

INTEGRATED PEST MANAGEMENT PLAN

BIG BEND NATIONAL PARK

BIG BEND, TEXAS

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RATTLESNAKES
RINGTAILS
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SPIDERS
TICKS
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INTEGRATED PEST MANAGEMENT PLAN BIG BEND NATIONAL PARK

I. INTRODUCTION

The Integrated Pest Management (IPM) Plan for Big Bend National Park (BIBE) is designed to assist the park manager in making sound pest management decisions and to serve as a basic resource for other BIBE managers, employees, IPM Coordinators, and residents. The value of the IPM Plan to the park will increase if, through periodic review and revision, it continually reflects changes in pest management technology, locally available expertise, input from park Divisions, and remains a long-term consensus of pest management activities in the park.

II. AUTHORITIES, LEGAL REQUIREMENTS, POLICY

National Park Service (NPS) policy establishes IPM as the preferred method for managing pests in parks and monuments and development of this program is based on and directed by various policies, laws, regulations, executive orders, and a presidential memorandum.

A. Federal Regulations

Endangered Species Act

Executive Order 11787 concerning Exotic Organisms

Executive Order 11870 concerning Animal Damage Control

Executive Order 11987 concerning exotic organisms

Executive Order 12088 concerning Pollution Control

Federal Environmental Pesticide Control Act of 1972 (7 U.S.C. 135 et seq.)

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).

Migratory Bird Treaty Act

Occupational Health and Safety (OSHA) Hazard Communication Standard (29 CFR 1910.1200)

President Clinton's April 26, 1994, Memorandum concerning economically beneficial practices on Federal landscaped grounds.

President Carter's August 2, 1979, Memorandum requiring Federal Agencies to use integrated pest management technology for pest control and reduce the use of toxic pesticides

Resource Conservation and Recovery Act (40 CFR 165) concerning disposal of pesticides

Secretary Babbitt's July 12, 1994, Memorandum on the Department of Interior and the Federal Insecticide, Fungicide, and Rodenticide Act.

B. NPS Guidelines and Policies

NPS Management Policies (1988) outlines the basic framework of the NPS IPM program.

Full implementation of IPM practices in NPS field areas has been a Servicewide goal for more than 15 years. Information describing the design, application, and evaluation of park IPM programs (and regulations and policies governing them) are found in Chapter 2, Integrated Pest Management, of NPS-77, Natural Resources Management Guideline (1991). This guideline provides details of the program under the following headings:

- NPS approval and review process for all pesticides used in the park
- Overview of IPM
- Components of an IPM program

- IPM Program Operations
- Roles and Responsibilities
- Report forms and directions for completing them:

Additional guidelines relating to the park pest management program are found 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.

At this time, the IPM program has been reorganized. The administration of the program has changed, particularly in regard to pesticide review and approval processes. Consequently, some portions of Management Policies and NPS-77 are out of date. Annual memoranda from the Washington Office (Associate Director, Natural Resources Stewardship and Science) to the field are being used to convey the latest program management information. Consult the park files for the latest memorandum.

At present, pesticide use proposals are prepared by Park IPM Coordinators and are submitted to the Cluster IPM Coordinators for review and approval. In a few specialized cases, the proposals are forwarded to the Washington Office for final review and approval.

A new aspect of the IPM program is that when the park has an approved IPM Plan, the specified pesticides are approved for four years, without the need to request annual re-authorization via pesticide use proposals. The pesticides which have been authorized for Big Bend National Park may be found in the individual chapters under "Chemical Alternatives." A comprehensive list may also be found in Appendix IX.

C. Park Purpose

Big Bend National Park was authorized by an act of Congress on June 20, 1935 to provide lands for recreational purposes and for the benefit and enjoyment of the people. The act endorsed the provisions of the National Park Service Organic Act of August 25, 1916 for conserving the park's scenery, natural and historic objects, and wildlife to provide for the enjoyment of those resources in manners that leave them unimpaired for future generations. BIBE is nationally significant as the most representative protected area of Chihuahuan Desert topography and ecology in the United States. Pine Canyon was designated as a Research Natural Area by the U.S. Forest Service and Association of American Foresters. And, BIBE has been internationally recognized for its biological research and environmental monitoring potentials by being designated as an International Biosphere Reserve.

The Integrated Pest Management program is compatible within this wide framework of required management actions to ensure public and official use of the park are compatible with the highest standards of resource protection and to provide opportunities for public education in resource conservation ethics.

D. State Regulations Covering Pesticide Use

The State of Texas requires Federal employees applying restricted use pesticides in parks to be certified as pesticide applicators and receive at least 5 hours of approved pest management continuing education each year to maintain certification. For a copy of state pesticide regulations, contact the Texas Department of Agriculture for a current copy of Texas Pesticide and Agricultural Hazard Communication (Right-To-Know) Laws, regulations and related Statutory Provisions of 1994. Their address is: P.O. Box 12847, Austin, Texas 78711. The telephone number for the Pesticide Programs Division is 512/463-7544. Their Internet address is: <http://www.agr.state.tx.us>.

