dead insect parts, and sawdust from building construction in the nest, which the workers clean out when the nest needs to be expanded. This material is often seen in small piles on basement floors where it may be confused with carpenter ant frass. Pavement ants normally swarm in late spring, but large swarms may originate inside heated structures at any time of year.

Pavement ants are omnivorous scavengers with few food preferences, but they seek sweet and greasy materials, dead insects, and seeds. Outside, they tend honeydew-producing insects (root aphids and mealy bugs), and are often pests on eggplants, peanuts, and strawberries. Closely related, trailing species are often introduced via tropical plants into structures, where they flourish in warm, moist environments.

ODOROUS HOUSE ANT (*Tapinoma sessile [Say])*

The odorous house ant is a trailing, non-stinging, native species that occurs in all 48 continental states from sea level to over 10,000 feet in elevation. It has a single node on the petiole, is brownish to black in color, and .3 cm (1/8 in) long. Colonies are multi-queened and seldom swarm. The odorous house ant (and the Argentine ant) is probably the most common found in North American buildings. It is primarily distinguished from the Argentine ant by a darker color and an unpleasant odor when crushed.

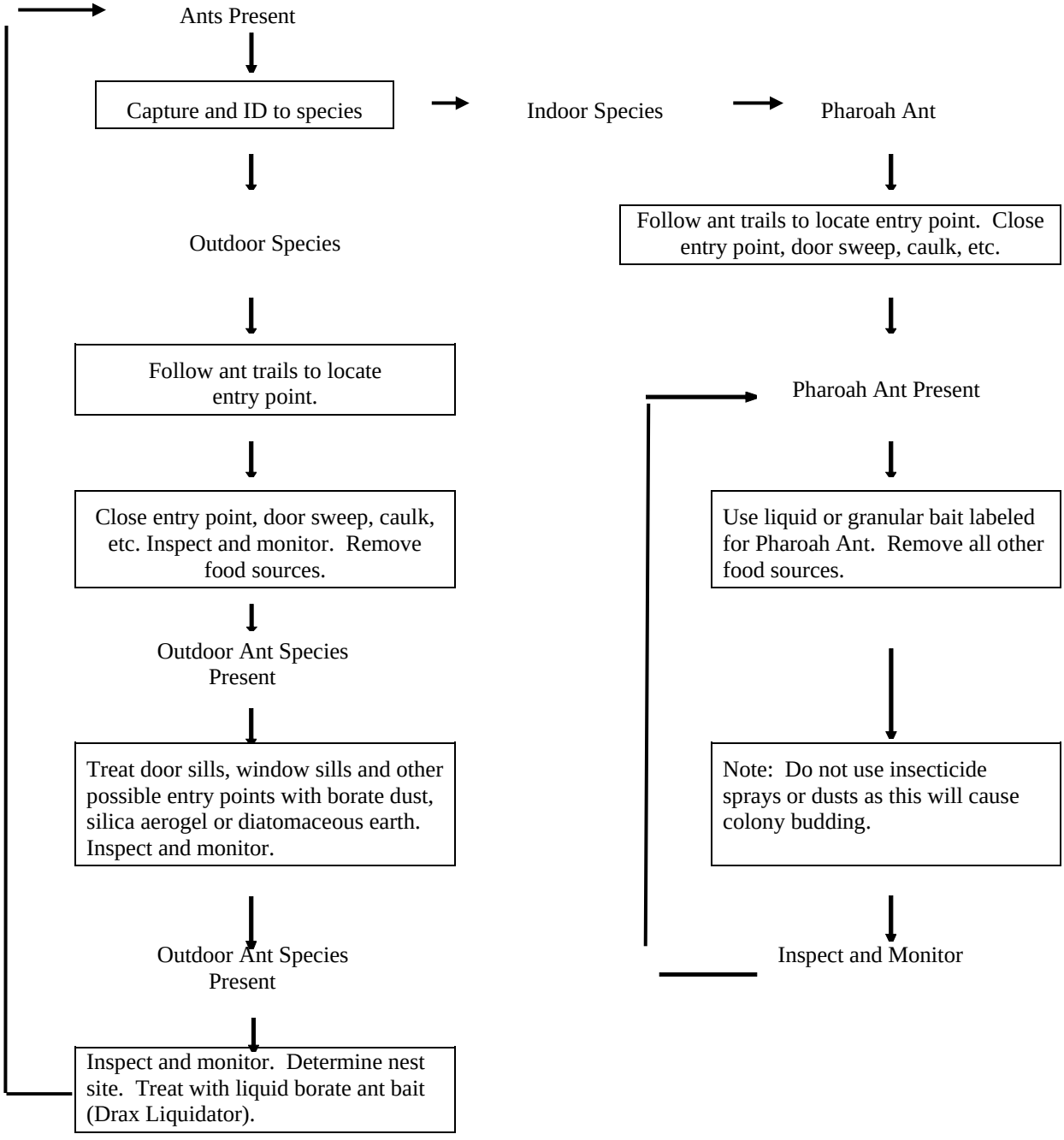


Odorous House Ant

Outside, odorous house ants tend honey-dew-producing insects. Inside, workers prefer sweets but, strangely, sweet baits are seldom effective. Although this ant may invade structures at any time of the year, it becomes an indoor pest at the start of the rainy season, when aphids and honeydew are washed down from plants by rain, and then again late in the year when leaves fall.

Odorous house ants nest outside, are usually shallow and located under boards or stone. Indoors, the nests are found in walls, woodwork, under floors (especially around heat sources), and sometimes in old termite tubes.

ANTS


Ants Present
Capture and ID to species
Indoor Species
Pharoah Ant
Follow ant trails to locate entry point. Close entry point, door sweep, caulk, etc.
Outdoor Species
Follow ant trails to locate entry point.
Pharoah Ant Present
Close entry point, door sweep, caulk, etc. Inspect and monitor. Remove food sources.
Use liquid or granular bait labeled for Pharoah Ant. Remove all other food sources.
Outdoor Ant Species Present
Treat door sills, window sills and other possible entry points with borate dust, silica aerogel or diatomaceous earth. Inspect and monitor.
Note: Do not use insecticide sprays or dusts as this will cause colony budding.
Outdoor Ant Species Present
Inspect and Monitor
Inspect and monitor. Determine nest site. Treat with liquid borate ant bait (Drax Liquidator).

BROWN ROT

Wood rots are a group of microscopic organisms (fungi) that discolor and decay wood. These fungi are unable to produce their own food so they feed upon natural organic substances such as wood and paper, etc. Fungi fruiting bodies release many spores that are moved by wind and rain. When the spores land on wood in the presence of water, they germinate, sending out thread-like hyphae. Enzymes secreted by the hyphae break down organic matter in wood so the fungi can use it for food. For fungi to use wood for food, it must have oxygen, 4 – 38ºC (40 – 100ºF) temperature range, a supply of moisture and a food source – wood.

Brown rot fungi feed on the wood's cellulose, a component of the cell wall. The fungi leave behind the brown lignin, which holds the wood cells together. Infested wood may be greatly weakened and becomes a darker brown than normal. Brown rot causes wood to crack across the grain and shows cubical checking. When brown rot damaged wood is dried, it will turn to powder when crushed. Brown rot that has dried is sometimes called dry rot.



Brown Rot Fungi

Treating wood with borates (BoraCare or TimBor Pro) will prevent brown rot and stop brown rot from further damaging the wood.

WHITE ROT

Wood rots are a group of microscopic fungi that attack and decay wood. These fungi cannot produce their own food so they feed on natural organic substances such as wood and paper, etc. Fungi fruiting bodies release spores that are carried by wind or rain until it reaches a susceptible substrate. When the spores land on wood where there is oxygen and 4 – 38ºC (40 – 100ºF) temperature, they germinate and send out hyphae to break down wood for its nutrients.



White Rot Fungi

When white rot attacks wood, it breaks down both lignin and cellulose causing the wood to lose its color and appear whiter than normal. Wood infested with white rot will shrink and collapse, eventually losing its strength and becoming spongy. Wood with white rot usually does not crack across the grain.

Wood treated with borates (BoraCare, TimBor Pro) will prevent white rot from infesting wood and/or stop further damage to the wood from white rot.

WATER-CONDUCTING FUNGUS, *Poria incrassata*

Poria can attack wood without the initial presence of water. This wood rot fungus can transport water for several feet through large root-like structures called rhizomorphs. When established, it can quickly spread through a building and destroy large portions of the structural wood.

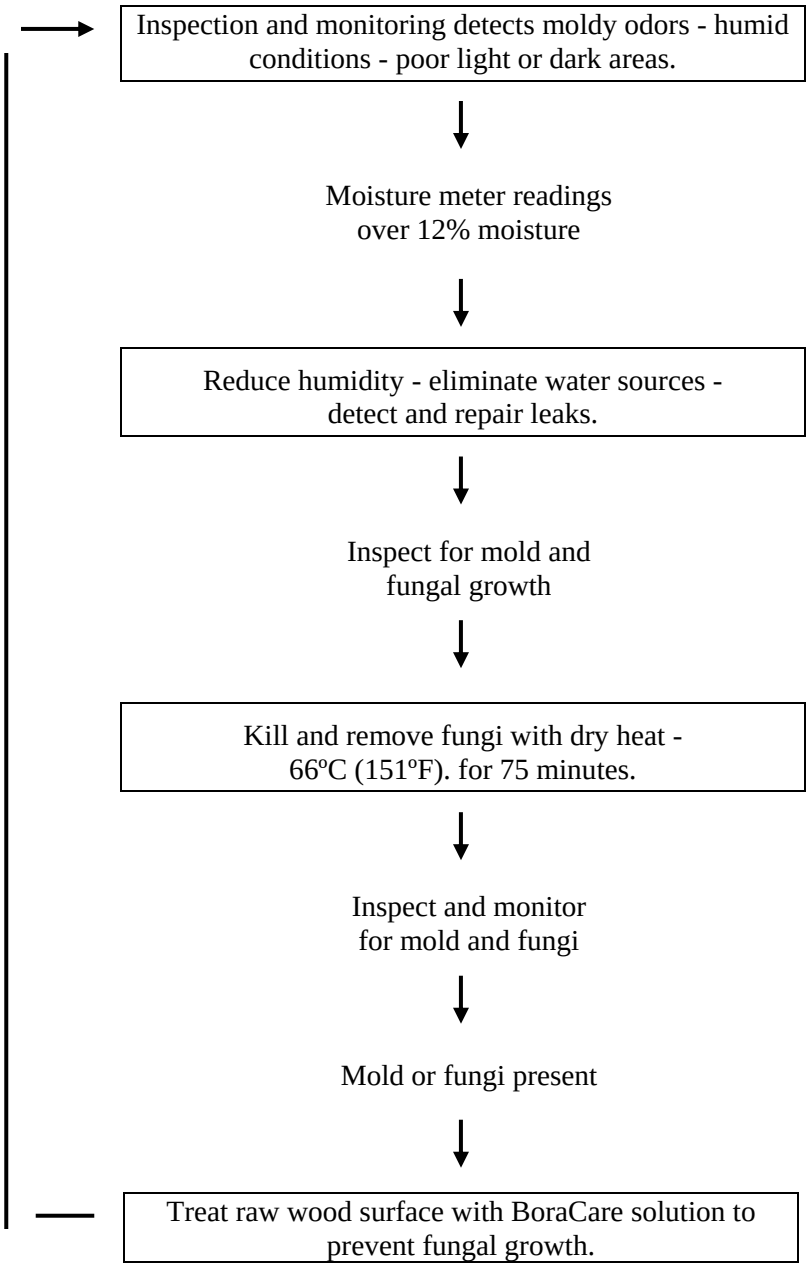


Poria incrassata

Typically, *Poria* infestations start in dirt-filled porches, damp crawlspaces and basements or where wood is in contact with soil. It can also begin in moist concrete or damp bricks. At first, yellowish mycelial fans grow over the surface of wood and other moist areas. The rhizomorphs are small hair-like hyphae that can grow to 2.54 cm (1 in) or more in diameter in older infestations. When *Poria* infested wood dries, it usually shrinks and cracks across the grain.

Wood treated with borates (BoraCare, TimBor Pro) will prevent *Poria* from infesting wood and/or stop further damage to the wood from *Poria.*

MOLDS AND FUNGI



HOUSE MOUSE

INTRODUCTION

The house mouse (*Mus musculus*) easily adapts to living with people. It thrives in a wide range of climatic conditions in a great variety of habitats, feeding on most human food, and reproducing at a remarkable rate. House mice subsist throughout the United States, and are found in most areas of human habitation. They are also found living in the wild. They are common inhabitants of grassy fields, and a problem in residences and structures. Not only does the house mouse destroy food and cause damage to structures and personal possessions, it also has the potential to transmit diseases and parasites to people and domestic animals.



House Mouse *Mus musculus*

CHARACTERISTICS AND RECOGNITION

The house mouse is a delicate, agile little rodent. Adult weights vary by region and usually range from 14 – 28 gr (1/2 – 1 oz). Adult house mice vary in color from light brown to dark gray, but most often are a dusky gray or medium brown over most of their bodies, except the belly, which may be a slightly lighter shade of their general color but never white. The mouse has moderately large ears for its body size. The tail is nearly hairless and about as long as the body and head combined (6.35 – 10.16 cm (2 1/2 – 4 in). The feet are small in proportion to its body, and the eyes are also relatively small.

Under optimum conditions, house mice breed year round. Out-of-doors, house mice may tend toward seasonal breeding, peaking in the spring and fall. Environmental conditions, such as the availability and quality of food, can influence the frequency of pregnancy, litter size, and survival. Females may produce as many as ten litters of five young in each litter in a year. At very high densities, however, reproduction may nearly cease despite the presence of excess food and cover.

Newborn mice are quite undeveloped, weighing between .57 – .85 gr (.02 – .03 oz) and are nearly hairless. Their eyes and ears are closed, but within two weeks the body is covered with hair and the eyes and ears are open. At about three weeks, the young begin short trips away from the nest and begin taking solid food.

While mice primarily are active at night, some day activity occurs. Movements of house mice are largely determined by temperature, food, and hiding places. Home ranges of mice tend to be smallest where living conditions are good. Mice tend to travel over their entire territory daily, investigating each change or new object that may be placed there. They are very aggressive. They show no fear of new objects. They dart from place to place, covering the same route over

and over again. This behavior can be used to advantage in management programs. Disturbing the environment at the beginning of a program by moving boxes, shelves, pallets, and other objects can improve the effectiveness of traps. Mice will investigate the changed territory thoroughly.

Mice have relatively poor vision, and are also color blind. They rely heavily on smell, taste, touch, and hearing. Mice use their keen sense of smell to locate food and to recognize other individuals, especially those of the opposite sex. Taste perception in mice is also good. Mice use their acute hearing to detect and escape danger. An important sensory factor for mice is touch. Mice use long, sensitive whiskers near the nose and guard hairs on the body as tactile sensors to enable them to travel in the dark, pressing against walls and boxes, scurrying through burrows.

It is a challenge to mouse-proof a building or manage mice without understanding their physical capabilities. For their size they are excellent jumpers. They can jump against a wall or flat vertical surface, using it as a spring board to gain additional height. They can run up almost any vertical surface including wood, brick walls, metal girders, pipes, weathered sheet metal, wire mesh, and cables without difficulty if the surface is rough. They can run horizontally along insulated electrical wires, small ropes, and the like, with ease. They can squeeze through openings slightly more than .64 cm (1/4 in). They are quick to explore any physical change in their environment.

House mice prefer cereals over other items, although they feed on a wide variety of foods. Mice satisfy much of their water need with moisture in their food, but they drink if water is readily available. Mice have two main feeding periods, at dusk and just before dawn, and they are nibblers, feeding twenty or more times during evening rounds. In any territory there will be one or two feeding sites, dark and protected, where mice eat more than at other places.

Mice are territorial and seldom travel more than thirty feet from their nest. When food is nearby, mice may restrict their activity to a few feet. Males average slightly larger ranges than do the females. House mice may nest in any dark, sheltered location, in nests approximately 10.16 cm (4 in) in diameter and constructed of fibrous, shredded materials such as paper, cloth, burlap, insulation, or cotton, which generally look like a loosely woven ball. Outdoors, house mice sometimes dig and nest in small burrows.

HAZARDS OF INFESTATION

When mice infest stored food, the greatest loss is not what mice eat, but what is thrown out because of real or suspected contamination. Mice also damage personal property and structures by gnawing, including electrical wiring in buildings. House mice frequently take up residence in electrical appliances and end up chewing into the power supply.

House mice and their parasites are implicated in the transmission of a number of diseases. Salmonellosis can be spread when some foods are contaminated with infected rodent feces. Mice are probably more responsible than rats for the spread of this disease. *Rickettsia akari* is the causal agent of Rickettsialpox, a disease causing a rash similar to chickenpox. Rickettsialpox

is transmitted from mouse to mouse, then to people by the bite of the house-mouse mite. Lymphocytic Choriomeningitis is a virus infection of house mice that may be transmitted to people (mainly to children) through contaminated food or dust. The mouse can also be a major carrier of Leptospirosis (Weil's disease). Rat-bite fever can be transmitted by house mice, as can ray fungus, *Actinomyces muris*. Certain tapeworms are spread in house-mouse droppings, and ringworm, a skin fungus disease, can be carried to human beings by mice or contracted indirectly from mice through cats. Tularemia has also been linked to house mice.

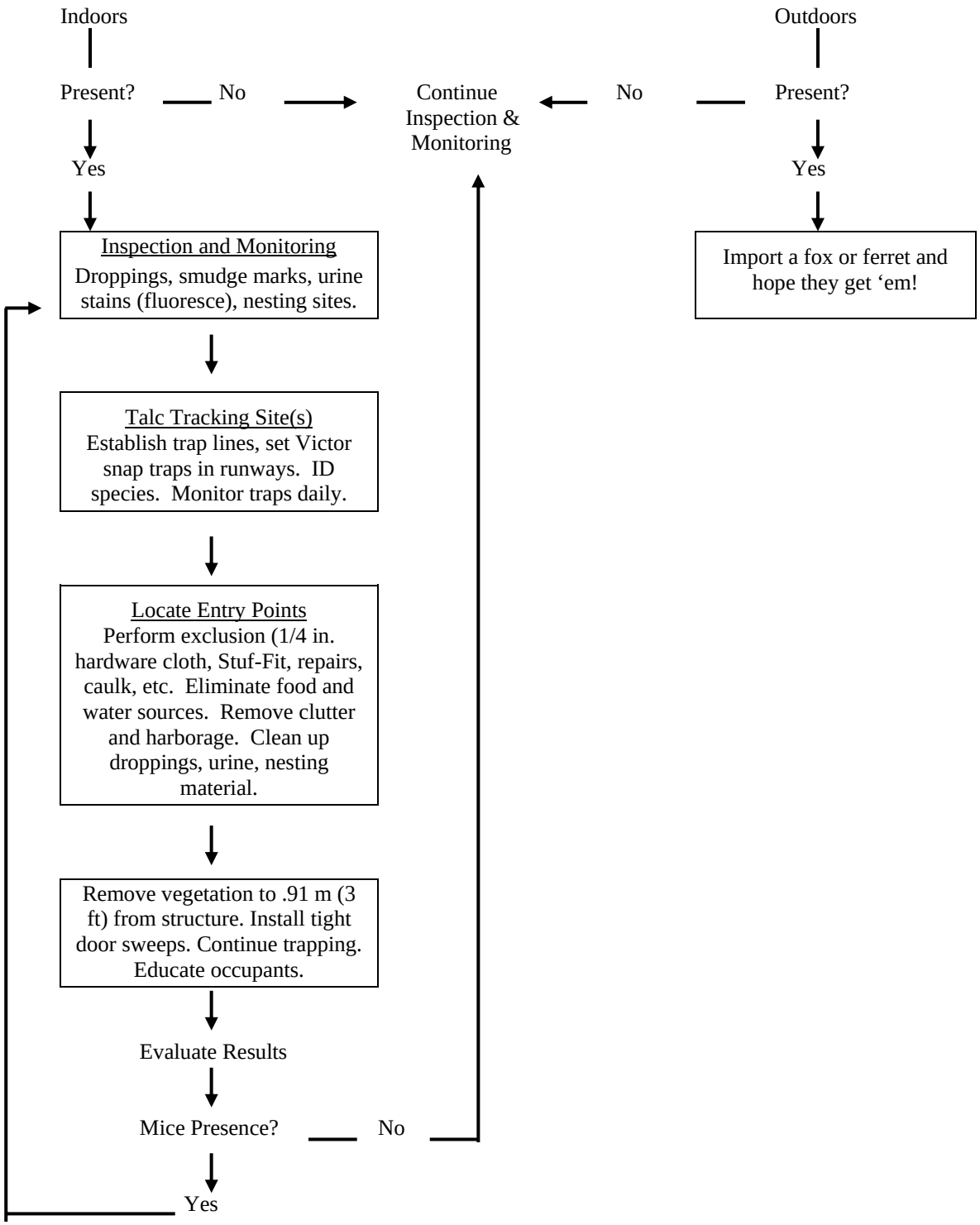
INSPECTION AND MONITORING

Sounds are common at night where large numbers of mice are present. Listen for squeaks, scrambling, and sounds of gnawing. An electronic stethoscope is useful.

Mouse droppings are frequently the first evidence that mice are infesting. Large cockroaches, bats, and other species of mice such as deer mice (*Peromyscus* sp.) and meadow mice (*Microtus* sp.), may produce droppings similar to those of house mice. Look along runways, by food, near shelters, and in other places mice may frequent. House mice occasionally make small mounds known as "urinating pillars." These consist of a combination of grease, urine, and dirt, and may become quite conspicuous. Look for many small drops of urine using a black light, since urine stains will fluoresce under ultraviolet light.

Like rats, mice produce greasy smears where dirt and oil from their fur mark pipes and beams. Recent gnawing damage on wood is light in color and will turn darker with age. Look for enlarged cracks beneath doors and small tooth marks. Such evidence frequently helps to distinguish between mice and rats. Look for wood chips with the consistency of coarse sawdust around baseboards, doors, basement windows and frames, and kitchen cabinets.

HOUSE MICE


Indoors
Outdoors
Present?
No
Continue Inspection & Monitoring
No
Present?
Yes
Yes
Inspection and Monitoring
Droppings, smudge marks, urine stains (fluoresce), nesting sites.
Import a fox or ferret and hope they get 'em!
Talc Tracking Site(s)
Establish trap lines, set Victor snap traps in runways. ID species. Monitor traps daily.
Locate Entry Points
Perform exclusion (1/4 in. hardware cloth, Stuf-Fit, repairs, caulk, etc. Eliminate food and water sources. Remove clutter and harborage. Clean up droppings, urine, nesting material.
Remove vegetation to .91 m (3 ft) from structure. Install tight door sweeps. Continue trapping. Educate occupants.
Evaluate Results
Mice Presence?
No
Yes

DEER MOUSE / WHITE FOOTED MOUSE

The native deer mouse (*Peromyscus maniculatus* [Wagner]) is the rodent in the United States that most commonly carries the Hantavirus, and is implicated in most of the cases of human infection by this strain. The white-footed mouse *(Peromyscus leucopus* [Raphinesque]) also carries Hantavirus. The deer and white-footed mice are also the most likely native rodents to be found in or near buildings. The deer and white-footed mice often invade homes and structures that are closed for the season. If outside populations are large, structures may have numerous *Peronyscus sp.* present, which may result in substantial amounts of saliva, urine and droppings with the Hantavirus aerosolized into the interior air and in dust. The opportunity for human exposure is great when the structure is reopened for use. See Introduction to Mice for Hantavirus remediation.

CHARACTERISTICS AND RECOGNITION



Deer Mouse *Peromyscus maniculatus*

Appearance

The deer mouse is the most widely distributed and the most variable member of the genus. Color ranges from pale grayish buff to deep reddish brown. The tail is always sharply bicolored, dark above and white below. Head and body are 7.11 – 10.16 cm (2 4/5 – 4 in) long and the tail is 5.08 – 12.7 cm (2 – 5 in). The deer mouse weighs only 19 – 35 gr (2/3 – 1 1/4 oz). The eyes and ears are moderate size and prominent and the tail is covered with short fur.

Habitat and Habits

The deer mouse is versatile and occupies nearly every dry land habitat within its range from forests to grassland and a mixture. With the exceptions of Virginia, North and South Carolina, Georgia, Florida, Alabama, Mississippi and Louisiana, the deer mouse can be found throughout the continental United States (including part of Alaska) and Canada. In the east, deer mice are found from the Hudson Bay south to Pennsylvania and the southern Appalachians. They build a large globular nest in burrows in the ground, in trees and stumps, and buildings. The deer mouse feeds on seeds, nuts, acorns, berries, small fruits, and adult and larval insects, and can carry food in a cheek pouch to be stored in its nest. The home range is one-half to three acres or more. A summer population of 10 to 15 per acre is high, although they may congregate in winter. They rarely live more than two years in the wild. Females may show territorial behavior in the breeding season, which may vary with latitude, normally February to November. There may be two to four litters per year with one to eight naked and blind young (usually three to five) per litter. Gestation period is 21 – 27 days. Deer mice are nocturnal, feeding mostly at dusk and dawn. They are excellent climbers and fast runners.

Appearance



White-footed Mouse
Peromyscus leucopus

The white-footed mouse is found in the east from Maine south to Georgia. Identifying the various species of *Peromyscus* may require a rodent taxonomist. The white-footed mouse is bicolored with the upper parts grayish to rich reddish-brown, with the belly and feet white. The tail is also bicolored. The head and body length are about 1.4 – 10.5 cm (3 9/16 – 4 1/8 in), tail length is 6.2 – 10.2 cm (2 7/16 – 4 in). Ears are small, 1.3 cm (1/2 in) and weight is about 10.6 – 42.5 g (3/8 – 1 1/2 oz).

Habitat and Habits

White-footed mice are nocturnal. They build nests in concealed locations such as old bird or squirrel nests, burrows, stumps, logs or buildings. They feed on seeds, nuts, fruits, beetles, caterpillars and other insects. Caches of seeds and nuts are stored near the nest. Home range is 1/2 – 1 1/2 acres. They are active year around. Females have two to six young per litter, and two to four litters per year. The gestation period is 21 – 24 days and females can begin breeding at 10 – 11 weeks old. The lifespan is two to three years in the wild.

INSPECTION AND MONITORING

Droppings

Observing droppings indoors where native mice have tunneled, fed and nested are telltale signs of their presence. Outdoors runways in grassy areas may be observed, and droppings may also be present. Fresh mouse droppings are dark and shiny, then turn dull and gray as they age. Large numbers of droppings in a small area indicate a feeding or resting site. Droppings and urine will also be found in the nest.

Runways

Outdoors runways may be distinct as grass is clipped and the trail may show. Inside the runways that are being used will show as dust free areas, usually next to walls or other objects.

Tracks

Outdoors in soft soil or dirt areas look for tracks and tail marks in the dust. Deer and white-footed mice (and others) have large hind feet with five toes and small front feet with four toes. Indoors a non-toxic tracking patch (talc) 15.24 x 25.4 cm (6 x 10 in) and .15 cm (1/16 in) deep can be placed on the floor to determine activity. Place several patches in the area near possible food sources, or other critical areas.

Visual Sightings

If possible, make observations at night as most *Peromyscus* are nocturnal. Use a powerful flashlight or spotlight to check storage spaces or other food or harborage sources. Disturbed mice will rapidly run to shelter.

PEST MANAGEMENT MEASURES

Management of native mice consists of preventive measures such as exclusion, sanitation, habitat modification, and population reduction with snap traps.

Exclusion

If you keep them out, they can't get in! Exclusion may be the most important aspect of native mouse management. All holes, cracks, crevices or other openings larger than .3 cm (1/8 in) must be filled, covered or otherwise blocked to keep mice out.

As the native rodents can gnaw through wood or other soft substances, burrow into soil, and are good climbers, keeping the structure in good repair is important. Use hard material such as metal flashing, concrete and 1/8 in. hardware cloth for exclusion. Doors and windows should also close tightly.

Sanitation

Keep food and water in clean, tightly closed containers that are resistant to rodent attack. Removal of clutter and debris will also deter rodent activity. If rodents are suspected or observed inside the structure, very strict procedures need to be followed.

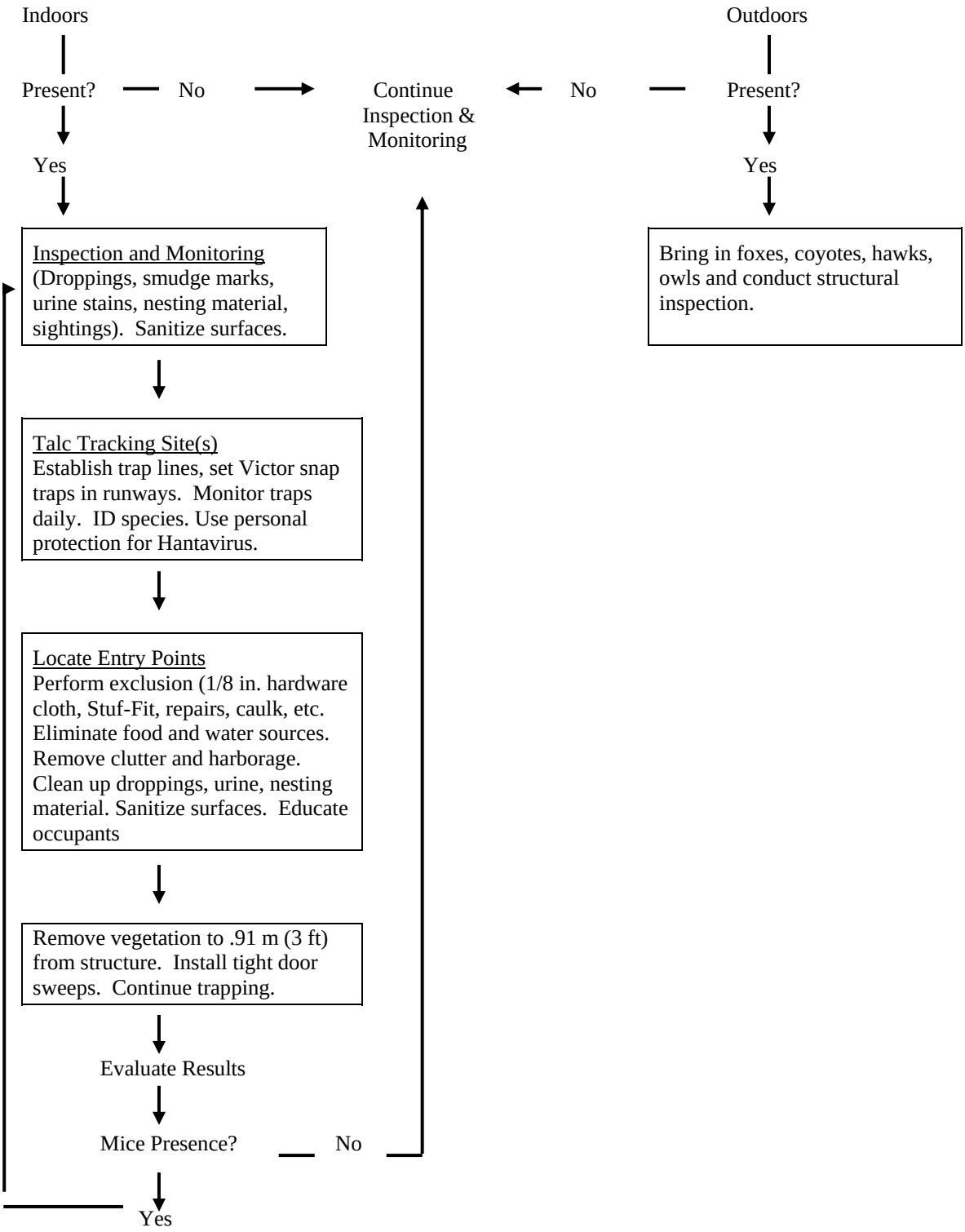
Habitat Modification

Another preventive or remedial measure that can be taken outdoors to reduce the opportunity for rodent/human exposure is to remove brush, weeds and other materials from around structures to reduce protected hiding places for rodents. Modifying protective cover makes native rodents more susceptible to predation by hawks, owls and other natural predators. A gravel barrier 10.16 – 15.24 cm (4 – 6 in) deep and .91 m (3 ft) wide next to the structure reduces rodent intrusion.

Trapping

Because of the risk of exposure to the Hantavirus, if native rodents are dwelling inside structures, lethal force in the form of snap traps is recommended. Do not use live traps. Do not use rodenticides or other toxic means for rodents inside structures. Baits that may be used in the snap traps are seeds such as conifer seed, chunky peanut butter, sunflower seed, oats, or cotton balls (plain or with vanilla flavor). Traps should be placed in observed runways or near resting and feeding sites. Check traps daily. Wear rubber or plastic gloves when handling killed mice. Remove dead mice and treat with a disinfectant to kill Hantavirus.

DEER / WHITE-FOOTED MICE



RATS

INTRODUCTION

A few vertebrates, such as rats and mice, are common pests in urban sites. Others may occasionally become pests when their presence conflicts with human use of a space.

Public concern for animal welfare and the potential risk from vertebrate poisons to people, pets, and other non-targets have made rules governing vertebrate pest management particularly strict. Laws and regulations at state and local levels may be more restrictive than federal regulations. The pest manager should ensure that the applicable regulations are satisfied.

CHARACTERISTICS AND RECOGNITION

Rats have caused more human suffering and economic damage than any other vertebrate pest. It is estimated that rats destroy 20% of the world's food supply every year, by feeding on or contaminating it. Rats have adapted to nearly all human environments. They live in granaries, fields, city sewers, attics, basements, street trees, on roofs, and food storage areas.

Rats can leap 1 m (3 ft) straight up and 1.22 m (4 ft) horizontally. They can scramble up the outside of a pipe 6.62 cm (3 in) in diameter, climb inside pipes of 3.81 – 10.16 cm (1 1/2 – 4 in) in diameter, and walk between buildings on telephone or power lines. Rats can swim through a half mile of open water, tread water for up to three days, swim against a strong current in a sewer line, and dive through a sewer trap to pop up inside a toilet. They can fall more than 15.24 m (50 ft) and survive.

Rats gnaw constantly to wear down their teeth which continue to grow, and their teeth are extremely hard. They commonly chew through building materials such as concrete block, aluminum siding, sun-dried adobe brick, wall board, wooden cabinets, lead sheathing, asphalt paving, and plastic or lead pipes. An adult rat can compress its body and squeeze through a 1.27 cm (1/2 in) opening.

Rats are very wary. Hundreds may be nesting in a city block, in underground burrows, in sewers, on roofs, inside buildings, and few people in the area will realize it. Their populations may be excessive.

Successful long-term rat management is not simple. The key is to manage the environment of rat populations, not individual rats. Rat management requires an integrated approach that includes non-lethal tools such as careful inspection, upgraded sanitation, and rat-proofing structures to exclude rat entry. Lethal methods may also combine the use of low-risk measures such as snap traps or Rat Zappers.

HAZARDS OF INFESTATION

Rats as Disease Carriers

Rats are responsible for the spread of many diseases. Sometimes they transmit the disease directly, by contaminating food with their urine or feces. At other times they transmit disease indirectly; for example, fleas may first bite an infected rat, then a person. Following are some typical diseases associated with rats.

Plague

The "Great Plague" of London killed half of the city's population. The "Black Death" of Europe lasted 50 years in the 14th Century and killed 25 million people. In the first quarter of this century, an estimated 11 million people died in Asia from plague. The disease is transmitted to human beings primarily by the oriental rat flea. The flea bites an infected rat and then, while feeding on people, inoculates them with the bacteria that cause disease.

Although no major urban outbreak of plague has occurred since 1924, this is not a disease of the past. A reservoir of plague exists in some populations of wild rodents in several western states, and human beings contacting these rodents could contract the disease. As suburbia expands into undeveloped areas, wild rodents can transmit the disease to urban rats. There is a concern that an outbreak of urban plague could occur in the United States.

Rat-Bite Fever

Rats bite thousands of people each year; most bites occur in inner cities. In some cases victims, particularly infants and bed-confined elderly, are bitten in the face while sleeping. Those who are bitten may develop rat-bite fever from the bacteria carried on the teeth and gums of rats. Although the disease is similar to flu, it can be fatal. It is of particular risk to infants.

Salmonella Food Poisoning

Rats frequent sewers, rotting garbage, cesspools, and similar sites where salmonella bacteria thrive. Rats can infest stored food or leave bacteria on dishes, silverware, or food-preparation surfaces, and thus transmit Salmonella food poisoning to people.

Leptospirosis or Weil's disease

This disease is seldom fatal to people. The disease organisms are spread from rat urine to water or food, and affect people through mucous membranes, minute cuts, and abrasions of the skin.

KINDS OF RATS

In the United States, the two typical species of rats are the Norway rat (*Rattus norvegicus)* and the roof rat (*Rattus rattus*). The Norway rat is also called the brown rat, house rat, sewer rat, and wharf rat. The Norway rat is considered the most common in the U.S. and is found in every state. The roof rat, also called the black rat, ship rat, and Alexandrine rat, is found primarily in coastal areas including California, Washington, Oregon, the Southeast and Middle Atlantic States, and the Gulf States.

The two species look similar, but there are noticeable differences. In general:



Norway Rat Climbing A Wall



Norway Rat (*Rattus norvegicus)*

A Norway rat looks sturdier than the roof rat; the roof rat is sleeker.

A mature Norway rat is 25% longer than a roof rat, and weighs twice as much.

A Norway rat's tail is shorter than the length of its head and body combined; a roof rat's tail is longer than its head and body.

A Norway rat's ears are small and covered with short hairs; a roof rat's ears are large and nearly hairless.

A Norway rat's snout is blunt; the roof rat's snout is pointed.

HABITS OF RATS

The knowledge of the life history, habitat, food requirements, patterns of behavior, range, and other factors is essential to the management of rat infestations. Since Norway and roof rats have similar habits, these discussions apply to either species.



Roof Rat *(Rattus rattus)*

Life Cycle

A mature female rat can give birth to about twenty young in a year (four to six at a time), if she lives that long. The average life span of a rat in the field is less than one year, although females live longer than males.



Roof Rat *(Rattus rattus)*

The young are born in a nest. They are hairless, and their eyes and ears are closed. Within two weeks their eyes and ears open, they become furry and rat-like, and they begin exploring the nest area. In the third week they begin to eat solid food, and imitate their mother in foraging, escaping, and watching for danger.

If the mother rat has become wary of rodenticides or traps, many of her young will learn to avoid them. This learning experience can make management difficult in sites where long-term rodent-baiting programs have been unsuccessful in the past.

Young are totally weaned at four or five weeks old, when they weigh about 45.52 g (1 1/2 oz), and at the age of three months, the young are independent of their mother. They will mate and continue the cycle in the same location, or will migrate to a new area.

Social Behavior

Rats live in colonies with well-defined territories that they mark with urine and glandular secretions. The colony has a complex social hierarchy with a dominant male leader and a "pecking order" of subordinate males and ranking females. The strongest and most dominant animals occupy the best nest and resting sites, and feed at their leisure. Weaker, subordinate rats are pushed out to less favorable sites, or forced out of the territory completely.

Rats are aggressive, and social conflicts are most common at feeding sites, prime resting areas, and territorial boundaries. Females fiercely defend their nest and young from other rats.

Rat Senses

<u>Vision, Touch, Taste, Balance</u>

Rats have poor vision. They are nearly color blind, and react to shapes and movement rather than identifying objects by sight. 9.14 – 13.72 m (30 – 45 ft) is the limit of their vision, and their eyes are adapted to dim light. Other senses, however, compensate for poor vision. They use their sensitive noses to locate food, follow pathways, tell whether another rat is friend or foe, and identify new objects in their territory. They use long whiskers and guard hairs to "touch" their way through dark burrows, pipe chases, wall voids, and other runways. Their ears detect faint

sounds that signal danger. Rats can taste certain chemicals at a parts-per-million concentration. This explains why rats often reject baits or avoid traps that have been contaminated with insecticides. Rats have an excellent sense of balance which allows them to walk on wires and always land on their feet in a fall.

Fear of New Objects (Neophobia)

Rats are wary of anything new that appears in their territory. A bait station, a trap, or a block of wood will be avoided for a few days until the rats become familiar with the new object. Even then, they approach cautiously. This fear of new objects can make baiting and trapping difficult. Rats will avoid poison bait when it is first placed. Later, they may nibble warily. If the poison bait makes them ill, but doesn't kill them, they will subsequently avoid similar baits or stations.

Food and Water

Rats need about one ounce of food daily. Norway and roof rats prefer different types of food. Norway rats prefer protein-based foods such as meat, fish, insects, pet food, nuts, and grain. Household garbage is ideal food for Norway rats. Roof rats prefer plant materials such as fruits, nuts, seeds, berries, vegetables, and tree bark. They occasionally feed on garbage and meats. Both rat species will feed on non-preferred food if nothing else is available.

Rats may hide or hoard food in hidden areas. This food may or may not be eaten when other food supplies run short. Hoarding food is important for three reasons. First, rats may be moving toxic bait into areas where perhaps the label does not permit its use. Second, rats may be hoarding poison bait while feeding on their regular food. In this case, a baiting program becomes ineffective. Third, hidden food may become a focal point for insect infestations.

Rats need water every day. The amount varies, depending on the moisture content of their food, but is usually around 14.17 – 28.35 g (1/2 – 1 fl oz). Rats prefer to nest where water is available.

Range

Rats usually begin foraging after dark. Most of their food gathering occurs between dusk and midnight, but short bursts of restlessness and activity can occur anytime, day or night. Rats commonly travel 30.48 – 45.72 m (100 – 150 ft) from their nest looking for food and water and patrolling their territory. It is not unusual for a colony that nests outdoors to forage inside a building 30.48 m (100 ft) away.

Nests

Outdoors, Norway rats usually nest in burrows dug into the ground. The burrows are shallow (less than 45.72 cm [18 in]) and usually short (less than 1 m (3 ft), with a central nest. Extra "bolt holes" are used for emergency escapes. They are hidden under grass or boards or lightly plugged with dirt. Burrow openings are 5.08 – 10.16 cm (2 – 4 in) in diameter. Indoors, Norway rats nest inside walls, in the space between floors and ceilings, underneath equipment, between and under pallets, and in crawlspaces, storage rooms, and any cluttered area that is normally unoccupied. Norways prefer to nest in the lower floors of a building.

Roof rats commonly nest above ground, in trees, particularly untrimmed palm trees, and in piles of wood or debris, vine-covered fences, and stacked lumber. Overgrown landscaping is also a prime nesting area. Roof rats will sometimes nest in burrows if above-ground sites are limited and Norway rats are not nesting in the area. Indoors, roof rats prefer to nest in the upper levels of a building in the attic and ceiling voids, near the roof line. But at times, they also nest in the lower levels of a building.

Both species also nest in sewers and storm drains, and highly unusual nest sites and can have several "hotel" nest sites in an area. A rat may spend a week in its home base and then move for a day or two into a secondary "hotel" nest site. Norway rats have been shown, on occasion, to have a home range of up to twenty acres when these secondary nest sites were included in calculations.

INSPECTION AND MONITORING

There are many signs of a rat infestation which can assist the inspector in identifying where rats are feeding and nesting, their patterns of movement, the size of the population, and the extent of infestation. This helps to influence what management measures to use, where and how to use them, and how much effort is needed to manage the population.

Signs of Rats

An inspection using a powerful flashlight after dark is the best way to see live rats. Dead rats are signs of either a current or past infestation. Dried carcasses and skeletons may indicate an old infestation. Fresh carcasses may indicate a recent poison baiting. If rats are seen during the day, the rat population is probably high.

Sounds

Squeaks and fighting noises in a building, clawing, scrambling, or gnawing sounds in walls may indicate the presence of rats. Use a stethoscope or electronic listening device to help pinpoint such noises.

Droppings

A rat may produce 50 droppings daily. Roof-rat droppings are generally smaller (1.27 cm [1/2 in]) than the Norway rat's (1.90 cm [3/4 in]). The highest number of droppings will be found in locations where rats rest or feed. Determine if a rat population is active by removing old droppings, and then reinspect a few days to a week later for new droppings.

Look at the appearance of droppings to determine if rats are present. Fresh rat droppings are black, glisten and look wet, and have the consistency of putty. After a few days the droppings become dry, hard, and appear dull. After a few weeks, droppings become gray, dusty, and crumble easily. Note that sometimes old droppings moistened by rain may look like new droppings; however, if crushed, they will crumble.

Urine

Both wet and dry urine stains will glow blue-white under an ultraviolet light (black light). Use portable ultraviolet light, as used in the food industry, to identify rat urine on food and other items. Other substances besides rat urine also glow, which can be confusing, so proper use of this inspection method takes practice.

Grease Marks

Oil and dirt rub off of a rat's coat as it runs along walls. Grease marks build up in frequented runways. Look for grease marks along wall and floor junctions, and at pipes, ceiling joists, and sill plates, where rats swing around obstacles. Grease marks are also found at regularly used openings in walls, floors, and ceilings. Fresh grease marks along baseboards are waxy.

Runways

Outdoors, rats constantly travel the same route. Their runways appear as beaten paths on the ground. Look for such paths next to walls, along fences, and under bushes and buildings. Indoor runways of rats may appear as well-polished trails which are free of dust.

Tracks

A rat's footprint is about 1.90 cm (3/4 in) long, and may show four or five toes. Rats may also leave a "tail drag" line in the middle of their tracks. Look in dust or soft moist soil. Place a tracking patch in suspected rat areas to show footprints. A tracking patch is a light dusting of an inert material such as clay, talc (unscented baby powder), or powdered limestone. Don't use flour, which may attract insect pests. A good patch size is 30.48 x 10.16 cm (12 x 4 in). Apply patches in suspected runways and near grease marks. When inspecting tracking patches, shine a flashlight at an angle that causes the tracks to cast a distinct shadow. Note that a tracking patch is not the same as a toxic tracking powder. Tracking powders are diluted rodenticides in dust form. Tracking patches use nontoxic dust. Do not use a toxic tracking powder to make a tracking patch.

Gnawing Damage

A rat's incisor teeth grow at a rate of about 12.70 cm (5 in) per year. Rats keep their teeth worn down by continuously working them against each other and by gnawing on hard surfaces. Look for gnawing damage on floor joists, ceiling joists, door corners, kitchen cabinets, and around pipes in floors and walls as evidence of rat infestation. Gnawed holes may be 5.08 cm (2 in) or more in diameter.

Nest Sites

Roof rats often nest or store food in the attics of buildings. Their nests may also be found in trimmed dense vegetation.

Burrows

Outdoors, rat burrows may be found singly or in groups along foundation walls, under slabs and dumpster pads, in overgrown weedy areas, beneath debris, and in embankments. Look for a burrow opening that is free of dirt, leaves, and debris. The openings may be covered with smooth, hard-packed soil. Look for rub marks at the opening, and soil pushed out in a fan-shaped pattern.

Fill the opening with a small amount of wadded-up newspaper or a few leaves and cover it with loose soil. Or, just kick in the open entrance to close it. If the rats are still using the burrow, they will reopen and clear the hole overnight. This is a good monitoring method to identify active burrows.

Pet Excitement

Cats and dogs may excitedly probe an area of floor or wall where rats are present, especially if the rats have recently invaded.

Odor

Heavy infestations have a distinctive odor which can be identified with practice. The odor of rats can be distinguished from the odor of mice.

Estimating Rat Numbers

It's not easy to tell how many rats are infesting a site. Rat signs, however, may categorize the population as low, medium, or high. In rat-free or low infestation conditions, no signs are seen. In the case of medium infestation, old droppings and gnawing can be observed and one or more rats are seen at night. No rats are seen during the day. When there is a high infestation, fresh droppings, tracks, and gnawings are common. Three or more rats are seen at night, and rats may be seen in the daytime as well.

MANAGEMENT

Most successful rat management programs use a combination of tools and procedures to reduce and eliminate a rat population. The methods combine habitat alteration and population reduction. Some of the tools, such as trapping, are lethal to the rat. Some tools are not. Rat-proofing by making building repairs or increasing the frequency of garbage pickup are examples of non-lethal management methods.

Sanitation

Rats may ignore bait since it can't compete with the rats' regular food. Reducing rats’ normal food supply encourages them to move to some other territory. This can be accomplished by closing or repairing open or damaged dumpsters and garbage containers, cleaning up food spills promptly, and not allowing food to be left out overnight.

Eliminate Hiding Places

Outdoors, remove plant ground covers such as ivy to .91 m (3 ft) from buildings. Remove high grass, weeds, wood piles, and construction debris that permit rats to live and hide adjacent to a building. Indoors, eliminate clutter in buildings and rarely-used rooms, basements, storage rooms, equipment rooms. Organize storage areas to remove clutter.

Rat-Proofing (exclusion)

The most successful long-term form of rat management is to build them out. Rat-proofing is an exclusion technique that makes it impossible for rats to get into a building.

Building Exterior

Seal cracks and holes in building foundations and exterior walls. Block openings around water and sewer pipes, electric lines, air vents, and telephone wires. Install 1/4 in. steel wire screen or hardware cloth on ventilation openings. Caulk and seal doors with door sweeps to ensure a tight fit, especially between door and floor threshold. Fit windows and screens tightly. Caulk and close openings on upper floors and the roof. Inspect under siding and repair damaged soffits. Repair breaks in the foundation below ground level.

Building Interior

Seal spaces inside hollow block voids or behind wallboard. Repair broken blocks and holes around pipes. Repair holes or stuff them with copper Stuf-Fit. Cover floor drains with sturdy metal grates secured firmly in place.

Trapping

Trapping for rodents is a widely used, low-risk method of rodent management. Trapping offers great usefulness and versatility in the form of snap or guillotine traps where toxicants cannot or should not be used. The snap trap is an effective method of killing rats when used correctly, and is advised for use inside structures. It has several advantages: there is less non target risk than from a toxicant bait; the pest manager knows instantly whether or not the trap has been successful; and trapping allows disposal of the carcass to eliminate hidden odor problems. Carcass disposal also eliminates the possibility of secondary infestation by blowflies and dermestid beetles that would feed on it. Traps should be strategically placed in sufficient number, otherwise rats will avoid them. Place bait on the unset trap for a few days until the bait is taken, then bait and set the trap.

Physical Condition of Traps

A trap physically incapable of holding a rodent should never be set out. Staples holding the spring should be firm; the trap jaw should be square and fit inside the trap base. The trigger mechanism should operate smoothly at the slightest touch. Use properly sized traps for the species to be managed: mousetraps for mice; rat traps for roof and Norway rats. The trap base should not be warped or the trap will rock when stepped on. If necessary, working parts should be lightly oiled with mineral or other inorganic oil, not machine oil. Traps should be kept away

from pesticides or other strong odors that might be repellent to the rodents. Don't clean a trap bloodied by a catch, since the odors enhance its acceptance. A shiny new trap increases the possibility of rejection in response to the "new object avoidance" instinct. For some situations, the best traps are those with enlarged bait pans (triggers) set for a light touch.

Enlarged Bait Pans

Some traps may need enlarged bait pans. Commercial traps with expanded bait pans are available, but the old style traps can easily be adapted with wire screen or light metal cut from metal cans or hardware cloth. The enlarged bait pan should be trimmed so that it is .63 cm (1/4 in) smaller than the trap jaw wire and securely fastened to the standard bait pan.