III. OVERVIEW OF IPM PLAN

A. Description of the IPM Program

Integrated Pest Management coordinates all available biological, environmental and modern pest management technology in an attempt to prevent unacceptable levels of pest damage through the most economical means available and with the least possible pesticide hazards to people and the environment. This approach relies on cost-effective and site-specific pest controls, decision-making processes, and risk reduction systems. Unlike any given single method of pest control, the IPM approach is more effective than traditional methods because it combines tactics like sanitation, monitoring, exclusion, habitat modification, and (only when necessary) judicious use of specific pesticides. Obvious economic benefits can be expected from a fully operational and proactive IPM program. Some examples are:

- better preservation of cultural and natural resources and property.
- reduced needs for manpower to manage pest problems during the busy visitor-use season
- reduced likelihood for transfer of pest diseases to employees or visitors
- reduced likelihood for staff or visitors to be affected by pesticides or carrier ingredients
- reduced potential for resource damage resulting from deterioration or structural fires caused by pest activity
- improved aesthetic appearances of museums, curatorial storage areas, offices, and residences
- reduced potential for tort and employee claims.
- improved relationships with staff

B. Review of Pest Control

BIBE is located in an ideal natural environment for supporting an extremely wide variety of insect and vertebrate animals, some of which interfere with management and personal objectives and become pests. Outdoors, such pest animals find abundant natural harborage in holes and caves beneath rocks and among native plants. They obtain food from plants and their products; accidental spillage, deliberate feeding (rodents, deer, javelina, etc.), and from garbage cans. They obtain moisture from succulent plant leaves, empty pop cans, plumbing leaks, and natural or man-made depressions in the ground sometimes holding run-off water.

Controlling destructive pests is important to better preserve the park's historic and natural resources and to protect the health, safety, and comfort of park staff, residents, and visitors. All actions to reduce pest numbers at BIBE and to prevent potential damage to historical resources or disease outbreaks must focus on reducing and managing pest populations by limiting available resources

(e.g., food, water, and harborage) and by making structures and cultural resources as pest proof as possible while still preserving the desired uses and historic appearances.

The best approach towards resolving pest problems in the park is one which makes use of a full array of all possible IPM methods and includes use of the widest possible spectrum of mechanical, physical, cultural, and chemical controls. Basically, that information includes:

- an established and approved plan which defines individual responsibilities and inter-divisional relationships within the park;
- a consolidated synthesis of biological and pest management information dealing with safe and successful alternative pest management measures; and
- reference information

The basic guideline for park IPM programs has been presented in a nine-step process which develops and makes available written information and protocols to help prevent pest damage and to protect the resources. The nine-step IPM process includes:

- close adherence to NPS policy,
- involvement of all park employees to build consensus for proper treatments,
- identification of pests and use of specific aspects of their biology to assist in their control,
- strong dependence on inspection and monitoring for early detection of pest invasion,
- establishment of priorities,
- establishment of Action Thresholds for pest management,
- integration of both chemical and non-chemical control measures,
- periodic evaluation of program efficacy, and,
- maintenance of records on treatments and results.

C. Objectives

- To define the roles and responsibilities of persons involved in the pest management program and provide sufficient information to enhance program success.
- To identify pest problems and to develop Action or Threshold Levels (i.e., points where pest populations or environmental conditions indicate management actions must be taken).
- To provide rational, safe, effective IPM alternative methods for pest management within NPS procedural policy guidelines which describe management actions necessary to modify habitats to reduce or limit the buildup of excessive high pest populations.
- To establish the necessity of periodic site inspections and monitoring to document when Action Thresholds are being exceeded.
- To emphasize the needs for evaluating the post-treatment results of habitat modifications or pesticidal treatments through periodic pest population monitoring and the need of written documentation for any management actions taken, data collected, and results obtained.
- To minimize the reliance on pesticides and establish that pesticides will only be used if absolutely necessary and as approved by the Southwest Systems Support Office (SWSO) and Washington (WASO) offices. Pesticides used will be the least toxic, most effective, and most efficient for providing longest contact time with pests, used only at times when pests are in the most vulnerable stage, and used at times posing the least possible hazards to persons, resources, or environment.

This Plan will provide, in addition to non-chemical controls, listings of effective pesticides which under given sets of conditions will be approved through SWSO and/or WASO.

The park manager may have to slightly adjust some elements of this Plan to the specific needs and organization of the park; however, this guideline, if followed, will greatly assist in preventing and managing pests in the park.

D. Roles, Responsibilities and Inter-Divisional Relationships

All operations in the park must support employee and visitor health, safety, and protection of park resources. Pest management activities which deal with all of these concerns is a program crossing several disciplines and all park divisional lines. Many persons in the park, ranging from managers to residents, are involved in pest management activities at some time or another. If the park pest management program is to be effective, it is important for the entire staff (as well as concessionaires and other non-NPS interests in the park) to participate as a problem solving "team". Various roles and responsibilities for a park IPM program are described below.

1. Superintendent: Responsibilities for the park IPM program are delegated to the park Superintendent and responsibilities for program implementation are delegated to both the Superintendent and to a designated park IPM Coordinator. The Superintendent also:

- having ultimate responsibility for the park IPM program, should make every possible attempt to provide manpower and funding to effectively carry out the program and to support the necessary pest monitoring, exclusion, and management needs.
- should outline the park IPM Policy and IPM Program and inform employees, through written memoranda, about the needs, requirements, and importance for conducting the program in the park.
- should designate IPM inspection, monitoring, and pest management duties to at least one permanent, trained IPM Coordinator and may select Assistant IPM Coordinator(s) for outlying districts or sites. If trained persons are not available, training should be made available to person(s) holding IPM duties within six months of designation. The Position Description for the IPM Coordinator should provide good coordination with park staff (especially museum and Maintenance staff), outline specific IPM duties, and provide scheduling to complete IPM activities.
- should designate museum and curatorial storage duties to a trained Museum Curator and assign a second employee as a "back-up" and who will be trained by the Museum Curator. Duties and responsibilities for these persons should be described in the official Position Descriptions.
- may set or modify threshold values or preferred pest control methods to meet existing needs or management objectives. Before initiating any pest control activity, the Superintendent must decide that pest management is necessary because: accepted Injury or Action Thresholds are being exceeded and pests are causing or will cause unacceptable levels of resource damage; existing infestations provide potentials for human health hazards; or, without control, pest numbers can be expected to continually and unacceptably increase.
- assign the park IPM Coordinator and Museum Curator and other staff to review the park IPM Plan at least every 3 years for possible changes or additions.
- will request professional assistance from the State Department of Health Services (Vector and Zoonotic Diseases Section, Division of Disease Prevention) for:

- Inspecting, testing, and/or necropsy of animals or parasites for the possible presence of plague, rabies, Hantavirus, or other infectious diseases.
- Collecting or identifying parasitic arthropods (fleas, ticks, mites, etc.) that may carry diseases.
- Current information on the occurrences of pest-borne disease outbreaks near the park

2. Park IPM Coordinator: General responsibilities of a park IPM Coordinator are addressed in NPS-77 Natural Resource Guidelines. The BIBE IPM Coordinator:

- will gain proper identification for all pests that detrimentally affect park resources or pose health or safety concerns. When rodents or small animals can not be identified in the park, specimens will be properly preserved and sent to specialists. Identifications of larger animals (porcupine size or larger) will be made by specialists from clear photographs.
- will maintain and continually update (as new information is available) permanent files for each pest listed in the IPM Plan.
- will inspect facilities and monitor for seasonal changes in the size of pest populations, document potential and actual damage caused by pests, and recommend the least toxic methods for controlling pests.
- will identify and monitor the cultural and/or environmental conditions in the park that encourage or support pests and will develop programs for remedial actions.
- will evaluate all available physical, mechanical, and cultural pest control options for acceptability and/or feasibility before using chemical pesticides.
- will assure required NPS approvals are obtained before any pesticide is used in the park. The Coordinator will be responsible to inform pesticide applicators, whether in-house or contracted, about NPS policies concerning pesticide use; monitor applicators for safe application; and assure applicators follow label precautions and application guidelines.
- will establish techniques to measure the relative efficacy of pest control success and keep the Chief of Maintenance informed about the results of inspections and evaluations.
- will consult with the Cultural Resources Specialist before initiating any structural modifications or other pest management activities that might affect cultural resources.
- will make the information on pesticides used or areas treated in the park available to both the public and employees.
- will prepare appropriate forms and maps for recording data from timely monitoring and inspection activities. Inspection and monitoring reports will list deficiencies found and "flag" them for repair by the Maintenance Division. The IPM Coordinator will establish and maintain permanent files of inspection and monitoring results.
- will train the park staff, to enable them to complement the IPM effort in the park.

3. Museum Curator: Pest management duties for the Museum Curator are important to the park IPM program. The Museum Curator will:

- at least semi-annually (preferably, monthly) physically inspect the entirety of the museum and museum storage areas and take notes on harborage available to pests, pest evidence,

damage to historical artifacts, and structural defects or conditions that encourage pests. Inspections will record defects or needed repairs on maps or floor plans. Additional "spot inspections" may be made at other times during the year, as dictated by needs. Inspection results will be recorded on Museum Inspection Reports and permanently filed for future reference.

- thoroughly vacuum museum storage areas at least weekly.
- will continually monitor park museum and museum storage areas with sticky, pheromone, light, or snap traps; flour tracking boards; or other suitable means to detect the presence of pests and record and file the findings on Museum Monitoring Reports.
- will semi-annually (preferably in early spring and late summer), as an assistant to the IPM Coordinator, inspect the exterior of the building(s) housing the museum and curatorial storage area and any other buildings used for incidental museum storage. Findings will be recorded on permanent Museum Inspection Reports. Open rodent burrows along the exterior of building(s) will be visibly marked, recorded on maps, filled with dirt, and re-visited to determine if they are being actively used by rodents.
- will increase monitoring efforts when inspections provide evidence of museum pest or rodent activity and, based on accepted Action Thresholds, and contact the IPM Coordinator for recommended methods of pest management.
- will send copies of all Inspection and Monitoring Reports to the park IPM Coordinator who will advise the Superintendent of the findings. The Museum Curator and/or IPM Coordinator will use findings from the Inspection and Monitoring Reports to justify Work Orders for structural repairs which will be directed to the Chief of Maintenance. The IPM Coordinator will maintain a permanent file of work completed.

4. Chief of Maintenance: The Maintenance Division serves an extremely vital role in park pest management.

- The park Maintenance staff must be alert to conditions and signs of pest and pest damage and, when found during routine maintenance, report such information to the IPM Coordinator (i.e., rodent feces on office or Visitor Center floors, termite damage, rodent burrows under structures, evidence of bat roosts, etc.) .
- Custodians will assure good sanitation in the Visitor Center/Office Building by thoroughly vacuuming the Visitor Center and display area floors daily and vacuuming other rooms and offices in the building at least weekly; not leaving trash in the building over night; keeping windows and doors closed; and quickly reporting obvious pest damage/infestations, plumbing leaks, and other conditions supporting or encouraging pests.
- The Maintenance Division will punctually schedule repairs of all reported structural, utility, or vegetative deficiencies that support or encourage pest infestations. Where possible, proper grade will be established around buildings for water drainage.
- The Maintenance Division will promptly remove all construction or other non-functional debris (rocks, lumber, etc.) lying in or around park structures or place it on elevated racks and otherwise assure good area sanitation procedures.

5. Park Rangers and other roving employees: Park Rangers and other employees whose duties cause them to frequently travel within the park will continually watch for food (in the form of trash or garbage), water, and harborage available to pests and promptly report such conditions to the IPM Coordinator. They must be alert to conditions supporting pests, signs of pests, and pest damage. Park Rangers will constantly remind visitors to not feed or water animals and to

place food refuse only in covered garbage receptacles.

6. Chief of Resources Management (both Cultural and Natural): The Divisions of Cultural and/or Natural Resource Management will prepare Resource Management Project statements covering significant IPM plans or operations. Where appropriate, proposals should seek to obtain support funding from the Natural Resource Protection Program, Forest Pest Management Program, and other sources.