Placement of Traps

Traps with enlarged bait pans, if properly placed in runways, do not need to be baited, but baiting adds to their effectiveness. Smear peanut butter in the center of the bait pan, sprinkle oats lightly across the pan, or tie a nutmeat or dried fruit piece to the center of the pan. Meat, like sausage, bacon, or peanut butter is attractive to Norway rats, while fresh or dried fruit will draw roof rats. Cotton balls also are attractive to females of both rat species. Traps must be placed in the rodents' regular active runways, as indicated by the presence of feces, smears, or tracks.

Place light tracking patches of talc or other odorless, innocuous fine-particled material to find where the rodents are most active and place traps there. All traps should be set perpendicular to and across the runway so that the bait pan is in the runway, and against the wall or other vertical surface. Make narrow runways to force the animals to cross over the trap pan. Put traps in concealed places where rodents are more apt to be found rather than in places the trapper can easily reach. Trap the area heavily, every 3.05 – 3.66 m (10 – 12 ft). Map the locations so traps can be more easily recovered later or by someone else if necessary. Move traps to other areas after two weeks (the first area can be retrapped after a lapse of several weeks).

Adhere to good public relations practices, and pick up trapped animals as soon as possible (at least daily). In areas used frequently by the public, use trap stations to cover trapped animals in snap traps. This also protects them from accidental tripping by maintenance personnel. Don't place traps above food or food handling areas or in areas where pets or children can reach, as rat traps can break their small bones.

Leaving the traps unset for a few days may increase the catch by reducing the chance that wary rats will trip the traps without capture. Set traps with bait, if food for rats is in short supply and without bait if they have enough. When runways are located on rafters and pipes, set expanded trigger traps directly across them, fastening them securely to pipes with wire or hose clamps, and to rafters with nails. Use enough traps. Set five or ten traps in an active corner of a space. Set three traps in a row so that a rat, leaping over the first, will be caught in the second or third. If unsure about sites of activity, set traps along possible runways spaced ten to twelve feet apart.

Camouflage traps when only a few rats remain and are difficult to capture. Set traps in a shallow pan of meal, sawdust, or grain. In stubborn cases, expose food in shallow pans until the rats readily feed on it. Then add a buried trap. Inspect traps frequently to remove dead rodents and change old bait.

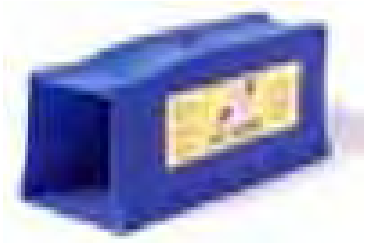


Victor Rat Trap

The Victor Snap Trap is the oldest trap and is still one of the most effective ways to humanely kill rats.

Rat Zapper 2000

The Rat Zapper 2000 is an electronic trap that humanely kills rats and mice. 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 plate, the rodent is given a lethal shock. Empty the trap by turning it upside down, allowing the dead rodent to slide out. A blinking red light alerts you to the dead rodent in the trap. Remote sensing is also available for multiple traps.



Rat Zapper

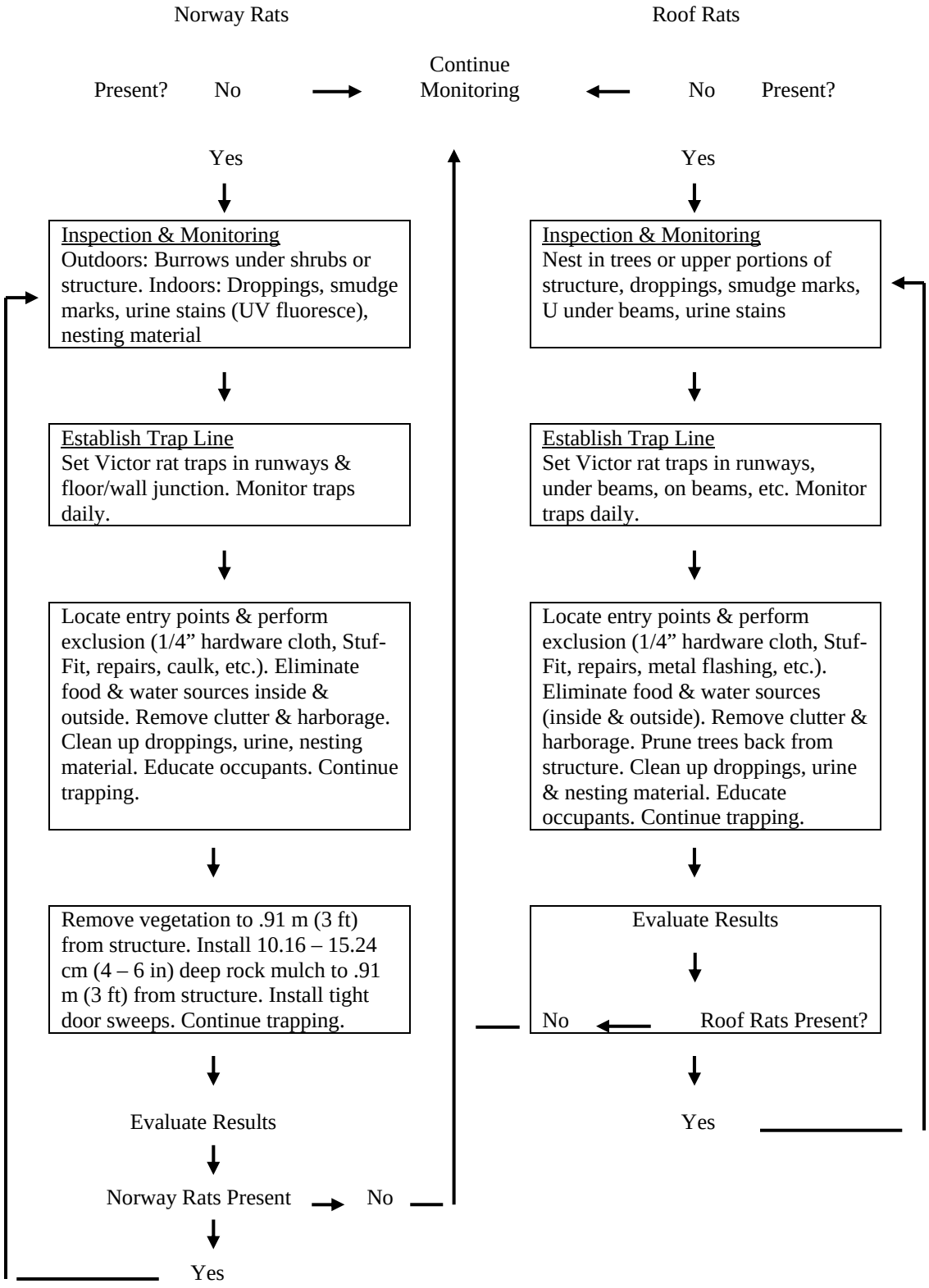
Glue Boards

Glue boards are not humane and must NOT be used on NPS sites.

Rodenticides

A rodenticide is a pesticide designed to kill rodents. Rodenticides are NOT recommended for use in NPS sites or other public areas.

RATS


Norway Rats
Roof Rats
Present?
No
Continue Monitoring
No
Present?
Yes
Yes
Inspection & Monitoring
Outdoors: Burrows under shrubs or structure. Indoors: Droppings, smudge marks, urine stains (UV fluoresce), nesting material
Inspection & Monitoring
Nest in trees or upper portions of structure, droppings, smudge marks, U under beams, urine stains
Establish Trap Line
Set Victor rat traps in runways & floor/wall junction. Monitor traps daily.
Establish Trap Line
Set Victor rat traps in runways, under beams, on beams, etc. Monitor traps daily.
Locate entry points & perform exclusion (1/4" hardware cloth, Stuf-Fit, repairs, caulk, etc.). Eliminate food & water sources inside & outside. Remove clutter & harborage. Clean up droppings, urine, nesting material. Educate occupants. Continue trapping.
Locate entry points & perform exclusion (1/4" hardware cloth, Stuf-Fit, repairs, metal flashing, etc.). Eliminate food & water sources (inside & outside). Remove clutter & harborage. Prune trees back from structure. Clean up droppings, urine & nesting material. Educate occupants. Continue trapping.
Remove vegetation to .91 m (3 ft) from structure. Install 10.16 – 15.24 cm (4 – 6 in) deep rock mulch to .91 m (3 ft) from structure. Install tight door sweeps. Continue trapping.
Evaluate Results
No
Roof Rats Present?
Evaluate Results
Yes
Norway Rats Present
No
Yes

EASTERN GREY SQUIRREL *Sciurus carolinensis*



Grey Squirrel

Eastern grey squirrels commonly occur in two color phases, grey and black, which leads people to think that there are two different species. Its most notable physical feature is its large bushy tail, which has important functions. It acts as a rudder when the animal jumps from high places, as a warm covering during the winter, as a signal to other eastern grey squirrels indicating an individual's mood, and perhaps as a sunshade. The tail can also be used to distract a pursuing predator.

The tracks of eastern grey squirrels are distinctive; forefeet leave a round print about 2.5 cm (1 in) long; the hindprints are more triangular, approximately 6 cm (2 in) long.

The eastern grey squirrel has two breeding seasons each year, the first in January and February and the second in June and July. Each of the mating periods lasts for about three weeks. Generally, only females over two years of age will breed in both seasons. Gestation takes 40 – 44 days. An average of three young are born, although the litter size may range from one to six.

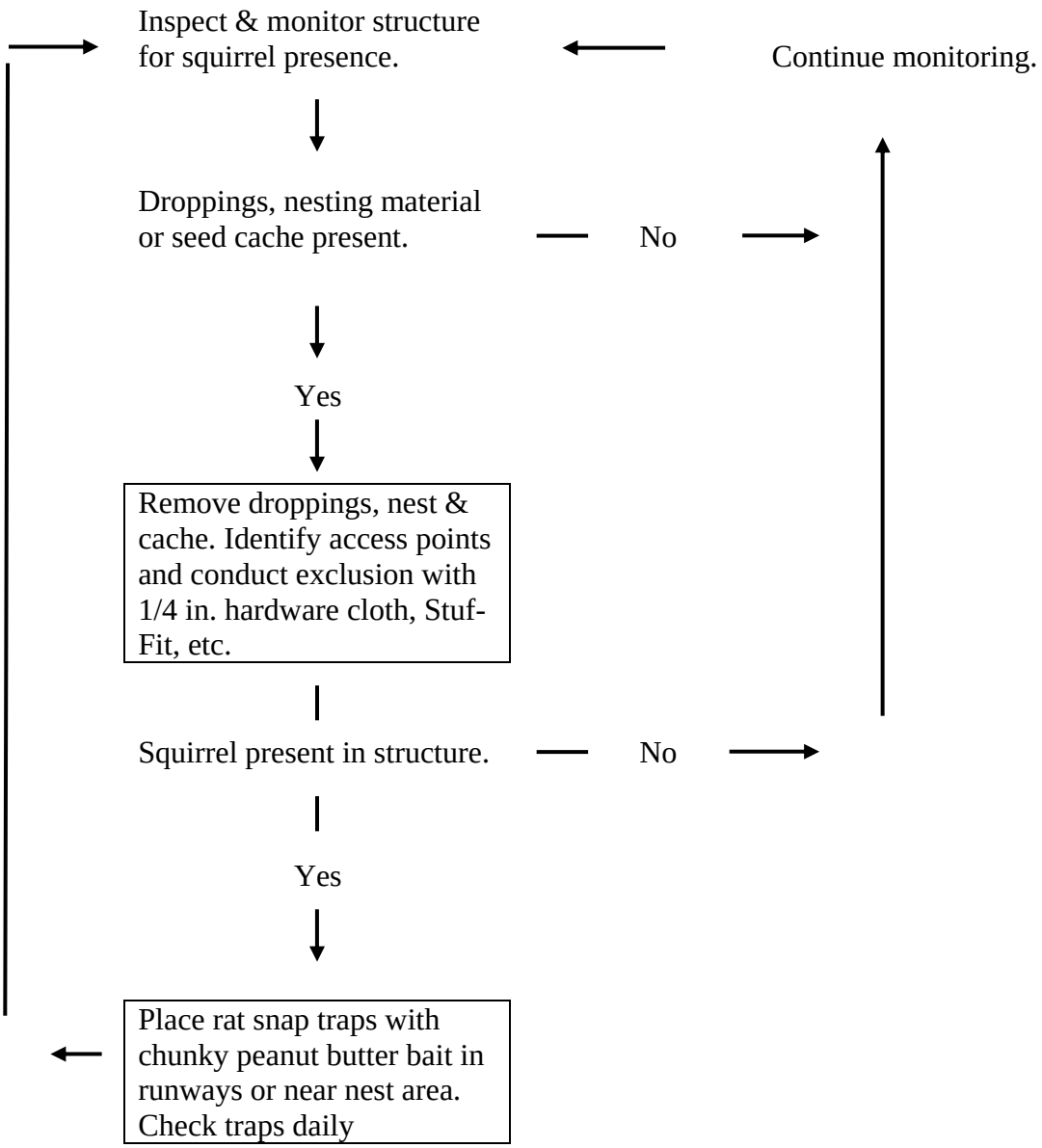
Squirrels build nests near the tops of large pine, hemlock, maple, birch and oak trees where they are lodged in a large crotch or on a limb near the trunk. Mosses, grasses and shredded bark line the nest, occasionally along with cloth, paper, vegetation and bird feathers.

The newborn young weigh about 15 g (1/2 oz), mature quickly and at about 12 weeks, the young

will be almost adult size and independent. The males reach sexual maturity at 15-18 months and the females at 11 months. The average lifespan is normally less than six years.

Grey squirrels can become a nuisance when they invade an attic, cause damage around the house, dig up bulbs in gardens or drive birds away from feeders. Prevent squirrels from climbing trees or poles by encircling them with a .61 m (2 ft) wide collar of metal 1.82 m (6 ft) off the ground. Overlap the metal collar to allow for tree growth. Trim trees back from structures to prevent squirrels from jumping onto them. Prevent squirrels from traveling on wires by installing a 1.82 m (2 ft) section of lightweight 6 – 7.62 cm (2 – 3 in) plastic pipe (slit pipe lengthwise to spread it open and place it over the wire). Close all openings into the structure with sheet metal or 1/4 in. hardware cloth to prevent squirrel access. If squirrels have gained access to the interior of a structure, rat traps baited with chunky style peanut butter are effective. Check traps daily to remove captured squirrels and reset traps.

GREY SQUIRREL



BIG BROWN BAT



Big Brown Bat *(Eptesicus fuscus)*

Big brown bat, *Eptesicus fuscus* (Beauvois) is not a pest, and is actually beneficial to the Park, except for roosting in the attics. Adult big brown bats are about 10.16 – 12.70 cm (4 – 5 in) long including the tail, with a wingspread of 30.5 – 36 cm (12 – 14 in), and they weigh 11 – 17 gr (2/5 – 3/5 oz). They are found throughout southern Canada and the United States (except southern Florida). These bats usually give birth to two young during April to July. The big brown bat females form nursery colonies in structures in the spring (the males roost elsewhere). Later in the summer, the two sexes roost together. They commonly roost in attics, behind shutters and loose boards in buildings. They usually feed near the ground on beetles, wasps, ants, planthoppers, leafhoppers, flies, moths, etc. The big brown bat commonly hibernates in structures, caves, mines or rock crevices from December to April.

Winter exclusion efforts are not suggested if big brown bats are hibernating in the Park attics. Summer exclusion can be accomplished when the young are flying after mid-August. Seal all exit/entry points except one or two, and all holes .64 cm (1/4 in) or larger. After a few days to a week when bats are used to only the two exit points, install bat check valves (which allow bats to exit but not return) or seal exits after bats have left for foraging. Providing a proper bat house before the exclusion will allow the bats to remain in the area to feed on flying insects.

LITTLE BROWN BAT

Little brown bat, *Myotis lucifugus* (LeConte), is actually a benefit to the Park except for roosting in attics. Adults are about 7.92 – 9.19 cm (3 1/8 – 3 5/8 in) long, including the tail, with a wingspread of 22 – 27 cm (8 11/16 – 10 5/8 in). They weigh .3.4 – 14 gr (1/8 – 1/2 oz). Little brown bats are found from middle Alaska through southern Canada, and in the United States except Florida, Texas and southern California.

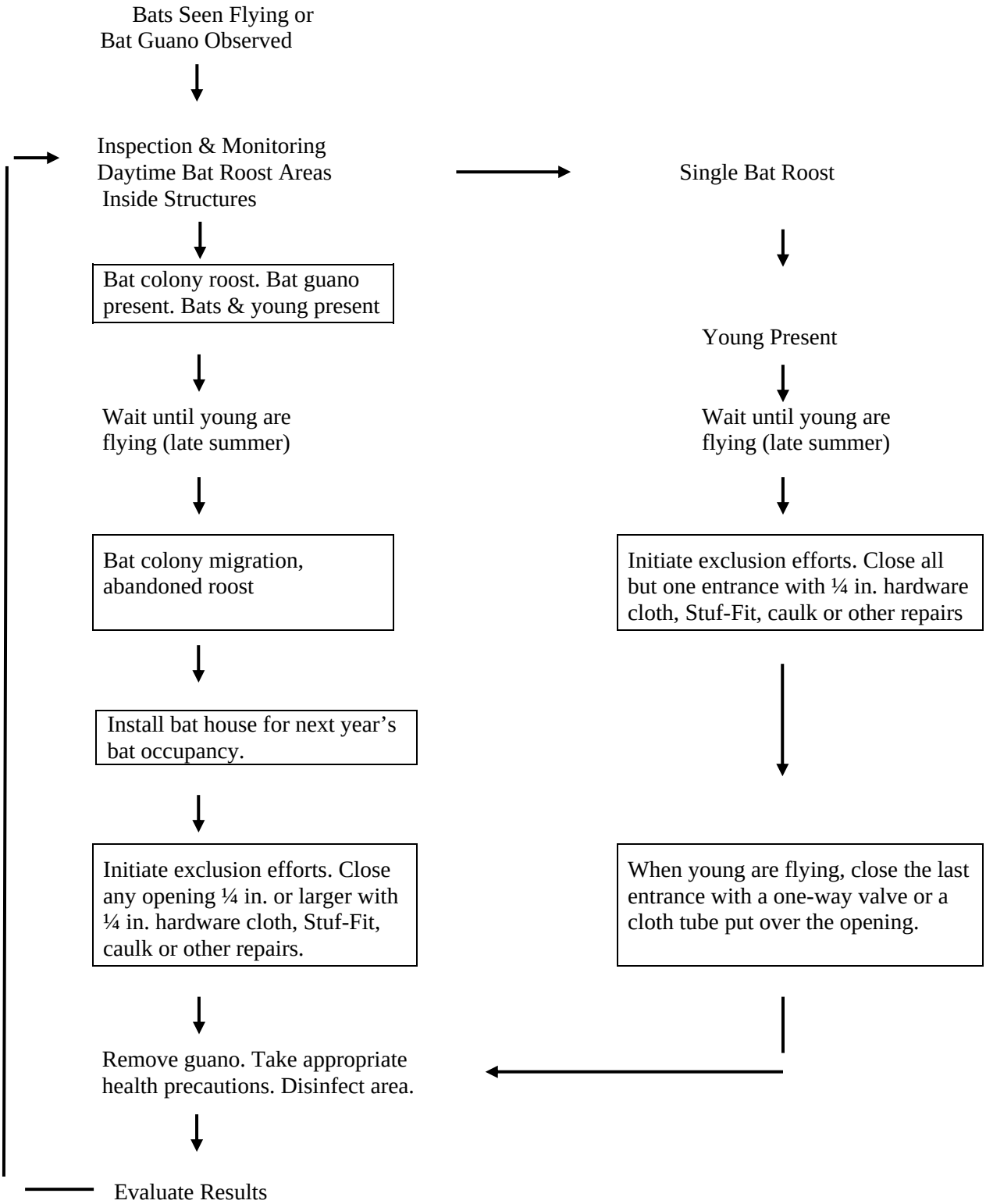


Little Brown Bat *(Myotis lucifugus)*

Little brown bats form nursery colonies in the spring. They feed on flying insects, especially flies and moths. They alternate feeding flights with rest periods to digest the catch. In the north, most little brown bats will migrate south where they hibernate from September/October through March/April in mines and caves in the eastern U.S.

If bats have left the attics of the Park structures in winter (and there are no big brown bats hibernating there), thorough exclusion of the attics at the Park can be accomplished. Otherwise, after mid-August when young are flying, close all exit/entry holes (over .64 cm [1/4 in]) except two exits. When bats have adjusted to those two exits, install bat valves or seal the last two holes after all bats have left for evening foraging. Providing a proper bat house before the exclusion will allow the bats to remain in the area to feed on flying insects.

BATS


Bats Seen Flying or
Bat Guano Observed
Inspection & Monitoring
Daytime Bat Roost Areas
Inside Structures
Single Bat Roost
Bat colony roost. Bat guano present. Bats & young present
Young Present
Wait until young are flying (late summer)
Wait until young are flying (late summer)
Bat colony migration, abandoned roost
Initiate exclusion efforts. Close all but one entrance with ¼ in. hardware cloth, Stuf-Fit, caulk or other repairs
Install bat house for next year's bat occupancy.
Initiate exclusion efforts. Close any opening ¼ in. or larger with ¼ in. hardware cloth, Stuf-Fit, caulk or other repairs.
When young are flying, close the last entrance with a one-way valve or a cloth tube put over the opening.
Remove guano. Take appropriate health precautions. Disinfect area.
Evaluate Results

BIRDS

INTRODUCTION

Birds provide enjoyment and recreation, enhancing the quality of life for those who view, enjoy, study, photograph, or hunt them. Over ten million people enjoy bird-watching as a recreational activity. For this reason, birds are protected by laws, regulations, and public opinion. However, birds can become pests when they create health hazards, roost on buildings, contaminate food, or create a nuisance. Pigeons and other birds, for example, cause human health problems when roosting in large numbers, and their droppings can foul buildings and walkways. Whether birds are seen as beneficial or harmful depends on time, location, and activity.

CHARACTERISTICS AND RECOGNITION

Pigeons (Worldwide)

The domestic pigeon, *Columba livia*, developed from the rock doves of Europe and Asia where they nested in caves, holes, and under overhanging rocks on cliffs. They have adapted to window ledges, roofs, eaves, steeples, and other portions of structures.



Pigeon *Columba livia*

Habits of Pigeons

Primarily seed or grain eaters, in urban areas pigeons feed on garbage, spilled grains, insects, food left by outdoor diners and food provided by bird lovers. Pigeons commonly feed, roost, and loaf together when ever possible. Feeding, roosting, and loafing sites are usually separate areas. Roosting sites are used for nesting, congregating at night, and shelter in bad weather. Loafing sites will be close to the roosting sites used by inactive birds during the day. Feeding sites may be several miles away from the nesting location. When pigeons are not feeding or mating, most of their day is spent cooing, preening, and sun bathing. Sun bathing is most common in the morning of cool days.

Pigeons prefer flat, smooth surfaces on which to feed, roost and nest.

Male pigeons are sexually mature at three to four months old, females at six months. After pairing and mating, a nest is built by the mated pair. Nests are usually located in protected openings in or on buildings.

One or two eggs are laid eight to 12 days after mating and are incubated for 18 days before hatching. Young pigeons are full grown in less than a month, and are fledged at 37 days.

Pigeons mate year around and live from three to 15 years. Fecal material from pigeons is very acidic and may damage structures. Pigeon nests harbor mites, clothes moths, dermestid beetles,

and other insects that feed on the feces, feathers and other organic material. When the nest is abandoned by the birds, these nest inhabitants may find their way into the structure in search of food and habitat.

Starlings

European starlings *(Sturnus vulgaris L.)* were introduced into the United States in 1890 and rapidly expanded throughout North America.

Habits of Starlings

Starlings nest in holes or cavities, and on buildings and other structures. Starlings average two broods per year with four to seven young per brood. Both parents build the nest, incubate the eggs, and feed the young. The young birds leave the nest at about three weeks old.

Starlings form large flocks and migrate to cities as weather cools, forming large roost sites.



Starling *Sturnus vulgaris L.*

Droppings damage buildings and build up to such levels that they become a human health hazard. Starlings have been responsible for outbreaks of a number of diseases.

House Sparrows (Worldwide)



House Sparrow Male & Female, *Passer domesticus (Linnaeus)*

The house sparrow *(Passer domesticus)*, also called the English sparrow, was introduced into the United States in the 1850's, and has spread throughout the continental United States except in heavy forests, mountains and deserts. It prefers human-altered habitats in cities and around farm buildings and houses.

The house sparrow is a brown, chunky bird 12.70 – 15.24 cm (5 – 6 in) long. The male has a distinctive black bib, white cheeks, a chestnut mantle around a gray crown, and chestnut upper wing covers. The female and young birds have a gray breast, buffy eye stripe, and a streaked back.

Habits of House Sparrows

House sparrows average three broods per season with four to seven eggs per brood. Breeding can occur in any month, though it is most common from March through August. Eggs are incubated for about two weeks, and the young stay in the nest another two weeks.

Nests are bulky and roofed over, and located in trees and shrubs, on building ledges, in signs, on light fixtures, and under bridges.

Sparrows are aggressive social birds, often out-competing native species. They have no recognized migration patterns, and will stay in an area as long as food and nest sites are available. Young birds, however, move out of an area to establish new territories. Sparrows are tolerant of human activity, a.nd will not hesitate to set up housekeeping in high traffic areas. House sparrows prefer to feed on grain. They will also feed on fruits, seeds, and garbage.

House sparrows can be pests in many situations. Droppings and feathers make unsanitary and smelly wastes. Sparrows can also become a pest when they nest inside a structure. The birds cause damage by pecking at rigid foam insulation in buildings. Sparrows transmit a number of diseases, internal parasites, and ectoparasites. They are thought to be a major reservoir of St. Louis Encephalitis.

HAZARDS OF INFESTATION

Large populations of roosting birds may present risks of disease to people nearby. The most serious health risks are from disease organisms growing in accumulations of bird droppings, feathers, and debris under a roost. If conditions are right, particularly if roosts have been active for years, disease organisms can grow in these rich nutrients. Birds may contaminate food. When parasite-infested birds leave roosts or nests, their parasites may invade buildings and can bite, irritate, or infest people.

Histoplasmosis

This systemic fungal disease (mold) is transmitted to humans by airborne spores from soil contaminated by pigeon and starling droppings (as well as from the droppings of other birds and bats). The soil under a roost usually has to have been enriched by droppings for three years or more for the disease organism (*Histoplasma capsulatum*) to increase to significant levels. Although almost always associated with soil, the fungus, in rare instances, has been found in droppings alone, such as in an attic. Infection is by inhalation of the spores carried by wind, particularly after a roost has been disturbed.

Most infections are mild and produce either no symptoms or a minor flu-like illness. The disease can, on occasion, lead to high fever, blood abnormalities, pneumonia, and even death.

The National Eye Institute (NEI) at National Institutes of Health has reported a potentially blinding eye condition, called ocular histoplasmosis syndrome (OHS). OHS results from infection by *Histoplasma capsulatum.* In this condition, the central part of the retina (the macula, used in straight-ahead vision) becomes inflamed and is damaged as blood vessels grow inside the affected area.

Cryptococcosis

Pigeon droppings appear to be the most important source of the disease fungus, *Cryptococcus neoformans*, in the environment. The fungus is typically found in accumulations of droppings in attics, on ledges, and on other roosting and nesting sites on buildings.

The disease is acquired by inhaling the yeast-like vegetative cells (two to three microns) of the organism. There are two forms of Cryptococcosis that may infect humans. Acne-like skin eruptions or ulcers characterize the cutaneous form with nodules just under the skin. The generalized form begins with a lung infection, and spreads to other areas of the body, particularly the central nervous system. It can be fatal. Like Histoplasmosis, outbreaks of this disease often occur after building renovation, roost clean-up, or other actions that disturb the old droppings.

Other diseases carried or transmitted by birds affect people to a lesser degree. Psittacosis, pigeon Ornithosis and Toxoplasmosis are normally mild in human beings, although serious illness or death can occur in rare cases. Pigeons, sparrows and many other species of birds have also been implicated in outbreaks of encephalitis.

Ectoparasites

Pigeons, starlings, and house sparrows harbor ectoparasites that can invade buildings. Some of these parasites can bite and irritate occupants. A long list of mites infest pigeons, but the northern fowl mite and chicken mite are usually the main culprits. These pests generally invade buildings from nesting and roosting sites. Other pigeon ectoparasites that may cause problems inside buildings are the pigeon nest bug (a type of bed bug), various species of biting lice, the pigeon tick, and the pigeon fly.

Droppings, feathers, food, and dead birds under a roosting or loafing area can also breed flies, dermestid beetles and other insects that may become major problems in the immediate area. These pests may fly or walk into windows, ventilators, cracks and crevices, and find other means to enter buildings. Structures that house museum specimens and historic artifacts can be invaded by dermestid beetle larvae that leave nesting and roosting sites.

Defacement and Damage to Structures and Equipment

Bird droppings under window sills, "whitewashing" down a building face, or accumulating on sidewalks and steps are the most obvious problems associated with roosts. Clean-up can be labor-intensive and expensive, particularly on high-rise buildings. Bird droppings are corrosive and will damage automobile finishes, metal trim, electrical equipment, and machinery. Down spouts and vents on buildings also become blocked by droppings, nest materials, and feathers. This accumulation of debris can attract insect pests such as dermestid beetles, spider beetles, and mealworms.

Legal Considerations

With very few exceptions, all birds are protected by one or more federal laws and regulations. Although pigeons, starlings, and house sparrows are considered pest birds and are not directly protected at the federal level, toxicants or repellents should be applied according to the product label and under the restrictions that apply under the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA).

Non-target birds in the treatment area are protected, and any actions that kill or damage protected birds or their habitats would be a violation of various federal and state regulations. State and local regulations may require permits or restrict the actions taken against pest birds.

When in doubt, contact your State Natural Resources Agency or the United States Fish and Wildlife Service District office in your area for further information.

INSPECTION AND MONITORING

The first step in managing birds is to conduct a detailed and accurate bird survey. Surveys should be conducted early in the morning, midday, and again in the evening to correspond to the different activity periods of birds. The survey should not be limited to information about pest birds; non-target bird activity is just as important in order to minimize risk to these birds. The surveyor should investigate:

- What birds are present?
- How many birds are present?
- Are they residents, migrants, adults, juveniles?
- Are they nesting, feeding, roosting, loafing?
- Where do they eat and drink?
- What is attracting them to the various sites?
- Are the birds causing a health risk?
- Are the birds causing physical damage?
- If dispersed, where would they go?
- Is risk involved to non-targets?
- What are the legal considerations?
- Could there be public relations problems?
- Is exclusion or habitat modification practical?

MANAGEMENT

Habitat Modification

Habitat modification for birds means limiting a bird's food, water, or shelter. Attempting to limit the food or water of pigeons, starlings, and house sparrows may be difficult. Elimination of food and water to local bird populations must be accomplished at sensitive sites. These birds will have a number of feeding and watering sites, often far from roosting and loafing sites. Where

people are feeding birds in parks or lunch areas, education can help reduce this source of food. In some cases, people may pay little attention to requests to stop.

The most successful kind of habitat modification is to exclude the birds from their roosting and loafing sites (addressed in the section on exclusion).

Pigeons may be induced to move from an infested site by the persistent destruction of nests and eggs. However, nest destruction is ineffective against sparrows and starlings.

High-pressure streams of water spray are the most cost effective method of nest destruction. It destroys the nest, eliminates ectoparasites, cleans droppings and feathers from the nest site, and harasses the roosting birds. Use high-pressure sprays only where the water will not damage buildings or equipment. Remove all droppings and nest materials from the area.

When spraying is not safe, use a hook fastened to a long pole to the remove nests. When the nests are within 6.1 m (20 ft) of occupied sites, treat the immediate nest area with an insecticide/ acaracide to eliminate ectoparasites.

Destroy nests every two weeks during the spring and summer months until the birds move to other nest sites. Nest destruction by any means is not allowed while young are in the nest.

Exclusion

Some building designs and conditions lend themselves to bird infestation. Flat ledges, openings in water towers and vents, unscreened windows, and other attributes make a building an attractive location for roosting, nesting, and loafing. Modification or repair can exclude birds. Typical solutions include replacing broken windows, adding screens, repairing damaged eaves or ventilation screens, eliminating large crevices, and blocking openings into vents, cooling towers, and roof-top equipment with hardware cloth or similar material.

Exclusion methods also include the use of netting, custom-designed sheet-metal or plastic covers, porcupine wire (Bird Barrier products, for example), electrified wires, and sticky repellents to keep birds from roosting on ledges, roof edges, window sills, building signs, and other surfaces favored by pest birds. Modifying flat ledges by the addition of a 45° angle plastic or metal device eliminates the site for roosting or nesting by birds, and is the most effective approach. Two advantages are that the birds are not killed and the management is comparatively long-lasting.

Netting

Netting is used to block access of birds to large roosting areas in structures. Netting is especially useful in warehouses and around mechanical equipment areas where aesthetics are of minor consideration. It has been used successfully on cooling towers.

Plastic nets are alternatives to metal and fiber nets in bird management. Plastic nets are normally extruded black polypropylene and are made with an ultraviolet inhibitor to reduce UV

degradation. Knotted nets are also available. Nets will last from two to five years depending on exposure to sunlight. Use the best quality affordable.

Covers or Ramps

Custom-designed covers for ledges, window air conditioning units, and roof edges are the best technical solution to keep birds from infesting these sites. The cost of this method may deter you from exercising this option on large buildings that have extensive roosting sites. But covers are valid options where limited applications will keep birds off selected sites, and where aesthetics are an important consideration.

The covers usually consist of sheet metal installed at a 45° angle to prevent the birds from landing. Sometimes plastic inserts are custom-fit into the indentations in order to block off ledges.

Plastic or metal 45° angle inserts are now available commercially. These devices become almost invisible when properly installed.

Spikes

Porcupine wire, sharp metal spikes, or any similar "bed of nails" can deter birds from roosting on ledges. Where they can be used, they usually work fairly well. If aesthetics are important, these devices are usually limited to areas where they cannot be easily seen.

If pigeons are likely to drop nest material and other debris on top of the newly installed spikes in an attempt to create a new roosting surface, install metal spikes on potential landing sites above the installation.

Check metal spikes every six months for accumulated debris or nest material. Advise occupants to regularly remove falling leaves and other matter that can cover the spikes and reduce their effectiveness. Prune to ensure that no tree branches hang over protected ledges.

Sticky Repellents

Sticky repellents are tacky gels or liquids. The products are designed to be sticky enough to make a bird uncomfortable, but not so sticky that the birds are trapped. After a few attempts, the birds stop trying to land on treated surfaces. The active ingredient is polybutene or isopolybutene (the same substances used in some adhesive bandages) or petroleum naphthenic oils.

Before applying sticky repellents, clean ledges that are covered by bird droppings, feathers, and nest material with a wire brush, paint scraper, high pressure hoses, or by steam cleaning. Ensure that surfaces are clean and dry.

Seal concrete, unpainted wood, or brownstone with silicone or other sealant, paint, or shellac before applying repellent. Sticky repellents will be absorbed into porous materials.

Use a caulking gun to apply repellent. The depth of the bead necessary to repel different species of pest birds is roughly as follows: crows and sea gulls .95 cm (3/8 in); pigeons .63 cm (1/4 in);

starlings .3 cm (1/8 in); sparrows .15 cm (1/16 in). The pattern of application will depend on the site and personal preference. The caulking gun should be held at an angle of 30-45°.

Place breaks in the bead every few feet to avoid trapping rainwater against the building.

Environmental conditions, particularly dust, make a big difference in the effective life of sticky repellents. In an area with no dust, applications should be expected to remain effective for a year or more.

Precautions should be followed when sticky repellents are used. Be sure migratory or other non-target birds are not harmed. Do not place sticky repellant material where it will become unsightly over time.

The disadvantages of sticky bird repellants are so great that they are not recommended for use in school sites or other urban areas.

Spike, glues and other deterrents become ineffective over time and are unsightly.

Remove Nests

Check state and local regulations that may prohibit destroying or disturbing nests containing eggs or young.

Ultrasonic Sound Devices

Tests by university, government, and private independent researchers have failed to demonstrate any efficacy against birds by any of the ultrasonic devices tested. These devices do not work against most birds.

Trapping

In many instances, trapping can be an effective supplemental measure. Trapping is especially effective against pigeons. Where a group of birds are roosting or feeding in a confined and isolated area, trapping could be considered a useful tactic.

The best time to trap pigeons is in the winter when their natural food is at a minimum. There are many pigeon traps to choose from; which type and size is best is a matter of choice. Most pigeon trapping programs use large walk-in traps. These can be 1.22 – 1.83 m (4 – 6 ft) high and designed to be disassembled and moved. Another common type is a low-profile bob-trap that is about 20.32 cm – .61 m (8 in – 2 ft) high. The door or entrance through which pigeons are lured is the principle feature of a trap.

Set traps in inconspicuous places where pigeons commonly roost or feed and where traps are not likely to be vandalized (a major risk in trapping programs). Trap placement is important, and moving an inactive trap just 3.05 – 4.57 m (10 – 15 ft) may significantly improve catches.

Feeding areas are the best trap sites, but are rarely on the same property as the roosting sites. Rooftops that have water from cooling towers or air conditioning units are often good trapping sites in summer. The most difficult part of trapping is motivating birds to feed in a nonfeeding

area so that they will follow the bait into the trap. Whole corn or sorghum are generally the best baits but wheat, milo, oat groats, millet, popcorn, sunflower seeds, peas, greens, bread, or peanuts can be very effective if the birds are feeding on similar food. Once a few birds have been trapped, putting different foods in for the birds can show which bait they prefer.

In the first few weeks of a program, scatter small quantities of bait throughout the area to start the birds feeding and determine the best trap sites. Some specialists leave traps propped open for the first few days to allow the birds to get used to them. When they calmly enter the trap, set it. Put water (a "chick font" is ideal) and bait inside and just a handful or so outside the trap. Leave one or two "decoy" birds in the trap to draw in other birds. Light-colored birds make better decoys than drab ones.

Remove trapped birds regularly (except for decoys), otherwise other pigeons will be frightened by fluttering trapped pigeons in the trap. Since pigeons can fly great distances and find their way home, trap and release is not normally effective. Trapped birds should be humanely destroyed.

Some experts recommend gassing, but many feel it is simpler and more humane to kill the bird by breaking its neck. Local rules may require taking birds to the animal shelter.

Sometimes, indoor roosting sites can be used as a giant trap. Pigeons often use attics, rooftop elevator houses, or empty floors of poorly maintained structures as nest and roost sites. By screening all but one or two entrances these areas can be made into a giant trap. Late in the evening, after a two-week acclimation period, these last entrances can be closed after the pigeons have settled down for the night. The trapped birds can be captured by hand or with butterfly nets.

Sparrow traps come in various sizes and shapes. The sparrow funnel trap is a double funnel that prevents sparrows from escaping after they have traveled through two funnels going for a food bait. Fine cracked corn, millet, wheat, or bread crumbs make good bait. Trap sites should be baited for a few days before you actually begin trapping. Sparrow traps are usually more effective when placed on the ground. Nest box traps attract a sparrow with a potential nest site. Once inside, the bird trips the mechanism, dumping the bird into a collecting bag. This trap also works against starlings, as does the center drop trap. The birds, attracted by food, drop through an opening and cannot escape. However, starlings are not usually good candidates for trapping programs.

<u>Avitrol</u>
AVITROL is a poison bait with flock-alarming properties used to manage different kinds of birds. There are different AVITROL baits for each pest bird species. Within 15 minutes of eating a toxic dose of AVITROL, birds flutter erratically and go into convulsions.

AVITROL should only be used by a professional who specializes in vertebrate animal control measures. Before using Avitrol, the park IPM Coordinator must obtain written approval from the regional IPM Coordinator.

Risks to Non-targets

Most lethal tactics in bird management pose some risk to non-target birds, as well as other animals. All migratory and game birds are considered non-targets, and are protected by various federal, state, and local regulations, as well as by public opinion. Care must be taken to minimize the threat to non-targets or to use tactics that pose the least risk.

First, identify any non-target birds or animals in the area.
Second, use tactics that are least at risk.
Third, modify tactics to minimize risk.
Fourth, monitor operations to be sure that no non-targets are being adversely affected.

Public Relations

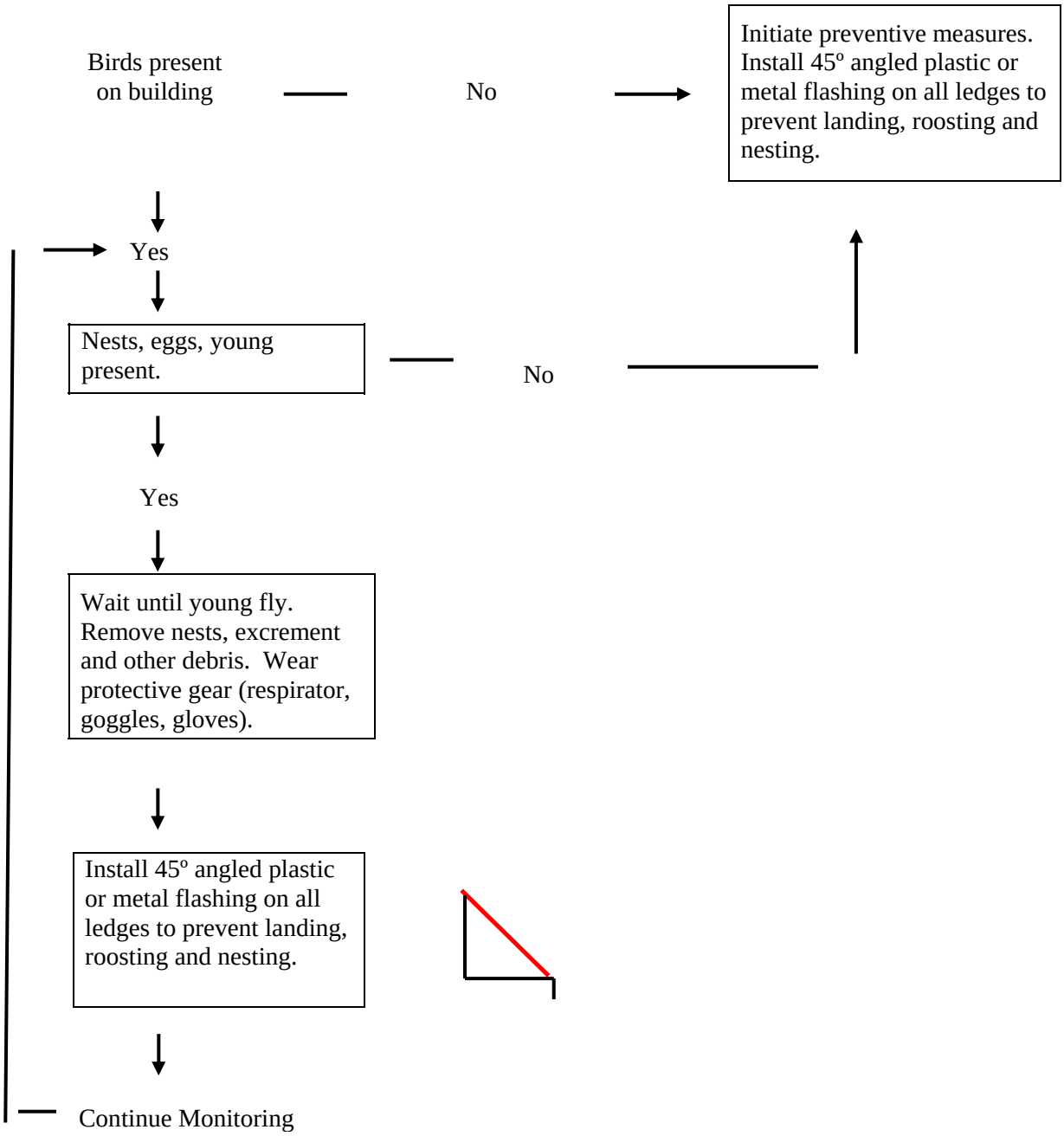
People often react more negatively to one dying bird than to accumulated pigeon droppings on sidewalks or potential risks of parasites and disease from bird roosts. Pigeons and sparrows can be seen as pets rather than pests. The public's perception of bird management operations must be considered. All bird management programs should put some effort into avoiding "people problems," particularly when using AVITROL or other toxic techniques.

BIRD DROPPINGS REMOVAL AND CLEAN-UP

Workers removing large quantities of bird droppings should follow these precautions to minimize risk from disease organisms in the droppings:

- Wear a respirator that is labeled to filter particles down to 0.3 microns.
- Wear disposable protective gloves, hat, coveralls, and boots.
- Wet down the droppings to keep disease spores from becoming airborne, and avoid drying them out.
- Put droppings into sealed plastic garbage bags and wet down the outside of bags.
- Dispose of trash bags. Disposal should be permissible through standard trash pick-up.
- When finished, and while still wearing the respirator, remove the protective clothing and place them in a plastic bag.
- Wash up or shower.

BIRDS


Birds present on building
No
Initiate preventive measures. Install 45º angled plastic or metal flashing on all ledges to prevent landing, roosting and nesting.
Yes
Nests, eggs, young present.
No
Yes
Wait until young fly. Remove nests, excrement and other debris. Wear protective gear (respirator, goggles, gloves).
Install 45º angled plastic or metal flashing on all ledges to prevent landing, roosting and nesting.
Continue Monitoring

PUBLIC HEALTH

PESTS

COCKROACHES

GENERAL

Cockroach infestations are among the most widespread and persistent of all pest problems. The five most common types of cockroaches in urban areas of the United States are: German, brown-banded, American, oriental, and smoky-brown cockroaches. Six additional cockroach species sometimes found in other than buildings include: brown, Australian, Surinam, woods, Asian and Turkistan cockroaches.

Except for size, most cockroaches are relatively similar in overall shape and appearance. They like tight places where their bodies touch surfaces both above and below them. Once inside a building, cockroaches find harborage in cracks, crevices, and voids, and easily move among floors, rooms, and compartments through hollow walls, electrical and plumbing access holes, on conduits and ducts. In dining halls, cockroaches are commonly found under work benches, tables, and counters where spilled food accumulates, behind and under refrigerators, stoves, and other bulky equipment, in serving-line areas, near raw garbage storage, in wall voids, and in hollow legs of equipment and tables.

The most common pest cockroaches inhabiting buildings are nocturnal and remain in the dark whenever possible, only emerging to search for water and food. Large infestations should be suspected when cockroaches are seen in the open or in the light during the day.

Cockroaches are strongly attracted to food and water. Although they can survive many days without food, they must have frequent access to water. Newly hatched cockroaches die in three days without water, and although adult cockroaches may live 20 to 30 days without it, during that time they are unable to reproduce. Because of the wide range of food available to cockroaches, they cannot be starved out of a building; but, good sanitation and cleanliness may prevent cockroach populations from increasing.

HAZARDS OF INFESTATION

Cockroaches affect more people than any other insect. They vomit partly-digested food materials and continually defecate while eating and pose significant health hazards by transmitting diseases (bacillary dysentery, typhoid fever, cholera, polio, amoebic dysentery, urinary-tract infections, diarrhea, and infectious hepatitis). In some parts of the country, even human allergy is attributed to cockroaches.

Cockroaches are scavengers that live on food waste and are attracted to human foods, particularly bakery products, cereals, meat, and cheese, which they contaminate since they also feed on dead animals and animal feces. Cockroaches also feed on or damage items like leather, wallpaper paste, book bindings, soiled clothing, artwork, books, legal documents, postage stamps, draperies and banknotes. Cockroaches are attracted to electrical switches, outlets, and smoke detectors, where their bodies and body fluids corrode points, activate or deactivate alarm systems, create pump failures, and cause short circuits in or damage to computers. Cockroach droppings, body parts, and dead cockroaches may accidentally be incorporated into

human meals. Cockroach excrement, scent-gland secretions, and regurgitations spoil the palatability of human food. They strongly attract more cockroaches to established feeding sites, causing additional staining and contamination of food, food packages, and kitchen cabinet cracks and crevices where cockroaches gather.

German Cockroach (*Blattella germanica L.)* – Worldwide

The German cockroach is the most common and most rapidly reproducing of this country's cockroach species. A German cockroach population, given favorable conditions, can increase in number at least 20 times within three months.

The German cockroach is 1.27 cm (1/2 in) long, honey brown in color, and with two dark streaks on the pronotum. Both adult males and females have fully developed wings and can fly short distances, although they seldom fly. Incubation of young lasts about two weeks at 27EC (80ºF). The female protects the eggs by carrying a .63 cm (1/4 in) long egg case, containing from 30 to 40 eggs, until just before hatching, when she deposits it in a protected area.



German Cockroach Male

A female produces from four to eight egg cases in her lifetime, during which time she mostly remains hidden in cracks and therefore less exposed to pesticides. Young (nymphs) German cock-roaches resemble adults but are smaller and lack wings. Nymphs shed their skins (molt) six to seven times before they mature in about 12 weeks. German cockroaches complete a generation in four to six weeks, and the entire life cycle lasts from 14 to 28 weeks. Infestations can be detected by finding shed skins and empty egg cases on shelves, even when cockroaches themselves are not noticed.



German Cockroach Female with Ootheca

The optimum indoor harborage areas for German cockroaches are in areas where protection, food and moisture are available. These areas include the motor area of refrigerators and around stoves, under kitchen and bathroom sinks, undisturbed cabinets, around toilet bowls, leaking sink traps and faucets, condensation, standing water, and wet sponges. Although bathrooms have less food available, cockroaches may live in bathrooms and move through electrical and plumbing pipe chases and floor and wall cracks into adjacent rooms containing food. Small nymphs use cracks, 1 cm (1/64 in) for harborage, but larger adults require crevices about .46 cm (3/16 in) wide.

German cockroaches are usually imported into tightly constructed buildings with bottled-drink containers, in potato, onion, dried pet food, and grocery sacks, and in furniture and corrugated

cardboard. When German cockroaches are moved into buildings from outdoors, they may be accompanied by American or Oriental roaches.

Brown-Banded Cockroach (S*upella supellectilium)* – Worldwide



Brown-banded Cockroaches

The brown-banded cockroach is the second most typical U.S. species, but it does not generally constitute a widespread problem as the German cockroach. The brown-banded cockroach is about the same size as the German cockroach (1.27 cm [1/2 in]), but does not have two dark stripes on the pronotum. Wings of both sexes of brown-banded cockroaches show a light, brownish-yellow, horizontal band across the pronotum, and at the base of wings with another partial band about one-third down from the pronotum. Recently hatched young (nymph) brown-banded cockroaches resemble adults, but are smaller and lack wings. Nymphs are dark; the two light bands separated by a dark band behind their pronotum is more obvious than banded markings on adults. Adult males fly readily, but females do not fly.

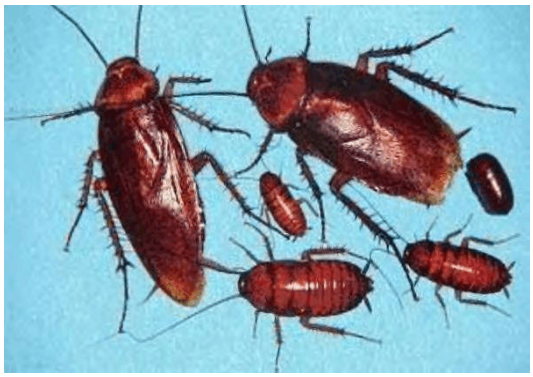
Brown-banded female cockroaches produce up to fourteen .94 cm (3/8 in) long egg cases (each containing 13 to 18 eggs) during their lifetime. The female carries the new egg case less than two days and then glues it to the underside of furniture, behind kitchen cabinet drawers, and in corners inside cabinets and cabinet frames. Incubation time is about 50 days, similar to that of the American cockroach. Nymphs molt six to eight times before reaching maturity in five to six months. Time required for their complete development varies from three to nine months.