7. Park Safety Officer: The Park Safety Officer serves an influential role in park pest management. During all safety inspections, the Safety Officer will watch for and report to the IPM Coordinator any evidence of pests, destructive or hazardous conditions caused by pests, and inappropriate pesticide storage. Health and safety hazards concerning pest infestations will be noted in Safety Inspection Reports. The Safety Officer will:

- coordinate with the IPM Coordinator and staff to assure employees are provided with the latest information concerning health and safety matters surrounding pests.
- during safety inspections or monitoring of park resources, encourage employees to follow safety and health requirements.
- monitor applications of Restricted-Use or state-limited-use pesticide compounds for safe application methods.

8. Chief of Interpretation: The Division of Interpretation will inspect for, monitor, and correct (if possible) any conditions of inadequate sanitation or the availability of pest harborage in the Visitor Center, display, and other interpretive areas. Interpretation will assure stored boxes, papers, equipment, and other materials are placed on shelving or pallets off the floor to allow for cleaning, inspection, and pest management measures. Employees in the Division will constantly remind visitors to not feed the animals and to place food scraps and garbage in covered receptacles.

9. Concessions Specialist: The Concessions Specialist is responsible for assuring concessions and other non-Federal operations are regularly inspected and monitored for pests and will report to the IPM Coordinator poor sanitation conditions, irregular cleaning schedules, poor garbage practices, availability of pest harborage, and use of non-approved pesticides. The Concessions Specialist will insure non-Federal operators comply with recommendations from Public Health Officers and the park IPM Coordinator.

10. Other Employees: All persons (Contracting Officer, Warehouse Manager, Housing Officer, Supervisors, Foremen, and private contractors, concessionaires, cooperative associations, etc., as appropriate) who may be involved in purchase, storage, and use of pesticides in the park are responsible for assuring proper IPM procedures and NPS and Departmental pesticide approval policies are followed.

11. Park Residents: Park residents (including non-NPS residents) are responsible for assuring their quarters and areas surrounding their quarters are kept clean and do not attract or harbor pests. Residents are responsible to promptly report structural deficiencies and other maintenance needs supporting pests to the IPM Coordinator and Division of Maintenance. Residents are not allowed to use pesticides (insecticides, rodenticides, herbicides, etc.) which have not been previously approved through the park IPM Coordinator.

12. Southwest System Support Office IPM Coordinator: The SWSO IPM Coordinator is a major part of the park IPM program and serves as a liaison between the park and the Servicewide IPM Coordinator to: provide IPM training and information to develop management strategies, keep the park apprised of changes in policy or pest management technology, review proposed pesticide application programs and projects, and confirm proposed use of pesticides are essential

within an IPM strategy.

IV. MAJOR PEST MANAGEMENT ISSUES

Major pest issues at BIBE relate to the needs for preserving cultural and natural resources to the maximum extent possible while also providing for the health, safety, and comfort of visitors and staff. The following list of pest concerns at BIBE was gathered as background for the current IPM Plan:

Mice and woodrats inside structures: Native mice (Peromyscus eremicus and other Peromyscus species) and pack rats (i.e., woodrats; Neotoma albigula, Neotoma mexicana, and Neotoma micropus) are the most common rodent pests that enter residences, NPS warehouses, and other structures. Although only 2 cases of Hantavirus (Sin Nombre virus) have been reported in Texas, none of the rodents submitted for testing by BIBE showed positive for the disease. Yet, the park staff remains concerned about unsanitary conditions caused by mice and possible transmission of the disease as well as potential rodent-caused damage to structures, electrical lines, and equipment.

Cockroaches: German cockroaches are a continual problem in residences, Visitor Center coffee room, and other NPS buildings. Oriental cockroaches infest the sewers that serve the concession operation in the Chisos Basin. Cockroach infestations possess great potentials for spreading disease and causing allergies.

Fleas: Nearly all park residents keep pets and periodically experience flea problems in their residences. Flea problems can also occur in residences, offices, and other buildings when wild animals make dens under buildings or in chimneys/vents.

Bees, wasps, hornets, and yellow jackets: Every fall, wasps and yellow jackets become common problems around residential areas and continue to worsen until the arrival of cold winter weather. Yellow jacket problems are greatest under buildings and in partially-buried water control boxes. Numerous swarms of Africanized bees have been found in the park but swarms have not yet appeared in the Chisos Basin area which is heavily used by visitors.

Scorpions and centipedes: Scorpions and centipedes are common pests in park residences during most of the year.

Ants: Numerous kinds of ants occur in BIBE but at least 3 of those species become common residential pests in houses and around the concession buildings. Stinging harvester ants are an additional species which poses continual problems in developed areas.

Vertebrate pests: Skunks, ringtail cats, and other larger mammals sometimes enter residence attics or crawlspaces and other structures where they cause odors, nuisances, damage, and introduce fleas. Javelina, deer, and bears often enter visitor-use areas and seek food from visitors or scatter garbage and become nuisance pests.

Spiders: Black widow spiders occur around residences and park shop buildings.

Bedbugs: About 2/3 of the park seasonal employee trailer residences are infested with bedbugs.

Conenose bugs: The K-Bar Research Station and some park residences have experienced serious problems with conenose bugs and various persons sleeping in the buildings have been bitten. Conenosed bugs can be of serious health concern to persons allergic to the bite and this insect can be a vector for Chagas' Disease in some parts of the United States.

Rattlesnakes: A number of rattlesnakes are found each year around residential and visitor-use areas but there has only been one rattlesnake bite suffered in BIBE during the last 5 years.

Vultures: Vultures are continual pests in the campgrounds. The birds stain campground facilities with their feces and steal or contaminate food left out by campers.

Vegetation: Many aggressive exotic plants which out-compete native vegetation occur in BIBE such as saltcedar, mesquite, Johnsongrass, Bermudagrass, thistles, and buffleggrass. Mesquite occurs throughout the park but is particularly troublesome in the campground. Saltcedar is very dense along the Rio Grande River and around some desert springs. Vegetative growth around buildings poses fire hazards and encourages insect and vertebrate pests. Spiny weeds along roadways sometimes cause tire damage to vehicles.

V. IPM METHODS

A. Pest Identification

An important first step in IPM is the accurate identification of suspected pests. Correct identification provides ways for obtaining additional information on pest species. All problem pests in BIBE will be identified to genus and, if possible, to species. Records will be kept on the occurrence, relative seasonal frequencies and dates of pest sightings, potential and actual damage caused by pests, health threats, and other pertinent biological data.

B. Inspections and Monitoring

The underlying reasons for most pest infestations are usually found through inspection and pre-treatment monitoring. Any pest management measures taken in the park will first begin with an inspection to identify the sources, kinds, and extent of infestations and then followed with monitoring programs to detail changes in pest infestation.

Inspections and monitoring in BIBE will be keyed to identifying the occurrence, abundance, and trends of pest populations and to note conditions forecasting increased numbers of animals (increased deterioration of structures or habitat productivity). These activities will serve as a forewarning for potential future pest problems, document and "flag" needed repairs, and provide descriptions of deficiencies on area maps and/or structural floor plans.

The terms "Inspections" and "monitoring," although appearing as similar activities, may at times be confusing. They differ in the following way:

- "**inspection**" refers to the initial discovery of pests or conditions possibly supporting them
- "**monitoring**" is to watch or measure conditions over time to determine if pest populations are static, decreasing, or increasing and then making judgements regarding the significance of those findings. The need for continual monitoring, especially for rodents, is clear when it is known that pest populations can rapidly increase during even one year and, when large, require much more effort and time to control. Additional guidelines for inspection and monitoring are found in NPS-77, Chapter 2, pages 226-227 and in Appendix III.

Monitoring and inspections for pests and pest damage will concentrate on obtaining information on the:

- existence, extent, and severity of pest infestations
- locations of pest harborage, food, water, and activity areas
- reproductive, life history, and behavioral information for pests
- safest and most appropriate management strategies as based on site limitations

1. Periodicity of Inspections and Pre-Treatment Monitoring

The IPM Coordinator will make full inspections of all park facilities at least twice a year. The first inspection will be made during early spring (from February to March) before pest populations begin to increase and the second inspection will be made during late fall (probably in November) before native rodent pests begin to enter structures. Additional "spot inspections" may take place at other times during the year, as dictated by need. The park IPM Coordinator will schedule inspections and prepare appropriate inspection and monitoring forms and maps for use in documenting inspections.

Continual monitoring of park facilities by the IPM Coordinator will provide comparisons of monthly data and information on reproductive and/or immigration influxes in pest numbers, possible changes in damage caused by pests, information on the relative effectiveness of pest controls, and serve as a guide for planning future controls. Annual trends in precipitation and other weather data will be recorded as an "early warning" of potential future pest problems.

Once or twice a year, during monitoring, photo point records may be made of various or selected special problem areas most susceptible to pest damage. A comparison of records will provide insights into accumulative damages.

When completed, inspection and monitoring data will be filed by the IPM Coordinator in a permanent IPM file and necessary structural repairs will be documented and referred to the Chief of Maintenance for prioritization.

2. Post-Treatment Monitoring and Evaluations

One of the most important parts of a successful pest management program is post-treatment monitoring. It provides for evaluations of the adequacy of treatment, cost-benefit ratios, and guidance for future programs. Where treatments are shown partially or wholly ineffective, post-treatment monitoring and evaluations will provide ideas for improvements that lessen cost, make treatments easier or faster, or increase the permanency of control. The need to improve treatments may indicate a need to re-schedule treatments to different times of the season, year, or day or to make treatments at different stages in a pest's life or activity. All new ideas or alternatives that appear during control activities should be evaluated for possible inclusion in the program.

C. Sanitation

Environmental cleanup is vital in pest management by reducing food, water, and harborage available to pests. Although no amount of effort will remove all the potential resources available to pests, good attention to sanitation will do much to limit a site's "carrying capacity" and ultimately reduce pest numbers and make early detection easier.

1. Interior Sanitation

Because insect pests survive and rapidly reproduce inside structures, good interior sanitation is mandatory for controls to be effective. Many pests go for great lengths of time without feeding at all or obtain abundant food from such unusual but commonplace things as lint, fabric fibers, and mold. All rooms and curatorial storage areas should be inspected to assure such areas are not attractive to or do not support pests.

-Frequently vacuum in and around equipment, furniture and cracks and crevices, closets and other dark areas. Cleaning denies pests both food and harborage and reduces insect survival rates. Remove or clean vacuum bags as soon as vacuuming is finished; do not allow bags that may contain live pests to remain in the building.

- Remove all possible sources of food materials, especially grains and potted plants from museums and curatorial areas. Do not bring live flowers into the museum or curatorial areas.
- Check for dead insects or rodent carcasses on traps and remove them from the building.
- Establish an orderly storage of goods and boxes up off the floor onto shelves or pallets to allow for cleaning.
- Proper refuse and garbage disposal are very important, do not leave garbage in buildings overnight.
- Repair leaking plumbing. Insulate cold water pipes which collect condensation. Control sources of sub-floor moisture with increased ventilation.
- Place all pop and candy or snack machines outside of the building so that water condensation and crumbs will not attract pests into the building and to assure pests are not imported into buildings with supplies. Do not keep empty recyclable aluminum cans inside buildings.
- Clean lint and other organic materials out of: stoves, refrigerator coils, other motors, closets and storage areas.
- Keep all foods in the break rooms and at desks in tightly sealed glass or plastic containers. Immediately clean up food, dirty dishes, and food spills. Do not leave garbage inside the building at night.