Brown-banded cockroaches occur throughout the United States and become established in warm apartments and office buildings where infestations may quickly build to rival those of German cockroaches. Lesser water requirements allow them to occupy more locations in a building than German cockroaches. Brown-banded cockroaches flourish in rooms with high temperatures and, like German cockroaches, build up the largest populations near food sources. Brown-banded cockroaches more often frequent cabinets near ceiling level, but also find harborage behind picture frames, in areas near stoves, and other warm equipment (refrigerators, electric clocks, light timers, televisions, radios, and computers), as well as in ceiling voids, clothing, drapery, and clutter.

Brown-banded cockroaches gain access to buildings by being imported, along with supplies and containers (particularly corrugated cardboard boxes). Eggs and adults may often be introduced into structures on furniture. After gaining entry, infestations can quickly spread throughout a building.

American Cockroach (*Periplaneta Americana*) – Worldwide

The American cockroach is very common in the southern U.S., where it is sometimes called “waterbug" or "palmetto bug." This cockroach is about 3.81 cm (1 1/2 in) long, reddish brown with light markings on the thorax, and has fully developed wings. True flight is not common; flying American cockroaches are usually found in the southern states. Adult males, however, can glide extended distances. The pronotum on this cockroach may be ringed by various irregular patterns of light color that darken toward the center; the rear margin is always light colored.



American Cockroaches

Females can produce a .79 cm (5/16 in) long by .46 cm (3/16 in) wide egg capsule each week during the 12 to 24 weeks of spring and summer, each containing 14 to 16 eggs. She carries an egg case for about a day and then deposits it in a protected spot. A very high population should be suspected when egg cases are found in the open. Incubation lasts from one to two months. Mature American and Oriental cockroach nymphs can be difficult to tell apart. American nymphs normally go through 13 molts before reaching maturity in from seven to 20 months.

Where climate allows, American cockroaches normally live outdoors and enter buildings through holes from crawlspaces or underground ducts, steam tunnels, manholes, and sewer line drains. American cockroaches are found in warm and moist basements, around water heaters, in boiler rooms, floor drains, and water sumps. Large numbers of American cockroaches may move into buildings when triggered by blocked drainage systems, heavy rains, or changes in barometric pressure.

Oriental Cockroach (*Blatta orientalis)* – Worldwide

The Oriental cockroach, sometimes called "water bug" or "black beetle", can be a serious pest. It is dark brown to shiny black in color. Females are 3.17 cm (1 1/4 in) long, about 20% longer than males. Males have fully developed but short, broad wings extending over about 70% of their bodies; females only have short triangular wing pads resembling lobes. Neither males nor females fly. Unlike other cockroaches, Orientals lack specialized pads on their feet and cannot climb smooth surfaces. Each year a female produces about five to ten egg capsules (.75 cm [3/8 in] long by .63 cm [1/4 in] wide) containing 14 to 18 eggs.



Oriental Cockroaches

She carries the egg case for about 24 hours before leaving it in a warm, sheltered spot near available food. Incubation lasts about two months, and nymphs undergo seven to ten molts before reaching maturity in about 1 1/2 years. Late instar American and Oriental cockroach nymphs may be difficult to tell apart.

Oriental cockroaches are more sensitive to a scarcity of water than other cockroaches, but are able to survive 13 weeks of continuous freezing temperatures outdoors when protected under stones and leaf debris. The Oriental cockroach is normally an outside species and its activity is usually restricted to ground or below-ground level. It favors crawl spaces, gaps between the soil and building foundations, undersides of stoops and sidewalks, landscaping mulches, sewers, storm sewers, trash receptacles, and water meters. Large numbers of Oriental cockroaches enter dwellings to find moisture and optimum temperature, and are often triggered by drought, approach of winter, flooded drains, heavy rain, or changes in barometric pressure. Oriental cockroaches mainly invade structures under doors and through holes, cracks, and pipes joining crawlspaces, underground ducts, manholes, and sewer line drains. The Oriental cockroach prefers harborage on damp, porous surfaces, such as concrete or brick, and is mostly found in dark and damp basements, floor drains, and other moist places having a temperature between 20E and 28EC (68º and 82ºF).

Reducing food is not an effective control for Oriental cockroaches because they feed on a wide assortment of naturally occurring organic matter such as dead insects, slugs, and animals, animal wastes, rotting grass and weeds and human garbage.

Smoky-Brown Cockroach (*Periplaneta fuliginosa)*

The smoky-brown cockroach resembles its relative, the American cockroach, in size and shape. This cockroach is dependent upon high moisture. In humid coastal areas, smoky-brown populations can infest every level of a structure. Adult smoky-brown cockroaches average just over 2.54 cm (1 in) long and have wings longer than the abdomen. Both sexes fly. Their dark-brown mahogany color is striking, and they do not have light markings on the pronotum nor on the wings. Antennal tips of young nymphs are white, as are the base antennal segments of older nymphs. The egg capsule of smoky-brown cockroach is generally longer than that of the American cockroach and is black to brown in color. It contains from 17 to 24 eggs. The female usually carries an egg case for one to two days and then if outside, glues it under bark or to a building surface. Inside, egg cases are glued to walls, ceilings, drapery, or sometimes just dropped on the floor. Nymphs hatch within 50 days and mature in about a year. The life cycle of the smoky-brown cockroach is about one year, and usually ends with most adults dying off each fall.



Smoky-brown Cockroach

The smoky-brown cockroach is primarily a plant feeder found in warm and moist areas. It forages in mulch, trees, and vegetated areas near dwellings. It may invade structures and, inside, feeds on human food, soiled clothing, and garbage. This cockroach is found in the South and southeastern sections of the United States, especially gulf coast regions of Texas and

Louisiana. It may invade or is accidentally imported into dwellings. Cockroaches gain entry into dwellings with infested firewood, through doors and cracks in the structure, adjoining garages, and under roof eaves. This cockroach also lives in gutters and under roof shingles, from where it can invade attics. Smoky-brown cockroach infestations commonly begin on upper floors and attics of buildings, after gaining access from trees overhanging roofs.

They are also found in water-damaged areas as they require moisture. This cockroach is difficult to manage because it lives in such a wide variety of outdoor and indoor sites. Effective management requires a complete and thorough inspection of the structure in order to find and correct deficiencies.

INSPECTION AND MONITORING

Inspection

When daytime occupants of a site report seeing cockroaches, a thorough inspection of a structure is necessary to discover the presence and centers of cockroach activities in order to be able to identify them and the available harborage, food, and water sources before management treatments should be initiated. Estimates of the pre-treatment size of cockroach populations compared with post-treatment population estimates provide important data for evaluation of the effectiveness. Placing sticky monitoring traps in suspected harborage area the evening before the inspection will provide valuable information about the pest population.

Refrigerators pose weak links in cockroach management programs because they provide heat, harborage around coils, constant water supply, and hiding places that are difficult to treat. The presence of surface molds and water damage under or around refrigerators will help pinpoint concealed cockroach habitat.

Make inspections, if possible, during evening hours when cockroaches leave harborage. During the day, cockroaches remain deep within cracks. Use a flashlight during inspections (even if the area is not dark) to help concentrate your focus. Inspect for cockroaches every two weeks unless a decrease in roach problems justifies extending the time between inspections to 28 days. When management methods have reduced pest populations to near zero, quarterly thorough inspections may be sufficient if monthly monitoring is continued.

Monitoring

A thorough inspection and the use of sticky traps to determine approximate pest numbers should identify reported infestations. This would provide pre-treatment data for evaluation of the effectiveness of management measures. There are several effective sticky traps, some with attractive food baits such as the ■Lo-Line• that have entered the commercial pest management market.

Numbering traps and analyzing their locations and captures, which should be indicated on room diagram maps, helps to identify cockroach harborage and needs for additional attention to sanitation measures, exclusion, or pesticide treatments.

Monitoring is done by placing sticky traps strategically in rooms and kitchens where harborage, warmth, water, and food are plentiful. The best trap locations are near corners where cockroaches congregate. Place traps against walls, fixtures, and under appliances; do not place them in the open or where they may become wet. Cockroaches tend to stay close to cracks and crevices when foraging for food.

Examine cockroaches found on traps to determine the direction from which they entered the trap. Placing sticky monitoring traps in a standardized approach (always the same way) helps to determine direction of travel. This information will help point out likely harborage sites.

Additional follow-up monitoring with sticky traps is necessary four to eight weeks after the first monitoring session to see if young cockroaches are still hatching, and to determine if management methods are effective.

COCKROACH MANAGEMENT

Action Thresholds

When an average of five or more cockroaches per night per sticky trap are caught in a room, daytime sightings are probable. The action threshold should be set at two to three captures, so that corrective action can be taken before the population expands.

Prevention of Cockroach Infestations

Infestations can be prevented by reducing conditions which support cockroaches, including access to structures and harborage, moisture, and food. Otherwise, cockroach populations are very difficult to manage because small, residual populations can survive in even the most sanitary of environments. Further, residual populations can explode into major problems. The use of pesticides, however, cannot be regarded as a substitute for either prevention or good sanitation practices. Pesticidal suppression of cockroach populations without a change in environmental conditions that support them only gives a false and temporary sense of security and may also result in chemical resistance in the pest populations.

Good building maintenance is mandatory if cockroaches are to be denied access to structures. This requires elimination of holes and cracks used by cockroaches to gain entry into buildings. To eliminate access to structures, install tight-fitting windows, doors, screens, and door sweeps; caulk all exterior and interior cracks and holes in foundations, walls, sills, floors, splash boards, and water, heating, and electrical service chases; screen open sewer lines and drains; and repair leaking plumbing facilities. Remove other sources of moisture.

An effective prevention program should contain the following major elements:

X Careful inspections of areas surrounding the building, noting and correcting conditions which attract or provide harborage for cockroaches such as stacks of firewood, dead tree stumps and branches, vines and other vegetation on or next to the building, piles of bricks, stones, or wood, and leaf litter.

X Careful inspections of building exteriors from foundation to attic; noting and correcting all possible points where cockroaches or other pests could enter the building.

X Careful inspections of building interiors, attics, and crawlspaces from floor to ceiling, noting and sealing all cracks, crevices, holes, and voids which could harbor cockroaches or other pests. Stainless-steel baskets can be used in sink and floor drains to prevent entry of cockroaches from sewers.

X Inspection of structures for accumulations of cardboard or wooden boxes, paper and plastic grocery bags, empty aluminum cans, beverage cartons, furniture, dried pet foods, seasoned firewood, and potted plants, through which cockroaches are often imported into a structure and in which materials cockroach populations flourish. Tactfully advise occupants about needs for improved sanitation.

X Inspection for accumulations of food scraps that are often found under refrigerators and other kitchen equipment and in cupboards. Tactfully advise occupants not to leave dirty dishes or puddles of water on cupboards, clean up all food scraps immediately after eating, store food in pest-proof containers, use tight-fitting lids on garbage containers and take garbage out every day.

Management of Existing Cockroach Infestations

Cockroach problems almost always indicate the presence of excessive moisture and poor sanitation. Effective management measures should include physical, mechanical, and cultural changes. When those methods are not sufficient, pesticide bait measures may also be utilized.

Physical, Mechanical, Cultural Measures

Because of adjoining rooms, attics, crawlspaces, pipes, and other connections, serious cockroach problems in structures usually require an intensive management program for the entire building. One area left untreated will supply cockroaches to other areas of the structure.

<u>Exclusion</u>
The entire building should adequately be sealed and secured against cockroach entry. Carefully check for and seal cracks and crevices in walls, around sinks, and gas, water and electrical lines, cupboards, and baseboards to eliminate all cockroach hiding and breeding habitats. Cockroaches may travel between portions of buildings in and along electrical conduits and enter rooms through open prong holes in electrical outlets; keep outlets covered at all times. Fit self-closing devices to screen doors and check that screens are not broken.
Repair leaking faucets, water and drain pipes, and ventilate or dry out moist areas such as crawl

spaces. Remove any other sources of moisture available to insects. Be sure indoor plants are not over watered. Place screens on fish tanks. Cover all air and ventilation vents with fine-mesh wire screens.

Direct runoff away from buildings. Remove rotting leaves from window wells, dense vegetation from around building foundations, and trim trees that touch the building. Place outside lighting away from the structure to prevent attracting cockroaches and other flying insects to the building.

Sanitation

Occupants should be instructed in the following procedures to eliminate all food, moisture, and harborage available to cockroaches:

X Remove unnecessary equipment and stored materials from the building to eliminate harborage areas.

X Store food in insect-proof metal cans, plastic jars, glass jars with tight-fitting lids, or keep in the refrigerator.

X Remove food and grease from stove doors, hinges, burner tops, joints and crevices each day. Thoroughly clean food particles on and under tables and counters as soon as possible after meals. Wash dishes promptly after use. Discourage eating in non-dining areas. Do not use liners on shelves or in drawers, as they provide harborage for cockroaches and other insects under loose edges.

X Place all food, garbage, empty drink and food cans, and other materials providing potential insect food in sealed plastic bags or tightly sealed canisters as soon as possible. Do not store empty aluminum cans or bottles inside the building. Keep garbage cans tightly covered and take garbage out daily. Do not permit garbage to remain exposed overnight.

X Clean cockroach infested "focus" sites by emptying all kitchen or break room cabinets, drawers, and pantries and wash them out with soapy water before replacing items. Empty stored clothing from boxes and bags, and wash and dry them before repacking in sealed plastic bags or in new, clean boxes.

X Egg cases and adult insects are frequently imported into structures on foodstuffs and containers coming from other cockroach-infested areas. A quarantine area should be set up to accept any incoming food or other material into the building. Cockroaches hide and breed among folds of paper sacks and in voids of corrugated cardboard boxes. Carefully inspect (or sterilize) all incoming containers and shipments for cockroaches and egg cases before putting items on shelves. Seal all paper sacks and cardboard boxes in plastic garbage bags as soon as they are emptied and properly dispose of them.

Provide written information and graphic handouts to familiarize occupants with cockroach management programs and of the needs for sanitation. Occupants should understand and be

willing to follow steps to reduce the availability of food and harborage to cockroaches and to take measures to prevent reinfestation.

No amount or frequency of pesticide application is sufficient to control or eliminate cockroach infestations where sanitary conditions are not met.

Direct Controls

Sterilize equipment and furniture that is infested with cockroaches or egg cases by steam cleaning or in dry heat (in excess of 60EC [140ºF]) for 30 minutes. This method is useful when occupants move from an infested area to another location.

Pesticide Treatments

When deemed necessary, pesticide applications shall be performed by licensed applicators only. Applications shall be made according to the procedures guidelines, according to pesticide label directions, and following applicable laws and regulations.

Pesticides provide only temporary relief from insects in structural units unless moisture, food particles, and grease, found in kitchens or other areas are eliminated. When pesticides dissipate, cockroaches may reinvade structures. Thus, good exterior area sanitation is just as important as inside sanitation and management. To be effective, any short-residual pesticide treatment should attain 95% or greater cockroach kill within the first few days and later follow-up treatments should concentrate on the remaining cockroach reservoirs. Before any pesticide is applied, it is vital to know the kind(s) of cockroaches present and where they are hiding so harborage areas can be effectively treated.

Borate based dusts can be used for effective treatments. This pesticide is applied through a narrow diameter tube into harborage cracks and crevices where cockroaches live and breed. Borate dusts may also be applied under cabinets, drawers and around pipes. When applied in cabinets, be sure to remove utensils and supplies and apply the dust into cracks. Do not treat shelf surfaces. Refined, pesticide grade, 99% borate dust should be used. Borate dusts are harmful (as are most pesticides), therefore, a dust mask, goggles, and gloves should be worn during the treatment process. Various brands and formulations of borates are commercially available, some use aerosol carriers which makes application into small cracks easier.

The Borates may take seven to fourteen days to kill cockroaches, whereas other pesticides may kill some cockroaches in a shorter time. Borates remain active for a long time, and do not evaporate away. After over fifty years of use, cockroaches have not become resistant to the Borates. There are also several borate baits available on the market.

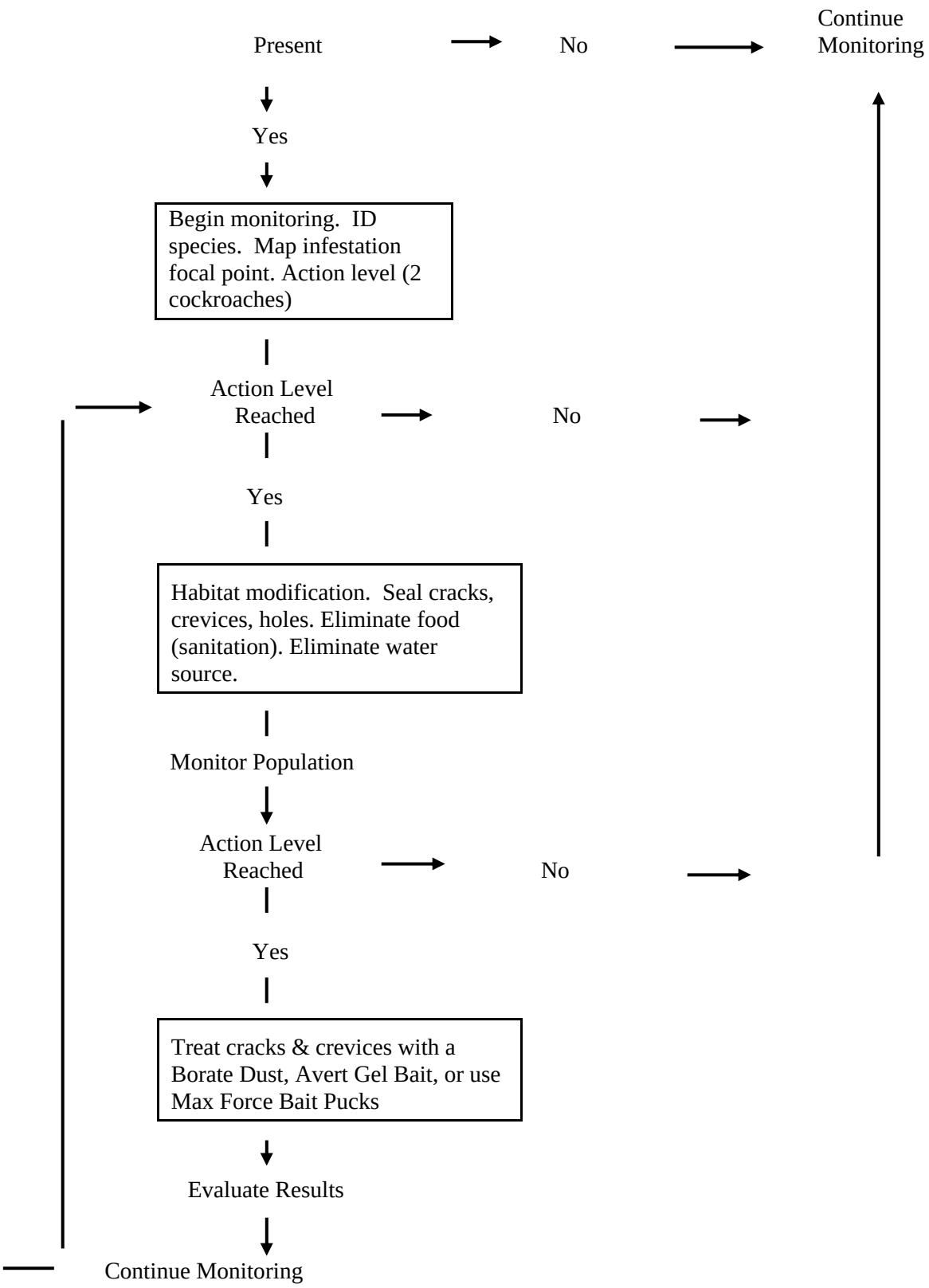
After applying pesticide dusts into cracks and crevices, caulk cracks and crevices to eliminate future harborage and to keep out moisture.

Various types of solid, semi-solid, and liquid cockroach bait stations are commercially available. Many contain low-risk chemicals that are attractive to cockroaches and help control cockroach populations. Normally, about 12 or more bait stations are placed in cockroach harborage areas in a normal sized kitchen. Some bait stations (or pucks) contain hydramethylnon which is effective for cockroach management and has reduced risk to occupants. Some bait stations have

sticky tape on the back for applying baits to vertical surfaces. However, if sanitation is poor in a site, bait performance will also be poor because of the availability of alternative foods.

Several new toxic paste or gel baits have been developed that are attractive to cockroaches. One of the more effective gel baits for crack and crevice treatment contains abamectin (a low-risk pesticide). Toxicants can be stomach poisons, nerve poisons, chitin inhibitors, or insect growth regulators (IGRs). Also, bait guns have been developed to inject paste or gel baits directly into the cracks and crevices or other places where cockroaches hide.

COCKROACHES



FLIES

CHARACTERISTICS AND RECOGNITION

In terms of both numbers and health concerns, flies make up one of the largest groups of insect pests. Although the major features and management measures given here are for urban pest flies, the principles generally apply to all flies.

The main urban fly pests in the United States are the house fly, fruit fly, hump-backed fly, bottle fly, moth fly, and fungus gnat, each of which has very similar life cycles. Adults seek moist garbage, dead animals, or manure in which females deposit eggs. Eggs develop into grub-like larvae (or maggots) that feed on the food source on which eggs were deposited. After a week or so, larvae leave the food source and spend another week or so in a non-feeding, cocoon-like form (pupa) from which adult flies emerge in a few days. Adult flies quickly mate and may move from the breeding site into human occupied structures through open doors and windows, seeking food.

Food for a fly consists of almost any organic material. House flies (among many others) eat solid food by vomiting digestive enzymes onto the food source and macerating it into a liquid form that can be lapped up with sponging mouth parts. Since flies continually vomit and defecate while feeding, germs are deposited on the food they feed on.

HOUSEFLY (*Musca domestica L.)*



House Fly Life Cycle

Worldwide, the common house fly is one of the most widely distributed insect pests. House flies are soft-bodied, gray-colored, about .63 cm (1/4 in) long, and have only one pair of wings that span about 1.5 cm (5/8 in). Their faces have two soft stripes that are silver above and gold below. The upper surface of its thorax is marked with four dark longitudinal stripes, and the abdomen is yellowish-white at the sides and base. House flies are active year-round outdoors in mild weather and indoors during fall and winter.

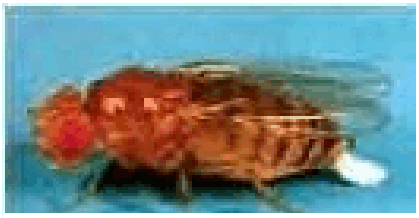
The housefly rarely moves more than a mile to food from its breeding sites. They have an excellent sense of smell, which leads them to food and water. Their range of vision is about eighteen inches. They are attracted to red colors.

Over her lifetime, a female house fly will lay from 350 to 900 eggs in any moist excrement, garbage, decaying fruit, vegetable waste, and soil containing organic matter. After eggs hatch, larvae feed and eventually migrate to cool sites (for instance, soil beneath boards or stones), where they pupate. In three days to four weeks, depending on temperature and humidity, adult flies emerge from pupae. Normal adult life span of the house fly is two to three days if denied food, but flies live up to 54 days when food is present. The time from egg to adult ranges from seven to 45 days, and in warm weather two or more generations can be produced per month. House fly populations may be greatest in early fall (September and October). Because larval

house flies produce a glycerol compound, which keeps their body fluids from freezing, they mostly over-winter as maggots or pupae. Various similarities in appearance and behavior make it important to be sure that suspected "house fly" problems are not really flesh fly problems, which originate with dead animal carcasses.

FRUIT FLY (*Drosophila spp.)*

Fruit flies, also called vinegar gnats and pomace or vinegar flies, are made up of a number of species with worldwide distribution, and are the most common of all small flies. They are .3 to .63 cm (1/8 to 1/4 in) long, dull yellow to dark-brown, and some kinds have distinctive bright red eyes. Fruit flies are small enough to pass through window screens with a mesh size larger than 12 per inch. Fruit flies breed in such decaying matter as juices or other liquids remaining in empty cans, ripe fruits and vegetables, drain slime, wet mops, and dumpsters.



Fruit Fly with Egg

Female fruit flies lay from 400 to 1,000 eggs on the surface of decaying organic materials and in garbage cans; some species prefer briny or vinegary liquids around jar lids. Larvae hatch within 30 hours and begin to feed near the surface of the food source. Mature larvae move into dry areas to pupate, and development is completed in nine to twelve days. Outside, fruit fly numbers quickly build in summer until populations peak during fall harvest. Fruit flies can be present year round, especially indoors where preferred foods and breeding sites are available. Fruit flies are able to quickly reproduce in large numbers and may contaminate food if not managed.

MOTH FLY (*Psychodidae)*

Moth flies - or drain, moth, filter, and sewer flies or sewer gnats - are generally found in drains, especially in kitchens or bathrooms. Adults resemble moths, and are about .3 cm (1/8 in) long. They have light gray, tan, black, or brown bodies, and lighter colored wings that are held roof-like over the back when at rest; both body and wings are covered with long hairs, giving the body a fuzzy look. Moth flies are poor fliers and are most commonly seen just walking or running along walls. Their flight is short and jerky and of short duration (a few feet). Some species are active in winter.



Moth Fly

Moth flies breed in similar material to fruit flies. Females lay masses of eggs, especially between loose floor tiles in wet areas, in drain pipes, dirty garbage containers, water traps, and plumbing fixtures, around built-in sinks, and near decomposing organic matter. Larvae (maggots) develop in shallow, polluted water and feed on sediments, decaying vegetation, and microscopic plants and animals found in gelatinous drain film. The life cycle is usually two to three weeks but may be as short as one. Adult moth flies emerge from sink, tub, shower, and floor drains. Some species are small enough to pass through window screens. Moth flies are mostly active in the evening, around drains or sinks. Moth flies do not bite and are of little health significance.

HUMP-BACKED FLY (*Phoridae)*

Hump-backed flies, or phorid or coffin flies, are .15 to .3 cm (1/16 to 1/8 in) long and similar in appearance to fruit flies, except that they are more humpbacked. Most species are brownish-yellow with brown wings, a small head, and a large and humped thorax. Larvae are whitish, legless, and worm-like and feed on sewage, dead animals, insects, rotting plant material, animal feces, and open wounds.

Hump-backed Fly



They infest clogged drains and dirty garbage containers, and adults are attracted to light. These flies are active in buildings during winter. Hump-backed flies have strong legs and are reluctant to fly. They are seen running across surfaces in quick and jerky motions. Hump-backed flies can infest building complexes.

Hump-backed fly adults and larvae are common around decaying vegetation (mold and organic matter). They can penetrate several feet into the soil to infest animal carcass or organic waste. Flies emerging in large number inside a structure may indicate plumbing leaks in the crawlspace or beneath floor slabs, and considerable effort may be required to locate the hidden wet breeding areas attracting them.

FUNGUS GNAT (*Sciaridae or Mycetophilidae)*

Adult fungus gnats are .3 cm (1/8 in) long and resemble small mosquitoes, except that they do not bite. Fungus gnats are readily identified by their small size, distinctively long legs, and pointed
abdomens. Adults are not strong fliers and are seen running across soil surfaces as potted plants are watered. Adults are also attracted to light, and collect at windows. Larval fungus gnats are worm-like, about .63 cm (1/4 in) long, have a transparent body and dark head, and are usually found in the top layer of damp potting soil.

Fungus Gnat



Outside, fungus gnats are usually found in gardens, where some larvae live near the soil surface, and others are deeply buried where they feed on plant roots. Fungus gnats reproduce all year long indoors, and the life cycle is 12 to 27 days, depending on temperature.

Over-watering of potted plants supports fungal growth. Larvae thrive in dampness, decaying vegetation, and outdoor compost. These flies do not generally damage plants.

BLOWFLY OR BOTTLEFLY (*Calliphora spp., Phaenicia spp.,)*



Green Bottlefly

A number of blowflies - blue, green, and black blowflies or bottleflies - are common throughout the United States and may enter dwellings where they are attracted to windows. Blowflies are common in populated areas, especially near slaughter houses, meat-processing plants, and garbage dumps. Blowflies are usually the first flies to appear in spring, sometimes emerging from hibernation on warm, sunny winter days. Blowflies mainly invade buildings during cool weather, when they are readily attracted to garbage cans. At night blowflies rest on shrubs or building walls from which they can easily enter buildings when doors and windows are left open. Blowflies are found in trash compactors and chutes, compost piles, on the ground, and in wall voids, attics, and chimneys. Blowfly larvae are sometimes observed on floors or falling from ceiling fixtures.

Adult blowflies are primarily scavengers. They are larger than house flies, make annoying buzzing sounds, and have metallic blue, green, or yellow or brown-colored bodies. Blowflies range in size from .79 to more than 1.27 cm (5/16 – 1/2 in) long and have a single pair of wings. Females usually lay 200 to 700 eggs (one species, up to 3,000 eggs) on meat, dead animals, decaying plant matter (such as lawn clippings), solid animal waste (dog manure is preferred), or at the edge of wounds in living animals. They can produce more than 30,000 flies per week.

Larvae are large and develop fast; they feed for up to ten days on the surface of decaying matter and, when larger, burrow into less decayed areas. When mature (about 1.90 cm [3/4 in] long), larvae wander away from the food source and burrow into the ground to pupate. In one to three weeks they emerge as adults. The time from egg to adult in some species is only nine to 18 days, which allows four to eight generations per year. Some species over-winter in the soil as full-grown larvae, and others hibernate in attics, walls, and ceilings, but not in clusters. The life cycle is from two to four weeks. The presence of either adults or larvae in a structure indicates the presence of dead animals (usually rodents) or rotting organic matter.

CLUSTER FLIES (*Polenia rudis [Fabricus])* (North America)



Cluster Fly

Adult cluster flies are about .9 cm (3/8 in) long, stout, and have a dark grey thorax with short golden hairs. The abdomen has irregular lighter portions. The adult flies often enter structures in the fall as days shorten and the weather cools. They overwinter in attics and wall voids, forming compact clusters of flies. They usually inhabit the side of the structure that gets the most sunlight. The adults overwinter in sheltered places and emerge in spring to mate. Eggs are deposited in soil and hatch after about three days. The hatched larvae search and enter earthworms as parasites. From

egg to adult takes 27-39 days, depending upon temperature; which produces about four generations a year. Cluster fly adults are relatively sluggish in movement.

HAZARDS OF INFESTATION

Flies in General

Flies provide great potential for disease transmission because of their feeding habits. Along with mosquitoes, flies are responsible for spreading serious diseases like malaria, sleeping sickness, leishmaniasis, and filariasis. Other disease-causing organisms that have been collected on flies include germs causing dysentery, tuberculosis, cholera, tularemia, anthrax, poliomyelitis, yellow fever, and typhoid.

Houseflies

Houseflies alone transmit more than 20 human diseases and parasitic worms (including salmonella, typhoid and paratyphoid fever, cholera, summer and infantile diarrhea and dysentery, tuberculosis, and anthrax) which adhere to the fly's sponging mouth parts, sticky foot pads, wings, body surface, or live within the fly's gut.

Blowflies

Blowflies deposit eggs on meat which, when eaten, are responsible for cases of intestinal myiasis (caused when live fly larvae are accidentally ingested, causing nausea and other conditions similar to food poisoning).

Eye Gnats

Eye gnats are suspected transmitters of conjunctivitis.

Cluster Flies

Overwintering cluster flies in attics and wall voids have substantial mortality. The dead flies in their typical clusters become a food source for dermestid beetle larvae. The dermestid beetle larvae can then become a source of infestation of historic organic artifacts in museum collections.

IDENTIFICATION, INSPECTION, AND MONITORING

Identification

If it is difficult to identify flies, request assistance from state health departments or preserve flies in alcohol and send them to university departments of entomology when necessary.

Inspection

Do not stop inspecting after finding the first breeding site, nor concentrate efforts only on those areas where flies were seen. Seek out all possible places which could contain decaying material, garbage, rotting fruits, vegetables, meats, dead animals or grass clippings. When inspecting for fly-breeding sites, first search for wet areas: floor drains, open drums, buckets, cans, bottles, potted plants, dish washers, machinery, and around cracks, roof lines, and loose tiles. Look for moist animal feces, garbage, wet mops, and towels. Housefly maggots on floors or pupae under carpets signal the probability of fly-breeding sites inside the building.

Begin inspections outside by intensively searching for breeding sites, first concentrating on garbage and refuse areas. Look under equipment for maggots in dead animal carcasses (mice, trapped animals, dead rodents), and in garbage and drain sludge. Examine building cracks and crevices, dumpsters and garbage cans, drains and refuse piles. Cat, pigeon, and rodent feces and dead rodents are ideal breeding sources. Develop maps of likely breeding sites and periodically re-check those areas for live fly larvae.

Inside the building, inspect trash container interiors and areas prone to litter (such as break rooms and lounges). Look for empty soda cans, coffee cups, rotting fruit products, misplaced lunch bags, wet towels, and debris in locker and lounge rooms. Inspect all cracks at baseboard level, crevices around loose floor tiles, hollows and voids, and inaccessible areas in machinery that are caked with dirt and organic matter. Inspect potted plants and grease traps.

In kitchens and food processing areas, thoroughly search for decaying food. Inspect floor drains, floors under work counters and equipment, and enclosed counters which permit water or food to accumulate inside or beneath them. Look under ovens, and in both hard-to-reach and under clean machinery at floor level

General Monitoring

Houseflies have certain preferred resting places. During the day and when not feeding, adult flies may be found resting on floors, walls, ceilings, in crack and crevices, and other interior surfaces as well as outdoors on the ground, fences, walls, privies, garbage cans, clothes lines, and vegetation. To monitor for adult flies, place scatter grids out for 30 seconds (or other standard time limit) in locations near preferred resting places and count the numbers of flies landing on grids. Sticky tape, 6.62 x 12.70 cm (3 x 5 in) wide sticky paper, or sticky strings can also be used to monitor adult flies.

When problem flies are attracted to light (for instance, cluster and hump-backed flies), place light traps in dark places or capture flies at windows. Use monitoring information to establish levels of infestation upon which to base management actions.

Monitoring Information on Specific Kinds of Flies

Housefly

Sticky or light-trap monitoring which produces, on the average, 50 to 75 house flies per trap per day indicates a moderately heavy population. More than 150 house flies per trap per day indicate a heavy population.

Drain Flies

To find possible entry points of drain flies:

- Place sticky traps near suspected sites;
- Set clear glass or plastic containers over drains or tape plastic bags over drains to capture emerging drain flies;
- Fit a piece of fine screen over the drain to see if drain flies stop appearing;
- Scrape a pocket-knife blade around the film inside the drain and look for tiny, worm-like drain fly larvae;
- Look for points of drain fly entry through cracks in the slab or expansion joints on the floor to suggest sewage-soaked soil or broken sewer lines;

MANAGEMENT

Mistakes in Fly Management Programs

The following are the most common mistakes made in fly management programs:

- Failure to properly identify flies and to find and correct conditions providing breeding sites.
- Stopping after finding the first breeding site; all possible breeding sites must be discovered and eliminated.
- Trying to manage adult flies without first managing larval breeding sites. Management of adult flies may be helpful to alleviate complaints, but it is not as effective as managing larval breeding sites.
- Attempting to manage flies with only pesticide chemicals. Pesticides alone will not eliminate fly problems and are only effective when good sanitation and exclusion are practiced as primary steps.

Physical, Mechanical, Cultural Measures

Sanitation

General: The first step in any successful fly program is to reduce fly numbers; the key to that is an effective sanitation program for potential breeding sites.

Outside:

- Eliminate conditions responsible for fly-breeding sites around buildings by properly disposing of food materials and garbage (especially under dumpsters), preventing accumulations of moisture, and removing weeds.
- Do not throw waste water from cleaning operations onto the ground; pipe it into covered drains. Keep areas around garbage cans clean. Assure that tight-fitting lids on garbage receptacles are used.
- During warm weather, steam-clean and rinse out garbage cans and dumpsters with disinfectant solutions on a weekly basis.
- Be sure that garbage is picked up twice weekly so larvae will not have time to develop into adults.
- To assure that fewer flies will enter structures, keep garbage cans and dumpsters tightly closed and as far from buildings as possible.
- Keep dumpster bottoms as dry as possible by installing bottom drains and lead water drainage into sewer systems.
- Release fly parasitoids *(Pteromalidae)* near areas where flies may pupate to prevent adult fly emergence.
- Seal cracks and crevices that lead to the inside to prevent adult cluster flies from entering.

Inside:

- Fit garbage cans and dumpsters with tight-fitting lids and always keep receptacles closed.
- Routinely clean cans and dumpsters with disinfectant solutions.
- Seal all wet and dry garbage up in plastic bags before placing it into receptacles; this excludes flies and reduces both odors and the attractiveness of garbage to flies. Be sure to take garbage out every night.
- Keep floors, walls, cooking, and food-preparation surfaces clean and dry.
- Examine plumbing pipes for possible leaks and water condensation.

<u>Notes on Management of Specific Flies</u>
Housefly: Housefly management requires a fully integrated approach based on exclusion and improved sanitation. Reliance on pesticides usually fails in the long-term since house flies have developed resistance to most pesticides.

Fungus Gnats: Allow potted plants to dry out between waterings. Remove potted plants if they supply fly food, water, or harborage sites.

Fruit Flies: Management of fruit flies first requires that sources of infestation be removed. This is often difficult because fruit flies feed on a wide array of organic materials, much of which may be well concealed behind plumbing, in janitorial closets, stagnant drain traps, bottoms of garbage cans, and cracks, under appliances or counters, or outside the building. Unless thorough sanitation is practiced to achieve fruit fly management, problems continue to develop.

Drain Flies: Finding and removing breeding sources and good sanitation practices are the only permanent solutions for drain fly problems. Use a brush and industrial cleaner to remove slime and film from drains and flush drains with hot water and commercial caustic drain cleaners or disinfectants. Check carefully under the crawl space for leaks or water backups from possibly broken garbage disposal or sewer pipes. Inspect such other possible breeding sites as clogged roof gutters, air conditioners and cooling towers, clogged storm drains, septic tanks, loose floor tile, water beneath potted plants, rain barrels, sewage treatment plants, dirty garbage cans, and moist compost piles.

Hump-Backed Fly: The presence of hump-backed flies most often indicates that plumbing is leaking. Hang yellow sticky traps in various places in the room to show where flies are entering, or tape a plastic bag over suspected floor drains. Hump-backed flies are attracted to light, and windows are a good place to collect them. Electric-light traps can also be used in dark areas where there is no other source of light. Once found, eliminate larval food sources (there may be more than one). If broken pipes are found, excavate and discard and replace all gooey soils saturated with organic material. Ventilate and dry out areas so as not to support insects.

Cluster Fly: A vacuum can remove clusters of the adult flies as they are found overwintering. Killing them with a pesticide may leave behind (unless removed) the bodies in an inaccessible void where dermestid larvae can feed upon them. In June or July, when all live adults have left the structure, screen all vents, weepholes and overhangs with at least 16 mesh screen. Caulk all openings, cracks, crevices, cable entrances, windows, doors and other potential entrance points. Cluster flies are attracted to lights.

Exclusion

Exclusion is second only to sanitation in effective fly management programs, because flies are always attracted to the warmth and odors of buildings.

- Assure that all doors, windows, air curtains, and door closing devices are in good repair and maintained to keep flies from entering the structure. Fit windows and doors with 16 mesh-to-the-inch, tight-fitting screens and install self-closing door devices.
- Screen doors should open outward; double sets of screen doors may be required.

Other Management Methods

Heat: Flies die in 30 minutes when exposed to 49°C (120ºF) dry heat.

Vacuum: A vacuum may be used to collect flies in groups (such as cluster flies).

Sticky traps: The best place to put sticky traps is where flies usually rest: in corners, on edges, on thin objects (suspended wires or strings), and on ceilings. Sticky paper and sticky strings are useful to capture house-flies, but flies are also trapped when encouraged to light on cotton balls.
Live-Capture Fly Traps: Outdoor, mechanical, and food-attractant fly traps are useful in some locations to lessen fly numbers, but they require attractive fly bait.

- Home-made fly trap: Place one cup of sugar, one cup of vinegar, and one banana peel in an empty two-liter bottle; fill with water to within 10.16 to 12.70 cm (4 to 5 in) from the top; tie a heavy cord around the neck to hang it from a tree. This trap catches flies all season long.

- Fruit-Fly Trap: For fruit flies, use "fly-in" type traps having specialized saucer-like lids that fit a quart-size mason jar. Bait these traps with a 2.54 cm (1 in) piece of freshly sliced banana and add one teaspoon of water to keep the banana moist. Replace the banana every two to three days. In areas of high infestation, a trap may become filled with fruit flies in less than 24 hours. In kitchens, place traps out of sight and covered with paper. To kill flies before removing them from the trap, run hot water (66EC [150ºF]) into one of the entry holes. Keep the outside of the jar clean and dry, or fruit flies will feed on the outside and not enter the trap. Since fruit fly eggs hatch in 10 to 15 days, clean the jar every two to three days. Meanwhile, carefully inspect the building to find the source of the flies.

Insect Light Traps

Electric and ultraviolet (UV) insect light traps (ILTs) offer good captures when used according to manufacturers' directions. Correct use of ILTs can help solve many flying pest problems in small facilities. Proper maintenance of ILTs requires annual (or more frequent) lamp replacement, weekly trap cleaning to manage dermestid beetle problems, and a sufficient number of properly located traps. Locate traps three or more meters (12 or more feet) from doorways so flies cannot see them from the outside (to prevent attracting flies into the building), less than 1.52 meters (5 ft) from floor level, and at ceiling level in front of large overhead doors, but not facing outside. Each situation is different and it should be determined in advance how flies enter and move through a building. Clean light-trap trays often, both to monitor efficacy and to prevent scavenger insect problems.

Outside Lighting

If practical, place outside lamps on poles away from buildings but shining onto doors, so as to attract night-flying insects away from the building. High-pressure sodium-vapor lamps help to minimize flies when installed at, but not over, entrance ways.

Temperature

Flies become sluggish or do not fly in lower temperatures. Keep inside temperatures as low as practical.

Other

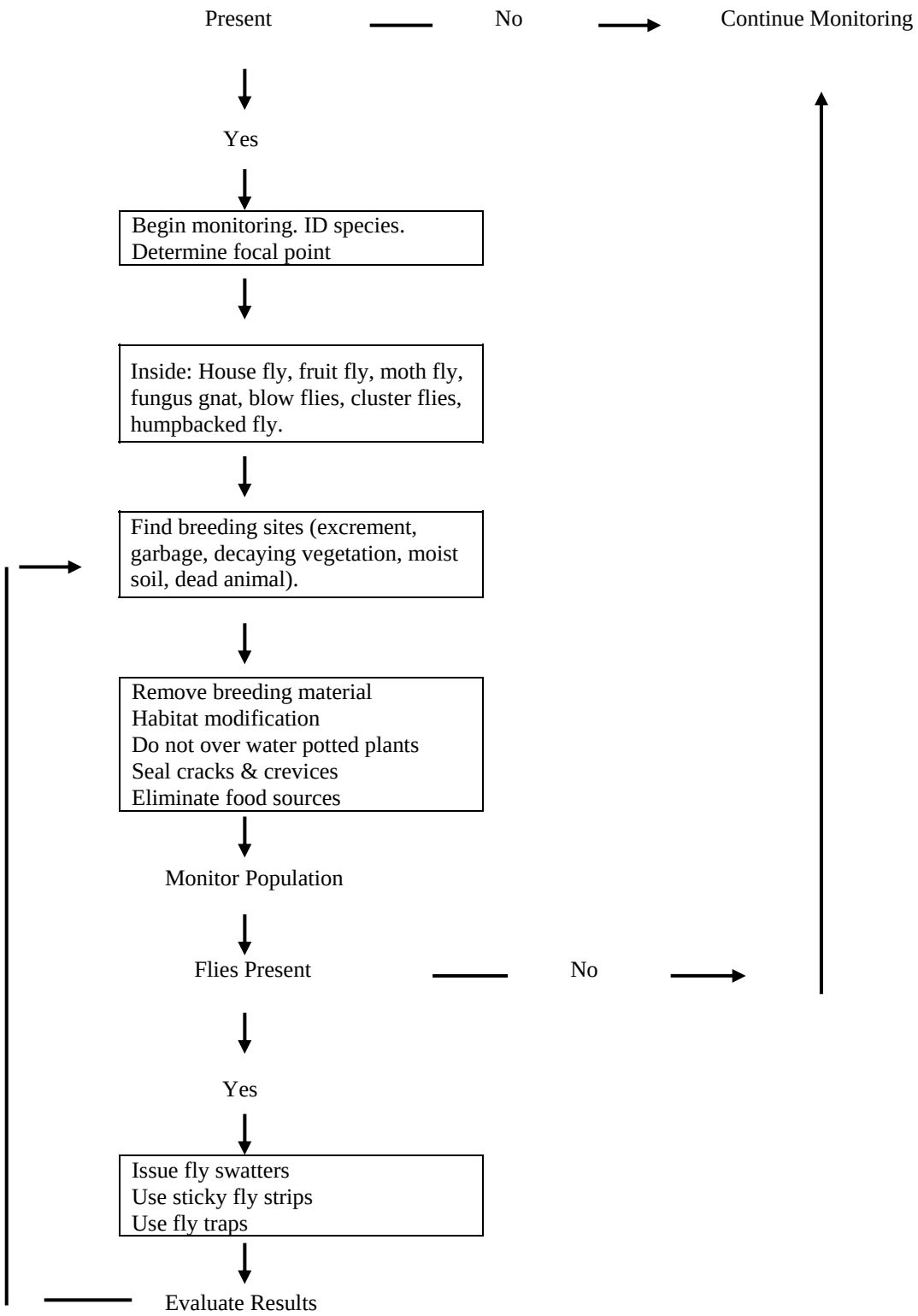
Fungus gnats: Where fungus gnats are a problem inside, stir soil of potted plants so it will dry out. Allow soil to dry out between waterings (just until plants begin to show very first signs of wilting). Discard dead plants, rotting vegetation, and infested soils. Pot new plants and transplants only in sterile potting soil. Store unused soil separately in a covered container where it cannot become infested. Hang yellow sticky cards (used by the greenhouse industry) above the plants; this will also help control white flies and other plant pests.

PESTICIDES

When deemed necessary, pesticide applications shall be performed by approved licensed applicators only. Applications shall be made according to National Park Service policy and procedures guidelines, according to pesticide label directions, and following applicable laws and regulations.

Pesticide applications for flies are generally unnecessary since sanitation, cultural controls and exclusion will reduce or eliminate fly infestations in structures. Do not treat for cluster fly in attics or wall voids.

FLIES

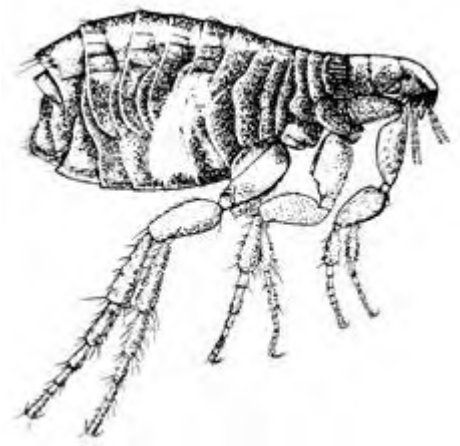

Present
No
Continue Monitoring
Yes
Begin monitoring. ID species.
Determine focal point
Inside: House fly, fruit fly, moth fly, fungus gnat, blow flies, cluster flies, humpbacked fly.
Find breeding sites (excrement, garbage, decaying vegetation, moist soil, dead animal).
Remove breeding material
Habitat modification
Do not over water potted plants
Seal cracks & crevices
Eliminate food sources
Monitor Population
Flies Present
No
Yes
Issue fly swatters
Use sticky fly strips
Use fly traps
Evaluate Results

FLEAS

CHARACTERISTICS AND RECOGNITION

Fleas are common indoor problems throughout the United States, except in very dry areas. The most typical species, and the one used here as a model for flea management, is the cat flea. It feeds on a number of hosts, including cats, dogs, rodents, opposums, etc., and is found in a wide range of environmental conditions. This flea prefers animals but also affects people. Some conditions may encourage large numbers of fleas because:

- Summertime provides optimum temperature and humidity for flea-growth;
- After an absence of a host, large numbers of emerged and emerging adult fleas are ready to feed on <u>any</u> warm-blooded host.



Cat Flea

Adult cat fleas are about .3 cm (1/8 in) long, have sucking mouthparts, and exclusively feed on a host's blood. Flea bodies can withstand substantial pressures. Egg production in females begins two days after her first blood meal and peaks about the fourth day. She produces from 150 to 400 round, light colored eggs, the size of a fine-point pen tip, and lays about 20 of them per day for up to three weeks. Since about half of the fleas on an animal or pet are female, up to 500 flea eggs per day can drop onto turf and other resting areas in a site. Larvae hatch in two to fourteen days and then move to the base of turf or other fibers seeking food.

Larvae of cat fleas are also .3 cm (1/8 in) long, have chewing mouthparts, and feed on adult flea feces (which are partly digested blood), and organic debris. They must have a source of dried-blood or blood-containing materials to be able to complete the three necessary molts of larval development. Cat flea larvae are not very mobile. They are usually either in the animal's resting areas or protected spots. They shun heat, sunlight, and decreased humidity but are attracted to moisture. When molts are completed, larvae spin a sticky silken cocoon within the substrate and pupate. When pupal development is complete, they become adult but may remain within the cocoon until some stimulus triggers their emergence: for instance, being stepped near by an animal, carbon dioxide exhaled by a host, vibrations, or increased temperature and humidity. Most adult fleas emerge from pupal cocoons in ten to fourteen days; adult fleas can remain in the pupal stage cocoon, inactive but ready to emerge, for as long as a year while waiting for the proper host stimulus.

Flea larvae and pupae are mostly found in undisturbed areas which provide optimum humidity and temperature, regularly visited by animals and contain larval food. Fleas may be imported into structures by pets or squirrels entering the house through chimneys or other openings.

HAZARDS OF INFESTATION

Typical flea bites show as a central, small red spot where flea mandibles penetrated the skin, surrounded by a red halo. Some animals may be allergic to flea bites which may be seen as dermatitis, hair loss, excessive scratching, and skin inflammation.

INSPECTION AND MONITORING

Inspection of Buildings

Conduct a close inspection of the living unit to find "hot spot" areas with flea development.

- Look under furniture, in rugs, etc. for granules resembling salt and pepper which indicate flea presence. These salt-and-pepper granules are made up of flea feces, empty egg cases, shed larval skins, and dried blood.

- Collect fleas and have them identified. Fleas can be trapped in a number of ways:

  Collect fleas that land on an inspector's long white socks after a one-minute walk-through of flea-infested areas.

  Collect fleas from pet bedding, or by combing infected animals with a flea comb; place fleas in a plastic bag and kill them by freezing or heating to 49ºC (120ºF).

  Use commercial flea traps available from pet-supply dealers.

- Watch for animals going into yards or under dwellings. Look for bird or mammal nests under the structure and in unscreened chimneys and pipes. Opossums carry large populations of cat fleas, which may subsequently infest areas they travel through.

MANAGEMENT

Major Mistakes in Flea Management Programs

The effectiveness of flea management programs can be diminished by:

Failure to identify fleas and find the source of the problem;

Failure to exclude animals bringing fleas into the site;

Failure to clean indoor areas where fleas find harborage; failing to instruct occupants on cleaning methods;

Failure to gain occupant cooperation or inform them of what to expect after treatment -- because of the flea's life cycle, a few adult fleas will be seen after treatments;

Physical, Mechanical, and Cultural Measures

Sanitation

Thoroughly vacuum in a criss-cross pattern all flea "hot spots" and other areas used by animals (rugs, sofas, drapes) with a strong vacuum cleaner. Vacuuming can remove a large percent of the flea larvae present and flea eggs. Good vacuuming can keep a flea population low. Removal of flea larvae from carpeting is the most important action in reducing an indoor infestation. Carefully dispose of sealed vacuum bags containing live fleas.

If possible, lower the relative humidity in the structure to less than 50%.

Remove vegetation near the structure that may provide rodent harborage.

Exclusion

Screen vents, crawl spaces, and chimneys to keep animals out from under structures, outbuildings, or chimneys.

Ultrasonic devices have not been shown to be effective for flea control.

Fleas are killed in dry or moist air temperatures of 43 ºC (110ºF).

Pesticides

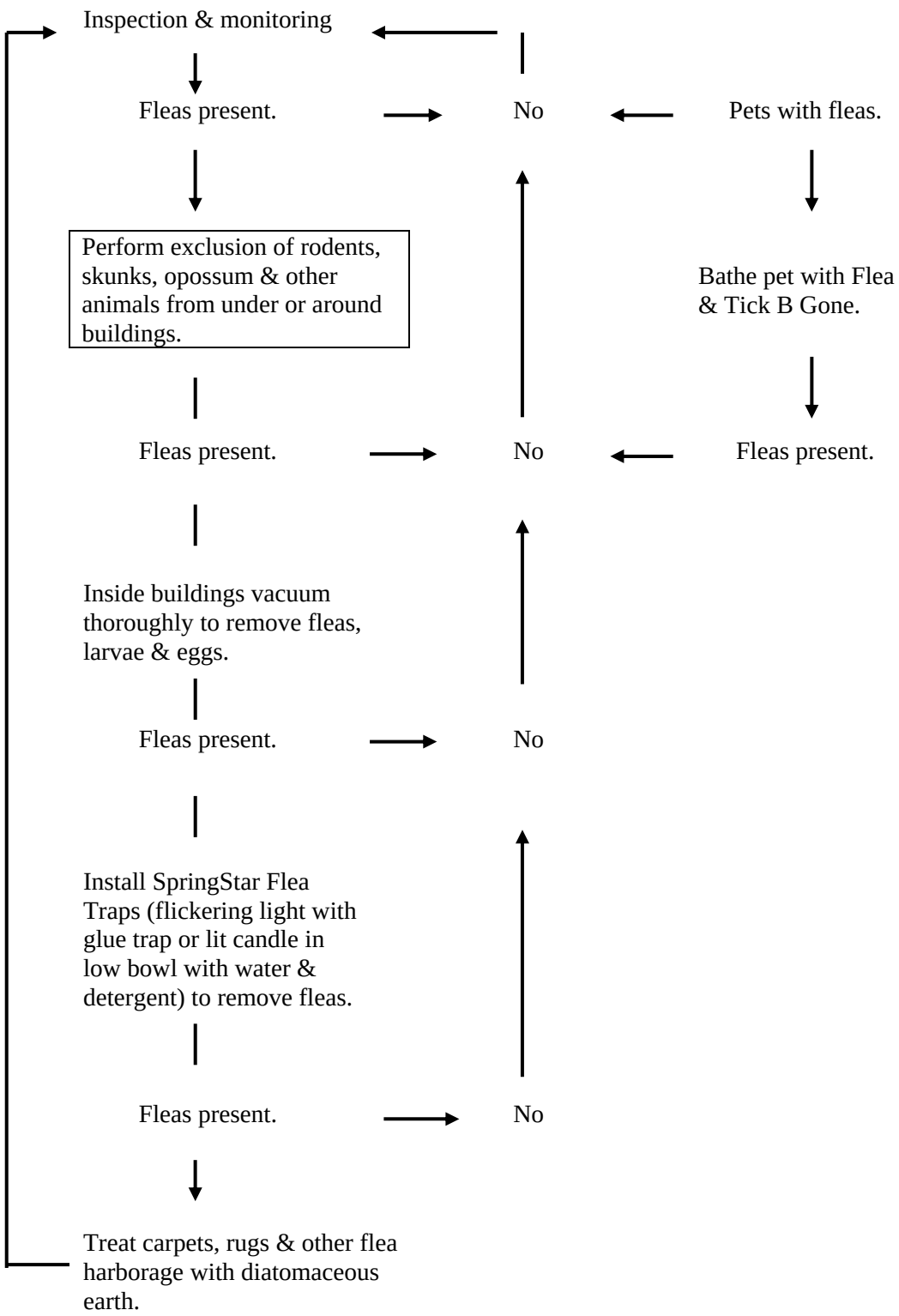
Pesticides alone will not eliminate flea problems. The management should be with combined physical and mechanical means. The following are additional items for flea management:

- If low-risk, enzyme products such as Flea and Tick B Gone are used on pets such as dogs; there is no need to wear protective equipment.

- Insect-growth regulators offer best results when used before spring flea activity begins. Follow label directions.

- Commercial, non-pesticidal flea soaps may also be effective against fleas; bathe pets with flea soap according to the label.

FLEAS


Inspection & monitoring
Fleas present.
No
Pets with fleas.
Perform exclusion of rodents, skunks, opossum & other animals from under or around buildings.
Bathe pet with Flea & Tick B Gone.
Fleas present.
No
Fleas present.
Inside buildings vacuum thoroughly to remove fleas, larvae & eggs.
Fleas present.
No
Install SpringStar Flea Traps (flickering light with glue trap or lit candle in low bowl with water & detergent) to remove fleas.
Fleas present.
No
Treat carpets, rugs & other flea harborage with diatomaceous earth.

WASPS AND BEES

CHARACTERISTICS AND RECOGNITION

General

There are thousands of different kinds of wasps and bees in North America, most of which are small wasps that are parasitoids of other insects and solitary burrowing bees. However, there are only 50 or so 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, cicada killer wasps, and carpenter bees.

Social wasps and honeybees build nests in and around structures. Typical nest sites include beneath eaves, on porches, behind blinds, in trees, shrubbery, and vines, in stone walls, and in the ground. Most of the social wasps prey on destructive insects (house flies, blowflies, caterpillars, and moths) that they feed to their young (larvae). From this standpoint, they are considered beneficial. Honey bees gather nectar from flowers and convert it into a thick viscous liquid we call honey, which is fed to both adults and larvae. Solitary wasps prey on insects they paralyze and place, along with eggs, into individual nests. After the eggs hatch, the larvae feed on those insects until they can emerge from the nest.

Social Wasps

Social wasps live in colonies that have a caste system (division of labor) with overlapping generations, and a single fertile reproductive female called the queen produces all offspring. The other two adult forms in social-wasp colonies are the fertile males that mate with queens and the female workers, which are sterile. Their social colonies may persist for many years, unlike other stinging wasps which start anew each year.

All social wasps develop in similar ways. In the autumn, queens and males leave the nest to mate. The males die after mating, but the queens hibernate over winter in some protected area such as a crack, under tree bark, in buildings, attics, and basements, or in a hole in the ground. Next spring, the queens come out of hibernation, find a suitable nest site, construct simple, small, paper-like nests made from masticated wood and plant fibers mixed with water, and lay 25 to 70 eggs. The queen will not lay more eggs until that first brood has matured. Larvae hatch in a few days and glue themselves into the cells. The queen will feed the larvae chewed up bits of insects over the next 12 to 18 days until larvae mature. When mature, larvae spin a silken cap to close the cell and pupate (undergo metamorphosis into an adult). Once the first brood emerges as adults, the queen resumes egg-laying. Subsequent larvae produced by the queen are fed by the first generation of workers who also expand the comb or nest. The queen and workers do not eat the insects they collect for larvae. They subsist entirely on flower nectar and a sweet liquid provided by larvae when fed. With the onset of cold weather, wasps abandon the nest, which

disintegrates from actions of weather, birds, or squirrels. The only member of the colony that over-winters is the fertilized queen.

Although yellow jackets and umbrella wasps are closely related and have similar life histories, their nest-building habits differ.

Umbrella Wasps



Umbrella Wasp & Nest

The nest of the umbrella wasp best demonstrates a basic building pattern. Nests are made of paper-like material produced by the wasps, but appear as a flattened, circular-shaped comb of cells opening downward.

These are initiated by the umbrella wasp queen, which starts the nest with a thick paper-like strand attached to an overhanging structure, then adds a small number of cells.

Umbrella wasps are slender, elongated wasps, about 1.9 to 2.54 cm (3/4 – 1 in) long. They are black, brown or red with a few yellow markings. An umbrella wasp nest usually contains less than 250 individuals.

Hornets and Yellow Jackets

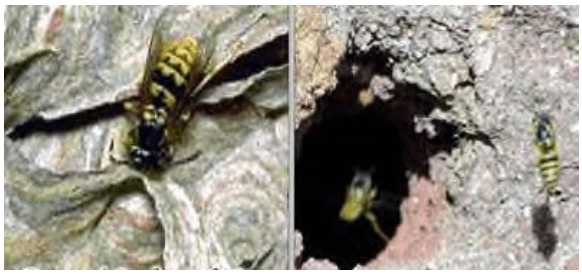
Hornets and yellow jackets build two different kinds of nests.



Bald Faced Hornet Nest

Aerial Nest Builders: Aerial nest builders include hornets and some yellow jackets, which build large football-shaped nests from paper materials similar to those of the umbrella wasp. These nests do not consist of a single, flat comb like that of the umbrella wasp, but contain from four to six wide circular combs, one hanging below the other, and all enclosed in an exterior multi-layer oval paper envelope which provides insulation. These nests are usually found on branches of trees, in shrubbery, and on gables. Hornet nests may only contain 500 to 600 workers, but yellow-jacket nests can support up to 10,000 individuals.

Underground Nest Builders: Underground nest builders include other yellow jackets that place a protected nest in a natural ground depression, rodent or animal burrow, or into building wall voids, attics, hollow trees, and other enclosed spaces instead of in the ground.



Yellowjacket & Underground Nest

Once workers begin to care for the nest, they enlarge the entrance hole and try to expand the nest. Combs are placed in tiers, one above the other. Nests can become very large and contain up to 15,000 individuals.

Hornets and yellowjackets are black with yellow or white markings and are more compact appearing than umbrella wasps.

Hornet and yellowjacket queens measure about 1.9 cm (3/4 in) long. The males and workers are about 1.27 cm (1/2 in) long. These wasps are feared because they sting. Populations are at a peak from late July to late September. Hornets and yellow jackets become more aggressive and easily irritated in the fall as the colony becomes old and there are fewer larvae to provide foraging adults their "sugar hit."

Solitary Wasps and Bees

Solitary wasps and bees do not build large social nests. The female digs a hole in the ground, tunnels into wood, or builds a nest out of mud. She then constructs a cell or group of cells into which she deposits eggs, provides them with a food source (pollen, or paralyzed insects), and abandons the nest, leaving the young to hatch and mature on their own.

<u>Mud Daubers</u>

Mud daubers are slender wasps, about 1.9 – 2.54 cm (3/4 – 1 in) long. They are black and yellow, metallic blue, or shiny black, and do not sting unless provoked. Their nests are long clay cells placed in such protected places as electric-motor housings, stored machinery, sheds, outhouses, attics, on building siding under overhangs, and under porch ceilings. Occasionally, wasps construct their nests on painted surfaces, which may create an added burden of repainting the area after the nest is removed. Mud daubers stock their clay nest tunnels with a paralyzed spider, caterpillar, or other insect. Then, inside a silken cocoon, they deposit a fertilized egg on the prey and close the nest hole. The egg hatches and the larvae feed on the prey.



Mud Dauber

Adults emerge in the spring. In the fall and spring, abandoned nests often house carpet beetle larvae that feed on residual organic debris in the open clay tunnel. Indoor carpet beetle infestations have been traced to abandoned mud-dauber nests.

Cicada Killer Wasps





Cicada Killer Wasp **Killer with Cicada**

Cicada killer wasps are very large (2.84 – 4.04 cm [1 1/8 – 1 5/8 in] long) solitary wasps with a black body. The first three abdominal segments are marked with yellow across the thorax, similar to smaller yellow jackets. Legs of the cicada killer wasp are yellowish and wings are brownish. Adult cicada killer wasps feed on nectar. In late summer, the female digs a conspicuous burrow (nest) in the ground (often in lawns or gardens) that has a horseshoe-shaped mound of dirt at the entrance. Burrows may be one inch to 3.81 cm (1 1/2 in) in diameter, .61 – 3.05 cm (2 – 10 in) under the surface of the ground, and up to 45.72 cm (18 in) long. The female constructs three to four cells at the end of the tunnel, which she stocks with a paralyzed cicada or two, and then lays an egg in each cell. After eggs hatch, larvae feed on the cicada. Mature larvae hibernate over winter in the burrow, pupate in the spring, and emerge as adults from late July to August.

Although cicada killer wasps are helpful in reducing cicada populations, they frighten people because of their large size and the number of wasps frequenting attractive egg-laying sites. Male cicada killer wasps guard the burrows. Although they may aggressively fly at an invader, they do not sting. Females rarely sting, usually only if provoked.

Carpenter Bees



Carpenter Bee

Carpenter bees are smooth and shiny solitary bees with a mostly black abdomen. Carpenter bees are similar in appearance to bumble bees, but lack hair on the dorsal side of the abdomen, except on the first segment.

They bore into wood to make a tunnel in which they lay eggs and supply developing young with pollen. The tunnel is divided into cells where the individual larvae develop. The tunnels bored by carpenter bees may cause structural damage to buildings where they nest. Typical nesting sites in a structure include fascia, window trim,

eave areas, rafters, wood shingles, wood siding, patio furniture and exterior wood trim. Although many different types of wood are selected for nesting sites, softer woods are preferred. Additional damage to the structure can be made by woodpeckers as they bore into the wood to feed on the developing larvae.

Honey Bees

Honey bees make social colonies of up to 60,000 individuals that live through a number of seasons. Individuals survive the winter by clumping together into a tight group to conserve heat and feed on honey collected and stored during the preceding summer. The number of individuals in a honey-bee colony increase during the spring nectar flow (flower bloom) and the members develop a queen cell. Before the new queen hatches, the old queen and about half of the bees leave (swarm) the colony and establish a new one in a protected hollow tree, rock void, attic, or building void.



Honey Bee

Both the original and new colonies increase in number over summer and swarm again the next spring. Africanized or "Highly Defensive Bee" colonies have the same life cycle as the European honey bee in the United States, except that Africanized honey bees produce less honey during summer and the colonies swarm much more frequently. Wild (colonies not housed in hives) honey-bee combs appear as long, hanging tiers of cells joined together at the top and made from wax that worker bees produce.

HAZARDS OF INFESTATION

Hazards

Yellow jacket problems develop in August or later, when their populations and nest activities are the greatest. Yellow jackets are extremely aggressive wasps and, when stinging, release odors that further enrage the entire colony.

When disturbed, bees and wasps drive a needle-like stinger into a victim's flesh and inject a venomous fluid. The venom causes painful swelling that may last several days. Stings may prove fatal to persons allergic to the venom who do not immediately use an anti-venom or consult a doctor.

Africanized honeybees or "Highly Defensive Bees" are a serious health and safety threat due to their aggressive nature. The Africanized bees will respond to threats to the hive by sending out as many as ten times the number of European bees to protect the hive, resulting in more incidences of bee stings and multiple sting events. Africanized bees have also been known to follow a moving target after stinging has begun.

Africanized bees and European honeybees can live almost anywhere around buildings, making the Africanized bee an even greater threat. Nesting sites include hollow tree wells, chimneys,

storage, in trees, in abandoned automobiles, under eaves or overhangs and anywhere they can find shelter from the sun large enough to protect their wax combs. Eliminating access to potential nesting sites when possible is one way to prevent honeybee infestation. This can be accomplished by:

- Removing and discarding stored items around the exterior of buildings and grounds.
- Repairing holes in exterior walls to prevent bees from nesting in the hollow wall areas.
- Install fine meshed (.3 cm [1/8 in] hardware cloth) screens over tops of rain spouts, vents and openings in utility boxes.
- Secure sheds and outbuildings; close void areas if possible.

INSPECTION AND MONITORING

Inspect areas above doorways, holes leading into structures, and hollow trees or rotten tree stumps for stinging-insect nests. Monitor garbage cans for the numbers of wasps or bees feeding there over a set period of time. Take management action when fifteen or more foraging wasps or bees visit an open garbage can in ten minutes. Good records should allow correlation of stings with numbers of foragers. This monitoring information can be used to predict when action may need to be taken to manage these generally beneficial insects.

Heed the following precautions when working with wasps and bees:

- Listen for buzzing indicating presence of bees nearby.
- Use caution when entering sheds, outbuildings or any storage area that is infrequently accessed.
- Inspect work areas before using outdoor power equipment including lawnmowers and weed cutters.
- Perform exterior inspections of buildings and outbuildings regularly (at least twice per year).
- From spring to fall, check once or twice a week for bees entering or leaving the same area of the building or yard.
- Teach staff to be cautious and respectful around all bees.

Treatment for Wasp and Bee Stings

If stung by a wasp or bee, take the following steps:

- Go quickly to a safe area inside a building and close the door.
- Remove stinger(s) as soon as possible.
- Don=t squeeze the stinger; pressure will release more venom.
- Scrape the stinger out with fingernail, knife blade or credit card.
- Wash the sting area with soap and water.
- Apply an ice pack for a few minutes to relieve pain and swelling.
- Seek medical attention if breathing is troubled, if stung numerous times or if allergic to bee stings.

MANAGEMENT

Sanitation

Good sanitation manages the amount of food available to wasps. Denying food forces worker wasps to find less abundant natural prey and limits the amount of nutrition which larvae receive during periods of exponential colony growth. This ultimately restricts the colony size. Following are sanitation measures which will reduce wasp and bee problems:

- Keep garbage cans tightly closed.
- Check cans often for gaps and holes; request frequent garbage pickup.
- Install garbage liners in cans and promptly clean up garbage spills.
- Frequently clean both inside and outside of garbage cans with steam or soap and water.
- Move dumpsters and trash barrels away from doorways or other areas of human traffic.
- Prevent the accumulation of standing liquid waste from garbage or dumpster containers underneath the dumpster or in low-lying areas.
- During summer, yellow jackets are attracted to meat; keep food covered.
- Clean up all food or drink spills that attract bees and wasps. Wipe outdoor food-preparation surfaces and picnic-table tops with appropriate cleaning solutions.

Exclusion

Some methods of exclusion appropriate to a public building site are:

- Assure that all doors and windows close tightly and that screens are in good condition.
- Frequently and carefully inspect structural exteriors and seal all possible wasp or bee entry spots.
- Seal holes in hollow trees and remove rotten stumps.

Physical, Mechanical, and Cultural Measures

Whenever working around wasps and bees, wear protective bee veils and coveralls. Do not allow bystanders and pets to remain nearby. Approach honey bee nests on warm and calm days. Bees are more aggressive on cloudy and windy days when foraging is not possible. Avoid walking through the flight paths of foraging wasps and bees leaving and returning to the colony. At night, avoid shining lights or casting shadows on the nests; use red lights when working on colonies at night. Walk softly near ground-nesting bees and wasps to avoid making vibrations that alert the bees. Carefully and slowly brush off a bee or wasp that lands on a person, or wait until it flies off. Inspect and remove all small wasp nests early in the spring, while nests are still small. Removal at this time of the year is easily done with a broom, vacuum cleaner, garden hose, or other mechanical means. Later, nests will be much larger and better guarded by workers. Watch for honey bee swarms in April and May when they begin to search for new nesting places: including holes leading into structural voids. Swarms can be discouraged from nest establishment in buildings by various mechanical means such as providing a hive box.

Nesting pests in wall voids can be detected by using a stethoscope. Yellow jacket nests in wall voids do not necessarily require removal since they do not contain honey and are not reused in the following year. Abandoned nests, however, may attract fabric pests such as dermestid beetles. Do not seal up active nests before killing the insects. If wasps or yellow jackets are sealed into wall voids without an exit, they will chew through the wall to exit somewhere else, even into the interior of the building. If honey bees are sealed into wall voids, melting honey will spoil, rot, and stain the wall. After destroying and removing nests, close up holes with copper gauze, caulk, duct tape, spackle, putty or screening.

Use outdoor lights that are not attractive to insects. Remove stumps, dead limbs and hollow trees that can be used for nest sites. Remove plants that attract wasps and bees, including those that are vulnerable to scale or aphid attack which produce honeydew food sources for wasps.

Sticky or jar traps may be used to capture wasps, however, traps reduce only a small number of foragers.

Keep a list of local bee keepers who may voluntarily remove honeybee nests. Remove dead honeybee colonies and residue from walls so remaining organic debris and odor does not attract more insects.

Don't go barefoot; don't make unnecessary movements, and don't strike at individual wasps or bees flying nearby. In areas frequented by such insects, avoid wearing perfumes, scents, hair spray, suntan lotion, shaving lotions, talcum powder, cosmetics, and brightly colored or highly patterned clothing, which are attractive to bees and wasps. Examine wet towels before use to see if insects are taking moisture from them. Reduce honey bees on lawns by closely mowing clover and flower heads.

Other Measures

Biological

Biological methods show little promise; parasites, predators, and pathogens are mostly effective only on small, weakened colonies.

Heat

Wet or dry temperatures of 54°C (130ºF) effectively kill wasps and bees. If an infested area is covered with a plastic tarp, the summer sun generates sufficient heat to kill them.

Vacuum

Wasp and bee nests can be removed with an industrial vacuum cleaner. (Wear protective clothing.) Be sure the vacuum nozzle is placed over the only entrance hole before disturbing the nest. When the last of the colony is removed, plug the vacuum bag with cotton and heat it in the sun to kill the insects.

Pesticides

Poison Baits

When deemed necessary, pesticide applications shall be performed by licensed applicators only.

Applications shall be made according to National Park Service policy and procedures guidelines, according to pesticide label directions, and following applicable laws and regulations.

A number of commercial pesticides are available which foraging wasps and bees carry into the nest. Choose the appropriate bait material to mix with the insecticide depending on feeding habits, which change with the season. Poison baits should not be accessible to children and non-target insects and animals.

Aerosol Sprays for Aerial Nests

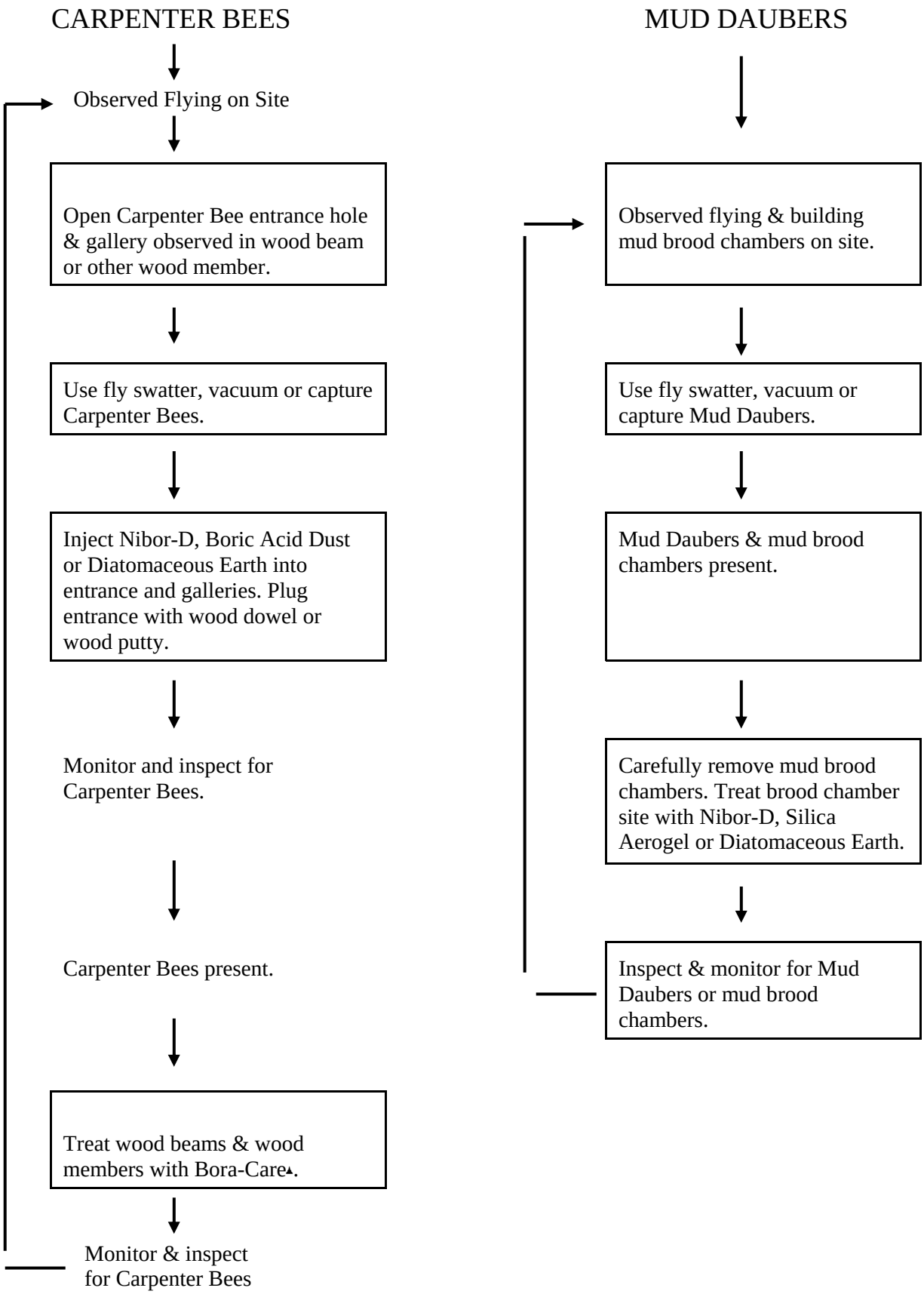
A number of commercial aerosol preparations are available that quickly and safely destroy aerial wasp and bee nests. Follow label directions.

Insecticides for Subterranean Nests

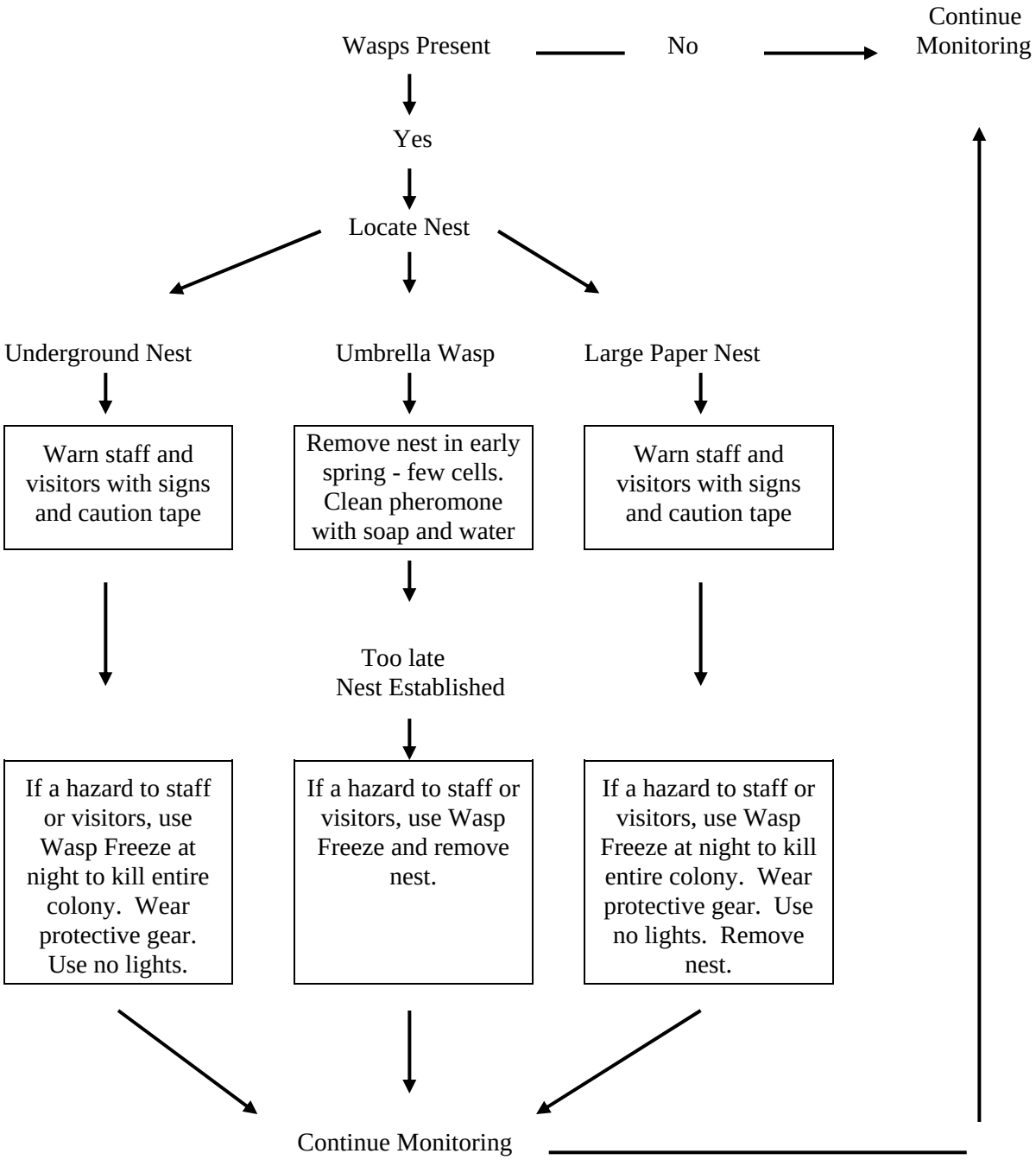
After locating and sealing all entrances but one, properly labeled insecticides can be poured into subterranean colonies and the entrance plugged.

Dusts and Aerosols for Wasp and Bee Nests in Wall Voids and Attics

A number of residual pesticide dusts and aerosol formulations are available to treat nests in building walls and attics. Follow label directions. Having found the location of a nest (listening for buzzing behind plasterboard), drill a hole and inject aerosol or dust directly into the colony. Killing honey bees in walls with pesticides causes deterioration of honey and nest combs and attracts other bees and troublesome insects; melting honey and wax may stain walls unless the structure is opened up to remove the debris. Contact your local beekeeper association for assistance, if necessary, to remove honey bees by means other than pesticides. Do not seal all entrances of nests located in building walls without killing the colony since wasps and bees may find an exit into the interior of the building.


CARPENTER BEES
Observed Flying on Site
Open Carpenter Bee entrance hole & gallery observed in wood beam or other wood member.
Use fly swatter, vacuum or capture Carpenter Bees.
Inject Nibor-D, Boric Acid Dust or Diatomaceous Earth into entrance and galleries. Plug entrance with wood dowel or wood putty.
Monitor and inspect for Carpenter Bees.
Carpenter Bees present.
Treat wood beams & wood members with Bora-Care.
Monitor & inspect for Carpenter Bees
MUD DAUBERS
Observed flying & building mud brood chambers on site.
Use fly swatter, vacuum or capture Mud Daubers.
Mud Daubers & mud brood chambers present.
Carefully remove mud brood chambers. Treat brood chamber site with Nibor-D, Silica Aerogel or Diatomaceous Earth.
Inspect & monitor for Mud Daubers or mud brood chambers.

WASPS


Wasps Present
No
Continue Monitoring
Yes
Locate Nest
Underground Nest
Umbrella Wasp
Large Paper Nest
Warn staff and visitors with signs and caution tape
Remove nest in early spring - few cells. Clean pheromone with soap and water
Warn staff and visitors with signs and caution tape
Too late
Nest Established
If a hazard to staff or visitors, use Wasp Freeze at night to kill entire colony. Wear protective gear. Use no lights.
If a hazard to staff or visitors, use Wasp Freeze and remove nest.
If a hazard to staff or visitors, use Wasp Freeze at night to kill entire colony. Wear protective gear. Use no lights. Remove nest.
Continue Monitoring

SPIDERS

CHARACTERISTICS AND RECOGNITION

General

Only a few species of spiders live in structures; most are accidentally carried into buildings on firewood, laundry, or plants. 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. These generic names, however, represent several different species. The following discussion describes these two spiders, but generally applies to all spiders.

Black Widow Spider

Several kinds of black widow spiders are widely distributed over the eastern, southern, western, and northwestern states of this country. Black widow spiders are normally outdoor species that sometimes move or are accidentally brought indoors. Young spiders may migrate inside on ground-floor levels. Outside, the black widow can be found in crawl spaces and bird nests, on low-growing plants and grape arbors, and under porches, garages, and sheds. They are also found in stacked pots, baskets, boards, firewood piles, rodent burrows, and water meters, and under bricks and stones.



Female Black Widow with Egg Sac



Female Black Widow

The female black widow has poison glands and fangs with which she kills insect prey. These spiders can go for as long as three to four months without eating. Although the female black widow rarely leaves the web, males are more adventurous, especially when seeking a mate. When they first hatch, males are slightly venomous, but the potency of venom is lost as they mature. Male black widow spiders are not dangerous to people.

The adult female black widow spider has a shiny black abdomen that is usually decorated on the underside with red or yellow-red markings resembling an hourglass. This mark is visible when the female hangs upside down in the web. The markings, which may be absent, vary in different individuals from that of a typical hourglass shape to a pattern of two or more triangles; occasionally, some spiders may only possess a long, irregularly colored area. Male black widow spiders are small, white, and streaked with red, white, or yellow. Female black widows are about 1.27 cm (1/2 in) long; males are only about half that size and have longer legs.

The adult female black widow spider is primarily nocturnal. She weaves tangled webs of coarse silk in dark locations, and in late summer she begins to lay batches of eggs in units of 300 to 400 on the web. Four to nine batches of eggs, covered with a silken sac, can be produced during a season. The female guards the egg capsules and moves them as necessary when repairing the web. Females tend to be hungry and aggressive after egg laying, during which time most human-related bites seem to occur. Eggs hatch in eight to 10 days, and the young disperse by riding air currents on short strands of web. Young black widows mature in about four months and only mate once. Although some believe the female kills the male after mating (hence, the name "widow"), others contend that the female rarely does so. The life span of a spider is from eighteen to twenty-four months.

Brown Recluse Spider

Seven varieties of brown recluse spiders make up this group. These are dusky-tan or brown spiders that range over most of the United States, sometimes "hitch-hiking" into dwellings on luggage or household furnishings imported from other places.



Brown Recluse Spider

The brown recluse spider is an outdoor species that hunts at night. It doesn't use a web to capture prey; but rather runs fast to overtake it instead. In the south, the brown recluse lives under loose bark, in woodpiles, under sheds and beneath debris. In the north, it has to live indoors, especially in the sleeves of clothing hung for long periods of time in closets. The brown recluse spider has a high moisture requirement, and is often found near water heaters. It may also be found behind or under furniture and boxes.

The brown recluse is a medium-sized spider (about .79 – 1.27 cm [5/16 – 1/2 in]) and smaller than the black widow. Unlike the black widow, the brown recluse has an oval abdomen that is uniformly tan-to-dark brown and without markings. A dark "violin-shaped" fiddle back mark is obvious on the cephalothorax (combined head and thorax portions) on most species. The broad base of the fiddle begins at the eyes and the narrow part of the fiddle neck ends just above the attachment of the abdomen. The brown recluse has three pairs of eyes (in groups of two) placed in a semi-circular pattern (rather than four pairs for most other spiders). Its legs are long, the second pair longer than the first.
Although the brown recluse makes a fine, irregular web, it wanders around to hunt after maturing. During a lifetime, females produce one to five egg cases of 30 to 50 eggs each. Eggs

are placed on the web in a loosely woven sac of wispy sheets of silk. Usually one or two young spiders per brood survive, because adults are cannibalistic (and also feed on black widow spiders). Recluse spiders mature in seven to twelve months, and they generally live one or two years.

HAZARDS OF INFESTATION

Black Widow Spider Bites

Death results in less than four percent of persons bitten by black widow spiders. Strong, healthy adults rarely succumb to a bite, but young children are more vulnerable. Deaths among the elderly are usually the result of complications beyond the spider's bite.

Female black widow spiders are quite timid and usually make no effort to bite, even when provoked. Bites may occur when a spider is accidentally squeezed against a person's body. Spiders make webs in the folds of clothing, shoes, or under objects in dark corners.

The severity of the black widow bite depends on the amount of venom injected, age and condition of both the victim and the spider, part of the body bitten, degree of immunity of the victim, and treatment given. A black widow spider bite is not always felt, and in most cases, only two tiny spots along with redness appear at the bite site. Pain begins to increase around the bite after half an hour or more, along with other symptoms such as headache, dizziness, shortness of breath, and abdominal and back pain. The pain lasts for 12 to 48 hours and is generally worse by the second or third hour. Muscles in the victim's abdomen become rigid, and the person may develop nausea and, in some cases, convulsions.

How to Treat a Black Widow Bite

Anyone bitten by a black widow spider should be treated for shock by being kept quiet, preferably in bed and covered with a blanket. Victims should receive hospital treatment as soon as possible; antivenom is readily available to most physicians. If a doctor is not available, wash the skin around the bite but make sure any venom still remaining on the skin is flushed away from and not into the wound. A recommendation is to continually apply ice to the bite site, since cold delays absorption of the poison and gives the body an opportunity to neutralize the venom. Never administer alcohol since it increases sensitivity to the venom. Give the patient plenty of water and sweet weak tea.

Brown Recluse Spider Bites

Brown recluse spiders generally avoid areas of human activity, and are usually found only in unused rooms. Even though indoor infestations may be large, household residents are seldom bitten. The brown recluse is not aggressive but bites and causes severe wounds when squeezed against a person's skin, as in putting on shoes or clothing (most bites occur on arms and legs). Bites can be expected when previously unused rooms are occupied or when clothing stored for a long time in closets is brought out for use. Brown recluse bites sometimes produce a sharp sensation at first, which may be mistaken for a bee sting or insect bite. However, it may not be noticed at all. Victims may not realize the full extent of the trouble for eight to 12 hours, when pain becomes intense. A reddened area and accompanying painful swelling develop at the bite,

and nausea, vomiting, fever, and a rash may follow. The site of the bite becomes dark and dry and after seven to 14 days, tissue surrounding the bite becomes an open ulcerous wound. Without prompt medical attention and over a period of days, the ulcerous wound becomes a festering sore. Although scabs may form over the wound, they tend to fall off and the wound continually grows deeper and fails to heal for several months (up to a year). There is always the potential for gangrenous infection and skin grafts are sometimes required to close the wound. Death from bites is extremely rare, but bites are very debilitating and traumatic.

How to Treat a Brown Recluse Bite

Apply ice to a bite as soon as possible, elevate the limb, and take the victim and captured spider (if possible) to a physician. The brown recluse is a delicate spider and after a bite it can usually be found near where it was slapped by the victim. The spider should be killed (without destroying it so it can be identified) and taken with the victim to the physician. Identification of the spider is important for proper treatment because a few other biting arthropods produce similar injury.

Other Hazards

Some spider webs may clog vent pipes and trap fumes or odors inside structures.

INSPECTION AND MONITORING

Move cautiously when inspecting or treating any sites where there is potential spider harborage.

Inspecting For Recluse Spiders

Wear long sleeves, long pants, socks, and gloves and use a flashlight during inspections along walls in little-used, cluttered storage areas such as closets and attics. Look for loose irregular webs, cast skins and silky egg cases (about .84 cm [1/3 in] in diameter) but avoid placing hands into dark places. Spiders shed their skins in order to grow. These "cast" skins are fragile but retain a characteristic violin marking. Such skins indicate infestation.

Inspect behind and under furniture, in kitchen and bathroom cabinets, closets, ceiling light fixtures, stacks of firewood, and water heater closets. Other locations for inspection should include mattresses and bedding; walls and floors and stacked boxes, bags, papers in store rooms and sheds; behind picture frames; under stairs; and hanging clothing that has not been used for some time. Concentrate on areas outside daily traffic patterns.

Outdoors, brown recluses are found between the soil and foundations, under door stoops, and in window wells.

Monitoring Brown Recluse Spiders

The presence of brown recluse spiders can be monitored in sticky traps. Tent-top or other sticky traps with covers seem the most effective.

MANAGEMENT

General

Spiders should be conserved whenever possible; they are natural control agents for many pests.

Major Mistakes in Spider Management Procedures

The following are the mistakes made in spider management procedures:

- Spiders are re-introduced into structures by way of firewood, laundry, and flowers.
- Failure to eliminate the insect food source.
- Over-responding in management measures due to spider misidentification.
- Extensive pesticide application when only a few harmless spiders are present, which could be managed by physical or mechanical means.

Physical, Mechanical, and Cultural Measures

Sanitation

Habitat modification, good sanitation, and exclusion are absolutely necessary for long-term spider elimination; inform occupants of the need and the techniques.

Frequently and thoroughly vacuum (with an industrial vacuum) all cracks and crevices, closets, behind furniture, and mop floors to destroy webs, egg sacks, and young spiders. Clean dark corners inside the structure using leather or rubber gloves. Concentrate efforts for brown recluse management in seldom-used rooms. Remove webs off exterior of building so that spiders leave.

Remove lumber, scrap, rubbish, and debris from near and under buildings and frequently clean rain gutters. Stack firewood, brick, and stone piles away from buildings; inspect firewood for spiders and egg sacs. Keep grass mowed and cut very short next to buildings; establish a three foot swathe of gravel cleared of vegetation all around buildings. Keep trees and shrubs trimmed back at least three feet from structural walls. Pick up leaf litter and other debris in yard, especially next to buildings.

Make occupants aware that spiders are often introduced into structures on firewood, lawn furniture, garden implements, and children's toys. Remove the bark from firewood before bringing it inside; don't bring in any more wood than will be burned in an hour or two.

Perform annual spring cleaning: turn mattresses, clean closets; dispose of unused items, rotate seldom-used items in garages, under beds; neatly stack items inside away from walls; remove

and wash all bedding; remove and clean drawers from dressers and remove cobwebs. This is very important for brown recluse management because it interrupts the spider's reclusive habits. Re-inspect spaces disturbed by dusting, vacuuming, and mopping the same evening, and kill any moving spiders.

Inspect winter clothing and other unused closets during spring and summer. Before returning clothing to storage, clean it and pack it in sealed plastic bags.

Repair all water leaks and sources of condensation on pipes.

Reduce the numbers of insects in and around building. To avoid attracting spiders, arrange outside lighting so as not to attract insects. Move lights onto poles and away from structures. Trim weeds and remove debris around foundations, caulk entry holes, install tight-fitting screens and door sweeps. Spiders need a ready supply of insects to survive and invade structures infested with insects.

Regularly clean floors and baseboards and remove debris. Do not leave old clothing, bedding, boxes or piles of paper on floors.

Thoroughly clean attached garages and basements, crawlspaces, and outbuildings.

Dry out crawlspaces or spider problems will recur.

Exclusion

Inspect doors and window casings to be sure screens function properly. Caulk holes large enough to admit spiders including openings around water pipes and electrical lines. Keep tubs, sinks, and drains stopped at night. Install tight-fitting door sweeps to exclude spiders and crawling insects.

Other Measures

Biological

Mud dauber wasps, birds, rodents, and predatory insects prey on spiders.

Heat

Infested rooms can be treated by heating them to over 49°C (120ºF) for one-half hour.

Direct Measures

Step on individual spiders, kill them with a fly swatter, or remove them with a vacuum.

Pesticides

When deemed necessary, pesticide applications can be performed by licensed applicators only. Applications shall be made according to the National Park Service Integrated Pest Management policy and procedures guidelines, according to pesticide label directions, and following applicable laws and regulations.

Pesticides, when used, should be combined with nonchemical measures. Although spiders are susceptible to most insecticides, chemicals are seldom used because of difficulties in getting spiders into contact with pesticides: they do not ingest pesticides during grooming and walk on hairs on their feet which prevent surface contact.

Web-building spiders seldom leave their webs.

Pesticide dusts, however, are sometimes applied in attics and crawlspaces. If a good spider reduction is done in the fall, few problems should occur until early to late summer of the next year.

When using pesticides to treat structures for spiders, warn occupants to be cautious in rooms that were treated, because spiders not killed will wander for a few days following treatment.

Carefully analyze the microhabitat occupied by problem spiders and use appropriate nonchemical and management methods.

Indoors

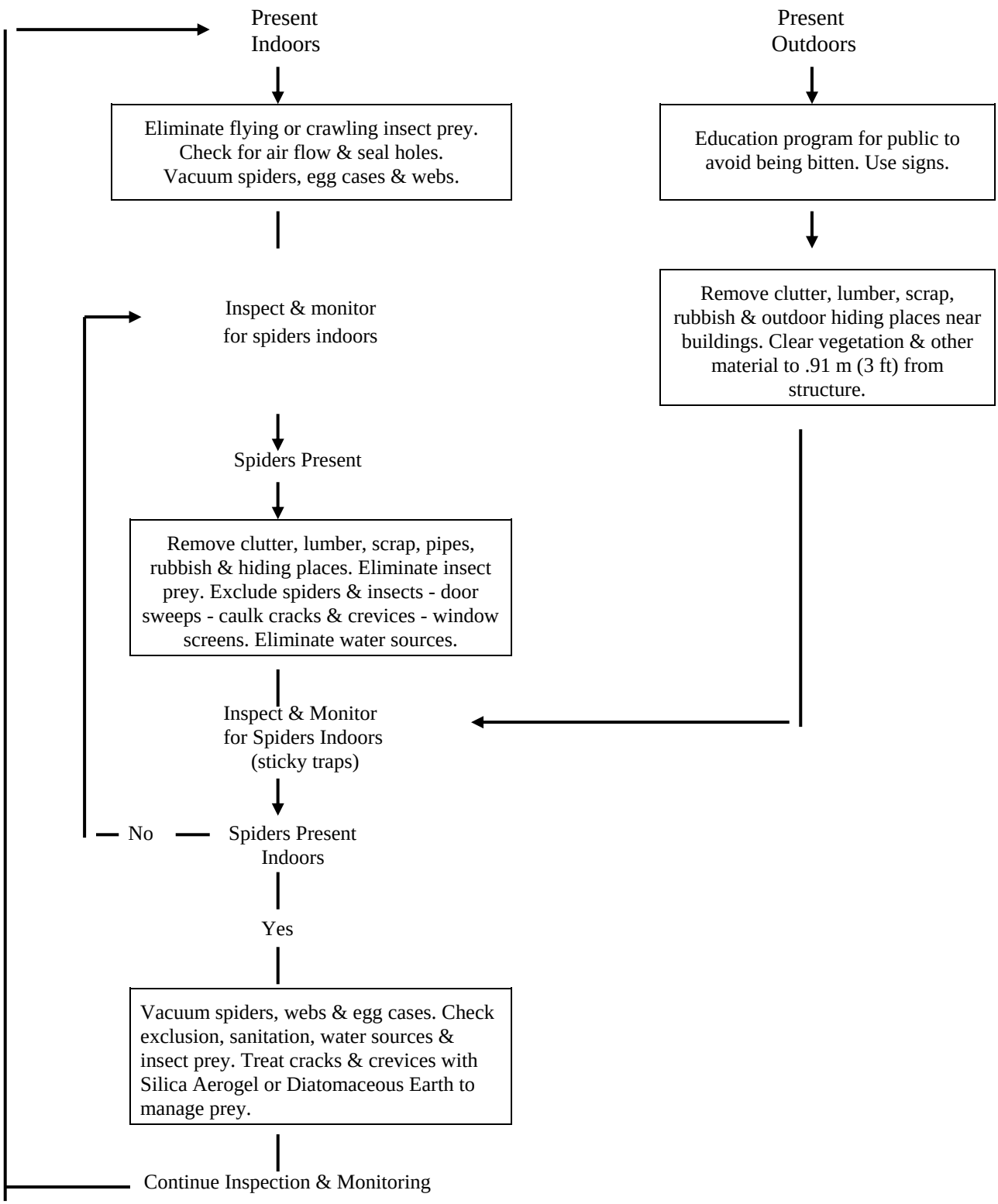
If necessary, use crack-and-crevice application dusts such as diatomaceous earth to treat the structure, including attic and crawlspace, window and door frames and casings, baseboards, cracks and crevices, room corners, beneath and behind furniture, closet bottoms, and garage in order to reduce insects spiders feed on. Since web-building spiders recycle silk (eat and digest old webs); light dust applications on webs may be effective.

If spider populations are not reduced, spot-treat areas of infestation with residual pesticides by directing insecticide into voids, cracks, and crevices.

Outside

Using the above techniques and materials, treat around foundations, windows, doorways, pipe openings, wooden fences, weep holes in brick walls or veneers, and building perimeters. Dustings should be wide-spread to eliminate spiders before they enter the dwelling. There is no need to treat the lawn. Follow label directions.

SPIDERS


Present Indoors
Present Outdoors
Eliminate flying or crawling insect prey. Check for air flow & seal holes. Vacuum spiders, egg cases & webs.
Education program for public to avoid being bitten. Use signs.
Remove clutter, lumber, scrap, rubbish & outdoor hiding places near buildings. Clear vegetation & other material to .91 m (3 ft) from structure.
Inspect & monitor for spiders indoors
Spiders Present
Remove clutter, lumber, scrap, pipes, rubbish & hiding places. Eliminate insect prey. Exclude spiders & insects - door sweeps - caulk cracks & crevices - window screens. Eliminate water sources.
Inspect & Monitor for Spiders Indoors (sticky traps)
No
Spiders Present Indoors
Yes
Vacuum spiders, webs & egg cases. Check exclusion, sanitation, water sources & insect prey. Treat cracks & crevices with Silica Aerogel or Diatomaceous Earth to manage prey.
Continue Inspection & Monitoring

TICKS

GENERAL

Ticks have recurved teeth or ridges on the central mouthparts (called the holdfast organ). They also have, on each of the first pair of legs, a sensory pit which detects stimuli such as heat and carbon dioxide. Ticks also detect light and dark as well as shapes, shadows, and vibrations—all stimuli that help them find their hosts. Soft ticks are not likely to be found at MORR. Worldwide, there are over 650 species of hard ticks.

Some ticks live their entire lives on one host, while others spend only their larval and nymphal stages on a single host; then drop off as an adult to find another host. Most ticks, however, have three hosts, one for each stage.

Life Cycle

Seed Ticks

Normally, thousands of tiny larvae hatch from a batch of eggs and crawl randomly in the surrounding area; larvae (or seed ticks) have only three pair of legs. Some attach to a small mammal or lizard. They suck blood. Their feeding (or engorgement) time lasts for hours or a day or so since they are small. The host may distribute them while wandering away from the site of the initial encounter. When the engorged seed ticks drop off, they are still usually in or near an animal run.

Nymph

After molting, the nymph climbs grass leaves or a plant stem. Ticks climb progressively higher as they develop, so that different stages reach different layers of vegetation. Because of this, developing ticks find larger hosts than they had during the previous stage. After several days of feeding, the engorged nymph drops off its host and molts. Nymphs and adult ticks have four pair of legs.