2. Exterior Sanitation

Rodents (and other pests) commonly move into structures from outside locations and then return outside again. Good exclusion is aimed at reducing or preventing such movement. Seasonally, outdoor environments can support high numbers of animals (by providing harborage and food) which results in crowding of populations and encourages pests to enter buildings. It is important to practice good sanitation and habitat reduction around buildings to lessen these population pressures.

- Remove all trash, debris, boxes, logs, stones, rocks and other sources of pest harborage.
- Store firewood, lumber, and other supplies up off the ground and away from buildings to lessen harborage available to pests.
- Remove weeds and accumulations of leaves, grass clippings, and other debris from around buildings. Establish a weed-free zone 24 or more inches wide next to buildings to eliminate pest harborage.
- Improve garbage and trash handling methods and keep trash cans and areas around cans clean. Keep tight fitting, secure lids on all garbage containers.
- Improve grade around buildings. Fill or drain low-lying areas that accumulate puddles of water. Repair leaking air conditioners or other pipes and faucets.
- Improve drainage from roofs and down spouts by cleaning gutters and drains frequently.
- Thin or remove dense vegetation around buildings. Some flowering shrubs (i.e., Spirea) draw adult Dermestid beetles during spring, just at the time doors are more likely to be left open. Beetles are attracted inside by food odors and warmth where they lay eggs.

-Do not place bird feeders near buildings. Continually remove bird nests from building eaves or doorways to prevent attracting pests to feathers, dead insects, animal excrement, etc.

-Mount outside lights at least 30 feet from buildings and aim them to shine back onto the building. Use high pressure sodium vapor lamps, which attract fewer insects.

D. Action Thresholds

Action Thresholds are criteria used to justify the initiation of pest controls. The principal objective of any IPM program is to suppress or manage pest populations to keep their numbers below an Action Threshold, rather than trying to eradicate pests (normally impossible or very expensive). Usually "working" Action Thresholds are first established and then refined with information gained through monitoring programs. Criteria used to establish Action Thresholds are based on estimates or observations of:

- pest population numbers
- documented damage to structures or natural resources
- costs for repair or replacement of damage
- data generated by monitoring programs
- knowledge of pest biology (especially reproductive potential)

Based on inspection and monitoring findings and specific biological attributes of pests, Action Thresholds will be established (see descriptions of individual species) to determine the needs for controlling specific pests. The Superintendent will review and may set or modify threshold values or preferred control methods to meet needs or management objectives.

E. Controls

Needed pest control in BIBE will be based on established Action Thresholds and then will employ all possible physical, mechanical, cultural, and biological control feasible; and to include exclusion, sanitation, habitat modification, and direct removal. NPS-approved chemical pesticides will only be used as a last resort when other controls do not achieve acceptable results.

Control alternatives are many; however, the success of controls relies heavily on persistence and diversification. Never give up on controls, don't rely on any one, single control or preventive measure, not even those that were effective last year. Keep trying different controls until finding those that work. Pest control methods are most effective when used in combination.

Additional information on the management of specific pests at BIBE is found in the attached descriptions.

F. Records

All pest management inspection, monitoring, and photo record point data and notes of exclusion and sanitation measures will be kept in permanent IPM files that document the timing, techniques, and kinds of pest control actions taken. Periodically, data will be evaluated to determine the relative effectiveness of specific control efforts.

The IPM Coordinator will complete, submit, and file all 10-21A Requests for Pesticide Use and annual Pesticide Use Log forms. These will be made available to interested parties.

Permanent IPM files will be maintained which contain the names and addresses of persons having technical expertise to manage specific pests. Files will also be maintained on the sources of pest management and chemical pesticide supplies, local pest control operators, local state health departments, and other pertinent information that applies to the park IPM program.

VI. HUMAN HEALTH AND SAFETY CONCERNS

A. Diseases

Most pests come into direct contact with rotting debris, soil, and other sources of disease organisms as a result of their feeding and secretive habits and may spread diseases to humans. The potential for the spread of disease is the most important reason supporting effective pest management.

Because of recent Hantavirus outbreaks in the United States, all persons engaged in rodent monitoring, trapping, inspecting programs or clean up of rodent debris or other duties where brought into contact with rodents or rodent debris will wear approved personal protective equipment and follow appropriate state Department of Health and Federal Centers for Disease Control (CDC) guidelines for both personal safety and removal of rodent feces/debris (see Appendix). At a minimum, personal protective equipment will include rubber gloves, hard hat, coveralls, and a respirator capable of filtering particles as small as 0.3 microns in size (e.g., HEPA filter). The use of a respirator equipped with a HEPA filter may also be required to prevent other aerosol-transmitted diseases such as spore-borne valley fever. Prior to use, persons wearing respirators will conform with OSHA guidelines for a Respiratory Program, 29 CFR 1910.134.

Some of the other more common and important rodent-borne diseases that can affect humans are: bubonic plague, murine typhus, leptospirosis, salmonellosis, lymphocytic choriomeningitis, rickettsial pox, rat bite fever, trichinosis, tapeworms, ringworms, tetanus, and hemorrhagic fever (or, "Sin Nombre" virus; i.e., Hantavirus). Additional descriptions of diseases are found in the Appendix.

Rodents (and other mammals) and birds carry parasites that can spread diseases to humans. In disease endemic areas, the State Health Departments recommend controlling rodent parasites (specifically ticks and fleas) both before and during rodent control programs in order to lessen the spread of parasite-borne diseases to humans.