Adult

The adult climbs vegetation, stretches its front pair of legs, and waits for vibrations or a shadow announcing a nearby host. Ticks sometimes wait for months or more for a suitable host. If heat or carbon dioxide is detected (for instance, from a passing mouse), the tick will seek it out. As the host passes by, claws located at the tips of the tick's legs grab hold of the host, and the tick moves to a place where it can engorge.

Attachment and Feeding

Adult female hard ticks will feed for several days to more than a week. Ticks usually grasp human hosts from a point close to the ground and crawl upwards until constricted by tight clothing or reach the head. On wild mammals or pets, they move until they reach the highest point on the host, the head or ears.

The tick's ability to creep undetected is matched only by its ability to attach for feeding without the notice of the host; stealth keeps ticks from being scratched off by the host before they can attach. When feeding is complete, the engorged female drops off of the host, lays eggs, then dies.

TICK RECOGNITION

American Dog Tick



American Dog Tick

Larvae and nymphs of the American dog tick, *Dermacentor variabilis,* prefer small rodents especially *Microtus,* the short tailed voles, called meadow mice.

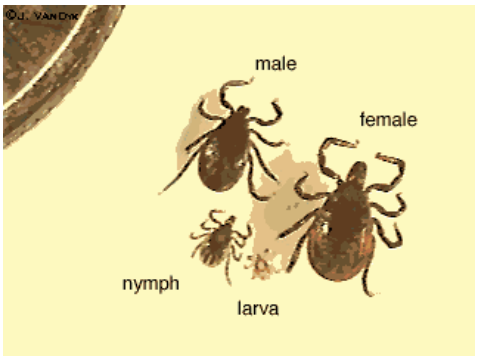
The adults, which are slightly over .3 cm (1/8 in) long, are found on dogs and people. The adult female is brown with a pearly light anterior dorsal shield. Males are brown-backed with pearly streaks. Both sexes have eyes, or unpigmented light-receiving areas, at the edges of the shield.

With a favorable food supply, American dog ticks can complete their life cycle in three months, with the female laying up to 6,500 eggs in late summer. Warm springs promote early adult and larval activity and egg-laying.

Adult ticks usually contact people on the lower extremities and crawl upwards until they are stopped by constricting clothing. Loose clothing allows ticks to proceed as far as the head. Because of possible communication of Rocky Mountain Spotted Fever (RMSF), any tick attachment should be noted and the victim observed for symptoms.

Deer Tick

The deer tick, *Ixodes scapularis* Say, larvae are very small. Nymphs are close in size to the adult, a little less than .15 cm (1/16 in), or the size of the head of a pin. Adult deer ticks are the size of a sesame seed. Deer ticks have a two-year life cycle and utilize three different hosts.



Deer Ticks

<u>Eggs and Larvae</u>
Eggs of the deer tick are laid in the spring by overwintering females. Tiny larvae hatch and feed on deer mice and white-footed mice in the late summer. Larvae can feed on human beings but will not transmit Lyme disease. After overwintering, larvae molt into the nymphal stage the following spring.

Nymphs

Nymphs are ready to feed in May and June. The body of the nymph is tan with black legs and a black shield (scutum) near its front. Nymphs climb vegetation and attach to passing animals such as dogs, cats, horses, cattle, raccoons, opossums, mice, migrating birds, and people.

Nymphs live in woodlands: bushy, low shrub regions and grassy areas where they can infect animals and people. Most human Lyme disease cases are the result of nymphal tick feeding. The remainder is due to adult activity. Nymphs usually molt into the adult stage in late summer, although they sometimes overwinter and molt in the spring.

Adults

The body of the adult female is brick red with black legs; she has a black shield (scutum) in the front. The male is entirely dark and smaller than the female. Adults feed in late fall or spring as well as on warm days in winter.

TICKS AND DISEASES

Several species of hard ticks are responsible for the spread and increase of Lyme disease and the persistence of Rocky Mountain Spotted Fever (RMSF).

Lyme Disease

Lyme disease is caused by a spirochaete (a spiral shaped bacteria). Symptoms vary and may resemble other diseases; many cases go undetected. The first indication of a potential infection may be the discovery of an attached *Ixodes* tick. Disease transmission does not occur until an estimated 10 – 12 hours after feeding begins, if the tick is located and removed within that time, no infection will occur. If infestation occurs, Lyme disease is a very debilitating and painful disease.

Rocky Mountain Spotted Fever (RMSF)

RMSF is caused by a rickettsia, a disease organism related to bacteria. It is an acute infectious disease characterized by pain in muscles and joints, fever, and spotty, red skin eruptions. At least four to six hours elapse after the American dog tick begins feeding before disease transmission begins. If ticks are removed during this non-infective period, infection will not occur.

Tick Paralysis

All species may cause tick paralysis if they feed at the base of the victim's skull for extended periods. Symptoms include paralysis of the arms and legs, followed by a general paralysis which can cause death. The victim can recover completely in a few hours, after the tick is removed.

TICK PEST MANAGEMENT

Where pest-management services are provided to a public site, it is important to know what kinds of ticks are present, where they are most numerous, and what the disease potential in the

area is, and what the host and reservoir populations are. Pest-management programs are critical for effective management of tick species that transmit Lyme disease or Rocky Mountain spotted fever.

Inspection and Monitoring

Dragging

A commonly-used method of off-host sampling involves dragging a white flannel cloth over the ground or foliage where ticks are questing for passing hosts. Ticks cling to the cloth, and can be removed for counting and identification. Sample sites should represent favored tick habitats, and sampling should be done under conditions favoring tick presence (when vegetation is not wet, and when temperatures are above 10ºC (50ºF). All stages of ticks will attach to the flannel.

Dry Ice Collection

This technique appears to give more reproducible results than the drag technique. This technique involves placing a half-pound block of dry ice in the center of a .61 x .91 m (2 x 3 ft) panel of white polyester cloth on the ground at the chosen sampling site. The sampling sites should be selected in areas favoring ticks. After one hour, ticks on the top side of the panel are collected and can be counted.

Habitat Modification

Outdoor Areas

Dense shrub or tree cover or tall grass provides harborage for animal hosts of ticks, and protects ticks from losing body fluids resulting from drying winds and direct sunlight. Removal of excess brush and shrubbery, and pruning of overstory trees so that approximately 50% of a site is exposed to direct sunlight are recommended. Grass should not be allowed to grow more than six inches high, to allow ventilation and illumination of soil. Most ticks prefer the transition environment next to forested areas. Pesticides are rarely needed for ticks when vegetation management is practiced. Inspection of the site should be performed regularly to determine when pest management techniques should be conducted.

Indoor Areas

Methods of indoor tick management include regular inspection, elimination of animal harborage areas and entry, and animal-proofing of each site. The latter includes sealing of all holes in foundations and walls, and screening with heavy-gauge, 1/4 in. hardware cloth metal screen, along with vents, and other openings through which animals may enter.

Periodic surveys of potential or known habitats can reveal the presence of low-level tick infestations, thus indicating the need for application of management procedures (such as habitat modification) to prevent or retard further population increase.

Pest Management

Inside:

Use crack-and-crevice pesticide dust applications such as food grade diatomaceous earth where ticks hide. Treat under the edge of rugs, under furniture, in cracks around baseboards, windows, door frames, and in dog boxes. Fogging for ticks is useless.

Outside:
Managing the host animals is the most effective means to reduce tick populations. Pesticides are more effective when applied to paths frequented by animals. Treat low vegetation, including low shrubs, thoroughly. Mow around weedy fences that provide cover for rodents moving in from nearby woodland edges. Remove all vegetation at least .91 m (3 ft) from the structure. Broad application of pesticides to mowed grass does not reduce tick populations because the host, white-footed mice, does not infest lawns. Dust rodent runs or burrows in areas where human traffic cannot be controlled and where there is a danger of disease transmission.

Follow up
Continued monitoring and record-keeping is important. Tick counts should be reviewed at least annually to evaluate and adjust the pest-management program. Educational programs and materials for at-risk groups are vital.

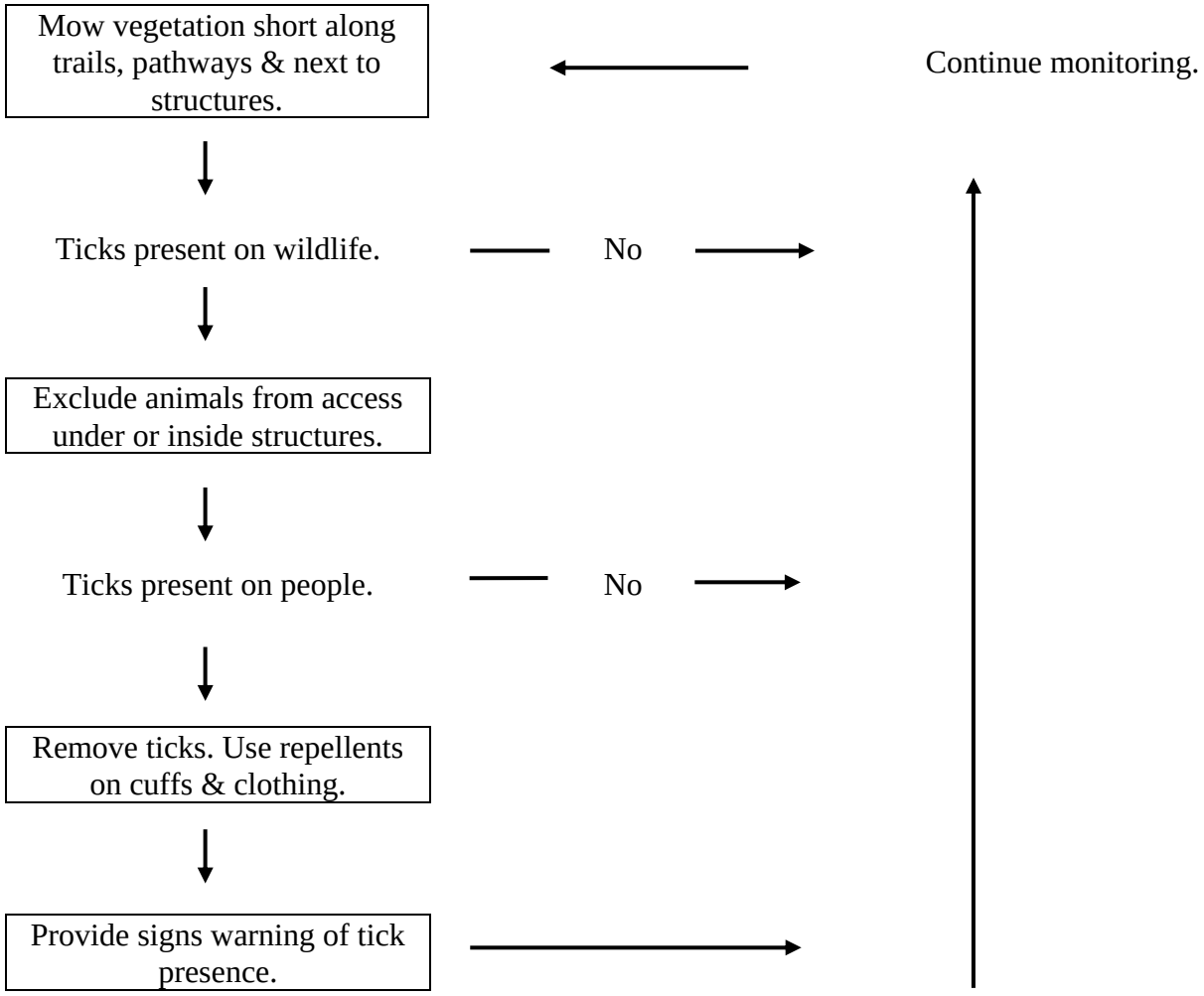
Precautions for At-Risk Group Members
Wear long pants tucked into socks while working or hiking in tick habitat. Use insect repellents on clothes and cuffs. Schedule regular body inspections for ticks at noon and at bedtime: Nymphal deer ticks are small, but they can be seen with close inspection. Larval deer ticks cannot be spotted easily, but they are not disease carriers.

Tick Removal
Regular inspection, location, and early removal of ticks prevent disease transmission. To remove feeding ticks dab them with alcohol. If feeding has just started, and mouthparts are not cemented in, ticks sometimes pull their mouthparts out. If they do not release in a few minutes, take tweezers, grasp the tick at the skin level, and pull steadily until the tick is removed.

Grasping the tick by the back end, or heating it, can force disease organisms into the wound. Place the tick in alcohol or otherwise keep it for identification. If the mouthparts are left in the skin, they will not transmit the disease, but the wound should be treated with an antiseptic to prevent secondary infection. Note the date of removal to calculate the time of symptoms onset.

If the tick is identified as a deer tick, see a physician. If it is a RMSF carrier, look for symptoms within a week after exposure, if they occur notify a physician.

TICKS


Mow vegetation short along trails, pathways & next to structures.
Continue monitoring.
Ticks present on wildlife.
No
Exclude animals from access under or inside structures.
Ticks present on people.
No
Remove ticks. Use repellents on cuffs & clothing.
Provide signs warning of tick presence.

MOSQUITOES

CHARACTERISTICS AND RECOGNITION

General

Mosquitoes usually are incidental pests in and around buildings, since their normal breeding habitats are outdoors. Mosquitoes may invade buildings during the warmer months from March to October.

Adult mosquitoes have one pair of oar-shaped wings that are partially covered with scales. The females have sharp, lancet-like proboscises used for sucking blood, whereas the males do not. Males have large bushy antennae. Eggs are laid singly or in rafts (depending upon species) either on or near the surface of a body of water. Larvae, sometimes called wrigglers, live in water, usually developing through four stages to become pupae. The larvae feed on organic debris on the bottom or suspended in shallow pools. The depth of pools inhabited by mosquitoes is limited by the need for larvae to return regularly to the surface to obtain air through an air tube on their posterior ends. Pupae have a "question-mark" shape and are active swimmers, but do not feed. Adult mosquitoes emerge from pupae at the surface of water, but usually do not feed until the second or third night after emergence. Their entire life cycle can take place in 10 – 14 days, depending upon temperature, with adults living less than two weeks on average.



Mosquito Larvae & Pupae

Biology of Domestic Mosquitoes

Aedes albopictus



***Aedes albopictus* Mosquito**

The Asian tiger mosquito, introduced from Asia in 1985, has spread to the eastern states south of New Jersey and the Midwestern U.S. east of the Mississippi River to the Great Lakes. The adults are black and white in appearance with a silver streak dividing the middle of the thorax.

The biology of this species is that they drink nectar between blood meals and eggs are deposited in artificial water containers. Eggs are placed into water in tree holes in addition to flower pots, vases, cans and

old tires. The females are less likely to feed on people than other mosquitoes. The egg stage over-winters in the northern states. Adults die when winter temperatures drop below 4ºC (40ºF).

This species is a known carrier of many arboviruses, including dengue, encephalitides viruses, and other viral diseases not normally indigenous to the United States.

Aedes vexans



***Aedes vexans* Mosquito**

Aedes vexans occurs throughout the continental United States and Alaska. The adult has an unmarked thorax and white bands on the legs and abdomen. It is a true floodwater breeder. Its larvae develop in large numbers following spring runoffs, when meadows and woodland pools are flooded. Unlike the other *Aedes,* this species prefers to lay eggs in sewage-contaminated water.

The egg stage overwinters in the northern states, while in the south larval development may continue year-round. Biting occurs in the early morning, early to late evening, or even daytime hours in shaded areas. Adults readily fly toward lights at night; they also are migratory and may fly 10 miles or more from the larval habitat to seek hosts. This species feeds on domestic animals much more readily than *Aedes albopictus*.

Aedes vexans is a fair potential carrier of encephalitides viruses, WNv, and a moderately efficient carrier of dog heartworm. Moreover, it is such a persistent biter that even small populations are irritating.

Culex pipiens complex

House mosquitoes consist of several species, two of which are major pests in the United States. The northern species, *Culex pipiens* occurs in a band across the northern tier of the U.S. These house mosquito species overlap across the middle tier of states. They are a rather dull light brown with light white bands across the base of each abdominal segment.



***Culex pipiens* Mosquito**

The last abdominal segment is blunt at the end in contrast to the pointed abdomen of the aedine mosquitoes. The house mosquitoes lay egg rafts containing 200 or more eggs each in foul water such as ground pools, tire ruts, catch basins, open cesspools, and street and roof gutters. They may also lay eggs in basements, where larvae may continue to develop even in winter. Eggs

hatch in a day or two and may develop through all larval stages in six to 10 days if temperatures are high, or several weeks if temperatures are low.

Although house mosquitoes are capable of transmitting encephalitides viruses, they are unlikely natural carriers because of their low human-blood feeding preference and comparatively short life span. However, they are competent transmitters of West Nile virus (WNv). Adults of *Culex pipiens* feed principally in the evening on birds and domestic animals, but will feed on people if given the opportunity. Adults hibernate in the northern states, while breeding takes place year-round in the southern tier of states.

INSPECTION

When occupants express concerns about mosquitoes it should be determined which species are present, and where their larvae are. The species can be identified by determining if the abdomen is pointed (generally aedine species) or blunt (generally *Culex* species). The inspection starts on the basis of such identification. The aedine larval mosquitoes may be found in domestic water containers and tree holes, while the *Culex* species larval mosquitoes in foul water areas in and around the building. Identification of adult and larval mosquitoes is work for mosquito taxonomy specialists.

MOSQUITO MANAGEMENT

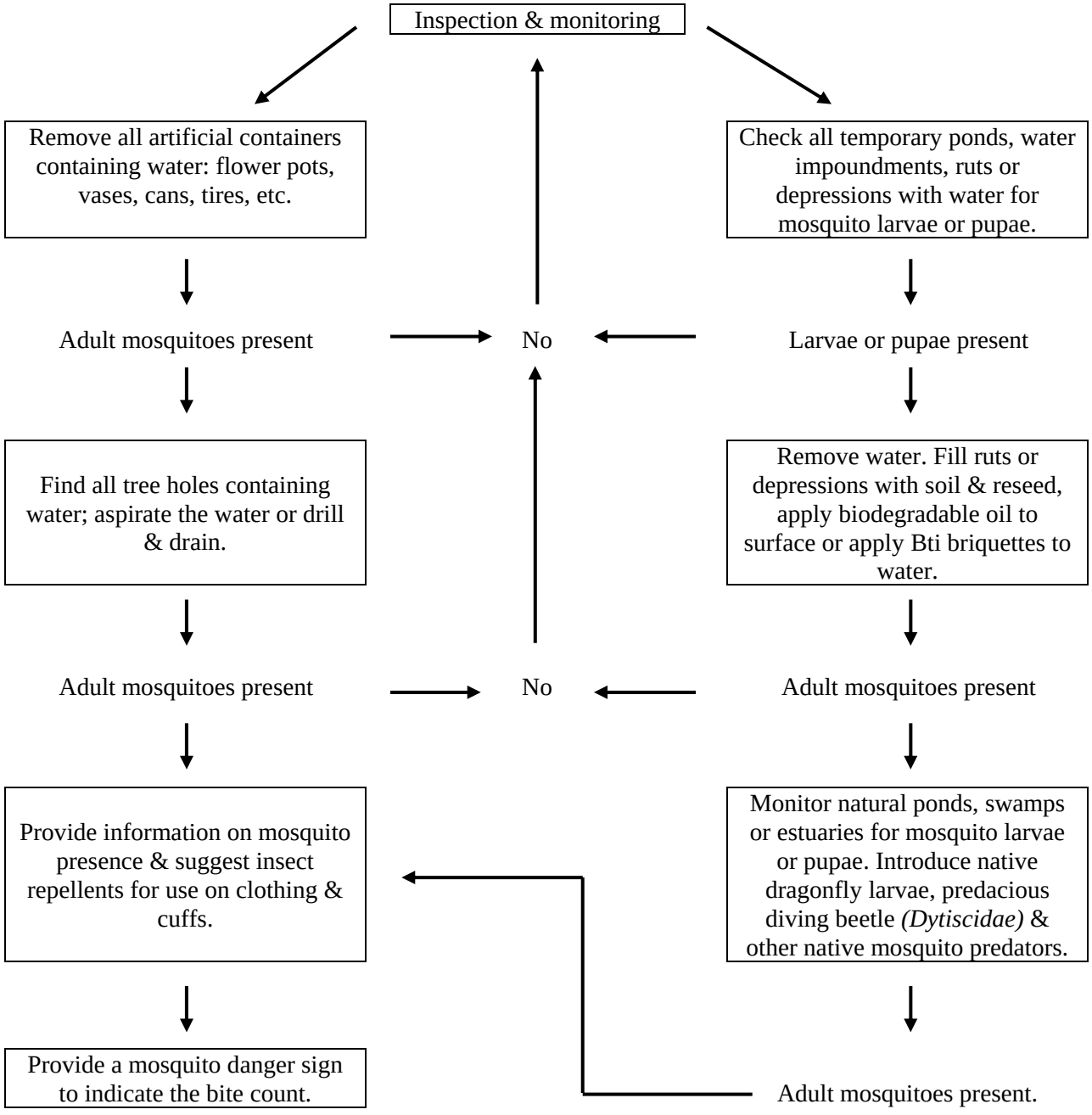
The best approach to managing mosquito populations is eliminating the larvae in their breeding habitat or the breeding habitat itself. A first step is not to keep water in pots, cans, or other containers. Often this just means letting plants dry out thoroughly between waterings. Major corrections may have to be made to reduce runoff from rains, especially in catch basins or in ground pools. Larger impoundments often produce predators such as frogs, fish, or predatory insects, so mosquitoes will not thrive there. Water in tree holes can usually be aspirated. If the water is removed in the spring, there will be no problem for months or perhaps even a year. Spaces having sewage backups or periodic flooding may require a permanent solution for continuous drainage.

If source reduction is not practical, mosquito larvicides may need to be used. This type of solution can become expensive if the larval habitats have to be continually retreated. There are relatively few pesticides registered for larval mosquito control in the U.S. Some of them include *Bacillus thuringiensis* (a bacterial insecticide) impregnated granules or "doughnuts." These formulations can be spread with a manual spreader where the breeding pools are small. Light biodegradable petroleum or vegetable oils spread on the surface of waters also manage larvae.

Adult mosquito management is frequently more challenging than larval control. Exclusion by use of screening is certainly the best means of preventing indoor infestations. Adult mosquito management, by black lights or "bug zappers" is ineffective outdoors and is destructive of the natural insect predators of mosquitoes such as crane flies and syrphid flies. Fogging or ultra low volume (ULV) treatment outdoors is rarely warranted or effective.

West Nile virus (WNv) is an exotic virus recently introduced into the United States that is of major concern as it has adverse effects on birds, horses and other animal species; and the elderly and very young humans. WNv is transmitted by several mosquito species. The most likely "competent" transmitters of WNv are *C. pipiens and Aedes vexans.* Infested water sources may be eliminated (drained or filled with soil) or treated with a larvicide or biodegradable oil. The introduction of mosquito fish can be used under certain circumstances (i.e., totally enclosed ponds so no possible escape, etc.). Adulticiding should be considered as a last resort.

MOSQUITOES


Inspection & monitoring
Remove all artificial containers containing water: flower pots, vases, cans, tires, etc.
Check all temporary ponds, water impoundments, ruts or depressions with water for mosquito larvae or pupae.
Adult mosquitoes present
No
Larvae or pupae present
Find all tree holes containing water; aspirate the water or drill & drain.
Remove water. Fill ruts or depressions with soil & reseed, apply biodegradable oil to surface or apply Bti briquettes to water.
Adult mosquitoes present
No
Adult mosquitoes present
Provide information on mosquito presence & suggest insect repellents for use on clothing & cuffs.
Monitor natural ponds, swamps or estuaries for mosquito larvae or pupae. Introduce native dragonfly larvae, predacious diving beetle (Dytiscidae) & other native mosquito predators.
Provide a mosquito danger sign to indicate the bite count.
Adult mosquitoes present.

POISON IVY *Rhus toxicodendron*



Poison Ivy

Poison Ivy is a woody vine that is known for its ability to produce urushiol, a skin irritant that causes an itching rash for most people. The oil is in the leaves, vines and roots. Poison ivy grows throughout much of North America. It can grow as a shrub up to about 1.2 m (4 ft) tall, as a ground cover 10 – 25 cm (4 – 10 in) high, or as a climbing vine on various supports. Older vines on substantial supports send out lateral branches that may at first be mistaken for tree limbs. Poison ivy rarely grows at altitudes above 1,500 m (5,000 ft).

The leaves are compound with three almond-shaped leaflets. The berries are a grayish-white color and are a favorite winter food of some birds.

The color ranges from light green (usually the younger leaves) to dark green (mature leaves), and bright red in the fall. The leaf surface is smooth and has few or no teeth along the edges. The stem and vine are brown and woody.

The reaction caused by poison ivy, urushiol-induced contact dermatitis, is an allergic reaction. For this reason, some people are immune to its effects. However, sensitivity can develop over time. If poison ivy is burned and the smoke then inhaled, this rash will appear on the lining of the lungs, causing extreme pain and possibly fatal respiratory difficulty. If poison ivy is eaten, the digestive tract and airways will be affected, in some cases causing death.



Poison Ivy in the Fall

Due to the potential human risks from exposure to the urushiol in poison ivy, management of this native plant can be difficult. Wear gloves, dust mask, goggles and other skin protection. Small plants can be mowed (repeatedly) when it moves into turf areas. Herbicides can be used to kill poison ivy; however, the dead vines must be removed and bagged for disposal. Do NOT burn poison ivy. Provide signage to warn visitors of the presence of poison ivy along pathways or other areas where it is present.

LANDSCAPE

PESTS

SUGAR MAPLE BORER *Glycobius speciosus* (Say)



Sugar Maple Borer

The sugar maple borer is a long-horned wood-boring beetle that is a common pest of sugar maple. The sugar maple is the only known host. When infested, trees seldom die; however, lumber production is severely impacted.

The adult borer is black and yellow, and about 25 mm (.98 in) long. Eggs are white and larvae are dirty white and about 50 mm (1.97 in) long when mature. The pupae develop deep within the wood and are seldom seen.

The sugar maple borer lives for approximately two years. Most eggs are laid in mid-summer under bark, scales or around wounds. When hatched, the larvae make a tunnel beneath the bark. This mining continues until fall when it digs a shallow cell in the sapwood where it spends the winter. The next season, the larvae resume tunneling through the wood until the tunnels eventually encircle the branch. They again overwinter deep within the wood until they emerge the following spring as adults.

The tunnels attract other micro-organisms which interact with the tree and wood-decaying fungi may invade. The tunnels occur low on the tree, often in the lower 6.10 m (20 ft). The first sign of infestation is discoloration on the bark, along with frass which exudes from the hole in the bark.

Management: In forested areas, selectively cut sugar maples as soon as they mature. Even in aged stands, removal of heavily infested trees prior to June will prevent reinfestation of the residual sugar maple. Maintain well-stocked stands of trees and promote vigor through sound management.

WHITE PINE WEEVIL *Pissodes strobi* (Peck)



White Pine Weevil Adults

The white pine weevil is a native insect that attacks eastern white pine. The Sitka spruce weevil and Engleman spruce weevil should also be classified as *Pissodes strobi*. Eastern white pine is the most suitable host for brood development, however, the white pine weevil may attack 20 different tree species including ornamentals. Trees severely attacked by white pine weevil are eastern white pine (*Pinus strobus* L.), Jack pine (*Pinus banksiana* Lamp.), Norway spruce (*Picea abies* L.); and commonly attacked are foxtail pine (*Pinus balfouriana* Grev. & Balf.), Japanese pine (*Pinus densiflora* Sieb. & Zucc.), limber pine *Pinus flexilis* James), western white pine (*Pinus monticola* Dougl. Ex D. Don), and Scots pine (*Pinus sylvestris* L.). A dozen other pine, spruce or fir are occasionally or rarely attacked.

Pissodes strobi has one generation a year. Adults hibernate in leaf litter over the winter under host trees and emerge in the spring and crawl up the host trees to the terminal shoot. Males and females begin feeding just below the terminal bud cluster. Eggs are laid in small urn-shaped feeding cavities made in the bark by the female. She seals the holes with a dark brown excrement cap to protect the eggs. Each female may lay 100 – 200 eggs. The 10 mm (.04 in) egg hatches in six to 14 days. As the eggs hatch, groups of larvae burrow down the leader in the inner bark, then between the wood and bark. During the following six weeks, the larvae molt four times. The larvae are white legless grubs, 9 – 10 mm (.36 – .4 in) long when fully grown. At the end of the feeding period, the larvae construct pupal cells in the pith and wood of the stem. They remain inactive for five to six weeks as pupae and as adults.

In July, August and early September, the adults chew small emergence holes through the cocoon and bark. As weather and temperature lower, the adults find shelter in the litter below the host trees. Although they may feed at the base of the tree, they eventually hibernate. Most will overwinter within 20 cm (8 in) of the boles of the host tree.

In the spring, tiny droplets of resin will exude from feeding sites made the previous year by adults below the terminal buds. Two to three weeks later, eggs are hatched in new punctures. Feeding by larvae can girdle the stem, causing the new shoot to wilt and the needles turn reddish-brown. Larval feeding may extend below one or more whorls of branches, thus all whorls above the larval feeding collar die. Weevil attack reduces tree height growth by 40 – 60% that year. Stem deformation is common to include forked or bushy tree form.

Monitoring and Inspection: Low water content of the terminal shoot reduces the numbers of eggs laid. Monitor rainfall before adults migrate to the terminal shoot. Do not water white pine at that time. Weevils prefer open growing trees with full sun on the terminals, so plant white pine under a hardwood overstory which slows terminal leader growth and lowers the temperature the weevils prefer for egg laying. Look for a crown closure of 50 – 70%. Plant white pine with mixed species in dense stands of 1.83 – 1.83 m (6 x 6 ft) spacing.

Management: Pruning infested terminals and branches at the first sign of wilting before adults emerge can reduce weevil populations. Destroy the pruned material. Band the base of the trunk with tape and apply sticky material (Tanglefoot) to the tape to prevent adult weevils crawling up the trunk in early spring (however, adult weevils are strong flyers). Removal of duff out to the drip line during winter after adult beetles have migrated into it may reduce the adult population. Natural enemies that may be effective are a dipteran predator, *Lonchaea cortices* (Taylor), and hymenopteran parasites *Eurytoma pissodis* Gir. and *Dolichotomitis terabrans nubilipennis* (Viereck). Parasitic nematodes may attack the overwintering adult weevils in the litter under white pine stands. *Heterorhabditis bacteriophora, Steinernema carpocapsae,* and *Steinernema feltia* are reported to attack soil-dwelling insects (although white pine weevil adults are not specifically listed). Chemical pesticides may be necessary if adult weevil populations are high (pesticides are not effective against larvae inside the terminal leader). Check with your local Cooperative Extension Agent.

BRONZE BIRCH BORER (*Agrillus anxius Gory*)



Bronze Birch Borer

The adult bronze birch borer, *A. anxius*, is a slender beetle about .94 – 1.27 cm (3/8 – 1/2 in) long. The larvae are about .06 – 3.17 cm (1/16 – 1 1/4 in) long and .24 cm (3/32 in) wide.

Adults emerge leaving a D-shaped hole in the bark of the birch. They feed on leaf margins; they mate and lay eggs, usually on the sunny side of birch trees. Mated females lay eggs in crevices in the bark near branch scars, under loose outer bark flakes or around wound areas. The eggs are creamy white to yellowish. The larvae bore through the egg shell directly into the bark in about 10 to 14 days. The larvae bore in the cambium layer or occasionally into sapwood. The larvae tunnel and feed laterally around a branch in a zigzag manner, girdling an upper branch which then suddenly wilts and dies. Reinfestation results in most of the branches dying from the top down, and when the trunk is girdled the tree dies. Many larvae may overwinter and take an additional year before pupation and emergence as an adult.

Birches prefer shady, cool and moist wooded areas. Providing adequate fertilization and management of aphids and leaf miners (with predators or parasites) will help keep the trees vigorous and better able to withstand the *A. anxius*. Preventive surface insecticide sprays applied to the tree bark before eggs are laid may provide a barrier to larvae attacking the tree. Thorough drenching of the trunk and larger than 3.81 cm (1 1/2 in) diameter branches will be necessary. Degree day (heat unit) models for *A. anxius* have been developed for timing of treatments to anticipate egg laying and larvae emergence.

Pruning out wilting or dead upper branches may help prevent reinfestation of the affected birch tree. *Betula pendula, B. papyrifera,* and *B. populifolia* are very susceptible to attack by *A. anxius*. Birches that are in a weakened condition from repeated attack, defoliation, adverse weather or old age are much more susceptible to *A. anxius* boring. The larvae do not survive in healthy trees. Chlorotic leaves and sparse foliage evident in the upper crown may be accompanied by increased adventitious growth in the lower crown. If such growth develops, it will be accompanied by twig die-back in the upper crown. Lumpy bark is another sign of attack by *A. anxius*.

The monarch birch, *B. maximowicztana, B. platyphyla* var. *japonica* and *B. nigra* are said to be more tolerant or resistant to *A. anxius*. Woodpeckers and a parasite (*Phasganophora sulcata* Westwood) are natural control agents. Vigorously growing birch trees are less likely to be damaged. Resistant birch species should be cultivated as replacements if the present trees succumb to *A. anxius*.

BRUCE SPANWORM *Operophtera bruceata* (Hulst)

The caterpillars of the Bruce spanworm attack a variety of hardwood trees in the northern part of the United States and Canada. Sugar maple, aspen and beech are their favored hosts. Moderate to severe defoliation can result in areas where the host trees are numerous, and for the past several years have caused widespread damage in the New England states.



Bruce Spanworm Caterpillar

The caterpillars can be seen on the unfolding leaves in the spring. They feed from the underneath eating everything but the veins. Full grown, the caterpillars are about 1.91 cm (3/4 in) long, bright green with three lighter green stripes on each side of the body. The caterpillars feed for four to five weeks, then drop to the ground in late June to pupate. Adult moths emerge in late fall. The females climb trees to mate and lay eggs singly in the crevices in the bark.



Adult Male

Management: The fruit bud and blossom clusters can be examined for larvae and feeding damage. This species is susceptible to some parasites and disease which seems to keep them under control, although periodic flare-ups occur. Sticky bands around tree trunks will protect isolated trees by preventing females from crawling up the tree to lay eggs. *Bacillus thuringiensis* is effective once larvae begin to feed on the leaves.

EASTERN TENT CATERPILLAR *Malacosoma americanum*



Eastern Tent Caterpillar

The eastern tent caterpillar is more a nuisance than a threat. While heavy infestations can cause serious defoliation, eastern tent caterpillars rarely kill trees except those already weakened by disease or climate and environmental stresses. Some studies indicate some defoliation strengthens trees and makes them hardier. These caterpillars get their name from the ugly tent-like nests that they spin in the crotches of host trees. They are native to North America east of the Rocky Mountains.

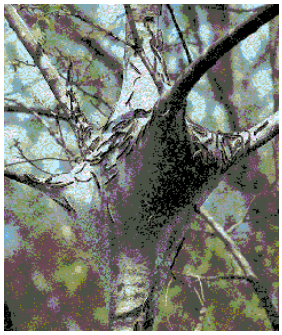
The preferred tree for these pests is the black cherry, but they will also infest other cherry trees as well as fruit trees such as apple and a variety of shade trees.

Eastern tent caterpillars are black and hairy with a white stripe and a series of blue dots along the length of the body. At maturity, they range from 5 – 7 cm (2 – 2 ½ in) in length. The moth is reddish in color with white bands on the forewings. Females can be double the size of the males with a wingspan of 7 cm (2 ½ in).



E. Tent Caterpillar Eggs

Eastern tent caterpillars survive the winter in masses of 100 to 300 eggs noticeable as shiny black bands encircling twigs. Eggs hatch in the spring at about the same time as the host tree comes into leaf. The young caterpillars then begin to consume leaves and spin the characteristic "tent" nest in the crotch of the tree. The nest continues to grow as long as the caterpillars keep feeding. When the caterpillars reach maturity, after about six weeks, they pupate in silken cocoons visible on trees, on the sides of buildings and on fences. Moths emerge in July to mate, lay eggs and then die.



E. Tent Caterpillar Nest

Management: Eastern tent caterpillar infestations rarely threaten the lives of trees, so management is generally for aesthetic purposes. Tents can be removed and destroyed at night after the caterpillars have returned from feeding.

During winter after leaves have dropped from host trees, search for the black bands of eggs encircling twigs. Physically remove the egg mass or prune it out of the tree and destroy them. If a treatment becomes necessary because of large numbers of "tents," *Bacillis thuringiensis* Kurstaki is effective.

FALL WEBWORM *Hyphantria cunea* (Drury)



Fall Webworm

The fall webworm is a native of North America and Mexico. Depending upon location, there can be one to four generations per year. Webworms enclose leaves and small branches in their light gray, silken webs. The fall webworm is usually of only minor economic importance as a forest pest. However, shade trees and ornamentals can be heavily defoliated and the presence of the large, unsightly webs can make them aesthetically distracting. Persistent infestations of individual trees can cause limb and branch dieback.

The fall webworm is known to feed on over 100 species of forest and shade trees, including American elm, hickory, maples, fruit trees, pecan and walnut in the eastern U.S. Adult moths have a wingspan of between 35 – 42 mm (1.4 – 1.7 in). They appear mostly from May to August and deposit their eggs in hair-covered masses of several hundred each, usually on the underside of host leaves. Larvae are usually pale yellow-green. Full grown larvae may reach a length of 2.54 cm (1 in). Newly hatched larvae immediately spin a silken web over the foliage on which they feed. As they grow, they enlarge the web to enclose more foliage. On heavily infested trees, several branches may be enclosed in webs. Pupation occurs in thin cocoons usually spun in the debris or just beneath the soil.

Management: Though the webs are unsightly, damage to most trees is considered to be minor. Small nests can be pruned out of small to medium trees. Monitor trees early to detect the nests when only several leaves are involved. These small nests can be easily crushed. Encourage parasites and predators. Over 80 species of parasites and predators have been identified. Yellow jackets, paper nest wasps, birds, predatory stink bugs, and parasitic flies and wasps are the most important. Apply *Bacillus thuringiensis*. It is quite effective against fall webworms if applied when the larvae are small. Apply thoroughly to cover leaves next to nests. As these leaves are incorporated into the nest and eaten, the Bt will be ingested.

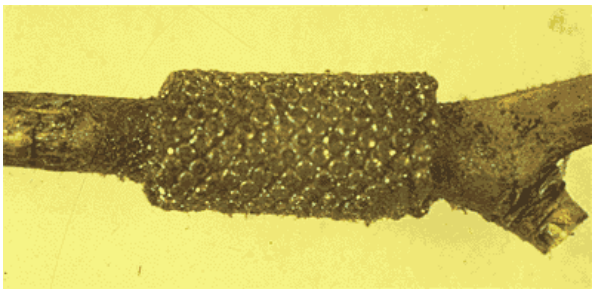
FOREST TENT CATERPILLAR *Malacosoma disstria*



Forest Tent Caterpillar

A cousin of the eastern tent caterpillar, the forest tent caterpillar prefers hardwoods like sugar maples and oaks. The term "tent" caterpillar is a little misleading as these insects don't construct large tent-nests in the crooks of trees. Instead they spin pad-like structures on trunks and on branches where they go to rest and to molt.

Other aspects of the forest tent caterpillar are similar to those of the eastern tent caterpillar. They may be ugly and unsightly, but their defoliation rarely kills host trees unless the trees are already diseased or under stress due to climatic or other environmental factors. Forest tent caterpillars have a brownish body with bluish lines along the side. With each molt, a line of white, footprint-shaped spots becomes visible. Mature caterpillars can reach 5 cm (2 in) in length. Moths are yellowish-brown and chunky with two dark lines on the forewings.



Forest Tent Caterpillar Egg Mass

Forest tent caterpillars start their lives as eggs laid in shiny brown bands of 100 to 300 around twigs. Caterpillars emerge as new leaves begin to appear and begin feeding and constructing their nests immediately. During the five or six weeks of the caterpillar stage, they go through four molts. After the last molt, the caterpillars spin yellowish cocoons in some sheltered place in which the final transformation to moth takes place. Moths emerge from the cocoons after about 10 days to mate, lay eggs and then die.

MANAGEMENT



Forest Tent Caterpillar Adult

If populations are large and widely distributed, the biological insecticide *Bacillis thuringiensis* Kurstaki is effective for forest tent caterpillars. The pad-like tents can be collected and destroyed at night when the caterpillars return. Egg bands can be pruned out or removed in winter when leaves have fallen (the bands become more visible).

HEMLOCK LOOPER *Lambdina fiscellaria fiscellaria* (Gn.)



Hemlock Looper

The hemlock looper is a native insect in North America and is regarded as a defoliator of primary importance. Its preferred hosts are hemlock and balsam fir. At times it will feed on other conifers, hardwoods and even resort to cannibalism when food is scarce.

Hemlock loopers have one generation per year and overwinters in the egg stage. Young larvae stay on the outside of the crown feeding on new needles. Larvae mature in July and August, and then seek shaded areas to pupate, feeding on older needles. When an outbreak is severe, trees may be stripped of foliage in a single season. The first few moths are seen around the middle of August with the majority of the moths flying in mid-September.

Small numbers of the loopers occur naturally in all fir and spruce forests. Serious outbreaks appear suddenly but rarely last more than a few years. It is thought that the sudden population reductions are due to a build-up of parasites and disease which act as natural biological control agents.

Management: Harvest stands of mature fir and spruce to remove potential population sites. Biological control products are recommended for large forested areas. For ornamental hemlock, *Btk* can be used while the larvae are in the open and feeding.

SPRUCE BUDWORM *Choristoneura fumiferana* (Clemens)



Spruce Budworm

The spruce budworm is one of the most destructive native insects in northern spruce and fir forests in the United States and Canada. Periodic outbreaks are part of the natural cycle of events associated with the maturing of balsam fir. Balsam fir is the most severely damaged species; however, red, white and black spruce are acceptable host trees, and some feeding is done on tamarack, pine and hemlock.

The newly-hatched larvae are very small and difficult to locate as they bore into and feed on needles or expanding buds. As they grow, needles are severed at the base and left hanging. These needles turn brown and give the tree a scorched look. This is apparent from mid-June through August.

The adult moth is usually grayish with dark brown markings. There is one generation each year. The female lays eggs on the undersides of needles, usually within 7.62 cm (3 in) of the buds. The eggs hatch in about two weeks and the newly-hatched larvae immediately seek a suitable place to spin their cocoons. They do move about some and feed on needles. At this point in time, the larvae may be carried off by wind currents. This dispersal at the larval stage is one means of spread within and beyond infested stands.

Management: Natural factors such as adverse weather, diseases, predators and parasites play an important part in holding budworm populations in check. High rates of larvae parasitism by tiny parasitic wasps such as *Meteorus trachynotus* Viereck and *Phaeogenes hariolus* (Cresson), and by a parasitic fly, *Lypha setifacies* (West), have been successful in helping budworm populations decline.

Both biological pesticides *(Bacillus thuringiensis)* and disease organisms *(Perezia fumiferanae* Thompson or *Polyhedral* virus disease) show promise in slowing the rate of budworm development. Spraying does not kill all the larvae because some are protected by foliage. However, use of a biological pesticide can slow damage sufficiently or until the trees can be harvested.

BIRCH LEAFMINER *Fenusa pusilla*



Birch Leafminer Adults

One of the major pests of birch trees is the birch leafminer. This pest gets its name from the larval habit of feeding or mining the plant tissues between the surfaces of the leaves. It was accidentally introduced from Europe. The adults are small, black, and about .3 cm (1/8 in) long. The adults overwinter in the soil and begin to emerge in early to mid-May. They congregate about birches, mate, and females lay their eggs in newly-developing leaves. Host trees are most likely to be gray, paper and European white birch.

Leaves that are attacked soon turn brown. Affected trees seen from a distance have a scorched or blighted appearance that is often mistaken for a disease. The top of the tree is most often the part most seriously affected; however, the entire tree can be attacked. A healthy tree can lose part of its current crop of leaves without being seriously weakened; but repeated losses year after year will weaken the tree and make it susceptible to attack by other insects and possibly death.

Eggs hatch in seven to 10 days, and the larvae begin feeding immediately. As the larvae grow, blotches and blisters begin to form on the leaves.

Management: Azadirachtin is shown to have systemic activity against birch leafminer following injection into the tree. Contact can be made with the local Cooperative Extension Office to determine if any other low-risk management methods are available and effective.

MAPLE LEAF CUTTER *Paraclemensia acerifoliella* (Fitch)

The maple leaf cutter is a native insect that is widely distributed over the northeastern United States. It skeletonizes maple leaves with numerous holes in late July or August, making the leaves appear light in color. The preferred hosts are sugar maple, beech, birch and red maples.



Maple Leaf Cutter

The insect passes the winter as a pupa in its case in the fallen leaves on the ground. The moths emerge in May and lay their eggs in pockets in the tissues of the leaf. Many eggs are deposited in a single leaf which gives the leaf a yellowish effect. After 10 – 14 days, the larvae emerge, begin life as a leafminer, and start eating the leaves in a circle around the egg. The larvae then feeds on the leaf surface as a skeletonizer. About mid-August, the larvae are full grown,

Management: Under certain conditions, infestations on individual trees can be controlled by collecting and burning the leaves as they fall in the autumn. Treatments of *Bt* applied to foliage early after emergence as a casebearer in June should provide management of the larvae present in or on the leaves. Monitor for the emergence of the casebearing larvae feeding on the leaf surface.

LOCUST LEAFMINER *Odontota dorsalis* (Thunberg)



Locust Leafminers

There are several similar leafminers which occur on locust, but none produce the rusty-red foliage characteristic of that mined by the locust leafminer.

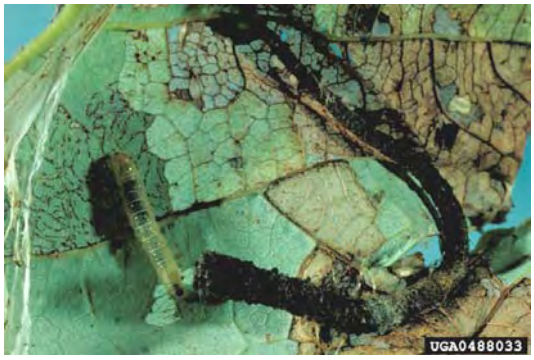
There are two generations per year. Winter is spent as an adult in leaf litter under host trees or in bark crevices. As new leaves develop in the spring, adults emerge and lay eggs in small clusters on the lower surfaces. Newly-hatched larvae form a common mine at first, but later separate and each larva mines several leaflets before pupating inside the last mine. Adults emerge and skeletonize lower leaf surfaces before seeking overwintering sites.

Black locust is the preferred host, but apple, birch, beech, cherry, elm, hawthorn and oak may also be attacked.

The overwintering flat, red and black adult beetles appear on leaves in May and those of the next generation appear in July. Larval feeding results in mines which eventually cause the leaves to turn brown.

Management: Most trees can survive continued infestations with only minor setbacks. However, reduced aesthetic value is a problem. Removing leaf litter reduces overwintering habitat. Application of a winter dormant oil to bark may reduce overwintering adults. Parasites (such as *Dacnusa sibirica* or *Diglyphus isaea*) and predators can cause significant reductions in leafminer populations.

MAPLE TRUMPET SKELETONIZER *Epinotia aceriella* (Clemens)



Maple Trumpet Skeletonizer

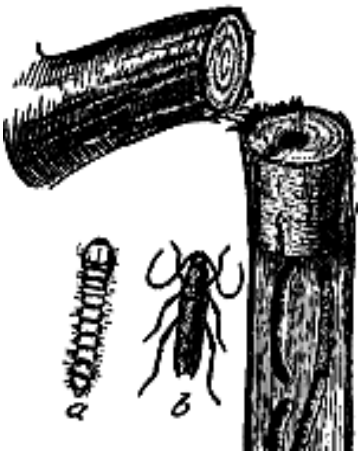
The adult of the maple trumpet skeletonizer is a small, white moth dusted with grey or brown. Its preferred hosts are sugar and red maples with occasional feeding on hawthorn and beech.

Winter is spent in the pupal stage on the ground. The adult moths emerge in June. Larvae are found on the foliage from late July into September, and feed only on the parenchyma cells. They live and feed under a web on the underside of the leaf. The larvae build a protective black case composed of web with frass on the outside. The tube increases in size with the development of the caterpillar, often reaching 6 cm (2 in) in length before the larvae mature. The mature larvae leave their tube and drop to the ground where they pupate.

Management: Injury is obvious, but damage is late in the season and usually of little consequence. Skeletonized leaves can be handpicked and destroyed. Raking and destroying leaves can also reduce populations in urban tree settings. Pesticide applications are not recommended.

TWIG PRUNER *Elaphidionoides villosus* (F.)

Adult twig pruners are longhorned beetles which are 11 – 18 mm (.43 - .71 in) long, slender and brown with two spines on the tip of each elytra. Their antennae are longer than the body. Mature larvae are about 25 mm (.98 in) long and are identifiable by their lemon-colored hairs on the prothorax.



Twig Pruner

Adults emerge in late spring and eggs are deposited into slits in the bark at twig tips and leaf axils. Larvae feed beneath the bark and then bore down the center of the stem until late summer. Host plants are hardwoods such as elm, hackberry, hickory, locust, maple, oaks, pecan, sweetgum and walnut. There is one generation per year. Pupae overwinter in twigs on the ground.

Larvae sever twigs by making circular cuts from the center outward under the bark, breaking off twigs. Heavily infested trees may be seriously injured. The appearance of trees may be affected, but trees are not killed.

Monitoring: Look under trees in August and September for fallen twigs and branches, and cut open a sample to detect larval tunnels and larvae preparing to pupate and overwinter. Since the larvae are in the twigs when they fall from the tree, gathering and burning the girdled twigs is a means of preventing further damage. This can be done in the fall and in the spring before the adults emerge. There is no insecticide specifically labeled to control this minor pest. Three hymenopterous parasitoids are recorded, but the degree of control is unknown.

OYSTERSHELL SCALE *Lepidosaphes ulmi* (Linnaeus)



Oystershell Scale

Oystershell scale is a common insect pest of many woody plants. They feed on the plant by sucking plant sap. Heavy infestations can kill branches and even cause the decline and death of the tree. In most areas, there is only one generation per year.

Oystershell scale overwinters in the egg stage. The eggs hatch in the spring and the newly emerged insects quickly attach themselves to the tree. The full-grown female scale overwinters attached to the bark of the tree. She is about .3 cm (1/8 in) long, brown or gray, and the general shape of an oyster shell. The insects are often overlooked because their appearance is similar to the bark. Old scales can stay attached to the tree for several years before falling off.

Newly-hatched scale insects are called crawlers. The crawlers are pale and smaller than a pinhead. This is the only mobile stage in the life cycle of the scale. After a few hours, the crawlers find a shady area of the tree. They then insert their mouthparts into the plant, begin to feed and soon molt. They remain in this location for the rest of their lives. Within a week they are covered with a waxy scale that protects them from most insecticides.

Management: Scales thrive on stressed plants. If possible, improve plant sites to reduce stress and promote growth. Severely prune back heavily infested branches, where accessible, and protect new growth with summer oil applications. Overwintering scales can be scrubbed off of small trees and shrubs with a plastic scrub pad. Branches can be pruned back where heavy infestations are present but limited to small areas. The scales and eggs on pruned wood should die within a few weeks, but precautions should be taken by removing prunings from the vicinity of host trees to prevent possible reinfestation by crawlers.