Bird nests on buildings and rodent nests, dead carcasses, and stored foods inside of structural voids attract a variety of insect pests (i.e., stored product pests) which often invade human food supplies or seriously damage museum collections. Many people who live in structures infested with cockroaches, mice, or birds develop serious allergies or otherwise become ill as a result of inhaling air-borne pest droppings or body parts.

Employees and residents will be informed about the mode of transmission of Hantavirus (and other pest-borne diseases and ectoparasites) and will follow CDC recommendations for controlling rodent populations and handling, disinfecting, and disposing of pest feces, debris, traps and other soiled items. Park management will decide whether traps that have captured rodents will be disposed of in approved manners or properly disinfected for re-use.

B. Wildlife Safety Concerns

Mice often nest in, under, and around electrical and kitchen appliances where they damage wiring, reduce ventilation around electrical motors, and contaminate foods. Rodents gnaw on electrical wiring and are considered an important initial cause of many structural fires. Serious consequences can develop when rodents damage electrical wiring or fluid hoses in emergency vehicles.

It is not uncommon, especially for children, to be bitten while trying to feed or catch deer, javelina, or rodents (ground squirrels and chipmunks). Although rabies is relatively common in the Southwest, rodents seldom carry the disease and rodent bites more likely result in tetanus. Venomous bites by rattlesnakes are a safety and health concern. Visitors are sometimes stung by harvester ants, bees, wasps, and yellow jackets on trails as well as in developed areas. Adequate public warnings will be posted to inform visitors and staff of potential hazards surrounding wildlife.

In areas where larger animals are known to be possible disease carriers, mammals caught in live- or other kinds of traps and dead animals should be handled with gloves. In disease-endemic areas, it may be advisable to control parasites (fleas, ticks, etc.) before approaching trapped animals. The local health authorities should be consulted for the latest recommendations on parasite control.

Snap, Conibear, snare, and foot traps used in above ground locations are not selective and may, if unprotected, kill or injure non-target animals. Whenever possible, traps used to control wildlife will be covered or protected to prevent injury to non-target species. Traps will be checked at least twice a day to prevent curious people/animals from being bitten or coming into contact with captured animals.

C. Pesticide Safety Concerns

Pesticides are insecticides, herbicides, fungicides, rodenticides and other chemicals used to control, prevent, destroy, repel, or regulate pests. Required approval processes must be met before using any pesticide on NPS property.

Because of their nature, pesticides are poisons and can injure or kill people, pets, and livestock; damage beneficial insects, birds, fish, and other wildlife; and they can harm desirable plants. Therefore, it is mandatory for such materials to be very carefully managed and handled during storage, transport, mixing and loading, application, and disposal.

Pesticide Storage, Use, and Disposal

Storage: Pesticides and fertilizers will be stored both before/after use in safe manners as described on pesticide labels and in posted, non-flammable, temperature-protected, and locked facilities. Pesticides will not be stored with other products; insecticides and herbicides will be stored in separate facilities; and established pesticide shelf-life guidelines will be followed. Material Safety Data Sheets (MSDS) will be kept on file in the park for all chemical pesticides used or stored.

Use: Pesticide labels contain directions to protect workers and reduce exposure to non-applicators. Violations of those directions is a violation of FIFRA. Existing labels on incoming chemical containers will not be removed or defaced and, under OSHA's Hazard Communication Standard (29 CFR 1910.1200), workers will be provided with training, protective equipment, and information (MSDS) about the hazardous substances they may handle. Pesticides will not be stored in or moved into unapproved or unmarked containers. Information will be made available to the public regarding any pesticides used and areas treated. Listing and records will be kept for all pesticides used or stored in the park.

Disposal: All pesticides, rinsates, and pesticide containers will be disposed of as per pesticide label directions and regulations established by EPA (40 CFR 116-117, 165, 170-172), and the Resource Conservation and Recovery Act, (40 CFR 261.30-33).

Residential pesticide storage: Safe storage of pesticides in personal residences in the park is critical for the protection of residents, their children, and domestic animals. Residents will be informed of the recommended guidelines for storing pesticides in the home.

- Do not purchase pesticides for use in or around your residence, garden, or yard which have not been approved through the park IPM Coordinator.
- Keep all pesticides locked up.
- Do not store pesticides in the same cupboards with food, animal feed, seed, or water.

- Do not store pesticides beneath the kitchen sink where they are in reach of children.
- Store pesticides in dry, cool, well-ventilated places, away from sunlight and at temperatures above freezing.
- Mark all entrances to pesticide storage areas with a sign: "Pesticides Stored Here - Keep Out."
- Store and keep all pesticides ONLY in original and originally-labeled containers.
- Clean up spilled and leaking pesticides immediately.
- Indelibly write the date of purchase on pesticide containers.
- Many pesticides are flammable, take adequate precautions against potential fire hazards.
- Keep all safety data and other information that comes with pesticides.
- Do not mix storage of herbicides and insecticides; keep them in separate storage lockers.
- Keep the Poison Center phone number available: 1-800-732-6985.

D. Other Safety Concerns

After applying pesticides in areas subject to visitor use, post the treated areas until the pesticides are dry.

Employees will take safety precautions in using ladders and tools and be informed about other specific work and pest hazards concerned with IPM duties. These may include:

Workers on ladders and scaffolds will be warned about the hazards of encountering stinging honey bee, wasp, hornet, and yellow jacket colonies.

The public will be kept away from bee and wasp control operations and employees will wear adequate personal protective clothing.

Employees handling live poisonous snakes will be trained and only use the proper equipment and keep the public back. Poisonous snakes will be transported and released in safe manners. Also see, EMPLOYEE TRAINING.

Trees located in park use areas that are severely injured or killed by pests will be evaluated by the park hazard tree program personnel.