Natural predators for scale can be released on specimen plants or cultural and forest plantings. Two scale predators are available commercially from insectaries supplying beneficial insects such as *Cryptolaemus montrouzieri* or *Rhyzobius lophanthae* that feed on scale insects.

Horticultural oils kill by suffocation or after penetrating overwintering stages of the insect. Therefore, they may be more effective where layers of scales have not yet accumulated. Summer oils can be used on many trees and shrubs during the growing season.

SADDLED PROMINENT *Heterocampa guttivitta* (Walker)

The saddled prominent defoliates hardwoods in the northeastern U.S. and southeastern Canada. Outbreaks of this native insect have occurred at intervals of approximately ten years since they were recorded in the early 1900s. Populations build rapidly, cause severe defoliation for one to three years, then collapse.



Saddled Prominent Caterpillar

The larvae feed on the foliage of a variety of broadleafed trees and shrubs. They favor beech, sugar maple, yellow birch and paper birch. The egg is smooth, pale green and about 1 mm (.04 in) in diameter. Unless it has been parasitized, the egg becomes reddish as the developing larva becomes visible. Parasitized eggs turn gray and are splotched with black. The larvae go through varying stages of size, color and shape. The pupa is stout, dark brown and is enclosed in a thin cocoon. The adults are inconspicuous moths which vary from greenish-gray to brownish-gray to olive with white and black spots. There is usually one generation per year.

The adults begin to emerge from leaf litter in late May. Emergence peaks in mid-June and ends the first week in July. The moths do not fly during the day. At dusk, they move into the crowns of the trees where they rest on the underside of the branches. The females begin to lay eggs about one week after emergence and continue for ten days.

The saddled prominent is a late season defoliator with most of its feeding occurring from late July until early September. Defoliation in late summer is not normally considered serious. However, several consecutive seasons of heavy defoliation can cause branch mortality.

Management: Predators and parasites of the saddled prominent include birds, mammals and insects, as well as starvation, fungal diseases and an unidentified virus. Common predators are the bronze grackle, shrews, a ground beetle *(Calosoma frigidum*) and a stink bug *(Podisus modestus)*. Two small wasps, *Trichogramma minutum* and *Telenomus coelodasidis*, have accounted for large percentages of egg mortality during previous outbreaks. None of these parasites and predators can prevent populations, but in combination with other factors such as diseases, they contribute to the demise of outbreaks. Removal of leaf litter 7.62 – 12 cm (3 – 4 in) deep in early spring (April) can remove overwintering pupae.

Chemical control is not recommended as a routine treatment. However, if application of an insecticide is considered necessary, correct application of *Bacillus thuringiensis* is effective against many lepidopterous defoliators and has no direct effect on the parasites or predators.

ASH FLOWER GALL MITE *Aceria fraxiniflora*



Ash Flower Gall Mite Damage

Adult gall mites are approximately .2 mm (.01 in) long, are carrot-shaped and have two pairs of legs.

Female ash flower gall mites move to developing male flowers in the spring and stimulate gall formation by their feeding. Eggs are laid in the developing galls. Several generations occur each summer. Fertilized females overwinter in bud scales or under bark.

Ash flower gall mites stimulate expansion of flower buds on male ash trees. Infested flower clusters become deformed and remain on trees as green masses until fall.

To monitor for ash flower gall mites, look for unsightly galls in male flowers.

Management: The ash flower gall mite causes only aesthetic injury, therefore, plant mortality is low. Oils or other chemicals can be applied at or just prior to bud break. To date, there are no reports of effective natural enemies, although predatory mites *(Pytoseiulus spp.)* may be useful.

LARCH CASEBEARER *Coleophora laricella* (Hubner)

The larch casebearer is a native of Europe and was introduced into North America in 1886, probably on planting stock. This insect now infests almost all species of larch and tamarack in the U.S. The larvae eat the inside tissue of needles. When severe defoliation occurs, 85 – 100% of the needles killed year after year results in the death of the trees. At a minimum, the infestation can reduce potential growth by as much as 95%.



Larch Casebearer

The larch casebearer produces one generation per year. The adults emerge from pupal cases from late May through early July. They are silver to grey-brown moths with no conspicuous markings. A female moth produces from 50 to 70 eggs which she deposits singly on the underside of needles. Newly laid eggs are yellow in color, but turn cinnamon. When populations are dense, moths may lay ten or more eggs on the same needle. The eggs hatch in about two weeks. The larval stage lasts about 11 months. The larvae hatch in July and pupate the following spring. They live first inside the needles; then as they grow, they convert the mined needles into cases and live on the surface in these tube-shaped shelters. They continue feeding throughout the fall. In October, they prepare to hibernate by attaching their cases to twigs or the bark of limbs.

Casebearer larvae injure trees by mining within the needles during spring, summer and fall; but the spring feeding on new foliage causes the most damage. Mining in the fall may again brown the trees, but by then the tree has completed its growth, so damage is minor. Larch can withstand repeated defoliations better than most other conifers because it drops its leaves in the fall and refoliates each spring. After several years of damage, however, stressed larch trees grow shorter needles. Eventually repeated defoliation causes branch tips to die back. Trees weakened by defoliation are susceptible to other insects and diseases.

Management: Natural control factors such as weather, diseases and native predators and parasites can help reduce populations. Prolonged cold, wet weather in the spring with frosts after the larvae emerge can cause considerable mortality. Droughts that last into late summer also reduce populations.

About 30 species of native parasitic wasps have been found to attack the casebearer; however, only a few of these parasites are of more than minor importance. Predators such as pentatomid bugs, spiders, ants, yellow jackets, mountain chickadee, dark-eyed junco, sparrows and orange-crowned warbler feed on the larvae and the pupae. A large red mite and predator bugs prey on the eggs. Two European parasites, *Agathis pumila* (Ratz.) and *Chrysocharis laricinellae* (Ratz.) have been credited with keeping populations at tolerable levels in the eastern U.S. Over large areas, the application of insecticides is usually not practical.

LARCH SAWFLY *Pristiphora erichsonii* (Htg.)



Larch Sawfly Larvae

It is not certain whether the larch sawfly is native to North America. It is specific to larch (eastern and western) and is considered the worst pest of larch in North America.

The damage to trees is twofold: the female sawfly cuts slits in new shoots to deposit eggs, and the larvae feed on needles. The larval feeding results in the greatest damage. Defoliation in one year is of little consequence, but repeated damage over several years will kill the tree.

Sawflies are related to members of the wasp family. The adult sawfly resembles a black wasp, is about 1.27 cm (1/2 in) in length, and has a thick waist and brown to orange markings on the abdomen. Larvae have black heads, gray-green bodies with white undersides, and curl their bodies upward in a "J" shape when disturbed. In the spring when new growth is expanding, the female can be seen depositing eggs on new shoots near the branch tips.

Winter is spent in the soil as a pre-pupa. Adults emerge in late spring and females immediately begin to lay eggs. Egg-laying causes shoots to curl as they grow. Larvae occur in groups or clumps and are very obvious when present. Most trees are able to tolerate defoliation and generally recover. Larvae feed on needles for approximately three to four weeks.

Curled shoots can be observed by mid- to late spring. Larvae can be found throughout the summer.

Management: Hand removal of larvae can be accomplished on smaller trees. The sawfly will drop off the tree and pupate in the litter and soil beneath the tree. Rake fallen leaves and debris from beneath trees in the fall to remove the pupating forms.

Several parasites maintain this sawfly at reasonable numbers, including a braconid wasp that is an ectoparasite of sawfly larvae and another internal parasite of sawfly pupae. Many birds (robins, chickadees and juncos) will feed on sawfly larvae and help keep numbers in check.

Chemicals should NOT be used as they are harmful to birds. Products containing *Bacillus thuringiensis* will NOT affect sawfly larvae since they are not a lepidopterous caperpillar. Spinosad is a low-risk product for use on ornamental shade trees. The active ingredient is derived from a naturally occurring soil-dwelling bacterium called *Saccharopolyspora spinosa*. Insecticidal soaps or horticultural oils should control larvae. Apply these soaps or oils at least three times, three to five days apart, to control larvae before they grow larger than 1.27 cm (1/2 in) in length. Treatments should target individual clumps of larvae and not entire trees.

HEMLOCK WOOLLY ADELGID *(Adelges tsugae Annand)*



Hemlock Woolly Adelgid

A. tsugae is a small .03 cm (1/32 in) reddish-purple (aphid-like) insect that covers itself with a white fluffy secretion. *A. tsugae* was probably imported from Asia. The nymphs and adults have thread-like mouth parts (stylet) used to suck sap from young hemlock twigs. The needles may drop prematurely and defoliate the tree, resulting in death within several years. The adelgid may also inject a toxic saliva that disrupts the tree's growth hormones.

Female adult *A. tsugae* lay eggs hidden by the white fluffy secretion, protecting them from many pesticides. The eggs hatch and the adelgid crawlers move about and settle to feed on twigs or the base of needles. The white, fluffy wool secretion soon covers them completely. The female adelgid overwinters within the mass and may begin to lay eggs in February. Some nymphs may develop into a winged adult which then may fly to another hemlock to lay eggs or to an alternate host such as spruce. Dispersion is by wind, birds and mammals.

MANAGEMENT

A second generation may develop in early fall and over winter, which can be time to attempt management sprays with insecticidal soaps and horticultural oils. This combination reduces the adelgid population and has minimal effects on natural predators and parasites. Horticultural oils may damage hemlock during growing season. Specimen trees may require a soil drench with Merit™ (Imidicloprid) which is taken up by the tree roots and translocated throughout the branches and leaves to kill the adelgid. Predators or parasites that are effective are not yet available.

More information may be obtained at the USDA Forest Service, northeastern area (610-975-4186). A "Summary of Hemlock Woolly Adelgid (HWA) Risk Assessment for Marsh-Billings-Rockefeller National Historical Park" by Ben Machin, Redstart Forestry, Inc., was proposed in 2004.

EMERALD ASH BORER *Agrilus planipennis* Fairmaire



Emerald Ash Borer

The emerald ash borer is an exotic beetle that was discovered in southeastern Michigan in the summer of 2002. The adult beetles nibble on ash foliage but cause little damage, but leave a D-shaped exit hole in the bark when they emerge in the spring. The larvae feed on the inner bark of ash trees, disrupting the tree's ability to transport water and nutrients.

Emerald ash borer probably arrived in the U.S. on solid wood packing material carried by cargo ships or airplanes originating in its native Asia. In Asia, the borer attacks and kills only ash trees that are already weakened by disease, stress or damage. However, thus far in North America, it attacks and kills healthy trees as well. This devastation is possible because our native trees have no built-in resistance to the borer. Many of the predators, parasites and diseases that help to keep the emerald ash borer populations low in Asia are not present in North America.

The adult beetles are bright metallic green in color. Adults are .84 cm (1/3 in) long and .15 cm (1/16 in) wide. They have rounded abdomens and flat backs, and are present from mid-May through late July. The larvae are creamy white in color and have flattened, segmented bodies. Older larvae grow up to 2.54 cm (1 in) long. They feed under ash tree bark from mid-summer through spring. As woodpeckers like emerald ash borer larvae, heavy woodpecker damage on ash trees may be a sign of infestation.



Emerald Ash Borer Larvae

Management: At present, research is currently being done at universities to understand the beetle's life cycle, find ways to detect new infestations, control both borer adults and larvae, and contain the infestation. Eradication efforts by state and federal agencies are under way to prevent small infestations from growing into large infestations. Quarantines are in place in Michigan, Ohio and Indiana to prevent infested ash firewood, logs or nursery trees from being transported and starting new infestations. Any ash trees suspected of being infested with emerald ash borer should be cut down and burned. Ash firewood should also be burned. At present, no other information is available on chemical, physical or biological control of emerald ash borer.

GYPSY MOTH



Gypsy Moth Caterpillar

Gypsy moth is a recent addition to the long list of insects that defoliate oak, aspen and other hardwood species in the United States. This exotic pest did not occur in North America until it was accidentally introduced into Massachusetts in 1869. Since then, gypsy moth populations have spread west and south.

Gypsy moth outbreaks can last one to five years. Outbreak populations then decline because of the buildup of disease, natural enemies and starvation. Low gypsy moth populations may be held in check by birds, insect predators and small mammals before the next outbreak occurs. In oak-dominated stands, gypsy moth outbreaks usually persist two to five years before collapsing. Populations then remain low for four to 12 years before increasing again. Outbreaks may build and decline faster in aspen dominated stands than in oak stands.

Effects of gypsy moth defoliation are usually most severe during the initial outbreak in a newly infested area. If more than 60% of the canopy is consumed by gypsy moth caterpillars, trees typically "refoliate," producing a second flush of leaves later in summer.



Gypsy Moth Egg Mass with Hatching Larvae

The amount of tree mortality and top kill sustained during a gypsy moth outbreak depends on the severity and frequency of defoliation and on tree health. Vigorous trees can often withstand severe defoliation for a few years. However, each refoliation stresses the tree, reducing its energy reserves. Subsequent stress, including additional defoliation, drought or frost injury, may kill the tree. Suppressed, diseased or low-vigor trees may be killed after one year of heavy defoliation. Severe gypsy moth defoliation, accompanied by an abundance of large hairy caterpillars and frass (fecal pellets), can be unsightly and may reduce the enjoyment of visitors at recreational areas.

Gypsy moth defoliation is primarily based on tree species composition. Stands dominated by oaks, aspen, birch, basswood, willow or other species preferred by gypsy moth will be at high risk of defoliation. Defoliation will be lower in stands dominated by tree species that are less preferred by gypsy moth, such as maples, ash and most conifers. Defoliation may also be higher

where many dead branches, bark flaps and stem wounds are present because these areas provide good hiding places for gypsy moth caterpillars and pupae.

Stand hazard is increased by factors that reduce stand vigor such as overmature trees, suppressed or diseased trees, compacted soil or severe competition. Hazard also increases when drought, late spring frosts, flooding or other stressful environmental conditions occur. Tree mortality has been observed primarily in oak-dominated stands where gypsy moth defoliation coincided with drought or late spring frosts.

MANAGEMENT OPTIONS

Appropriate strategies for gypsy moth management depend on the specific management objectives for each stand, and the quality of the site.

Release of the parasite (*Cotesia melanoscelus*) on gypsy moth larvae may be useful in reducing the population and thus reduce defoliation.

Remove suppressed and low-vigor trees that will be highly vulnerable to damage by gypsy moth and other pests. Leave healthy trees with large crowns that are likely to survive defoliation. Residual trees will require one to two years to recover from defoliation, drought or other stress and adjust to increased exposure.

Thinning to reduce stand density can increase vigor of residual trees and reduce stand risk and hazard. Thinning is most appropriate on medium- and high-quality sites, where costs are economically justified.

To reduce stand hazard, cut suppressed, wounded, diseased or low-vigor trees with poor canopies. Thin to levels appropriate for the species and the quality of the site. Prevent soil compaction, wounds and other injuries to residual trees. Anything that reduces vigor of the residual trees can increase stand hazard.

Selecting against tree species that are preferred hosts of gypsy moth will reduce long-term risk of defoliation. On fertile, mesic sites, altering the species mix can result in stands of high-quality hardwoods. Favoring ash, tulip poplar, maples or conifers in northern or mixed hardwood stands can help increase stand diversity while reducing the risk of defoliation. Increasing species diversity within stands may also reduce the long-term risks of damage by other forest pests.

High-value oak-dominated stands approaching economic or pathological rotation age can be protected with an aerial application of Bt (Bacillus thuringiensis var. kurstaki), a short-lived microbial insecticide that causes a bacterial disease in foliage-feeding caterpillars. Bt is not toxic to other insects or to fish, birds, humans or other animals. An alternative pesticide for killing gypsy month larvae is Dimilin (diflubenzuron) as an aerial application. It is applied at 1.7 g (0.06 oz). per acre and is effective. Other effective materials are Gypchek (gypsy moth neucleopolyhedrosis virus, NPV) and disparlure (Disrupt II) pheromone. The naturally occurring fungus *Entomophaga maimaiga* has also managed large gypsy moth populations in the environment.

Sometimes taking no action is the best alternative. Young, vigorously growing stands are likely to tolerate even severe defoliation for two to three years or longer. Stands with a mixture of species are less likely to sustain severe, repeated defoliation than are stands of nearly pure oak or aspen. No action may also be the best option when stands are at or near optimal levels, especially if vigorous non-host species are present.

Managing stands to provide wildlife habitat may result in greater numbers of natural enemies that feed on gypsy moth. Understory plants and shrubs, trees with cavities and fallen trees are important for maintaining populations of predatory and parasitic insects, insectivorous birds, rodents and other small mammals. When leaving trees for wildlife, select species that are not preferred by gypsy moth.

Avoid using Bt to protect foliage in stands managed primarily for wildlife. Bt can kill caterpillars of "non-target" butterfly and moth species that are present during spraying. However, high gypsy moth populations may also temporarily reduce diversity and abundance of some native insect species.

Recreational areas experiencing a gypsy moth outbreak can be unpleasant places for camping or picnics. The swarms of large caterpillars and frass are distasteful, and the hair on the caterpillars may trigger allergic reactions in some people.

Use burlap, sticky or Teflon-coated bands on the lower trunk of gypsy moth host trees in recreation areas. Use burlap and sticky bands to trap or destroy caterpillars as they move up and down tree stems. Use Teflon-coated bands to prevent caterpillars from crawling up into tree canopies to feed. Banding is economically viable for high-value ornamental or shade trees. Where practical, water defoliated trees during warm dry periods. Prevent soil compaction and wounds to gypsy moth host trees.

PEAR THRIPS *Taeniothrips inconsequens* (Uzel)

The pear thrips is an imported species first noted in California in 1904. It is now throughout the United States and is found on many plants, particularly fruit trees. Pear thrips is now considered a serious forest pest and infestations have been reported in New England, New York and Pennsylvania.



Pear Thrips

Adult pear thrips are less than 2 mm (.01 in) long, slender, dark brown, and have narrow wings covered with a hairy fringe. Immature stages are white with red eyes and wingless. Around mid-June, the thrips enter the soil as larvae where they mature and overwinter. They emerge in early spring to feed on new foliage and buds, and to reproduce. They have sharp, sucking mouthparts which destroy plant cells. Eggs are laid in leaf veins and petiole leaving brown scars. Development is complete in about four weeks when the nymphs drop to the ground.

In forest stands, maples, birches, ash, black cherry and beech are all affected. Symptoms include fallen green leaves, leaves smaller than normal and wrinkled, and resembles late frost damage.

Management: Trees attacked by pear thrips should be fertilized to promote the production of new foliage. These trees should be watered deeply once a week during dry weather. If possible, avoid other stresses such as aphids and leaf-feeding caterpillars.

An early spring application of dormant oil as the buds begin to open is recommended for pear thrips. Oil sprays will reduce populations of emerging adults and lower the number of eggs laid.

ASIAN LONGHORNED BEETLE *Noplophora glabripennis*



Asian Longhorned Beetle

The Asian longhorned beetle was introduced from China in 1996 in wood pallets and other wood packing material in cargo shipments, and is currently limited to areas of New York, New Jersey and Chicago. It is large, ranging from 1.92 – 3.18 cm (3/4 – 1 ¼ in) long with very long black and white antennae. The body is shiny black with white spots. The beetles post no threat to public health, however, they feed on many species of hardwood trees, including several species of maple (Norway, sugar, silver and red), box elder, horsechestnut, buckeye, elm, London plane, birch and willow. The adults can be seen from late spring to fall, depending on the climate.

The Asian longhorned beetle is a member of the wood-boring beetle family, *Cerambycidae*. After mating, adult females chew depressions into the bark of various hardwood trees in which they lay their eggs. Once the eggs hatch, small white larvae bore their way through the bark into the tree, feeding on the vascular layer beneath the bark. The larvae continue to feed deeper into the heartwood forming galleries in the trunk and branches. This damage weakens the integrity of the tree and, if the infestation is severe enough, will kill it entirely.



Over the course of a year, the larvae mature and pupate under the bark. From the pupa, an adult beetle emerges, chewing its way out of the tree, forming round holes about .9 cm (3/8 in) in diameter. Many of these holes will be seen on a heavily infested tree along with frass and sap oozing from the holes. The beetles emerge from June through October, with adults flying in search of mates and new egg-laying sites to complete their life cycle.

Currently there are no chemical or biological defenses against the beetle, and in North America there are few natural predators. After an infestation is confirmed, in all cases, the affected trees are cut down and the wood is chipped and burned. No infested wood should be transported outside the infested area before chipping. Replanting is then suggested to maintain and replenish forested areas.

WHITE PINE BLISTER RUST *Cronartium ribicola*



White pine blister rust may be the most destructive disease of five-needle (white) pines in North America. Important white pine hosts are eastern white pine (*Pinus strobes* L.), western white pine (*Pinus monticola* Dougl.), or sugar pine (*Pinus lambertiana* Dougl.). The rust fungus cannot spread from pine to pine, but requires an alternate host, *Ribes sp.* (currants and gooseberries) to complete the cycle. Establishment of pure pine stands is no longer possible. A project to select and improve blister rust-resistant white pines may become the means to manage the disease.

White Pine Blister Rust

The early symptom of blister rust is a yellow or red spot on needles soon after infection occurs, but this is indistinct and easily overlooked. The next symptom is a slight swelling of the infected branch which becomes a spindle-shaped canker. After one or two years the fungus produces spores from the canker which will completely girdle the branch or bole of the tree and kill it. The needles become red to form a blister rust flag. The bark around the margins of the canker turns a distinct orange color.

Infection of pine occurs in late summer by basidiospores produced from teliospores on *Ribes sp.* leaves. Basidiospore germ tubes enter needle stomata and the fungus grows into the branches forming a blister rust canker. Cool, moist conditions favor the basidiospore survival, germination and entry into pines. Pycnia (spermogonia) form at the margin of the canker and pycniospores (spermatia) are produced over the following year or two. Pycniospores fertilize receptive hyphae, resulting in mycelium that produces dikaryotic aeciospores the following year. Aecia erupt through the bark as white blisters. The blister erupts to release masses of yellow-orange aeciospores, which are wind-borne to infect the alternate hosts (*Ribes sp.*). Within a few weeks, uredinial pustules develop on the lower surface of *Ribes* leaves, which spread to other *Ribes*. Hair-shaped telial columns emerge from uredinal pustules. Teliospores form into basidiospores to infect white pines.

Monitoring: Inspect the general area for the alternate *Ribes* species (currents or gooseberries). Check white pine for swollen branches indicating canker formation.

Management: There are no known chemicals for treating or preventing white pine blister rust. Remove weeds to improve air circulation. Remove understory branches to 1.83 m (6 ft) high from the white pine trees. Find and prune out branches that show early stages (swelling) of canker formation. Eliminate all *Ribes sp.* in the area. Provide proper water and nutrients to promote white pine health.

EARWIGS *Forficula auricularia* L.



Earwigs may cause alarm to occupants when discovered indoors. They have a scary appearance, move rapidly around baseboards at the ground level, and may emit a foul-smelling liquid from their scent glands. They are active at night around lights while hiding during the day, normally live outdoors and do not establish themselves inside. They are harmless to humans and animals, although if handled carelessly, the earwig can give a slight pinch with its forceps.

Earwigs are oblong, flattened insects ranging from light reddish-brown to black, and are easily recognized by the forceps at the end of the abdomen. They range from 1.27 – 1.91 cm (1/2 – 3/4 in) long with banded legs and reddish head. During the spring and autumn, the females lay 20 to 50 eggs in a below-ground chamber. She provides maternal care until the new young first molt. The young then leave the nest, fend for themselves and mature in one season. Both eggs and adults overwinter. The adults may dig as deep as 1.83 m (6 ft) below ground to escape cold winter temperatures. They are rapid runners and feed on mosses, lichens, algae, fungi, insects, spiders and mites. Some earwigs are predators, feeding on aphids and living plants, becoming pests in greenhouses and ornamentals. Serious feeding damage may occur on flowers, vegetables, fruits and other plants, giving the leaves a ragged appearance with small, irregular holes. Earwigs are considered temporary pests in spite of sometimes occurring in large populations.

Earwigs rarely fly and are unable to crawl long distances. They prefer moisture and may migrate indoors during periods of prolonged heat and drought, where they feed on sweet, oily or greasy foods or houseplants. The forceps at the end of the abdomen are used to defend the nest, capture prey, probe narrow cracks, and fold and unfold wings.

Management: For best indoor management, first control earwigs outdoors. Since they are attracted to lights, move lighting away from buildings and other potential entry sites. Use special sodium vapor yellow lights which are less attractive to insects instead of white, neon or mercury vapor lights.

During hot, dry weather, earwigs sometimes migrate inside. They are easily killed by residual (borate or diatomaceous earth) insecticide treatments in cracks and crevices, along baseboards, beneath cabinets, along door and window sills and other hiding places. Find insect entry points into the structure and seal with Stuf-Fit, caulk or other material.

Earwigs need moisture. High populations invisible during the day may be found around foundations, in landscapes, mulch, under boards, etc. at night. Eliminate damp, moist conditions in crawl spaces under structures, around faucets and air conditioning units. Rain gutters and spouts should carry water away from structures. Use caulk, putty and weather stripping around doors, windows, pipes and other entry sites, especially at ground level. Change landscaping by creating a .91 m (3 ft) wide, 10.16 cm (4 in) deep border immediately around the foundation walls of structures. Use 1.27 – 1.91 cm (1/2 – 3/4 in) gravel to make an efficient and attractive

barrier against earwigs and other pest invaders.

Earwigs can be trapped outdoors in cardboard boxes baited with oatmeal. Punch pencil-sized holes in the sides of the boxes near the bottom. Collect captured insects daily. Inside, earwigs can be disposed of with a broom and dustpan or a vacuum cleaner.

GROUNDHOG (WOODCHUCK) *Marmota monax*

The woodchuck, which inhabits most of North America, is sometimes known as a groundhog. This name is taken from the underground burrows that it digs and lives in. Each burrow consists of several rooms with sleeping areas located in the higher elevations and smaller chambers below which are used for hibernation or toilet facilities.



Woodchuck (Groundhog)

The woodchuck is large with a heavy body (45.72 – 67 cm [18 – 26 in]) atop short but powerful legs. Males are slightly larger than females. They have a coat of silver gray and brown with a lighter underneath side. The head is dark brown and the feet are so dark they appear black. Woodchuck incisors are ever-growing, and if not worn down properly in the course of chewing, they may continue to grow with fatal results. In both agricultural and garden areas, the burrows are hazardous to humans and animals alike. Typical woodchuck habitat includes rolling farmland, grassy pastures, small woodlots and fence lines. They prefer forest edges and openings where they are never far from cover, and are partial to loamy and sandy soils for burrowing.

Woodchucks are primarily herbivores, preferring the vegetative parts of plants. In the early spring when vegetation is sparse, they may eat the bark, buds and twigs of plants such as dogwood, sumac and fruit trees. They prefer to eat clover, grasses, forbs and herbs, as well as farm crops such as alfalfa, corn, fruits and vegetables. Females have a single littler of one to nine (average three to five), usually born in May. Young are weaned after approximately 45 days and dispersed when six months old. Woodchucks begin a true hibernation in October which ends in March or April. They live up to six years in the wild.

Woodchucks are prey for large predators (cougars, bobcats, wolves), and can be taken by coyotes or large hawks and owls. Modifying the habitat around woodchuck burrows may discourage them. Remove the cover around burrows and install objects that can move in the wind or randomly. Applying urine from large predators in the area of burrows may also encourage woodchucks to abandon the area. Burrows under structures can be modified with one-way doors to allow exit but not entry. Do not exclude woodchucks until after young have been weaned in late summer. Hardware cloth may need to be installed underground in an L shape to discourage digging new burrows under structures. Fasten hardware cloth to the bottom edge of the deck or structure, burying it 25.4 – 30.48 cm (10 – 12 in) underground with the bottom of the L-shaped angle leading outward.

EASTERN MOLE *Scalopus aquaticus*



Eastern Mole

The eastern mole is about 15.24 – 20.32 cm (6 – 8 in) in length and can weigh 84 – 168 gr (3 – 6 oz). Each year a mole can have one litter of two to six young, depending on the female's health. Gestation lasts about five to six weeks and the young are born between mid-April and mid-May. Young moles have less than a 50% chance of surviving long enough to reproduce.

Moles are insectivores whose primary food source is earthworms. They spend the majority of their life below the ground, and their activity can cause damage to lawns and turf. This damage is in the form of tunnels and/or mounds that can be unsightly and disturb root systems. Moles can quickly colonize and spread through adjacent properties. Because they need a well-established tunnel network to survive, management will be more difficult the longer they are allowed to tunnel and become established. In large areas, moles may move from one part of the property to another. This movement is affected by climate and ground moisture. They will also respond to changes in food supply as different insect larvae become available in different places and different times throughout the year. If disturbed, moles may temporarily leave an area, but will return. Even without disturbance, mole activity may only last a short time in a particular area.

Over-watering turf can bring soil invertebrates and moles closer to the surface making tunnels more visible. Reducing the amount and frequency of watering may help. Numerous home remedies have been used, but results are generally ineffective. Moles provide benefits to meadows and turf by turning soil, mixing soil nutrients, and improving soil aeration. Modifying the turf species to include native grass and forbs for an environmentally sound landscape can eliminate mowing and other manipulations.

If necessary, trapping is the most effective and practical method of managing moles. Trapping success tends to be greatest in the spring and fall, especially after rain. In the summer and winter, moles are active in deep soil and are more difficult to locate. To ensure safe and humane deployment, be sure to follow printed instructions. Traps should be set in active surface burrows. Two types of traps are available: harpoon traps and chokers. The harpoon trap consists of two prongs that straddle the mole tunnel and a set of spring-driven spikes. The spikes are raised above the tunnel and catch in the trigger release. When the mole triggers the trap, the prongs are released and driven through the sod, impaling and killing the mole. A choker trap consists of a cast-metal frame with two spring-retractable loops. Two slits are cut in the tunnel and the set loops are placed inside. When the mole triggers the trap, it is immediately crushed. When using traps, place a plastic pail with a warning sign over each trap. Set three to five traps per acre.

WHITE-TAILED DEER - *Odocoileus virginianus*



White-Tailed Deer

The white-tailed deer is tan or brown in the summer and grayish brown in winter. It has white on its throat, around its eyes and nose, on its stomach and on the underside of its tail. The male has antlers. Males weigh between 150 and 300 pounds and females weigh between 90 and 200 pounds.

The white-tailed deer can be found in southern Canada and most of the United States, except for the Southwest, Alaska and Hawaii.

A deer's home range is usually less than a square mile. Deer collect in family groups of a mother and her fawns. When a doe has no fawns, she is usually solitary. Male bucks may live in groups consisting of three or four individuals, except in mating season, when they are solitary.



White-tailed Doe & Fawn

The white-tailed deer lives in wooded areas. In many areas, deer overpopulation is a problem. Gray wolves and mountain lions used to be predators of the white-tailed deer and helped keep their population under control.

Disease and parasites like lice, mites and roundworms can weaken or kill deer. Young deer and old deer often get sick and die, especially in the winter. Their long narrow legs and pointed hooves make it hard for them to move around in the snow and ice and it is easier for predators like dogs to catch them.

Deer and people are living closer to each other because of human development and growth in deer and human populations. Because humans and deer often share a habitat, there can be problems for both of them. When a deer's habitat becomes smaller because of human development, deer will often eat food from gardens.

The white-tailed deer is an herbivore or plant eater. It follows well-used trails to its feeding areas. It feeds in the early morning hours and in the late afternoon. A deer's diet changes depending on its habitat and the season. It eats green plants in the spring and summer. In the fall, it eats corn, acorns and other nuts. In the winter, it eats the buds and twigs of woody plants.

The white-tailed deer is a ruminant. Its stomach has four chambers for digesting food. This digestive system lets the white-tailed deer eat foods like woody plants that other animals can't digest! If deer have enough food, water and shelter, their population can grow very quickly.

White-tailed deer mate in November in the northern parts of their range and in January or February in the southern parts of their range. The female has one to three fawns about six months after mating. Fawns are reddish-brown at birth with white spots that help camouflage them. They can walk at birth and forage for food a couple of days later. They are weaned at about six weeks.



When a white-tailed deer is alarmed, it may stomp its hooves and snort to warn other deer. It may also "flag" or raise its tail and show its white underside. White-tailed deer are very good runners. They can run at speeds of up to 30 miles an hour. They are also good leapers and swimmers.

JAPANESE BEETLES *Popillia japonica* Newman



Japanese Beetle Adults

The Japanese beetle is a major pest of urban ornamentals. The beetle occurs in much of the United States.

Adult beetles are .94 cm (3/8 in) long, metallic green, with hard copper-brown wing covers. Five small tufts project from under the wing covers on each side and a sixth pair at the tip of the abdomen. Adults emerge from the ground in late May or early June. Individual beetles live about 30 – 45 days with activity concentrated over a four to six week period. Beetle numbers begin to decline in late July.

Japanese beetles feed on about 300 species of plants, ranging from roses to poison ivy. Odor and location in direct sun are important in host plant selection. The beetles usually feed in groups, starting at the top of a plant and working down. While a single beetle doesn't eat much, group feeding causes severe damage. Adults feed on the upper surface of foliage chewing tissue between the veins. This gives leaves a skeletonized appearance. Japanese beetles can fly up to five miles, but one to two miles is average. They usually make only short flights as they move about to feed.

Management of the beetle grubs in turf grass is the most effective and efficient approach. The bacterium, *Bacillis* popilliae, is effective on Japanese beetle grubs in turf. It may take a few seasons to achieve lasting management. The use of parasitic nematodes (*Heterorhabdtitis bacteriophora*) in turf will also reduce grub populations. Apply nematodes while it is raining to get good penetration into the turf (see the Pest Profile on white grubs.). Direct spray applications of insecticidal soap kills adult Japanese beetles on contact, but does not provide any residual protection.

The hard body of the Japanese beetle may make them unattractive to many predators such as birds. Hand collecting can be a control option to protect valuable plants when beetle activity is low. When beetles are removed from a plant daily by hand, only about half as many are attracted to that plant compared to those on which beetles are allowed to accumulate.

Commercially available traps attract the beetles with two types of bait. One mimics the scent of female beetles and is only attractive to males. The other bait is a food lure that attracts both sexes. This is a powerful attractant that can draw thousands of beetles into traps in a day. If traps are used, place them near turf well away from gardens and landscape plants, and check (and empty) them daily.

WHITE GRUBS



Japanese Beetle Grub

White grubs are the C-shaped larvae of a large group of beetles called scarabs. Many species are found in the United States, and several attack turfgrass. The most important species are: Japanese beetle *(Popillia japonica* Newman), May or June beetles *(Phyllophaga* spp.), northern and southern masked chafers *(Cyclocephala* spp.), and black turfgrass ataenius *(Ataenius spretulus* [Haldeman]).

White grubs are perennial pests of the cool season and transition zone turf grasses. The species listed above are generally found east of the Mississippi River. White grubs eat organic matter including the roots of plants. Damage first appears to be drought stress. Heavily infested turf appears off color and wilts rapidly in the hot sun. Continued feeding will cause the turf to die in large patches. The tunneling of the larvae can cause the turf to feel spongy under foot. Grub populations may not cause observed turf injury, but predatory mammals such as skunks, raccoons, opossums and moles dig in the turf in search of a meal.

Scarabs have a complete life cycle with eggs, larvae, pupae and adults. Japanese and other beetles and chafers have annual life cycles. Most eggs are a creamy-white in color, about 1.5 mm (1/16 in) long and slightly oval when first laid in the soil. They absorb water from the soil, swell slightly and become more round. The C-shaped white grub larvae are thick bodied, creamy white with brown heads and short legs. The pupae are often slightly longer than the adults and are formed in chambers 1.27 – 2.54 cm (1 – 2 in) in the soil. The pupae are cream colored, then darken before the adults emerge. The adults are typical scarabs – robust, oval beetles with the antennae ending in a large club.

The adults are easily identified, but the grubs are the stage usually found in turf. White grubs seem to be periodic pests attacking turf areas irregularly from year to year. Soil moisture and rainfall are major factors which influence development. In general, years with normal or above normal rainfall see grub populations increase. Well maintained turf next to ornamental plants favored by the adults seems to be more commonly attacked.

MANAGEMENT

Modify host plants. Certain species of adults prefer specific host plants; i.e., where Japanese beetles are common, do not plant roses, grapes and lindens around high maintenance areas.

Practically all white grubs require moist soil for their eggs to hatch. The larvae are also susceptible to desiccation. In areas where the turf can tolerate moisture stress, do not water in July and early August when white grub eggs and larvae are present.

Several parasitic wasps, *Tiphia* spp. and scoliids, attack white grubs and may reduce populations in certain areas. These parasitic wasps, however, may take two to three years to build up effective populations.

Several strains of the bacteria, *Bacillus popilliae,* have been found that attack white grubs. The commercial preparation of this bacterium is extracted from Japanese beetle grubs and is most active against this species. The bacterium applied to the turf is picked up by feeding grubs and causes the body fluids to turn a milky-white before death. Fresh bacterial preparations should be used; three to five years are needed to establish lasting management.

Some insect parasitic nematodes are also used; however, available strains may not be effective from one season to another, and result in less than desirable control percentages.

Since white grub occurrence is sporadic, applying pesticides for management of anticipated grub populations is not recommended. Pheromones have been identified for Japanese beetles to monitor adult populations. White grub populations can be assessed when the grubs become large enough to be easily seen. Square foot samples can be taken in several places over the turf area. This is done by cutting through the turf on three sides and pealing back the turf. Inspect the thatch and upper portion of soil for grubs.

LILAC LEAFMINER MOTH *Gracillaria syringella (Fabricus)*



Lilac Leafminer Moth

The lilac leafminer moth is an introduced insect that feeds primarily on the leaves of lilac and green ash trees. The first sign of damage is a small linear tunnel on the underside of the leaf surface. As the larva grow inside the leaf, light green to brown blotches will appear on the upper surface of the leaves. The blotches develop in response to the larva eating the inner layer of the leaf. Gradually the blotches grow larger, turn a darker brown and become brittle. The larva then exits the inner leaf surface, rolls the leaf up and begins to feed on the upper leaf surface within the curled portion.

The adult lilac leafminer moth is slender, grayish-brown and about 6 mm (.24 in) in length. The eggs are very tiny and transparent, and are not usually noticed. Small green larvae emerge from the eggs. As they mature, they change to a pale yellow color. At maturity, the larvae will appear flat and reach approximately 8 mm (.32 in) in length. The larvae will then pupate in the soil within a small white cocoon.

Management: The lilac leafminer is best managed by simply removing the leaves as soon as damage is noticed. Collect and dispose of leaves and leaf debris in the area.

SLUGS

Several species of slugs are frequently damaging, including the gray garden slug (*Agriolimax reticulatum*), the banded slug (*Limax marginatusi*), the tawny slug (*Limax flavus*), and the greenhouse slug (*Milax gagates*). Slugs move by gliding along on a muscular "foot." This muscle constantly secretes mucus which dries to form the "slime trail" that signals the presence of the pest. Slugs reach maturity after about three to six months, depending on species, and lay clear oval to round eggs in batches of three to 40 under leaves, in soil cracks and other protected areas.



Slug

Slugs are most active at night and on cloudy days. During cold weather, slugs hibernate in the topsoil. They feed on a variety of living plants as well as on decaying plant matter. On plants they chew irregular holes with smooth edges in leaves and flowers. They can also chew fruit and young plant bark.

Management: A slug management program relies on a combination of methods. If possible, eliminate areas where slugs can hide during the day; i.e., boards, stones, debris, weedy areas around tree trunks and dense ground covers. Handpicking can be effective if done on a regular basis. Several types of barriers will keep slugs out of planting beds. The easiest to maintain are those made with copper flashing and screen. Copper barriers are effective because it is thought that the copper reacts with the slime that the slug secretes, causing a flow of electricity. Copper bands can also be placed around trees

Slugs have many natural enemies, including ground beetles, pathogens, snakes, toads, turtles and birds, but most are rarely effective enough to provide satisfactory control.

Sluggo is a registered slug bait containing iron phosphate. This is a low-risk choice for an IPM program as it is relatively innocuous for use around animals, birds, fish, children and wildlife. Ingestion of the iron phosphate bait will cause slugs to cease feeding, although it may take a few days for the slugs to die. Iron phosphate bait can be scattered on lawns or on the soil around trees or ornamental plantings.

POWDERY MILDEW



Powdery Mildew

There are numerous fungi that fall under the general description of a powdery mildew. Outdoors there are numerous plants that may be infected in any year; but lilac, phlox, some rose varieties and fruit trees seem to be infected most frequently. The actual injury to the plant varies greatly with the species and even the variety attacked. For instance, lilacs are typically infected late in the growing season and this does not usually cause serious injury to the plants. Lilacs are able to survive year after year in spite of the disease. On the other hand, begonia may be seriously injured by even a mild infection. The tissue under the fungal growth dies soon after infection resulting in leaf drop and poor plant growth. Thorough management practices must be implemented in this case. Among roses there are varieties that are more seriously affected than others. If powdery mildew has been a problem in the past, choose a variety that has some resistance to the disease.

Powdery mildew appears as a dusty white to grey coating over leaf surfaces or other plant parts. In most cases this fungal growth can be partially removed by rubbing the leaves. Powdery mildew will begin at discrete, usually circular, powdery white spots. As these spots expand they will coalesce, producing a continuous mat of mildew.

Symptoms usually appear late in the growing season on outdoor crops. The fungus is favored by periods of high relative humidity or site conditions that promote a more humid environment, such as close spacing of plants, densely growing plants or shade.

Injury due to powdery mildews includes stunting and distortion of leaves, buds, growing tips and fruit. The fungus may cause death of invaded tissue. Yellowing of leaves and death of tissue may result in premature leaf drop. Nutrients are removed from the plant by the fungus during infection and may result in a general decline in the growth and vigor of the plant. The seriousness of the disease will depend on the extent of the various types of injury.

The fungi which cause powdery mildew are spread by spores produced in the white patches. These spores are blown in the wind to other parts of the plant or to other plants during the growing season. Generally each species of fungus will be limited in the number of plant species that can be attacked. For example, the species of fungus infecting lilacs will not cause powdery mildew on apples.

During the winter the fungus survives on infected plant parts and in debris such as fallen leaves. It may produce resting structures known as cleistothecia, which resist harsh winter conditions. These will appear as small black dots within the white powdery patches. The next spring, sexual spores (ascospores) are released from the cleistothecia, shot up into the air, and carried by air

currents to leaves of plants where new infections will begin. During the growing season, the fungus produces asexual spores (conidia) that help the fungus to spread and the infection to build. This is the general cycle for most powdery mildews of outdoor plants.

MANAGEMENT

There are several effective fungicides available for different sites and plants, but use on plants varies with each product, and not all fungicides registered for use to treat powdery mildew may be used on all plants. Be certain the product you purchase is labeled for the intended use(s), and follow directions on that label.

For outdoor ornamental plants, gather up fallen leaves in autumn and destroy them. Where powdery mildew is a problem, resistant varieties (if available) should be grown. If needed during the growing season, begin fungicide applications when the first white patches are noticed. Repeat as indicated on the product label during cool humid weather. Some products with a broad range of applications for outdoor ornamentals include *Bacillus subtilis*, jojoba or neem oil, potassium bicarbonate, sulfur or lime sulfur. Some of these products may also be used to treat powdery mildew infections in the vegetable garden. Other products may also be available, so your local Cooperative Extension Office can be contacted for more information.

Management of powdery mildew on fruit trees should begin at the green tip bud stage for apples and may include some products containing the active ingredients *Bacillus subtilis*, neem oil or potassium bicarbonate.

Wettable sulfur is known to cause injury to some plants. Check labels for cautions about sensitive plants.

GILL-OVER-THE-GROUND *Glechoma hedercea*
aka CREEPING CHARLIE, GROUND IVY



Gill-Over-The-Ground

Gill-over-the-ground (ground ivy) is a trailing European aromatic plant of the mint family having rounded leaves and small purplish flowers. It is often grown in hanging baskets and has naturalized in North America.

It is a perennial herbaceous plant with creeping square stems that grow about .61 m (2 ft) long with erect flowering stems. The leaves are opposite, long stalked, bright green and shiny. The flowers are light blue to purple, tubular, and bloom from April to June. The roots grow from each leaf node that creeps along the soil surface spreading vegetatively as well.

It is not a threat to healthy native plant communities. Ground ivy grows best in semi-shaded to shaded moist soils and forms a dense mat which can smother other vegetation. It is a common garden weed and grows mostly in disturbed soils, and is found in most moderate climates all over the world.

Management: Repeated pulling can manage small infestations. Spraying with herbicides is not recommended.

BLACK SPOT OF ROSES



Black Spot of Roses

Black spot is the most important infectious disease of roses. It occurs only on roses (*Rosa* spp.) and is widespread among rose species and cultivars. Round to irregular black splotches with fringed margins are quite obvious, mostly on upper leaf surfaces. Leaf yellowing develops around these black spots with defoliation of these leaves common. Repeated defoliation weakens plants, leading to poor blooming and greater sensitivity to stress.

The fungus overwinters on fallen leaves and diseased canes. Spores are then splashed to newly emerged leaves and stem tissue in the spring. Under ideal conditions of leaf wetness, humidity and temperature, the spores can germinate and infect in one day, cause symptoms in four to five days, and produce new spores that can infect additional leaves, flowers and tissue within 10 to 11 days. Spores are spread to new locations by air currents.

MANAGEMENT

Cultural: Keep foliage dry. Roses can be planted in open locations to encourage drying after rains. Avoid sites with dense surrounding vegetation so good air movement will dry leaves. Black spot is most severe in summers with sustained rainy periods.

Sanitation: Remove all black spotted leaves from and around plants. This should be done throughout the season. Before winter, remove and clean up all diseased leaves and remove diseased canes where possible.

Fungicides are not successful if cultural and sanitation practices are not followed. For fungicides to work, applications must be made preventively, providing a protective barrier which kills germinating fungal spores that have landed on plants.

BLACK VINE WEEVIL *Otiorhynchus sulcatus* (Fabricius)



Black Vine Weevils

The black vine weevil was first detected in Connecticut in 1910; however, there is evidence that this species was actually seen in the 1830's. It was probably introduced from Europe through movement of ornamental plants. The weevil has now spread across much of North America. Adult black vine weevils feed on over 100 different kinds of plants including trees, shrubs, vines and flowers. The preferred hosts are yews, hemlock and rhododendrons.

Black vine weevils are oval shaped, about 1.27 cm (1/2 in) long and have a short, broad snout with elbow-shaped antennae. The body is grey to blackish-brown and the forewings have small pits and short hairs. Females emerge from soil pupation in late May to early June. These weevils feed on plant material for 21 – 45 days before they are ready to lay eggs. The females then place several eggs each day into the soil or leaf litter near host plants. The weevils hide during the day at the base of plants or in mulch or leaf litter. The adults may live 90 – 100 days and usually lay 200 eggs during this time. The eggs hatch in two to three weeks. The legless larvae feed on young tender roots of plants. If young roots become scarce or the soil becomes overly wet, the larvae will move to the larger roots near the base of the plant. Girdling around the plant may indicate large larval populations. By late fall, the larvae have matured and are about 1.57 cm (5/8 in) long. A single generation occurs each year.

The weevils cannot fly but are active walkers, and are easily transported in potted plats and soil root balls.

Inspection and Monitoring: Adult black vine weevils feed along leaf edges and produce crescent-shaped notches. Light to moderate notching has little effect on plant health. Careful searches should be made to try and locate specimens. Since several other weevils and some caterpillars produce similar notching, they may be difficult to distinguish.

Management: These weevils are difficult to manage once established because of their nocturnal behavior, the underground habits of the larvae, and the lack of natural predators or parasites. Habitat Modification: Egg and larval survival is helped when soil moisture is moderate to high in the summer. Mulches also help maintain moisture levels. Remove mulch layers and do not water plants unless absolutely necessary. Properly maintain downspouts and adequate soil drainage around plants. Biological Control: The *Steinernema* and *Heterorhabditis* spp. have been effective for controlling black vine weevil larvae in potted plants. Enough water must be used during application to wash the nematodes into the soil and root zone. Applications of nematodes in landscapes may have variable results.

LACE BUGS



Lace Bug

Adult lace bugs are about .3 – .45 cm (1/8 – 3/16 in) long and have clear, ornamented wings that look like lace. There are several species that feed on trees and shrubs in the northeastern states. Most lace bugs have a limited host range. Nymphs are dark brown to black and are quite spiny. Eggs are inserted into the midrib or veins on the underside of leaves, or cemented to the leaf with a brown, crusty material. Brown patches or black droplets of excrement are an indication of lace bug feeding.

Lace bug damage to host plants is a result of feeding on the lower surface of leaves, sucking juices through slender, piercing mouth parts. Damage shows as yellow or white spots on the upper surface of the leaf. Lace bug damage is most common and severe on andromeda (*Pieris*), azalea, pyracantha and rhododendron. More damage on azalea and rhododendron occurs if the plants are in a sunny location. Azalea and rhododendrons are understory plants and do better in shady locations.

Lace bugs that attack evergreens overwinter in the egg stage. Those that attack deciduous plants overwinter as adults under bark or in leaf litter. Lace bugs have one to three generations per year, depending upon the species.

Management of lace bugs involves early spring monitoring of susceptible plants, looking at the underside of leaves for nymphs, adults and the black excrement spots. Leaf damage by the first generation will not disappear, even after the lace bugs are gone. Use a hard water spray to dislodge overwintering adults and new nymphs from the leaves. Encourage or release green lacewing larvae, predator mites or assassin bugs to keep lace bug populations down. Insecticidal soaps may be necessary to treat the underside of leaves to control the nymphs that have not been eaten by the predators. Be sure to monitor the plants for lace bug nymph populations as well as numbers of the predators at least monthly.

SNOW MOLDS

Snow mold is a fungal disease that appears in early spring as the snow melts. There are two types of snow molds, grey and pink, that become active under snow cover. Grey snow mold (also called Typhula blight) is caused by *Typhula spp.*, while pink snow mold (also called Fusarium patch) is caused by *Microdochium nivalis*.



Snow Mold in Turf

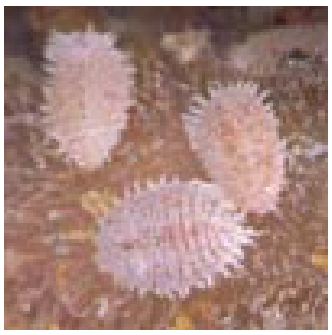
Symptoms first appear in the lawn as circular, straw-colored patches when the snow melts in the spring. These patches continue to enlarge at temperatures slightly below freezing as long as the grass remains cold and wet.

Snow molds do not occur in the turf every year, but are most common during years when an early, deep snow cover prevents the ground from freezing. The damage caused by snow molds is seldom serious. Generally infected areas are just a little slower to green up in the spring.

Management: Gently rake affected areas of the lawn to promote drying in spring and prevent further fungal growth. Fungicides are not recommended. The following steps can be taken to minimize damage:

- Avoid applications of nitrogen fertilizer in the fall.
- Continue to mow the turf at the recommended height until it is no longer actively growing. The taller the grass, the more likely it will mat down and encourage snow mold development.
- Rake up leaves in the fall.
- Manage the thatch layer to avoid accumulations of more than 1.27 cm (1/2 in).
- Spread out large snow piles to encourage rapid melting. Use snow fencing to minimize snow accumulation in problem areas.

MEALYBUGS



Mealybugs

Mealybugs are part of the insect families collectively known as scale insects, although they are soft-bodied without the hard outer shell. They are usually covered with a white, waxy powder. Mealybugs have the ability to feed on a very wide range of host plants, and are especially problems on foliage plants in greenhouses and interior landscapes.

Mealybugs have sucking mouthparts. Feeding weakens plants, causes leaf distortion, yellowing, and sometimes total leaf loss and plant kill. They produce large amounts of honeydew similar to that produced by aphids and whiteflies, which coats plants with a sticky layer. A black fungus commonly known as "sooty mold" grows on the honeydew. The presence of honeydew and sooty fungus is one way to detect infestations of these insects.

Mealybugs produce about 200 eggs and females need to mate in order to produce eggs. Females either produce live young or the eggs hatch into crawlers very quickly. The eggs hatch in no more than ten days, move about the plants and locate feeding sites. After that, there is not much movement. There can be up to six generations per year.

Management: There are excellent non-chemical and biological control options for managing mealybugs. The key is to detect the infestation before it becomes too difficult and costly to deal with. Mealybug management seldom requires chemicals if they are detected early enough.

Horticultural oil and insecticidal soap sprays are effective, low-risk controls for mealybugs. Oil sprays suffocate the insects and can aid in managing scale crawlers and eggs, while soap sprays cause the insect cell membranes to rupture, effectively causing it to desiccate.

There are excellent biological controls for mealybugs. One biological control used most often is the mealybug destroyer, *Cryptolaemus montrouzieri*. The larvae of this ladybird beetle are very effective predators, especially when mealybug numbers are high. Adults will also feed on mealybugs. A parasitic wasp, *Leptomastix dactylopii*, can be used in combination with the predators. Small releases of the mealybug destroyer at two to three week intervals are more effective than one large release. This can also be used in conjunction with other biological controls. The citrus mealybug parasite, *Leptomastix dactylopii*, is a tiny wasp that lays eggs in mealybugs. Two to four releases should be made at two to four week intervals. These parasites do best in warm, humid conditions.

WHITEFLIES



Whiteflies

Whiteflies develop rapidly in warm weather and populations can build up quickly where natural enemies are destroyed. Whiteflies have a wide host range that includes many weeds and crops.

Whiteflies lay their eggs on the undersides of leaves. All stages feed by sucking plant juices from leaves and excreting excess liquid as honeydew as they feed.

As whiteflies suck phloem sap, large populations can cause leaves to turn yellow, appear dry and fall off plants. Like aphids, whiteflies excrete honeydew, so leaves may be covered with black sooty mold. The honeydew attracts ants, which interfere with the activities of natural enemies that may manage whiteflies and other pests. Exclude ants from plants (trees or shrubs) with a band of Tanglefoot around the base.

Management of heavy whitefly infestations is difficult as they are not well managed with insecticides. In many situations, natural enemies will provide adequate control of whiteflies. Avoid or remove plants that repeatedly host high populations of whiteflies. In ornamental plantings, populations in the early stages can be held to a minimum by removing infested leaves and hosing down with water sprays to dislodge adults.. Reflective mulches can repel whiteflies and sticky traps can be used to monitor or reduce numbers. If insecticides are used, insecticidal soaps or oils such as neem oil may reduce populations, but will not eliminate them.

Whiteflies have many natural enemies and outbreaks frequently occur when these natural enemies have been disturbed or destroyed by pesticides, dust buildup or other factors. Some predators include lacewings (*Chrysoperla carnea* or *C. rufilabris*), bigeyed bugs (*Geocoris punctipes*), and minute pirate bugs (*Orius tristicolor*). Several lady beetles and scale predators also feed on whiteflies. Whiteflies also have a number of naturally occurring parasites that can be very important in managing them (*Encarsia formosa* or *Eretmocerus californicus*). Avoiding the use insecticides that kill natural enemies is a very important aspect of whitefly management. Removing leaves by hand in heavily infested areas can reduce populations to levels that natural enemies can contain.

In ornamental plantings, yellow sticky traps can be posted around to trap adults. Such traps won't eliminate damaging populations but may reduce them as a component of an integrated management program relying on multiple tactics. Whiteflies do not fly far, so many traps may be needed.

APHIDS AND SOOTY MOLD



Aphids

Aphids are small, soft-bodied insects with long, slender mouth parts that they use to pierce stems, leaves and other plant parts to suck out plant fluids. They may be green, yellow, brown, red or black, depending on the species. Most adult aphids are wingless, but aphids have the ability to produce winged individuals which provides the pest with a way to disperse to other plants when the population increases or the quality of the food source decreases. Almost every plant has one or more aphid species that occasionally feeds on it. Many species are difficult to identify; however, identification to species is not necessary to manage them in most situations.

Aphids have many generations a year, with females giving birth to as many as 12 per day without mating. Nymphs shed their skins four times before maturing. There is no pupal stage. When the weather is mild, many species of aphids can develop from newborn nymph to reproducing adult in seven to eight days.

Aphids produce large amounts of honeydew similar to that produced by mealybugs and whiteflies, which coats plants with a sticky layer. A black fungus commonly known as "sooty mold" grows on the honeydew. The presence of honeydew and sooty fungus is one way to detect infestations of these insects.

Monitoring: Check plants regularly for aphids. Many aphids cause the greatest damage when temperatures are warm but not hot. Catch infestations early. Once aphid populations are high and they have begun to distort and curl leaves, it is often hard to manage them as they are sheltered by the curled leaves. Check for evidence of natural enemies such as lady beetles or lacewings. Substantial numbers of natural enemies can mean that the aphid population can be reduced without treatment.

Ants are often associated with aphids. If you see large numbers of ants climbing up tree trunks or on plants, check for aphids on limbs and leaves above. To protect their food source, ants ward off many aphid predators and parasites. Management of ants is a key component to managing aphids.

Management: Natural enemies can be very important in the control of aphids, especially in gardens not sprayed with pesticides that kill the natural enemies as well as pests. Parasitic wasps lay their eggs inside aphids forming a "mummy." Many predators such as the syrphid fly, lacewing and lady beetles feed on aphids. Both parasites and predators can greatly reduce aphid populations.

If you see ants crawling up aphid-infested plants, put a band of Tanglefoor around the trunk or stem to prevent ants from climbing up. Teflon products, which are too slippery for ants to climb up, have also been used on mature plants. Fabric wrap or duct tape can also be wrapped around the trunk and the sticky material applied to the wrap. Ant stakes or baits may also be used on the ground to manage the ants without affecting the aphids or their natural enemies.

Insecticidal soap or neem oil can provide temporary control if applied to thoroughly cover infested foliage. Other low-risk insecticides are available to use on aphids, however, these materials are not recommended as they will also kill the natural enemies that provide long-term management of aphids and other pests.

ARBORVITAE LEAFMINER *Argyresthia thuiella* (Packard)

Leafminer adult moths are small, silvery tan in appearance, and are active starting mid-June into early July. Eggs are laid on the foliage from which larvae soon hatch. The larvae are 3 mm (1/8 in) long caterpillars with a light green body and a black head. They then chew their way into the leaves. Their entrance holes are so small they can only be seen with magnification. Larvae will feed within the foliage until the fall, where they will overwinter. Feeding resumes in the spring and pupation begins by late May.



Arborvitae Leafminer

Browning of the foliage from all arborvitae leafminer species' feeding activity will not appear until late January or February, and is often misdiagnosed as being winter injury. The greatest injury occurs to hedge rows and ornamental plantings.

The use of yellow, sticky cards for monitoring adult flight is not effective for this leafmining pest and visual observations are necessary. During the flight period, gently shake the foliage. If adults are present, they can be observed in this forced flight.

Management: Under forest conditions, leafminers are usually kept in check by natural management factors, including tiny hymenopterous (wasp) parasites. Some management may also be obtained by cutting off infested, discolored tips of branches in the fall and destroying them. The leafminer parasites *Dacnusa sibirica* or *Diglyphus isaea* may be useful and are available from IPM Laboratories in New York.

EUONYMUS CATERPILLAR *Yponomeuta cagnagella*



Euonymus Caterpillar

The euonymus caterpillar is a member of the ermine moth family and has long been a pest of the spindle tree euonymus in Europe, the Middle East and Asia. Since 1967, this caterpillar has also been found in the eastern United States and Canada. The larvae feed in colonies on foliage within loose webs they have woven. They feed on the ends of branches and make their way up toward the center of the plant. If not managed early in their development, these caterpillars can defoliate entire plants over a brief time and envelope the plant in webbing.

The euonymus caterpillar is creamy white with rows of black spots on each segment. This contrasting coloration makes the caterpillar very distinctive and easy to identify. The larvae reach 1.91 cm (3/4 in) long at maturity. The adult moth is also white and has the distinctive spots arranged in three rows along the forewings. The wingspan of the adult moth is approximately 2.54 cm (1 in).

Adult moths appear in mid- to late July when they mate and lay eggs. After mating, the adult female lays her eggs on twigs, branches and in the bud axils of susceptible plants. The eggs are covered with a gummy substance that hardens and becomes almost invisible. The eggs hatch in mid-August and the larvae feed briefly before preparing to overwinter beneath the egg shells.

The following spring, the larvae produce webs and begin to feed on the new foliage. There is only one generation per year.

Management: Scouting for euonymus caterpillars should begin in mid-May to early June. Examine susceptible species for small caterpillars and early signs of webbing. Small infestations may be successfully treated by hand-pruning to remove infested foliage. For larger populations, *Bacillus thuringiensis kurstaki* is effective against the euonymus caterpillar. Treatments should be made to the early larval instars to ensure success.

AUTUMN OLIVE *Eleaganus umbellate* Thumb.

Autumn olive is a medium to large shrub in the Oleaster family often reaching a height of 6.1 m (20 ft). The leaves are generally oval in shape, approximately 2.54 – 7.62 cm (1 – 3 in) long. The upper surface of the leaves is dark green in color, while the underneath side is covered with silvery scales. Small light yellow flowers bloom in late April and May after the first leaves have appeared. Small fleshy fruits range in color from pink to red.



Autumn Olive

Autumn olive was introduced into the United States in 1830 from Asia, and is found from Maine south to Virginia, and west to Wisconsin. In the eastern U.S., autumn olive has been planted for revegetation of disturbed areas. It is rarely encountered in dense forests or in very wet sites. It has nitrogen-fixing root nodules which allow it to thrive in poor soils. Autumn olive is drought tolerant and may invade grasslands and sparse woodlands. Birds forage on its fruits and contribute to seed dispersal.

Autumn olive is a very troublesome invasive species. In addition to its prolific fruiting, seed dispersal by birds, rapid growth and ability to thrive in poor soils, autumn olive resprouts vigorously after cutting or burning. It creates heavy shade which suppresses plants that require direct sunlight.

Management: Young seedlings can be hand-pulled in early spring when the root system is small enough to allow total removal. It is easily seen in early spring because its leaves appear when most native vegetation is still dormant. Cutting the plant off at the main stem and wiping or spraying each stump with Glyphosate or Triclopyr is an effective control measure. Repeated pruning of established plants without cut-stump herbicide application is not effective for control. Each regrowth results in a thicker stem base and denser branches. Burning during the dormant season also results in vigorous resprouting.

BLACK LOCUST *Robinia pseudoacacia* L.

Black locust is a fast growing tree that can reach 12.2 – 30.48 m (40 – 100 ft) in height at maturity. Its native range is from the lower slopes of the Appalachian Mountains throughout the southeastern United States; however, black locust has been planted in many climates and is naturalized through the U.S.



Black Locust

The bark of the mature tree is dark brown and deeply furrowed with flat-topped ridges, while the young saplings are smooth and green. They are easily identified by long paired thorns. Fragrant white flowers appear in May and June. The black locust prefers full sun and well drained soils, and is commonly found in disturbed areas. Because of its rapid growth, the black locust has been promoted by government agencies and nurseries as a desirable landscape plant. It has been planted extensively for its nitrogen fixing abilities, as a source of nectar for honeybees, and for fence posts and hardwood lumber.

The black locust reproduces vigorously by root suckering and stump sprouting to form groves of trees connected by a common root system. Physical damage to roots and stems increases suckering and sprouting, making management difficult. Even though the black locust produces many seeds, they seldom germinate.

Black locust poses a serious threat to native vegetation outside of its historic range. Once introduced to an area, black locust expands readily into areas where their shade reduces competition from other plants.

Management: Mowing and burning are effective in reducing the further spread of young shoots from a parent tree. Cutting alone is ineffective. Using Glyphosate or Triclopyr to cut stumps provides good control. However, monitoring is necessary as resprouting and suckering may require follow-up treatment even several years after the herbicide treatments.

BLACK SWALLOW-WORT *Vincetoxicum nigrum*



Black Swallow-wort

Black swallow-wort vines twine .91 – 1.83 m (3 – 6 ft) high, often smothering nearby vegetation. It is also called Dog-strangling vine and climbing milkweed. The leaves are 6 – 12.70 cm (2 – 5 in) long, opposite, toothless, oval-shaped and dark green with smooth, shiny surfaces. Flowers are dark purple and each of the five pointed petals are triangular and covered with downy white hairs. Ripe seeds are wind-dispersed on silky filaments. Roots are fleshy with a rhizomatous crown just below the soil surface.

Black swallow-wort is native through Europe and Asia. It was introduced into North America as a horticultural plant that quickly escaped cultivation. It is common throughout the northeastern U.S. Swallow-wort is an aggressive exotic species. It readily invades disturbed sites and is commonly found in old fields, pastures, fence rows and road ditches. It has also been found invading managed landscapes.

Management: Digging up the root crowns is effective but the whole crown must be removed. Pulling the plants by hand generally leads to resprouting but can prevent seed production, especially if repeated during the growing season. A less effective method is pod picking, which also limits seed production, but does little damage to the existing population. Mowing is best for preventing seed production. Mow frequently (one to two visits per season) just as the pods are beginning to form.

The use of a Triclopyr-based herbicide (Garlon 4) is an option in grassy areas. Repeated herbicide applications will most likely be necessary in vigorous stands. Cut-stem applications are recommended for small infestations or if nearby desirable vegetation might be adversely affected. Burning and grazing do not appear to be effective.

BLUETS *Houstonia caerulea*

This is a perennial, herbaceous plant which can reach 15.24 cm (6 in) in height. The leaf arrangement is opposite. Leaves can reach 1.27 cm (1/2 in) in length. The flowers have four regular petals that form a cross and are up to 1.27 cm (1/2 in) wide. They are blue with yellow centers. Blooms first appear in mid-spring and continue into early summer. The flower style is dimorphous with different size pistils and stamens.



Bluets

Bluets are found in a variety of semi-disturbed habitats such as fields, grasslands, roadsides and forest margins. Fertile seeds are produced only by cross-pollination between plants with different style lengths.

Bluets are also called Innocence or Quaker-ladies. They are common and are easily transplanted.

Management: As bluets are considered a very desirable planting, no management strategies were found. Hand-pulling plants from undesired locations will be effective in managing this plant.

LESSER CELANDINE *Ranunculus ficaria* L.



Lesser Celandine

Lesser celandine was introduced into the United States as an ornamental plant. It is an herbaceous, perennial plant that has a basal rosette of dark green, shiny stalked leaves. The flowers open in March and April. It is commercially available in many colorful varieties, and occurs in moist, forested floodplains and in some dry upland areas, preferably in sandy soils. All varieties should be assumed to be invasive.

Lesser celandine is an exotic and vigorous growing groundcover that forms large, dense patches on the forest floor, displacing and preventing native plans from coexisting. The ecological impact of lesser celandine is primarily on the native spring-flowering plant community and the various wildlife species associated with them. Because lesser celandine emerges well in advance of most native species, it can establish and overtake areas rapidly.

This plant spends much of the year (summer through early winter) underground as tubers or underground stems. During the winter, leaves begin to emerge. After blooming in March and April, the above-ground portions die back. Lesser celandine spreads mainly by vegetative means through abundant tubers and bulblets.

Management: Lesser celandine is difficult to control, but it can be with persistence over time using methods that are appropriate for the site. No biological control agents are currently available for this plant.

Manual control methods are possible for small infestations. Lesser celandine can be pulled up by hand or dug up using a hand trowel or shovel. It is very important to remove all bulblets and tubers. When conducting mechanical removal, care should be taken to minimize soil disturbance as much as possible.

If herbicides are to be used, they should be applied in late winter or early spring (March to May). This will have the greatest negative impact to celandine and the least impact to desirable native plant species. Treatments with systemic herbicides such as Triclopyr or Glyphosate can be done. Care must be taken to avoid application to anything but the celandine. As these herbicides translocate through the plant to the roots, the full effect may take one to two weeks. Winter applications should be done when the temperatures are over 10ºC (50ºF).

A portion of this profile was taken from information compiled by Jil Swearingen, IPM Coordinator, NPS National Capital Region, Center for Urban Ecology, Washington, D.C.

COMMON & GLOSSY BUCKTHORN



Common Buckthorn

Common and glossy buckthorn were introduced to North America from Eurasia as ornamental shrubs for fence rows and wildlife habitat, and are still used in landscaping. These species are distributed throughout the northeast and north central U.S.

Both common and glossy buckthorn are woody shrubs or small trees that can reach up to 6.05 m (20 ft) in height. Cutting the stems of either species reveals a distinctive yellow sapwood and pink to orange heartwood. Common buckthorn is primarily an invader of upland sites including open woods, woodland edges and open fields. Glossy buckthorn typically invades wetlands including swamps, bogs, fens and wet meadows, but also occurs in upland habitats. Both species are capable of growing in full sun as well as heavily shaded areas.

Plants flower from late May until the first frost and fruits ripen from early July to September. Common buckthorn has smooth, deeply veined, oval leaves with toothed margins. Glossy buckthorn has gray-brown bark and lightly colored lenticels, which give the bark a speckled appearance. Its leaves are shiny on the upper surface, oval shaped and slightly wavy.



Glossy Buckthorn

Both common and glossy buckthorn have a wide habitat tolerance, rapid growth rates and extensive root systems. They both produce abundant flowers and fruits throughout the growing season. Seeds are widely dispersed by birds. Once established, these species aggressively invade natural areas and form dense thickets displacing native species. They leaf out very early in the growing season and keep their leaves late into the fall, helping to shade out native trees and shrubs.

Management: Prescribed burning has been used to control buckthorns in some natural areas. Fire will top kill stems, however, resprouting will occur and seed germination may increase. Hand pulling may be successful in small infestations, although several seasons may be required as resprouting will occur if part of the root is left behind. This method also disturbs the soil, increasing seed germination. Repeated mowing is also effective in maintaining open areas and preventing seedling establishment. Application of Glyphosate or Triclopyr to cut stumps during the growing season and in warm days of winter has proven to be effective. A foliar application of Triclopyr in dense thickets may be effective in the spring and fall. Biological controls are not available, however, studies of possible fungal and insect pests are ongoing.

A portion of this information was taken from a paper by Jil M. Swearingen, U.S. National Park Service, Washington, DC.

DUTCHMAN'S PIPE *Aristolochia elegans)*

Dutchman's pipe vine is a vigorous exotic vine that originates from Brazil in South America. This vine typically grows in protected situations with high humidity in full to medium light. It is a "garden escapee" and over time has spread rapidly along creeks or in moist gullies. It climbs over and smothers forest species, degrading the structure and reducing diversity, and can often reach heights of 6.1 – 9.15 m (20 – 30 ft).



Dutchman's Pipe

Butterflies are often attracted to the foliage as a food plant for their larvae. The result is that the emerging larvae are quickly poisoned by the toxins in the leaves of the vine, restricting successful expansion of populations.

Dutchman's pipe is recognized by its broad, heart-shaped leaf. The leaves are arranged alternately along the climbing stem and can be up to 12 cm (5 in) long. Flowers appear in summer, are an attractive reddish-purple with white and yellow spots, and are shaped like a pipe. Flowers are approximately 7 cm (3 in) long.

Management: Manual removal is possible. Seedlings and young plants can be hand-pulled, and small infestations of larger plants can be dug out. Dutchman's pipe vine roots at each stem node, so digging out a large vine could cause a lot of disturbance to adjacent native plants. Seed capsules of this vine can be collected, bagged and removed from the site if the vines cannot be dealt with timely.

Herbicides can also be used to combat this species. Canopy vines can first be cut at chest height and vine stems left in the canopy to die. For smaller diameter vines, make a second cut closer to the ground just above the first rooting node and immediately apply a systemic herbicide such as Glyphosate or Triclopyr to the basal stem cut. On larger vines, it is more effective to cut and scrape along the basal section of the stem and then apply the herbicide to the scraped stem section. This cut-stem application increases the surface area of exposed plant vascular tissue available for absorption.

Foliar spraying is ineffective against large vines because leaves are covered by a waxy cuticle which prevents herbicide penetration.

GARLIC MUSTARD *Alliaria petiolata* [Bieb] Cavara & Grande



Garlic Mustard Rosette

Garlic mustard (an invasive plant from Europe) is a cool season biennial herb with stalked, triangular to heart-shaped, coarsely toothed leaves that give off an odor of garlic when crushed. First-year plants appear as a rosette of green leaves close to the ground. Rosettes remain green through the winter and develop into mature flowering plants the following spring. Flowering plants of garlic mustard reach from .61 - .91 m (2 – 3 ½ ft) in height and produce buttonlike clusters of small white flowers, each with four petals in the shape of a cross.

Recognition of garlic mustard is critical. Several white-flowered native plants, including toothworts (*Dentaria*), sweet cicely (*Osmorhiza claytonii*), and early saxifrage (*Saxifraga virginica*), occur alongside garlic mustard and may be mistaken for it.

Beginning in May in the mid-Atlantic Coast Plain region, seeds are produced in erect, slender pods and become shiny black when mature. By late June, when most garlic mustard plants have died, they can be recognized only by the erect stalks of dry, pale brown seedpods that remain, and may hold viable seed, through the summer.

Garlic mustard poses a severe threat to native plants and animals in forest communities. Many native widlflowers that complete their life cycles in the springtime (e.g., spring beauty, wild ginger, bloodroot, Dutchman's breeches, hepatica, toothworts, and trilliums) occur in the same habitat as garlic mustard. Once introduced to an area, garlic mustard outcompetes native plants by aggressively monopolizing light, moisture, nutrients, soil and space. Wildlife species that depend on these early plants for their foliage, pollen, nectar, fruits, seeds and roots, are deprived of these essential food sources when garlic mustard replaces them.

Garlic mustard also poses a threat to one of our rare native insects, the West Virginia white butterfly (*Pieris virginiensis*). Several species of spring wildflowers known as "toothworts" (*Dentaria*), also in the mustard family, are the primary food source for the caterpillar stage of this butterfly. Garlic mustard is causing local extirpations of the toothworts, and chemicals in garlic mustard appear to be toxic to the eggs of the butterfly, as evidenced by their failure to hatch when laid on garlic mustard plants.

Garlic Mustard in Bloom



Garlic mustard is found from eastern Canada, south to Virginia and as far west as Kansas and Nebraska. Garlic mustard frequently occurs in moist, shaded soil of river floodplains, forests, roadsides, edges of woods, trails edges and forest openings. Disturbed areas are most susceptible to rapid invasion and dominance. Though invasive under a wide range of light and soil conditions, garlic mustard is associated with calcareous soils and does not tolerate high acidity.

After spending the first half of its two-year life cycle as a rosette of leaves, garlic mustard plants develop rapidly the following spring into mature plants that flower, produce seed and die by late June. Seeds are produced in erect, slender, four-sided pods, called siliques, beginning in May. Siliques become tan and papery as they mature and contain shiny black seeds in a row. By late June, most of the leaves have faded away and garlic mustard plants can be recognized only by the dead and dying stalks of dry, pale brown seedpods that may remain and hold viable seed throughout the summer.



Garlic Mustard Seed Pods

A single plant can produce thousands of seeds, which scatter as much as several meters from the parent plant. Garlic mustard flowers either self-fertilize or are cross-pollinated by a variety of insects. Self-fertilized seed is genetically identical to the parent plant, enhancing its ability to colonize an area. Although water may transport seeds of garlic mustard, they do not float well and are probably not carried far by wind. Long distance dispersal is most likely aided by human activities and wildlife. Additionally, because white-tailed deer prefer native plants to garlic mustard, large deer populations may help to expand it by removing competing native plants and exposing the soil and seedbed through trampling.

Management: Because the seeds of garlic can remain viable in the soil for five years or more, effective management requires a long term commitment. The goal is to prevent seed production until the stored seed is exhausted. Hand removal of plants is possible for light infestations and when desirable native species co-occur. Care must be taken to remove the plant with its entire root system because new plants can sprout from root fragments. This is best achieved when the soil is moist, by grasping low and firmly on the plant and tugging gently until the main root loosens from the soil and the entire plant pulls out. Pulled plants should be removed from site, especially if flowers are present.

For larger infestations of garlic mustard, or when hand-pulling is not practical, flowering stems can be cut at ground level or within several inches of the ground, to prevent seed production. If stems are cut too high, the plant may produce additional flowers at leaf axils. Once seedpods are present, but before the seeds have matured or scattered, the stalks can be clipped, bagged and removed from the site to help prevent continued buildup of seed stores. This can be done through much of the summer.

For very heavy infestations, where the risk to desirable plant species is minimal, application of the non-selective, systemic herbicide Glyphosate (e.g., Roundup) is also effective. Herbicide may be applied at any time of year, including winter (to kill overwintering rosettes), as long as

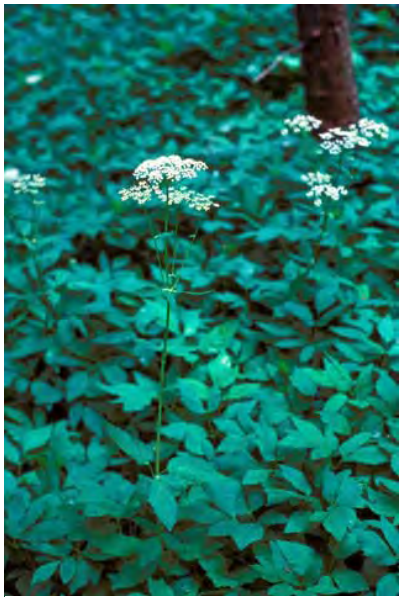
the temperature is above 10ºC (50ºF) and rain is not expected for about eight hours. Spray shields may be used to better direct herbicide and limit non-intentional drift.

Regardless of the management method employed, annual monitoring is necessary for a period of at least five years to ensure that seed stores of garlic mustard have been exhausted.

Researchers are investigating potential biological control agents for garlic mustard which may greatly improve management.

Portions of this document were taken from a paper done by Jil M. Swearingen, U.S. National Park Service, Washington, DC.

GOUTWEED *Aegopodium podagraria* L.



Goutweed

Goutweed was first brought to North America as an ornamental during the early stages of European settlement and was well established in the U.S. by 1863. It is currently known to occur in 29 states in the mid-Atlantic, northeast and northwest, and is reported to be invasive in most of those areas.

Also known as bishop's weed and snow-on-the-mountain, goutweed is an herbaceous perennial plant. Most leaves are basal with the leafstalk attached to an underground rhizome. The leaves can be either medium green or bluish-green with white edges.

Goutweed is an ecologically versatile species. It is found in old gardens and flower beds, around shrubs and other plantings, and in a variety of other disturbed habitats. Goutweed appears to do best in moist soil and in light to moderate shade, but is highly shade-tolerant and capable of invading closed-canopy forests.

Goutweed is an aggressive invasive plant that forms dense patches, displaces native species and greatly reduces species diversity in the ground layer. Goutweed patches inhibit the establishment of conifers and other native tree species as well. It is also sometimes used as a low-maintenance ground cover.

Management: A variety of management methods are available, depending on the extent of the infestation and the amount of time and labor available. Regardless of the method used, the plants should be monitored periodically for a few years. New shoots should be dug up and destroyed. Once control has been achieved, revegetation with native, non-invasive plant materials is recommended. There are no biological control organisms currently available in North America.

Systemic herbicides such as Glyphosate and Triclopyr that are translocated to the roots to kill the entire plant are effective for goutweed control. Cut stump treatment of these herbicides is the recommended method to avoid nontarget adjacent plants.

Small patches of goutweed can be eliminated by persistent hand pulling or digging up of entire plants along with underground stems. Pulled plants can be piled up and allowed to dry for a few days before bagging and disposal. Be careful to pick up all rhizomes which can resprout if left behind. Where appropriate, frequent short mowing may manage or slow the spread of goutweed in landscaped areas, along roadsides and other areas. Preventing goutweed from photosynthesizing in early spring can control the plant by depleting its carbohydrate reserves. Cover the patch with black plastic sheeting when the leaves start to emerge from the ground in the spring, and leave it in place through the summer; or cut all the plants once they have fully leaved out and then cover the area with plastic.

JAPANESE BARBERRY *Berberis thunbergii*



Japanese barberry is a dense, deciduous, spiny shrub that grows .61 – 2.44 m (2 – 8 ft) high. The branches are brown, deeply grooved, somewhat zigzag in form and bear a single very sharp spine at each node. The leaves are small (1.27 – 3.81 cm [½ – 1 ½ in] long), oval to spatula-shaped, green, bluish-green, or dark reddish purple. Flowering occurs from mid-April to May in the northeastern U.S. Pale yellow flowers about 0.6 cm (¼ in) across hang in umbrella-shaped clusters of 2 – 4 flowers each along the length of the stem. The fruits are bright red berries about 1 cm (1/3 in) long that are borne on narrow stalks. They mature during late summer and fall and persist through the winter.

Japanese barberry may be confused with American barberry (*Berberis canadensis*), a native species of barberry in North America, and common or European barberry (*Berberis vulgaris*) which is an introduced, sometimes invasive plant.

Japanese Barberry Fruit



Japanese Barberry

Japanese barberry forms dense stands in natural habitats including canopy forests, open woodlands, wetlands, pastures, and meadows and alters soil pH, nitrogen levels, and biological activity in the soil. Once established, barberry displaces native plants and reduces wildlife habitat and forage. White-tailed deer avoid browsing barberry, preferring to feed on native plants, giving barberry a competitive advantage. Japanese barberry has been found to raise soil pH (i.e., make it more basic) and reduce the depth of the litter layer in forests.

Japanese barberry has been reported to be invasive in twenty states and the District of Columbia. Due to its ornamental interest, barberry is still widely propagated and sold by nurseries for landscaping purposes in many parts of the U.S.

Barberry is shade tolerant, drought resistant, and adaptable to a variety of open and wooded habitats, wetlands and disturbed areas. It prefers to grow in full sun to part shade but will flower and fruit even in heavy shade.

Japanese barberry was introduced to the U.S. and New England as an ornamental plant in 1875 in the form of seeds sent from Russia to the Arnold Arboretum in Boston, Massachusetts. In 1896, barberry shrubs grown from these seeds were planted at the New York Botanic Garden. Japanese barberry was later promoted as a substitute for common barberry (*Berberis vulgaris*) which was

planted by settlers for hedgerows, dye and jam, and later found to be a host for the black stem grain rust. Because Japanese barberry has been cultivated for ornamental purposes for many years, a number of cultivars exist.

Japanese barberry spreads by seed and by vegetative expansion. Barberry produces large numbers of seeds which have a high germination rate, estimated as high as 90%. Barberry seed is transported to new locations with the help of birds (e.g., turkey and ruffed grouse) and small mammals which eat it. Birds frequently disperse seed while perched on power lines or on trees at forest edges. Vegetative spread is through branches touching the ground that can root to form new plants and root fragments remaining in the soil that can sprout to form new plants.

Management: Do not plant Japanese barberry. Because it is a prolific seed-producer with a high germination rate, prevention of seed production should be a management priority. Because barberry can resprout from root fragments remaining in soil, thorough removal of root portions is important. Manual control works well but may need to be combined with chemical in large or persistent infestations. No biological control organisms are available for this plant.

Treatments using the systemic herbicides Glyphosate (e.g., Roundup) and Triclopyr (e.g., Garlon) have been effective in managing Japanese barberry infestations that are too large for hand pulling. This non-selective herbicide should be used with care to avoid impacting non-target native plants. However, application in late summer during fruiting may be most effective. Triclopyr or Glyphosate may be used on cut stumps or as a basal bark application.

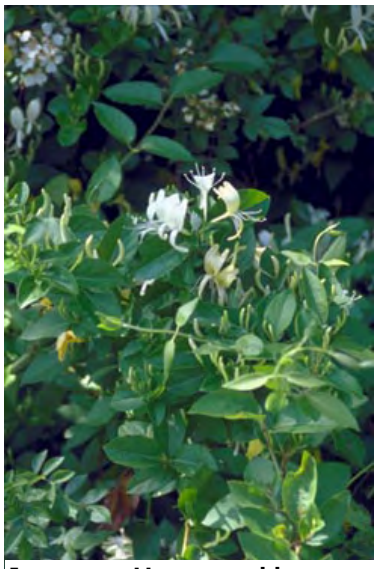
Because Japanese barberry leafs out early, it is easy to identify and begin removal efforts in early spring. Small plants can be pulled by hand, using thick gloves to avoid injury from the spines. The root system is shallow making it easy to pull plants from the ground, and it is important to get the entire root system. The key is to pull when the soil is damp and loose. Young plants can be dug up individually using a hoe or shovel. Hand pulling and using a shovel to remove plants up to about .91 m (3 ft) high is effective if the root system is loosened up around the primary tap root first before digging out the whole plant.

Mechanical removal using a hoe or weed wrench can be very effective and may pose the least threat to non-target species and the general environment at the site. Tools like the weed wrench are helpful for uprooting larger or older shrubs. Shrubs can also be mowed or cut repeatedly. If time does not allow for complete removal of barberry plants at a site, mowing or cutting in late summer prior to seed production is advisable.

To prevent reinfestation by exotic invasive plants, there are many attractive native shrubs available that make great substitutes for Japanese barberry. A few examples include bayberry (*Myrica pensylvanica*), ink-berry (*Ilex glabra*), winterberry (*Ilex verticillata*), arrow-wood (*Viburnum dentatum*), mountain laurel (*Kalmia latifolia*), ninebark (*Physocarpus opulifolius*) and hearts-a-bustin' (*Euonymus Americana).*

Some information in this section was taken from a paper by Jil M. Swearingen, U.S. National Park Service, Center for Urban Ecology, Washington, DC.

JAPANESE HONEYSUCKLE *Lonicera japonica* Thunb.



Japanese Honeysuckle

Japanese honeysuckle was introduced to the United States from Japan and Korea in the 1800s as an ornamental plant, for erosion control, and for wildlife forage and cover. It is a perennial vine that climbs by twisting its stems around vertical structures, and often remains evergreen except in the colder winter temperatures. Leaves are oblong to oval and flowers are white, yellow and very fragrant.

Japanese honeysuckle occurs across the U.S. from California to New England and the Great Lakes region. It is a ubiquitous invader and thrives in a wide variety of habitats, including all types of disturbed lands. It has few natural enemies which allows it to spread widely and out-compete native plant species. Shrubs and young trees can be killed when the vines twist tightly around the stems and trunks.

Management: Repeated pulling of entire vines and root systems when soil is moist can be effective. Monitor frequently and remove new plants. Cut and remove twining vines to prevent them from killing other plants. Mowing large patches twice a year may be useful if repeated regularly. Burning plants does not kill the underground rhizomes which will continue to sprout. In some cases, tethered goats have been used to remove growth. The goats must be monitored to keep them in the desired area. Spot treatment with Glyphosate or Triclopyr in late fall when native plants are dormant is effective. There are no biological control agents currently available for Japanese honeysuckle.

JAPANESE KNOTWEED *Fallphia japonica*



Japanese Knotweed

Japanese knotweed was introduced to North America in the late 19th century from Japan where it rapidly spread to become a problem weed. It is now regarded as a serious pest which is difficult to manage. Japanese knotweed has spread through most of North America and has been observed as far north as Alaska. It spreads quickly to form dense thickets that exclude native species. The rhizomes can reach 15 – 20 m (50 – 75 ft) in length.

Japanese knotweed grows in a variety of soil types and is found primarily in moist, unshaded areas. Its growth and abundance are decreased in shady sites. After overwintering, shoots appear from underground rhizomes early in the spring. Rapid growth, which can exceed 8 cm (3 1/2 in) per day, means that full height can exceed 4 m (15 ft) by early summer.

Management: To be effective, Japanese knotweed control will need to be undertaken on a watershed-wide basis as is being done with *Arundo donax* L., an ecologically similar species. Use of Glyphosate or Triclopyr are effective, however, herbicide costs may be prohibitive. Studies are under way at present to find natural enemies for Japanese knotweed, however, surveys have not yet been completed and not much information is yet available. Some species of Lepidoptera and fungal pathogens are being tested and look promising.

MORROW'S HONEYSUCKLE *Lonicera morrowii*



Morrow's Honeysuckle

Morrow's honeysuckle was introduced to the United States from Eurasia for use as an ornamental, wildlife cover and for soil erosion control. It ranges from the central Great Plains to southern New England south to North Carolina. Open-grown exotic bush honeysuckles fruit prolifically and are highly attractive to birds. In the eastern U.S., over 20 species of birds feed on the persistent fruits and widely disseminate seeds across the landscape. In established populations, vegetative sprouting also aids in the persistence of these exotic shrubs.

Exotic bush honeysuckles are upright, generally deciduous shrubs that range from 1.83 – 4.57 m (6 – 15 ft) in height. Pairs of fragrant, tubular flowers are borne along the stem with color varying from creamy white to pink. These exotic honeysuckles can rapidly invade and overtake a site, forming a dense shrub layer that crowds and shades out native plant species. They alter habitats by decreasing light availability, deplete soil moisture and nutrients, and release toxic chemicals that prevent other plant species from growing in the vicinity.

Management: Mechanical and chemical methods are the primary means of control. No biological control agents are currently available for this plant. Hand removal of seedlings or small plants may be useful for light infestations, but care should be taken not to disturb the soil any more than necessary. In shaded forest habitats, repeated clippings to ground level during the growing season may result in high mortality. Clipping must be repeated at least once yearly because bush honeysuckles that are cut once and left to grow will often form stands that are more dense and productive than they were prior to cutting.

Well established stands of exotic bush honeysuckles are sometimes best managed by cutting the stems to ground level and painting or spot-spraying the stumps with Glyphosate or Triclopyr. Prescribed burning has shown promise for honeysuckle growing in open habitats. In all instances, control should be initiated prior to seed dispersal (late summer to early fall) to minimize reinvasion of treated habitats.

NORWAY MAPLE *Acer platanoides*



Norway Maple Leaves

The Norway maple is a common tree throughout much of Europe, including Norway. An important commercial species in European timber markets, the Norway maple has similar uses in Europe as our sugar maple does here. Furniture and flooring are often made from the sawlogs, and the density of the wood makes it an excellent material for musical instrument soundboards.

Norway maples never grew in North America until they became recognized for two important landscaping attributes. The first is plasticity, for Norway maples have lent themselves to foliage color manipulations. The most popular variety has been the "Crimson King," a Norway maple with very dark red (nearly black) foliage. The second desirable quality has been the species' ability to withstand poor growing conditions, including infertile and compacted soils and atmospheric pollution. These two qualities quickly promoted the Norway maple to become overplanted in New England and can be found in virtually every town in this region.



Norway Maple Seedlings

But plasticity and aggressiveness are not without ecological shortcomings, particularly when a plant is non-native. Norway maples have "escaped" cultivation as they successfully germinate from seed. Norway maples are better competitors for light and nutrients than many of our native species, particularly in disturbed areas. The fact that Norway maples outcompete native species puts increasing pressure on native species. The solution is to become more informed about the invasiveness of the species that are planted.

Management: Hand-pulling of saplings (use weed wrenches) or mowing seedlings may be the most efficient means for management of Norway maple. Mature trees will continue to produce seeds, so must be removed. Cutting and removing the mature trees may involve the services of an arborist or commercial forester. Treating the cut stumps with Garlon 4 (Triclopyr) or Roundup (Glyphosate) is necessary to prevent resprouting. Large trees that cannot be removed can be girdled with an axe (cut into the cambium) encircling the base of the tree 15 cm (6 in)

above ground level. Glyphosate or Triclopyr can be squirted into the cut to kill the tree and reduce resprouting. When trees, saplings or seedlings are removed, replant the area with desired native trees or desirable undergrowth vegetation.

ORIENTAL BITTERSWEET *Celastrus orbiculatus* Thunb.



Oriental Bittersweet

Oriental bittersweet, an invasive exotic plant, is a deciduous, woody, perennial vine which sometimes occurs as a trailing shrub. Also known as round-leaved and Asiatic bittersweet, stems of older plants sometimes grow to four inches in diameter. Leaves of oriental bittersweet are glossy, rounded, finely toothed and arranged alternately along the stem. Clusters of small greenish flowers emerge from leaf axils, allowing each plant to produce large numbers of seeds. At maturity, globular, green to yellow fruits split open to reveal three red-orange, fleshy arils that contain the seeds. These showy fruits have made oriental bittersweet very popular for use in floral arrangements. Since this plant is easily confused with our native climbing bittersweet vine (*Celastrus scandens*), which flowers at the tips rather than along the stems, it is imperative that correct identification be made before management is attempted.

Oriental bittersweet is an aggressive invader that threatens all vegetation levels of forested and open areas. It grows over other vegetation, completely covering it, and kills other plants by preventing photosynthesis, girdling, and uprooting by force of its massive weight. Oriental bittersweet appears to be displacing the native climbing bittersweet (*Celastrus scandens)*, which occurs in similar habitats, through competition and hybridization. Oriental bittersweet occurs from New York to North Carolina, and westward to Illinois.

Oriental bittersweet infests forest edges, woodlands, early successional fields, hedgerows, coastal areas and salt marsh edges, particularly those suffering some form of land disturbance. While often found in more open, sunny sites, its tolerance for shade allows oriental bittersweet to invade forested areas. Oriental bittersweet reproduces prolifically by seed, which is readily dispersed to new areas by many species of birds. Its seeds germinate in late spring in partial to dense shade. It also expands vegetatively by stolons (above-ground stems), and rhizomes (underground stems), and through root suckering.

Management: Where hand labor is practical, vines can be pulled out by the roots and removed from the site, preferably before fruiting. If fruits are present, vines should be bagged and allowed to bake in the sun long enough to kill the seeds. Systemic herbicides, such as glyphosate (e.g., Roundup) or triclopyr (e.g., Garlon), that are taken into the roots and kill the entire plant, have been used successfully in bittersweet management. This method is most effective if the stems are first cut by hand or mowed and herbicide is applied immediately to cut stem tissue. In areas where spring wildflowers or other native plants occur, application of herbicides should be conducted prior to their emergence, delayed until after the last killing frost occurs, or carefully targeted. Herbicidal contact with desirable plants should always be avoided. No biological controls are currently known for oriental bittersweet.

A portion of this information was taken from a paper by Jil M. Swearingen, U.S. National Park Service, Washington, DC.

PERIWINKLE *Catharanthus roseus*



Periwinkle

Periwinkle is a perennial, evergreen herb in the dogbane family that was originally native to the island of Madagascar. It has been widely cultivated for hundreds of years and can now be found growing wild in most regions of the world. The plants grow .31 – .61 m (1 – 2 ft) high, have glossy dark green leaves and flowers all summer long. The blooms of the natural wild plants are a pale pink with a purple center; however, these plants have been cultivated with colors ranging from white to hot pink to purple.

Periwinkle has historically been used to treat a wide assortment of diseases. It was used as a folk remedy for many ailments, and had a reputation as a magic plant to ward off evil spirits. Because the alkaloids in this plant can have serious side effects, it is never recommended that anyone attempt to medicate themselves.

Management: As this plant contains many alkaloids, some of which are toxic, it is a good idea to wear gloves when removing this invasive plant. It can be hand-pulled, being careful to be sure to remove all of the roots. It can also be treated with a translocatable herbicide such as Triclopyr or Glyphosate. Be cautious to not allow drift or droplets to contact desired vegetation.

WILD CHERVIL *Anthriscus sylvestris* (L.) Hoffm.



Wild Chervil

Wile chervil is native to Europe where it is very common along roadsides and pastures. It was probably introduced in North America in wildflower seed mixes that were designed to imitate the plants commonly found in British meadows and hedgerows. It will grow in a variety of soil types, but prefers rich, moist soils.

Wild chervil is a weed belonging to the parsley family and is becoming a serious problem in hay fields and pastures in central Vermont. Its .91 – 1.22 m (3 – 4 ft) heights, fern-like leaves and white flowers are quite pronounced during late May to early July. They are commonly found along roadsides and in meadows. Over the past five years, this plant has spread rapidly. It propagates by both seed and by root budding, and is a heavy seed producer and spreads rapidly. It aggressively competes for light, water and nutrients and often kills off surrounding vegetation by shading it.

Wild chervil is not poisonous to livestock and although it is not palatable when large, animals will graze it effectively when small.

The plants produce hollow flower stems up to 1.83 m (6 ft) tall. The stems are branched and covered with soft hair. Flowers are produced at the top of the stems in a flat-topped mass starting around late May to early June.

Management: Wild chervil is difficult to manage because of its deep taproot and its resistance to herbicides. Pulling of flower stalks without removal of the entire rosette and taproot encourages the crown to resprout in the following year. The taproot is frequently up to 1.83 m (6 ft) deep, making hand-pulling almost impossible.

Mowing before seed set will eliminate seed propagation, but will have no impact on vegetative spread from root buds. Mowing can deplete root reserves if done repeatedly before the plant sets seed. Digging up the plant, including the roots, before flowering is an effective management means for seedling plants; but is very labor intensive. The cut-stump treatment using the translocatable herbicides Triclopyr or Glyphosate may be effective.

WINGED EUONYMUS *Euonymus alatus* (Thunb.)



Winged Burning Bush

Winged burning bush is a deciduous shrub from northeastern Asia to central China that will grow 4.57 – 6.1 m (15 – 20 ft) tall and equally as wide. The leaves turn bright red in the fall before dropping. Small green flowers bloom in May to early June.

This plant is also known as winged euonymous and was introduced into this country as an ornamental shrub. It is very adaptable to a variety of soils, performing best in well-drained soils. It grows well in full shade and full sun both. Burning bush is one of the most popular shrubs on the market; however, it may spread by seed from wherever it is used as an ornamental shrub.

The threat to natural areas from burning bush is that it shades out native herbs and crowds out native shrubs. Unfortunately, birds are fond of the red fruit and, therefore, distribute the seeds across the country where plants readily sprout and establish themselves. The shrub may become one of the most troublesome because of the ease with which its seeds are spread, the readiness of germination, its adaptability to various soils, its tolerance of full shade, and its spectacular fall foliage.



Winged Burning Bush Fall Foliage

Management: Control is considered difficult once a plant has become established. It may not be much of a problem in cities, towns or developed areas. However, any woodlands where birds can roost may quickly become infested. Abstaining from using the plant will become the most important step toward control. Primary control at this point is pulling and digging out of plants. Herbicide applications and foliar spot-spraying in early summer may be necessary if large populations have become established.

APPENDIX II

WORK PLAN /

BUDGET

ANNUAL WORK PLAN

The General Management Plan for the Park directs that conservation and stewardship related to the forest, fields, landscape and historic structures be the guide for Park management. The following section provides guidance on monitoring and maintenance activities to address IPM concerns for the collections, structures and Mansion grounds.

Forest monitoring has been initiated for the Park by Redstart Forestry, Inc., a consulting forestry firm with much more intimate knowledge of the Park's forest, weather and other factors than IPMI. Therefore, IPMI must defer to Redstart Forestry to develop an annual work plan for monitoring and managing the health and maintenance of the forest. The silviculture inventory system proposal (2004) is an excellent study on strategies to assess the current health of the forest stands, and can provide a good basis for the development of an annual work plan for monitoring forest insects and diseases and developing strategies for managing the health of the forest.

<u>January</u>

- Monitor 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.

<u>February</u>

- Monitor 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.

<u>March</u>

- Monitor 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 around buildings and monitor for impacts to buildings.

<u>April</u>

- 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 around buildings.
- Remove deer fencing from Mansion grounds.

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 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 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 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 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 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 pest entry into structures.
- Conduct maintenance and cleaning daily.
- Maintain vegetation around buildings

November

- Monitor for insect pests in Curatorial Storage areas. Treat cracks and crevices with diatomaceous earth if necessary.
- Conduct maintenance and cleaning daily.
- Maintain vegetation around buildings.
- Erect deer fencing around Mansion grounds.

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.
- 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 Marsh-Billings-Rockefeller National Historical Park 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 added financial support necessary for full implementation of this plan has some inaccuracies. A conservative estimate based on the additional response to pest management within the site (Table 1) is 4120 work hours among all units. Although this amounts to 1.98 FTE, it is distributed among several units and may not entail additional personnel.

Table 1. Estimated annual work hours and FTE equivalents of Marsh-Billings-Rockefeller National Historical Park staff for performing Integrated Pest Management related tasks:

Resource management		
Museum collection management		
Monitoring; daily, monthly, seasonal tasks	260 hrs	
Artifact cleaning, inspection and storage	1260 hrs	
Historic site pest management		
PUP plan oversight	40 hrs	
Seasonal and ad hoc inspections	260 hrs	
Landscape and deer exclusion		120 hrs
Public health and other pest management		
Insect management activities	80 hrs	
Rodent trap monitoring and exclusion	80 hrs	
Interpretive, goods handling		
Seasonal cleaning	80 hrs	
Daily/weekly cleaning and inspections	100 hrs	
Historic forest, landscape and garden IPM		
Monitoring for pests	520 hrs	
Facilities management		
Routine activities		
Refuse handling	200 hrs	
Cleaning services in buildings	360 hrs	
Seasonal activities		
Buildings maintenance	360 hrs	
Landscape management	200 hrs	
Forest management	200 hrs	
Total	4120 hrs	

1.02 FTE	Resource management	
		IPM program oversight and monitoring
		Museum collection IPM management
0.33 FTE	Interpretation	
		Museum collection and interpretive goods
		Historic landscape and garden pest management
0.63 FTE	Facilities maintenance	
		Routine cleaning and refuse management
		Buildings and grounds maintenance

FUNDING

Current routine Integrated Pest Management activities are supported under base funding for the park. Unusual or periodic treatments, such as wood preservative treatment or painting 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, forest 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.

The above figures do not include other miscellaneous tasks (other duties as assigned).

APPENDIX III

SAFETY

SAFETY

PESTICIDE SAFETY

Pesticides are insecticides, herbicides, fungicides, rodenticides and other chemicals used to control, prevent, destroy, repel or regulate pests. Pesticides have an EPA registration number on the label. This includes personal repellant products. As poisons, they can affect living organisms and usually may have adverse effects on other nontarget plants or animals, including humans. Because of their biological activity, pesticides can injure (or kill) adults, children, pets, livestock, wild animals, insects, birds, fish and plants. Pesticides must be carefully stored, handled and used to avoid exposure to nontargets.

Certification

Any person (park staff or contractor) who is involved in handling or applying pesticides should be trained in proper procedures. Protective equipment must be worn by the person handling, loading, mixing or applying any pesticide. Pesticides will only be applied by personnel who are properly trained and are supervised by a certified applicator or who are certified themselves. In Vermont, certified applicators must receive training, pass a test and attend periodic updating continuing education workshops or training to keep their certification current. The IPM coordinator should be a state certified pesticide applicator.

Pesticide Information

Pesticide labels contain information on precautions for the safety of the pesticide applicator and cautions to be taken to protect or reduce exposure to other workers and/or visitors. The label is the law. Violating the label directions is a violation of FIFRA. Chemical (pesticide) labels on containers must not be removed or defaced. OSHA Hazard Communication Standard requires workers be trained and provided appropriate protective equipment and information (MSDS) on any hazardous material they might handle. Treated areas will be posted to provide the public (staff and visitors) with information on the pesticide used, the area treated, and the safe re-entry time (5 half lives). Keep an inventory of all pesticides used or stored in the park; copies of labels and MSDS should be stored with the products and also with the IPM coordinator and the park safety officer.

Pesticide Storage

The pesticide storage facility should contain copies of labels, MSDS and inventory information. The pesticide storage structure must be properly posted with warning signs and securely locked. The structure must be fireproof and ventilated to the outside. Other materials such as cleaning fluids, paint, solvent, fuel oil, gasoline, kerosene or other chemicals should not be placed or stored in the pesticide storage structure because of the increased risk of fire or explosion. Different types of pesticides will be stored on separate shelves or compartments. The local Fire Department will be made aware of the storage location(s) and the types of pesticides stored so that a fire emergency plan is prepared.

Pesticide Disposal

The pesticide label has directions for procedures to follow to dispose of pesticide containers, pesticide and equipment rinsates. U.S. EPA and state regulations also address the disposal of hazardous substances. Limit the amount of material that needs to be disposed by:

- Purchasing only the amount needed for each treatment
- NPS policy limits the quantity of pesticide that can be purchased
- Mixing only the amount needed for the treatment
- Apply remaining mixed pesticide to the treated area according to label instructions
- Upon completion, triple rinse the spray equipment and apply the rinsate to the treated area (follow the label directions)
- Use single dose syringe applicator to apply gel baits
- Use containerized aerosol pesticides which can be reused until empty
- Use dust or granular pesticides that can be returned to the original container, if necessary, for storage

Excess unopened product can be considered to be "surplus property" and transferred to another agency in accordance with federal and state laws and regulations. Retain records of all donations of surplus pesticides.

Training

The IPM Coordinator should have attended the NPS IPM course, or be scheduled to take the course as soon as possible. Other key staff that have responsibilities related to pest management may also attend (forester, maintenance, natural resources, and supervisors). Pesticide applicators must take state certification classes and attend periodic updates. College or university courses on pesticide toxicology, wildlife management, botany, entomology and other life sciences can be useful.

The curator will complete the basic NPS curatorial training course and, if possible, the NPS 40-hour IPM training course. The curator may also maintain state pesticide applicator certification. Staff performing inspections or monitoring should receive at least eight hours of documented IPM training that includes methods of inspecting structures. Staff involved in rodent management should receive at least 16 hours of instruction including inspection and monitoring techniques, disease prevention, rodent management methods, sanitation, safety; tuning, setting and recovery of snap traps; rodenticide use processes and risks. Staff required to manage stinging insects (hornets, honey bees, yellowjackets) will receive at least four hours of training including protective equipment, insect and colony removal procedures, bystander management and emergency first aid. The IPM Coordinator will maintain copies of all staff IPM training documents.

Notification

Areas on the park (structures, grounds, forests, etc.) that are scheduled to be treated with any pesticide should be posted at least 24 hours prior to the treatment with warning information (target pest, pesticide to be used, signal word, date of treatment, area of treatment, re-entry date,

information phone number). The posted notice should be of a material that will not deteriorate in weather, and should be removed on the re-entry date. The local fire, police and EMS units should also be made aware of the treatment information. Members of the staff and local neighbors who are known to suffer from environmental illness (EI) or multiple chemical sensitivity (MCS) must also be notified at least 48 hours before the treatment so they can leave the area or protect themselves. Please refer to the Pesticide Treated Area Posting Form at the end of this section.

Spills

Pesticide spills need more detailed attention than spills of other materials. The spilled pesticide may also present a long-term hazard at the spill site and to responding or present personnel. If a pesticide spill has occurred, immediate procedures must be taken. The first action is to protect yourself: put on protective clothing, gloves, boots, tyvek coveralls, goggles and respirator. The second action is to isolate the area: do not allow unauthorized and unprotected personnel into the area. Identify the material and determine the hazard. If an unprotected person is involved or has succumbed, perform the rescue and administer first aid, then decontaminate the victim. Contain the spill. For liquids or dusts, dike off the area, stop any leaks, and use absorbent material to soak up the spill. A small spill (one pint or less, or one-half pound or less) may be contained with absorbent cloths, sand, bagged clay, or diatomaceous earth. A larger spill may necessitate soil dikes, sand snakes, commercial bagged clay or other containment efforts. For large spills, the Fire Department or other emergency responders may be called. For large spills of highly toxic pesticides, CHEMTREC can be called for containment and cleanup information. CHEMTREC may call the Pesticide Safety Team Network (PSTN) if a large quantity of pesticide is involved. Removing and decontaminating the material may require special procedures. Exposed staff or other personnel may need to be taken to hospitals for examination and treatment. Additional tests may be necessary over time, depending upon the pesticide exposure. The lesson is to not have toxic pesticides on site, and, if at all possible, avoid spills. Develop procedures for handling pesticides to avoid spills.

Spill kits can be developed and placed at storage, mixing and application sites. The kit should have diking or absorbent material sufficient to contain the amount of pesticide that may be involved (storage areas may need more than mixing areas), protective clothing and equipment, and emergency phone numbers. Absorbent material can be bagged clay, activated charcoal, diatomaceous earth or other highly absorbent material. There are also absorbent pads now available for absorbing pesticides.

HUMAN HEALTH

Disease Concerns

Most arthropod, bird and mammal pests come into direct contact with soil, dead and rotting organic material, and other sources of disease organisms which may provide opportunity for transmission to humans. This potential adverse effect of disease transmission to humans (park staff and visitors) is an important reason for an aggressive pest management program.

The advent of Hantavirus illness and death from exposure to rodent urine, feces and saliva poses a real concern for the presence of rodents in structures. Anyone involved in rodent management

actions should be aware of the risks of exposure to the deadly Hantavirus, which may be present in rodent urine, feces and saliva. Minimal protection may be necessary when inspecting for rodent activity, monitoring or setting traps (dust mask, surgical gloves). Trapped rodents can be removed by placing a zip loc bag inside-out over your hand, grabbing the trap and captured (dead) rodent with the zip loc bag, then turning the bag right-side out over the trap and dead rodent, zipping the bag closed and placing it into another sealable bag for disposal. If a person is involved in cleaning rodent-infested, enclosed areas (inside a structure) or removing rodent urine, fecal droppings, nesting or other rodent debris, that person must wear approved protective equipment and follow Department of Health or CDC guidelines. Minimum protective equipment includes rubber gloves, goggles, coveralls, and a respirator with a HEPA filter. Other rodent-borne diseases associated with rodents are bubonic plague (flea transmitted), murine typhus, rat bite fever, hemorrhagic fever, and several others.

Other sources of human disease can be transmitted by ectoparasites on rodents, other mammals, birds and insects feeding on dead animals or other organic material. Allergies, asthma and other serious health effects can manifest from contact with exuviae, pheromones and cockroach and other insect body parts and droppings.

Wildlife Concerns

Mice often nest in, under and around structures, and are particularly fond of the cavities (and warmth) in stoves and other kitchen appliances and cupboards. Their gnawing (to keep their teeth worn down) on wiring and other electrical appliances has been the cause of many fires. Some migratory birds are implicated in harboring and transmitting Avian flu through contact with the fecal droppings.

Insect stings by ants, bees, wasps and yellowjackets can also be a concern for human safety, especially those who are sensitized to the stings. Managing these pests where there may be contact by visitors or staff is important. In some cases, notices to wear repellants may be necessary to attempt to ward off mosquitoes, black flies, ticks or other biting pests.

WARNING

PESTICIDE TREATED AREA

An application of a pesticide was deemed necessary to manage pests that are invading this area.

This notice is: a 24-hour a 48-hour a 72-hour an Emergency posting

Product Name: _____ Mfg. Name: _____

Active Ingredient: _____ USEPA Reg. No.: _____

Target Pest(s): _____

Date of Application: _____

Date Sign May Be Removed: _____ (No less than 72 hours from application)

Signal Word: Danger Warning Caution

If you have questions regarding this notification or require additional information, please contact the Site IPM Coordinator at 802-457-3368 x 31.

APPENDIX IV

SUPPLIES

SUPPLIES

Inspection Tools

- Flashlight
- Hand lens, 16x or better
- Probe for testing wood for rot
- Spatula for checking cracks and crevices
- Notebook and pen
- Digital camera
- Moisture meter
- UV light for detecting rodent urine stains



Inspection Tools

Exclusion Materials

- **¼ in. hardware cloth** (stainless steel or galvanized). Used for excluding rodents, birds and larger pests
- **Stuf-Fit** (copper mesh – won't rust). Used for closing small holes, cracks, crevices and around pipes penetrating walls and ceilings. Easy to stuff into openings to prevent access by insects, rodents and other small pests. Compresses easily.
- **Stainless steel wool or scrubbies** (won't rust). Used for filling larger holes to prevent pest access. May be difficult to compress.
- **Dap Brand Caulk**. Many different sealants and fillers to cover cracks, crevices, small holes or openings filled with Stuf-Fit or stainless steel wool, and varied surfaces.
- **Door sweeps**. Metal framed with rubber or neoprene blade to prevent insects and mice from entering a structure under the door. Wooden thresholds may be installed on the floor below the door to close the gap if it is historic. Brush-type door sweeps do not exclude mice, large beetles or cockroaches.

Monitoring Materials

- **Unscented talc**. Used for tracking patches to determine runways of rats, mice or insects inside structures (non-toxic).
- **Lo-Line Crawling Insect Sticky Traps.** Used for monitoring and capturing crawling insects inside structures. Best designed trap on the market at this time.
- **Insects Limited Flying Insect Pheromone Traps.** Many different traps for monitoring presence and capturing flying and other insects. Traps are usually specific to species or groups of species.

Snap Traps

- **Victor Brand** mouse and rat snap traps. The oldest and best snap trap available today. Use only those with the metal trigger (the plastic ones are slower). The metal trigger can be fine-tuned (hair-triggered) with a file and minor adjustments. Must be checked each morning.

- **Rat Zapper** by AgriZap, Inc. An electronic trap that electrocutes rats and mice that enter the tunnel for the bait. Must be checked each morning.

Low-Risk Pesticides (for use in structures, museum and garden areas)

- **Borid.** 99% Boric Acid powder which can be applied into cracks and crevices in structures to manage crawling insects.
- **Dekko Paks**. Borate based bait station designed for management of silverfish.
- **Drax Liquidator.** Boric Acid in sugar water bait for sweet-feeding ants. This slow-acting stomach poison is very effective for eliminating ant colonies. An excellent bait station for either inside or outdoor placement.
- **EcoEXEMPT IC.** An organic insecticide concentrate containing rosemary and other oils for use indoors and outdoors for crawling and flying insects.
- **Flea 'n Tick B Gone.** An enzyme treatment made from natural plant sources which has proven to effectively remove fleas, ticks, lice and other pests.
- **Hinder Deer & Rabbit Repellant.** Contains ammonium high fatty acid soaps to protect plants by forming a mild odor barrier. For use on vegetable, fruit and flower plants and shrubs.
- **Matran 2.** A FIFRA 25b exempt, non-selective, post-emergence herbicide which contains clove oil, water and lecithin. Can be used in and around all crop areas.
- **Nisus Corporation. BoraCare.** DOT insecticide with solvent to aid wood penetration for wood-destroying organisms (WDOs). Solution can be mixed with water and applied as a spray.
- **Nisus Corporation. Jecta.** DOT in a gel to be injected into posts or wood in contact with soil to prevent or treat for termites, mold, fungi and wood rot; can be used for a spot treatment.
- **Nisus Corporation. Niban FG Bait.** Boric Acid for the control of ants, cockroaches, crickets and silverfish. Can be used both inside and outside.
- **Nisus Corporation. Nibor-D.** A borate powder used as a dust, liquid or mop solution to kill and prevent infestations of carpenter ants, silverfish and mildew. For both interior and exterior use.
- **Nisus Corporation. TimBor Professional.** Disodium Octaborate Tetrahydrate [DOT] insecticide. For use on insects in cracks and crevices, and treating wood to prevent (or treat) termites, wood-destroying insects, mold and fungi. A powder material for crawling insects that can also be mixed with water and applied as a spray; will penetrate into (and through) the raw wood member.
- **Perma-Guard Commercial Insecticide.** Diatomaceous Earth mixed with Pyrethrin and Piperonyl Butoxide which can be dusted into cracks and crevices to manage crawling insects such as cockroaches, ants and silverfish.
- **Perma-Guard Fossil Shell Flour.** Pure Diatomaceous Earth powder which can be used to manage museum pests such as Indian Meal Moth, grain weevils, etc.
- **Perma-Guard Garden and Plant Insecticide.** Diatomaceous Earth mixed with Pyrethrin and Piperonyl Butoxde. This is an effective material for insect management on field crops, yards and gardens.

- **Tri Die.** Pressurized Silica and Pyrethrin dust for management of museum pests and crawling insects in structures.
- **Victor Wasp and Hornet Spray.** Contains Mint Oil and Sodium Lauryl Sulfate for the management of wasps, hornets and yellow jackets.
- **WOODguard.** A petroleum oil and solvent with Copper 8-Quinolinolate which can be sprayed or brushed on raw wood surfaces to prevent fungus, mold, wood rot and mildew. Provides water repellency.
- **WOW (Without Weeds).** Contains Maize Gluten Meal for pre-emergent weed management for lawns and gardens.

APPENDIX V

GLOSSARY

GLOSSARY

ABSORPTION-The process by which a chemical or fluid is taken into the systems of human beings, plants, and animals.

ACARICIDE-A pesticide used to kill mites and ticks. A miticide is an acaricide.

ACTIVE INGREDIENT-The chemical or chemicals in a pesticide responsible for killing, poisoning, or repelling the pest. (Listed separately in the ingredient statement.)

ACUTE TOXICITY-The ability of a pesticide to cause injury within twenty-four hours following exposure. LD_{50} and LC_{50} are common indicators of the degree of acute toxicity. (See also Chronic Toxicity.)

ADJUVANT-A substance added to a pesticide to improve its effectiveness or safety. Same as additive. Examples: penetrants, spreader-stickers, and wetting agents.

ADSORPTION-The process by which chemicals are held or bound to a surface by physical or chemical attraction. Clay and high-organic soils tend to adsorb pesticides.

AEROSOL-A material stored in a container under pressure. Fine droplets are produced when the material dissolved in a liquid carrier is released into the air from the pressurized container.

ALGAE-Simple aquatic plants that contain chlorophyll and are photosynthetic.

ALGICIDE-A pesticide used to kill or inhibit algae.

ANTI-SIPHONING DEVICE-A device attached to the filling hose that prevents backflow or backsiphoning from a spray tank into a water source.

ANTICOAGULANT-A chemical that prevents blood clotting. An active ingredient in some rodenticides.

ANTIDOTE-A treatment used to counteract the effects of pesticide poisoning or some other poison in the body.

ARACHNID-A wingless arthropod with two body regions and four pairs of jointed legs. Spiders, ticks, and mites are in the class Arachnida.

ARTHROPOD-An invertebrate animal characterized by jointed body and limbs. It is usually covered by a hard exoskeleton covering that is molted at intervals. For example, insects, mites, and crayfish are in the phylum Arthropoda.

ATTRACTANT-A substance or device that lures pests to a trap or poison bait.
AVICIDE-A pesticide used to repel or kill birds.

BACTERIA-Microscopic organisms, some of which are capable of producing diseases in people, plants and animals. Some bacteria are beneficial.

BACTERICIDE-Chemical used to kill bacteria.

BAIT-A food or other substance used to attract a pest to a pesticide or a trap.

BAND APPLICATION-Application of a pesticide in a strip alongside or around a structure, a portion of a structure, or any object.

BARRIER APPLICATION-See band application.

BENEFICIAL INSECT-An insect that is useful or helpful to people, such as insect parasites, predators, or pollinators.

BIOLOGICAL CONTROL-Management of pests using beneficial arthropods as predators, parasites, and disease-causing organisms which may occur naturally or are introduced to reduce pest populations.

BIOMAGNIFICATION-The process by which one organism accumulates chemical residues in higher concentration from other organisms which they have consumed.

BOTANICAL PESTICIDE-A pesticide produced from chemicals found in plants. Examples are nicotine, pyrethrins, and strychnine.

BRAND NAME-The name, or designation of a specific pesticide product or device made by a manufacturer or formulator. (A marketing name.)

CALIBRATE, CALIBRATION OF EQUIPMENT OR APPLICATION METHOD-Measurement and adjustment to control the output or rate of dispensing pesticides.

CARBAMATES-(N-Methyl Carbamates). A group of pesticides containing nitrogen, formulated as insecticides, fungicides, and herbicides. The N-Methyl Carbamates are insecticides and inhibit cholinesterase in animals.

CARCINOGENIC-The ability of a substance or agent to induce malignant tumors (cancer).

CARRIER-An inert liquid, solid, or gas added to an active ingredient for delivering a pesticide to the target effectively. A carrier is usually water, oil, or other solvent, used to dilute the formulated product for application.

CARRYING CAPACITY-The number of organisms for which a specific site can provide life support.

CERTIFIED APPLICATORS-Individuals who are certified by the state to use or supervise the

use of restricted-use pesticides.

CHEMICAL NAME-The scientific name of active ingredients found in formulated products. This complex name is derived from the chemical structure of the active ingredient.

CHEMICAL CONTROL-Pesticide application to kill pests.

CHEMOSTERILANT-A chemical compound capable of preventing animal reproduction.

CHEMTREC-The Chemical Transportation Emergency Center which has a toll-free number (800-424-9300) for providing 24-hour information only for chemical emergencies such as a spill, leak, fire, or accident.

CHLORINATED HYDROCARBON-A pesticide containing chlorine, carbon, and hydrogen. Many are persistent in the environment, such as Chlordane and DDT. Only a few are registered for use in the U.S.

CHOLINESTERASE, ACETYLCHOLINESTERASE-An enzyme in animals that helps regulate nerve impulses. This enzyme is depressed by N-Methyl carbamate and organophosphate pesticides.

CHRONIC TOXICITY-The ability of a pesticide chemical to cause injury or illness (beyond 24 hours following exposure) when applied in small amounts repeatedly for a longer period of time. Chronic effects can also result from a single exposure. (See also Acute Toxicity.)

COMMERCIAL APPLICATOR-A state-certified applicator who for compensation uses or supervises the use of pesticides classified for restricted use for any purpose or on any property other than that producing an agricultural commodity.

COMMON NAME-A name given to a pesticide's active ingredient by a recognized committee on pesticide nomenclature. Many pesticides are known by a number of trade or brand names, but the active ingredient has only one recognized common name.

COMMUNITY-The different populations of animal or plant species that exist together in an ecosystem (See also Population and Ecosystem.)

COMPETENT-Individuals properly qualified to perform functions associated with pesticide application. The degree of competency (capability) required is directly related to the nature of the activity and the associated responsibility.

CONCENTRATION-Refers to the amount of active ingredient in a given volume or weight of formulated product.

CONTACT PESTICIDE-A pesticide that causes death or injury to pests when in contact with it.

The chemical does not have to be ingested. It is often used to describe a spray applied directly on a pest.

CONTAMINATION-The presence of an unwanted substance (sometimes pesticides) in or on a plant, animal, soil, water, air, or structure.

CULTURAL CONTROL-A pest management method that includes changing human habits, such as sanitation, changing work practices, or cleaning or garbage pick-up schedules.

DECONTAMINATE-To remove or break down a pesticidal chemical from a surface or substance.

DEGRADATION-A process by which a chemical compound or pesticide is reduced to simpler compounds by the action of microorganisms, water, air, sunlight, or other agents. Degradation products are usually, but not always, less toxic than the original compound.

DEPOSIT-The amount of pesticide on a treated surface after application.

DERMAL TOXICITY-The ability of a pesticide to cause acute illness or injury to human beings or animals when absorbed through the skin (see Exposure Route.)

DESICCANT-A type of pesticide that draws moisture or fluid from a plant or arthropod pest, causing it to die. Certain desiccant dusts destroy the waxy outer coating that holds moisture within an insect's body.

DETOXIFY-To render a pesticide's active ingredient or other poisonous chemical harmless.

DIAGNOSIS-The positive identification of a problem and its cause.

DILUENT-Any liquid, gas or solid material used to dilute or weaken a concentrated pesticide.

DISINFECTANT-A chemical or other agent that kills or inactivates disease-producing microorganisms. Chemicals used to clean or surface-sterilize inanimate objects.

DOSE, DOSAGE-Quantity, amount, or rate of pesticide applied to a given area or target.

DRIFT-The airborne movement of a pesticide spray or dust beyond the intended target area.

DUST-A finely ground, dry pesticide formulation containing a small amount of active ingredient and a large amount of inert carrier or diluent such as clay or talc.

ECOSYSTEM-The pest-management unit. It includes a community (of populations) with the necessary physical (harborage, moisture, temperature), and biotic (food, hosts) supporting factors that allow a population of pests to persist.

EMULSIFIABLE CONCENTRATE (EC)-A pesticide formulation produced by mixing or

suspending the active ingredient (the concentrate) and an emulsifying agent in a suitable carrier. When added to water, a milky emulsion is formed.

EMULSIFYING AGENT (EMULSIFIER)-A chemical that aids the suspension of a liquid in another that normally would not mix together.

EMULSION-A mixture of two liquids which are not soluble in one another. One is suspended as very small droplets in the other with the aid of an emulsifying agent.

ENCAPSULATED FORMULATION-A pesticide formulation with its active ingredient enclosed in tiny capsules of polyvinyl or other materials; principally used for slow release. The enclosed active ingredient moves out to the capsule surface as pesticide on the surface is removed (volatilizes, or rubs off).

ENDANGERED SPECIES-Individual plants or animals with a population that has been reduced to the extent that it is near extinction and that has been designated to be endangered by a federal agency.

ENTRY INTERVAL-See Re-entry Interval.

ENVIRONMENT-Air, land, water, plants, people, animals, and the interrelationships which exist among them.

EPA - ENVIRONMENTAL PROTECTION AGENCY-The federal agency responsible for ensuring the protection of people and the environment from potentially adverse effects of pesticides and other contaminants.

EPA ESTABLISHMENT NUMBER-A number assigned to each pesticide-production plant by the EPA. The number indicating the plant at which the pesticide product was produced must appear on all labels of that product.

EPA REGISTRATION NUMBER-An identification number assigned to a pesticide product when it is registered by the EPA for use. The number must appear on all labels of pesticide products.

ERADICATION-The complete elimination of a (pest) population from a designated area.

EXPOSURE ROUTE OR COMMON EXPOSURE ROUTE-The manner - dermal (through the skin), oral (through the mouth), or inhalation/respiratory - in which a pesticide may enter an organism.

FIFRA-The Federal Insecticide, Fungicide, and Rodenticide Act; a federal law and its amendments that controls pesticide registration and use.

FLOWABLE-A pesticide formulation in which very finely ground solid particles are suspended

(not dissolved) in a liquid carrier.

FOG TREATMENT-A pesticide in aerosol-sized droplets (under 40 microns). Not a mist or gas. After propulsion, the fog droplets fall on exposed surfaces.

FORMULATION-The pesticide product as purchased, containing a mixture of one or more active ingredients, and carriers (inert ingredients), with other additives making it easy to store, dilute, and apply.

FUMIGANT-A pesticide formulation that volatilizes, forming a toxic vapor or gas that kills in the gaseous state, penetrating voids to kill pests.

FUNGICIDE-A chemical used to kill fungi.

FUNGUS (plural - fungi)-A group of small, often microscopic, organisms in the plant kingdom which cause rot, mold, and disease. Fungi need moisture or a damp environment (wood rots require at least 19%). Fungi are extremely important in the diet of many insects.

GENERAL USE (UNCLASSIFIED) PESTICIDE-A pesticide which can be purchased and used by the general public. (See also Restricted Use Pesticide.)

GRANULE-A dry pesticide formulation. An active ingredient is either mixed with or applied as a coating to an inert carrier to form a small, ready-to-use, low-concentrate chemical which normally does not present a drift hazard. Pellets differ from granules only in their precise uniformity, larger size, and shape.

GROUNDWATER-Water source located beneath the soil surface from which springs and well water are drawn (see also Surface Water.)

HABITAT MODIFICATION-Removing food, water, shelter, and other conditions that support pests, or excluding access by pests to the site.

HALF LIFE-The time required for half of something (i.e. pesticide) to undergo a specific process (chemical degradation), so that only one-half of the applied material is still active (i.e. half life of Chlordane in soil is about 75 years).

HANTAVIRUS-A deadly virus transmitted to humans through contact with rodent feces, urine and saliva resulting in acute respiratory failure.

HARBORAGE-Shelter that provides the basic needs, including a safe place for the pest population.

HAZARD-See Risk.

HERBICIDE-A pesticide used to kill or inhibit plant growth.
HIGH-RISK PERSON-A person who has some condition that may put him or her at risk from

exposure to pesticides. Such persons include children, the elderly, pregnant women, newborns, asthmatics, the neurologically impaired, the environmentally ill (EI), and those with multiple chemical sensitivity (MCS).

HOST-Any animal or plant on or in which another lives for nourishment, development, or protection.

IGR, INSECT GROWTH REGULATOR JUVENOID-A pesticide which mimics insect hormones that control molting and the development of insect systems affecting the change from immature to adult (see Juvenile Hormone.)

INERT INGREDIENT-An inactive material without pesticidal activity in a pesticide formulation, but which may be hazardous for some other reason; i.e., petroleum derivatives.

INGREDIENT STATEMENT-A portion of the label on a pesticide container that gives the name and amount of each active ingredient and the total amount of inert ingredients in the formulation.

INHALATION-Taking a substance in through the lungs (breathing in). (See Exposure Route.)

INSECT GROWTH REGULATOR-See IGR.

INSECTICIDE-A pesticide used to manage or prevent damage caused by insects.

INSECTS, INSECTA-A class in the phylum Arthropoda characterized by a body composed of three segments and three pair of legs.

INSPECTION-A process for detecting pests, pest damage, and evidence of pest activity in a managed site. (See Monitoring.)

INTEGRATED PEST MANAGEMENT-See IPM.

IPM-Integrated pest management. 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. IPM includes reducing pests to a tolerable level. Pesticide application is not the primary management method, but is an element of IPM, as are cultural and structural alterations. IPM programs stress communication, monitoring, inspection, and evaluation (keeping and using records).

JUVENILE HORMONE-A hormone produced by an insect that inhibits change or molting. As long as juvenile hormone is present the insect does not develop into an adult, but remains immature.

LABEL-All printed material attached to or on a pesticide container.

LABELING-The pesticide product label and other accompanying materials that contain

directions for use that pesticide users are legally required to follow.

LARVA (plural - larvae)-The developmental stage of insects with complete metamorphosis that hatches from the egg. A mature larva becomes a pupa.

LC_{50}-Lethal concentration. The concentration of a pesticide, usually in air or water, that kills 50 percent of a test population of animals. LC_{50} is usually expressed in parts per million (ppm). The lower the LC_{50} value, the more acutely toxic the chemical.

LD_{50}-Lethal dose. The dose or amount of a pesticide that can kill 50 percent of the test population of animals when eaten or absorbed through the skin. LD_{50} is expressed in milligrams of chemical per kilogram of body weight of the test animal (mg/kg). The lower the LD_{50}, the more acutely toxic the pesticide.

LEACHING-The movement of a substance with water downward through soil.

LYME DISEASE-A debilitating disease mainly affecting joints that is transmitted to humans through the bite of ticks, especially the Deer Tick.

METAMORPHOSIS-A change in the shape or form of an animal. Usually used when referring to insect development.

MICROBIAL DEGRADATION-Breakdown of a chemical by microorganisms.

MICROBIAL PESTICIDE-Bacteria, viruses, fungi, and other microorganisms used to manage pests. Also called biorationals.

MICROORGANISM-An organism so small that it can be seen only with the aid of a microscope.

MITICIDE-A pesticide used to kill mites (see Acaricide.)

MODE OF ACTION-The way in which a pesticide exerts a toxic effect on the target plant or animal.

MOLLUSCICIDE-A chemical used to kill snails and slugs.

MONITORING-Ongoing surveillance. Monitoring includes periodic inspection and record-keeping. Monitoring records allow technicians to evaluate pest population suppression, identify infested or non-infested sites, and manage the progress of the pest-management program.

MSDS-Material Safety Data Sheet required by Department of Labor to be provided by manufacturers to those who request information on chemical substances. Included is data on flammability, eye hazards, protective equipment necessary, spill/clean-up instructions, and other hazard information.

NECROSIS-Death of plant or animal tissues which results in the formation of discolored, sunken, or necrotic (dead) areas.

NONTARGET ORGANISM-Any plant or animal other than the intended targets of pesticide application.

NYMPH-The developmental stage of insects with gradual metamorphosis that hatches from the egg. Nymphs become adults.

ORAL TOXICITY-The effect of a pesticide resulting in injury or acute illness when taken by mouth.

ORGANOPHOSPHATES-A large group of pesticides that contain phosphorus and inhibit cholinesterase in animals; i.e., Malathion and Diazinon.

PARASITE-A plant, animal, or microorganism living in, on, or with another living organism for the purpose of obtaining all or part of its food.

PATHOGEN-A disease-causing organism.

PERSONAL PROTECTIVE EQUIPMENT-Devices and clothing intended to protect a person from exposure to pesticides, including items like long-sleeved shirts, long trousers, coveralls, hats, gloves, shoes, respirators, and other safety items as needed.
PEST MANAGEMENT-See IPM.

PEST-An undesirable organism including any insect, rodent, nematode, fungus, weed, or some terrestrial and aquatic plants and animals, virus, bacteria, or micro-organism which the US EPA Administrator declares to be a pest under FIFRA, Section 25(c)(1).

PESTICIDE-A chemical or other agent used to kill, repel, or otherwise manage pests or to protect from a pest.

pH-A measure of acidity/alkalinity of a liquid: acid below pH7; basic or alkaline above pH7 (up to 14).

PHEROMONE-A substance emitted by an animal to influence the behavior of other animals of the same species. Some are synthetically produced for use in insect traps.

PHOTODEGRADATION-Breakdown of chemicals by the action of light.

PHYSICAL CONTROL-Habitat alteration or changing the infested physical structure, such as by caulking holes, cracks, tightening around doors, windows, moisture reduction, ventilation, and other means.

PHYSIOLOGICAL SENSITIVITIES-Human physiological reaction from exposure in the environment to perhaps minute amounts of chemicals that produce an adverse response.

PHYTOTOXICITY-Injury to plants caused by a chemical or other agent.

POINT OF RUNOFF-The point at which a spray starts to run or drip from the surface to which it is applied.

POISON CONTROL CENTER-A local agency, generally a hospital, which has current information on the proper first-aid techniques and antidotes for poisoning emergencies. Such centers are listed in telephone directories.

POPULATION-Individuals of the same species. The populations in an area make up a community (see Ecosystem.)

PORT-Small sealable hole that allows injection of pesticidal material into a wall or other void in a structure.

PRECIPITATE-A solid substance that forms in a liquid and settles to the bottom of a container; a material that no longer remains in suspension.

PREDATOR-An animal that attacks, kills, and feeds on other animals. Examples of predaceous animals are hawks, owls, snakes, spiders, lady-bird beetles and other insects.

PROFESSIONAL-One who is trained to conduct an efficient operation and able to make judgments based on training and experience.

PROPELLANT-The inert ingredient in pressurized containers that forces an active ingredient from the container.

PUPA (plural - pupae)-The developmental stage of insects with complete metamorphosis when major changes from larval to adult form occurs.

QUALIFIED APPLICATOR-An applicator who is certified (and licensed in some states) to apply restricted-use pesticides in the state. Qualification may also include training or experience.

RATE OF APPLICATION-The amount of pesticide applied to a plant, animal, unit area, or surface; usually measured per acre, per 1,000 square feet, per linear foot, or per cubic foot.

RE-ENTRY INTERVAL-The length of time following an application of a pesticide during which entry into the treated area is restricted. Also known as Entry Interval.

REGISTERED PESTICIDES-Pesticide products which have been registered by the Environmental Protection Agency for uses listed on the label.

REPELLENT-A compound that keeps insects, rodents, birds, or other pests away from plants, domestic animals, buildings, or other treated areas.

RESIDUAL PESTICIDE-A pesticide that continues to remain effective on a treated surface or area for an extended period following application.

RESIDUE-The pesticide active ingredient or its breakdown products which remain in or on the target after treatment.

RESTRICTED USE PESTICIDE-A pesticide that can be purchased and used only by certified applicators or persons under their direct supervision. A pesticide classified for restricted use under FIFRA, Section 3(d)(1)(C).

RISK-A probability that a given pesticide will have an adverse effect on people or the environment in a given situation.

RMSF-Rocky Mountain Spotted Fever is an acute infectious rickettsial disease transmitted to humans by the American dog tick.

RODENTICIDE-A pesticide used to kill rodents.

RUNOFF-The movement of water and associated materials on the soil surface. Runoff usually proceeds to bodies of surface water.

SANITATION-The practice of removing undesirable substances that support a pest or pest population (for instance, food or water).

SIGNAL WORDS-Required wording which appears on every pesticide label to denote the relative toxicity of the product. Signal words are DANGER-POISON, DANGER, WARNING, or CAUTION.

SITE-Areas of actual pest infestation. Each site should be treated specifically or individually.

SOIL INJECTION-The placement of a pesticide below the surface of the soil, a common application method for termiticides.

SOIL DRENCH-To soak or wet the ground surface with pesticide. Large volumes of pesticides are usually needed to saturate the soil to a sufficient depth.

SOIL INCORPORATION-The mechanical mixing of a pesticide product with soil.

SOLUTION-A mixture of one or more substances in another substance (usually a liquid) in which all the ingredients are dissolved. Example: sugar in water.

SOLVENT-A liquid which will dissolve another substance (solid, liquid, or gas) to form a solution.

SPACE SPRAY-A pesticide which is applied as a fine spray or mist to a confined area.

STOMACH POISON-A pesticide that must be eaten by an animal in order to be effective; it will not kill on contact.

SURFACE WATER-Water on the earth's surface such as rivers, lakes, ponds, and streams. (See Groundwater.)

SUSPENSION-A pesticide mixture consisting of fine particles dispersed or floating in a liquid, usually water or oil. Example: wettable powders in water.

TARGET-Plants, animals, structures, areas, or pests toward which the pesticide or other management method is directed.

TECHNICAL MATERIAL-Pesticide active ingredient in pure form, as it is manufactured by a chemical company. It is combined with inert ingredients or additives in formulations such as wettable powders, dusts, emulsifiable concentrates, or granules.

TOXIC-Poisonous to living organisms.

THRESHOLD-A level of pest density. The number of pests observed, trapped, or counted that can be tolerated without an economic loss or aesthetic injury. Thresholds in pest management may be site specific. For example, different numbers of flies may be tolerated at different sites (canoe warehouse and kitchen would have different thresholds).

TOLERABLE LEVELS OF PESTS-The presence of pests, at certain levels, is tolerable in many situations. Totally eliminating pests in certain areas is sometimes not achievable without major structural alterations, excessive control measures, unacceptable disruption, or unacceptable cost. The tolerable level in some situations will be near zero. Urban pest management programs may have lower tolerable levels of pests than rural programs.

TOXICANT-A poisonous substance such as the active ingredient in a pesticide formulation.

TOXICITY-The ability of a pesticide to cause harmful, acute, delayed, or allergic effects. (The degree or extent that a chemical or substance is poisonous.)

TOXIN-A naturally occurring poison produced by plants, animals, or microorganisms. Examples: the poison produced by the black widow spider, the venom produced by snakes, the botulism toxin.

UNCLASSIFIED PESTICIDE-See General-Use Pesticide.

USE-The performance of pesticide-related activities requiring certification including application, mixing, loading, transport, storage, or handling after the manufacturing seal is broken; care and maintenance of application and handling equipment; and disposal of pesticides and their

containers in accordance with label requirements. Uses not needing certification are long-distance transport, long-term storage, and ultimate disposal.

VAPOR PRESSURE-The property which causes a chemical to evaporate. The higher the vapor pressure, the more volatile the chemical or the more easily it will evaporate.

VECTOR-A carrier, an animal (such as an insect, nematode, mite) that can carry and transmit a pathogen from one host to another.

VERTEBRATE-Animal characterized by a segmented backbone or spinal column.

VIRUS-Ultramicroscopic parasites composed of proteins. Viruses can only multiply in living tissues, and they cause many animal and plant diseases.

VOID-Space inside walls or other inaccessible space that may harbor pests.

VOLATILITY-The degree to which a substance changes from a liquid or solid state to a gas at ordinary temperatures when exposed to air.

WATER TABLE-The upper level of the water-saturated zone in the ground.

WEST NILE VIRUS-A disease transmitted to humans and other animals by the bite of a mosquito. Birds (notably Corvids) act as a reservoir and may die as a result.

WETTABLE POWDER-A dry pesticide formulation in powder form that forms a suspension when added to water.

ZONE-The management unit, an area of potential pest infestation made up of infested sites. Zones will contain pest food, water, and harborage. A kitchen-bathroom arrangement in motel units might make up a zone; the canoe warehouse may make up another. Zones may also be established by eliminating areas with little likelihood of infestation and treating the remainder as a zone. A zone will be an ecosystem.

APPENDIX VI

IPM INSPECTION

FORMS

STRUCTURAL IPM INSPECTION FORM

Date_____ Inspector_____ Assisted by_____

Code Numbers for Problems on Form/Map:

1 = Roaches	2 = Flying Insects (flies, moths)	3 = Other Insects	4 = Rodent Sign	5 = Housekeeping
6 = Maintenance	7 = Bird Sign	8 = Squirrels	9 = WDOs	10 = Other

Abbreviations: PTW = Pressure Treated Wood FWJ = Floor Wall Junction

1. OUTSIDE - Curtilage:

Pests known present.....

Garbage/dumpster conditions.....

General area cleanliness.....

Dead trees/sod debris/termites.....

Pest harborage/debris on ground.....

Pest breeding (water, food, shelter).....

Paving/walk drainage problems.....

Wood too close to structure.....

Plants too close to building.....

General wood control.....

Hazardous trees/limbs.....

Shed/outbuilding problems.....

Rodent burrows/sign/holes.....

Pet/bird feeders/waterers.....

Insect evidence/harborage garden?.....

Vertebrate evidence/holes.....

.....

...

2. FOUNDATION - Exterior

Pests known present.....

A. Foundation:

Building corners square foundations.....

Foundation intact: dirt/wood contact?.....

Wood-concrete-soil contacts/PTW.....

Foundation cracks.....

36 in. clear area around structure (1 in. gravel).....

.....

...

B. Grade

Soil drainage characteristics.....

Grade from structure (6 in/10 ft.).....

Grade and water accumulations.....

.....

...

C. Siding/Building Exterior

Downspout drains splash on siding?.....

Splash blocks perforated pipe.....

Main siding peeling paint/buckling?.....

Water/air conditioner leaks.....

Rusty nails/wood streaking.....

Discolored/decayed wood siding.....

Wood pick test results.....

Wood moisture readings.....

Wood junctions caulked.....

Porch and soffit conditions.....

Tongue & groove flooring caulked.....

Door sweeps/good door closure.....

Metal kickplates on doors.....

Window frame conditions.....

Vents/exhaust/conduits screened.....

Cracks/holes around pipes/wires.....

Outside lights away from doors/on poles; high pressure sodium bulbs; covers clean.....

Trees touching/overhanging structure.....

Plants/plantings/planters/trellises.....

..

Trash/debris accumulations.....

Insect/vertebrate evidence/harborage.....

.....

...

D. Food Establishments

Loading docks/receiving areas clean.....

Garbage area removed from structure.....

Other outside storage/spills.....

Exterior wall/foundation cracks.....

.....

...

E. Structural Roof

Pests known present.....

Missing shingles/cracks in surface.....

Moss/lichen/algae/fungus on

roof.....
Rusty iron nails in
roofing.....
Shingles/roof
intact.....
Shingle extension 1 ft. eave (12-24-
30).....
Gutters clean, not
clogged.....
Chimney/vents
screened.....
Bird problems in
eaves.....
Chimney flashing/construction
tight.....
Dormer flashing/construction
tight.....
Soffit flashing
tight.....
Wires from roof pest-
protected.....
Insect
evidence/harborage.....
Fascia tight/painted (carpenter
bees).....
.....
...

3. INSIDE - Crawlspace
Pests known
present.....

Monitor (repair) structure twice a year (spring/fall) for moisture/

damage.....
.
Vents screened/open in
wells.....
Height of crawlspace (18 in.t joists).....
Wood/soil
contact.....
Wood pick test
results.....
Termite shields
installed.....
Leaking
pipes.....
Structural wood
type.....
Wet areas? Why? Moisture
readings.....
Mold/fungus/decay/insect
damage.....
Wood debris
present.....
Evident floor/wood
shrinkage.....
Vapor barrier?
Intact?.....
Pest access into structure thru
floor.....
Active insect
infestations?.....
Vertebrate
sign?.....
Ventilation: 1 sf/150 sf; within 3 ft. of
corner.....
Suspended ceilings/light
fixtures.....

C. Service/Custodial Rooms
Custodial storage
area.....
Wet mops/rags/sour
drains.....
Crawlspace access door
clear.....

4. INSIDE - Structural
Pests known
present.....

A. Basement
Walls dry/moisture
readings.....
Storage
condition/sanitation.....
Wood moisture in sill
area.....
Floor drains
clean/screened.....
Sticky trap
monitoring.....
Trash collection
practices.....
Insect
evidence/harborage.....

B. Offices; Classrooms
Reception desk
area.....
Exhibit area: general pest
risks?.....
Exterior door
conditions.....
Offices: neatness/problem
areas.....
Eating/storing food at
desks.....
Computers/elec equipment
problems.....

Insect attracting items in
building?.....
Insect
evidence/harborage.....
Lunchroom/coffeemaking
area.....
Vending
machines.....
Trash collection
practices.....
Decorative
plants.....
General
sanitation/lint.....
Cracks/holes in
floor.....
Walls:.....
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Windows/doors:……
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Electrical
boxes/equipment.....
Drains
cleaned/screened.....

D. Kitchens/Food Establishments
Countertops
caulked/intact.....

Exhaust vents.....
Water leaks/pipe sweating/hot water heater.....
Drains clear/good condition.....
Food stored in cans/glass.....
Shelves clean/no shelf paper.....
Refrigerator pan/motor.....
Windows tight/insect presence.....
Condition of walls/grease/moisture.....
Storage 6 in. off floor.....
Dishwasher cleanliness/pests.....
Stove vent clean/screened.....
Stove/refrigerator doors clean.....
Hollow legs on tables/chairs/rails?.....
Equipment elevated on legs.....
Conditions under lowest drawers.....
Trash covered; out every night.....
Dishes kept in water until cleaned.....
Outside trash covered; cans cleaned weekly.....
Insect evidence/harborage.....
Dry storage areas.....
Areas behind false fronts on equipment.....
Loose floor tile/screened drains.....
Regularly emptied trash containers.....
Area around can opener/grease hoods.....
Condition of window frames.....
Employee lockers.....
Air doors/vanes positioned correctly.....
Door sweeps.....

E. Bathrooms
Water leaks at tub/shower/toilet; fungus.....
Floor strength near toilet.....
Water leaks under sink.....
Condition of window frames.....
Blistered ceiling/wall paint.....
Insect evidence/harborage.....

F. Structural/Attic
Sufficient ventilation.....
Insect/pest evidence/harborage.....
Vents screened.....
Temperature.....
..
Roof/wall junction tight seal.....
Rodent evidence.....
Exposed/chewed wiring.....
Appliance venting.....
Frozen condensation/ice dams.....
Bat presence.....

G. Additional notes

Floors:……
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.Walls:.....
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Other:……
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EQUIPMENT CHECKLIST - personal protective equipment

- 9 Hard hat
- 9 Insect repellant
- 9 Knee pads
- 9 Gloves, heavy/medical
- 9 Face shield/goggles
- 9 Dust mask/respirator
- 9 Overalls and/or bee suit
- 9 Bee veil
- 9 Smoker and fuel
- 9 Wasp Freeze
- 9 Fly swatter
- 9 .....

TOOLS FOR SITE INSPECTIONS

- 9 Clipboard/grid/paper
- 9 Inspection forms
- 9 Pencil/pen
- 9 Insect keys/info
- 9 Aspirator/collecting vials
- 9 Flashlight/headlamp
- 9 Flashlight batteries
- 9 Hand duster
- 9 Vials w/alcohol
- 9 Polaroid/digital camera
- 9 Belt/leatherman/knife
- 9 15x Hand lens/loupe
- 9 Film/flash
- 9 Caulk
- 9 Lo-line sticky traps
- 9 Screwdriver/phillips/slot
- 9 Crescent/general wrench
- 9 Masking/filament tape
- 9 Portable vacuum cleaner
- 9 Ladders/rope/carabiner
- 9 Sharp probe (wood awl)
- 9 White coveralls
- 9 Belt pouch for tools
- 9 Extendable mirror
- 9 Tape measure/6 in ruler
- 9 Plastic zip locs
- 9 Slide camera
- 9 Colored sticky labels
- 9 Binoculars
- 9 Moisture meter/thermometer
- 9 Small hand trowel
- 9 Knee/elbow pads
- 9 Spatula
- 9 Rechargeable drill

9 Forceps	9 Stethoscope
9 Pocket tape recorder	9 Optivisor
9 Pliers	9 Hand mirror
9	9 ....
9	9 ....

ADDITIONAL
COMMENTS..
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FOREST/LANDSCAPE IPM INSPECTION FORM

Site_____ Date_____ Inspector_____ Assisted by_____

PESTS PRESENT

VERTEBRATES	LOCATION	ACTION

ARTHROPODS	LOCATION	ACTION

EXOTIC INVASIVE PLANTS/WEEDS	LOCATION/ GPS COORDINATES	ACTION

INSECT PHEROMONE MONITORING TRAPS

SPECIES	COUNTS	LOCATION

OTHER OBSERVATIONS – i.e., Plants too close to structures, hazard trees, etc.

_____

_____

_____

APPENDIX VII

PEST SIGHTING LOG

Marsh-Billings-Rockefeller National Historical Park

Have you seen any pests lately? Please jot down your observations!



Pest Activity Log: _____

Report of Pest Sighting			
Date	Name/Phone	Location/Building	Pest/Problem Description

PLEASE RETAIN ORIGINAL FOR COPYING.



APPENDIX VIII

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BIBLIOGRAPHY

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APPENDIX IX

PRODUCT

LABELS

SEE SEPARATE FILE

FOR LABELS

AND MSDS

APPENDIX X

VENDORS

VENDORS

AGRIZAP, INC., 4535 McGrath Street, Building B, Ventura, CA 93003. 1-888-332-3728. www.ratzapper.com. Electronic rodent management device.

BENEFICIAL INSECTARY, 9664 Tanqueray Court, Redding, CA 96003. 1-800-477-3715. www.insectary.com. Provides beneficial critters for managing aphid, whitefly, mites and more.

BIOCONTROL NETWORK, 5116 Williamsburg Road, Brentwood, TN 37027. 1-800-441-2847. www.biconet.com. Provides an extensive list of low-risk pest control critters and products.

DO-IT-YOURSELF PEST CONTROL, INC., 2823 Chamblee-Tucker Road, Atlanta, GA 30341. 1-800-476-3368. www.doyourownpestcontrol.com. Provides Dekko Silverfish Paks (manufactured by Dekko Manufacturing, LLC) for control of silverfish and more.

GARDENS ALIVE!, 5100 Schenley Place, Lawrenceburg, IN 47025. 1-812-537-8650. www.gardens-alive.com. Informative catalog with a wide selection of many biological-based pest controls, including beneficial predators, parasites, beneficial nematodes, fertilizers and much more.

INSECTS LIMITED, INC. 16950 Westfield Park Road, Westfield, IN 46074. 1-317-896-9300. www.insectslimited.com Provides pheromone traps for museum, stored product and other pests.

IPM LABORATORIES, Main Street, Locke, NY 13092-0099. 1-315-497-2063. www.ipmlabs.com. This company produces a very informative catalog and newsletter with helpful, expert information on using its many beneficial insects. Provides whitefly egg parasites and predators as well as a number of wasp parasites for aphid control, including the difficult to find *Aphelinus abdominalis* and *Aphidius ervi*. They always carry a quality product.

M&R DURANGO, INC., P.O. Box 886, Bayfield, CO 81122 aka The Good Bug Company, 970-259-3521. www.goodbug.com. Provides *Encarsia Formosa*, thrips predator, spider mite predator, green lacewing and more.

NEEM RESOURCES, THE AHIMSA ALTERNATIVE, INC., 5317 Whiting Avenue, Edina, MN 55439. 1-877-873-6336 or 1-405-538-0280. www.neemresource.com. Provides pure neem oil, karanja oil and other neem products for natural pest management.

PERMA-GUARD, INC., 625 East 2150 South, Bountiful, UT 84010. 1-877-801-2025. www.perma-guard.com. Supplier of diatomaceous earth product and pyrethrin and diatomaceous earth insecticides.

PEST CONTROL SUPPLIES, 1700 Liberty Street, Kansas City, MO 64102. 1-800-821-5689. www.pcspest.com. Termite and rodent control, herbicides, insect traps.

PRESERVATION PRODUCTS UNLIMITED, 6929 Seward Avenue, P.O. Box 29109, Lincoln, NE 68529. 1-800-648-7329.

RESIDEX, 8486-F Tyco Road, Vienna, VA 22182. 1-800-247-8528. www.residex.com. A source for pesticides, Lo-Line sticky monitoring traps, Victor snap traps and more.

RINCON-VITOVA INSECTARIES, INC., P.O. Box 1555, Ventura, CA 93002. 1-800-248-2847. www.rinconvitova.com. Provides a wide variety of pest management supplies and beneficial organisms.

TARGET SPECIALTY PRODUCTS, 15415 Marquardt Avenue, Santa Fe Springs, CA 90670. 1-562-802-2238. www.target-specialty.com. A source for pesticides, Lo-Line sticky monitoring traps, Victor snap traps and more.

UNIVAR USA. One Colonial Road (P.O. Box 730), Salem, MA 01970. 1-978-745-3700. www.univarusa.com. A source for pesticides, Lo-Line sticky monitoring traps, Victor snap traps and more.

VICTOR PEST AND SAFER PEST CONTROL PRODUCTS. 1-800-800-1819. www.victorpest.com. Provides a full line of poison-free and low-risk pest management products. There is a search feature on pests, what they are, what diseases they may carry, and how to prevent infestations.

NOTE:

These suppliers are known to IPMI as providing high-quality products and services. There are hundreds of pest management product suppliers in the U.S. that may also provide high-quality products and services.

- Victor brand snap traps are the oldest manufactured traps, are widely available, and can be easily “fine-tuned” for reliable kills.
- Lo-Line monitoring (sticky) traps for crawling insects are the best designed, reliable products on the market to date.

As the nation's primary conservation agency, the Department of the Interior has responsibility for most of our nationally owned public land and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

NPS D-31 November 2006

ON THE BACK COVER
The Belvedere
Photograph by: Jean A. Currie, President, International Pest Management Institute

National Park Service
U.S. Department of the Interior

Northeast Region
Natural Resource Stewardship and Science
15 State Street
Boston, Massachusetts 02109

http://www.nps.gov/nero/science/