VII. EMPLOYEE TRAINING

It is recommended that Park IPM Coordinators receive 40 hours of initial IPM training and be certified as a pesticide applicator in their state of residence. Training is critical for the safety of NPS employees and the success of the IPM program and recommendations are for all personnel who engage in pest management work to avail themselves of as much training as possible. This is especially true for those personnel handling venomous animals and/or large or dangerous animals. Important contacts for training (classroom and correspondence courses, videos, books, etc.) and other IPM information include the park and cluster training officers, professional pest control groups, and various state and Federal agencies.

It should be noted that the State of Texas does not require federal employees who only apply general

use pesticides on federal land to be certified. However, if the federal applicator applies federal or state restricted use pesticides, that applicator must be certified. For instance, although 2,4-D is not a federally restricted herbicide, it is a state restricted one and an applicator has to be certified by the state to apply it in the park. If there are any questions about the state registry status of any pesticide, call the State Department of Agriculture for information. Their telephone number is: 512/463-7544.

VIII. FREQUENCY OF PLAN UPDATES

This IPM Plan for BIBE will be kept current on computer disk and reviewed for updating no less than every 4 years in order to update pest management procedures; include new technological advances; note changes in the NPS pesticide approval processes; record changes in local technical resources and/or emergency numbers (County Extension, Department of Health, etc.); add data for new buildings or pest problems; include new information on local disease problems; update Federal, state, and local laws and park and Service policies; and solicit additional input from park Divisional chiefs or other sources, as applicable.

IX. SPECIFIC FTE AND BUDGET NEEDS FOR PRO-ACTIVE PARK IPM PROGRAM

The Superintendent will provide sufficient manpower and funding to effectively carry out a pro-active IPM program in BIBE and will make budget and manpower available to support annual monitoring, exclusion, and pest control needs.

X. STATEMENT BY PARK MANAGEMENT IN SUPPORT OF THE PARK IPM PROGRAM

The intent of the IPM Plan for BIBE is to fully support the goals included within the Service-wide IPM program and to provide for the health and safety of park staff, visitors, and residents. The Superintendent is responsible for the pest management program and will designate at least one trained park IPM Coordinator to direct and implement the park IPM program as outlined by NPS-77, Natural Resources Management Guidelines (May, 1991).

All pesticides used in BIBE shall be in strict accordance with Servicewide policy found in NPS-77, Natural Resources Management Guidelines. All pesticides used by residents, contractors, concessioner, special-use permittee, agricultural lessees, or any non-NPS personnel in the park will conform to NPS policies and guidelines and prior to use must receive approval, following NPS policies.

No "preventive" pesticide treatments will be made in the park unless prior NPS approval is obtained. Unapproved applications could result in environmental contamination, pose serious health hazards to personnel, or cause rapid development of pesticide resistant pest species. Preventative applications will be considered to be "application of a pesticide in the absence of a target pest" and, as such, a violation of Federal law.

Following use, the pesticide applicator or park IPM Coordinator will document treatments using the new NPS IPM computerized data base, copies of which will be submitted to the SWSO at the end of each calendar year. Personal use of pesticides by employees in residences or by individuals in community gardens must conform with established Service policies, guidelines, and approval processes. The park IPM Coordinator will monitor all use of pesticides by residents and supply them with the most recent IPM information available for managing households, gardens, or nuisance pests by the least toxic methods possible.

Native insects/diseases will be allowed to function unimpeded except where control is required:

- for reasons of public health (as defined by CDC) or safety.
- to prevent the loss of host or host-dependent species from an ecosystem

- to prevent outbreaks of insects or diseases from spreading to floral or faunal communities or populations outside the park
- to conserve U.S. Fish and Wildlife Service Listed or Proposed endangered species,
- to conserve and protect flora and fauna in developed zones, or
- to preserve, maintain, or restore the historical integrity of cultural resources.

Exotic plant and animal species already present in a park will be manipulated/eradicated whenever such species threaten the protection or interpretation of resources being preserved in the park by:

- being detrimental to public health
- disrupting faithful presentations of the historic scene
- damaging historic and archeological resources
- threatening perpetuation of natural features, native species, natural ecological communities, or natural ecological processes
- significantly hampering management of adjacent park or non-park lands

All decisions to control exotic pest species will consider all possible impacts on park resources and will consider available alternative control methods and their probabilities for success. Plans to control pests or implement pest control activities for any of the above reasons will follow prescribed Service-wide IPM recommendations and guidelines. Great care will be taken to assure programs to control exotic pests do not ultimately result in significant or unexpected damage to native species, natural ecological communities or processes, or historic objects.

XI. PESTICIDES PREVIOUSLY USED AND POTENTIAL FUTURE PESTICIDE NEEDS

The following table lists pesticides used in the park during the last 5 years and also provides a listing of pesticides that might be considered for use at various times in the future. This listing does not provide common trade names for all currently listed formulations of specific chemicals and is intended solely to familiarize park staff with alternative products presently available. **This listing does not provide NPS approval for use.** When this plan is approved, the pesticides listed in the "Chemical Alternatives" portion of each species discussion are approved for four (4) years. A synopsis of these pesticides is listed in Appendix IX, which will be updated as needed to reflect any changes. If circumstances should indicate a need for other pesticides, a Pesticide Use Proposal should be prepared in the park and sent through the appropriate NPS channels.

PREVIOUSLY USED AND POTENTIALLY NEEDED PESTICIDES

PESTICIDES PREVIOUSLY USED OR REQUESTED

CHEMICAL	TRADE NAME	USE
Benzyl-diethyl methyl ammonium saccharide	Ro-Pel	repel coyotes and woodpeckers in residential area, campground, roadside signs
Boric acid (baits)	Drax; MRF-2000	ants in concession units; cockroaches in concession structure
Chlorpyrifos	Dursban-TC	termites by professional pest control operator
Glyphosate	Roundup	grass and weeds in pavement cracks and retaining walls

Hydramethylnon	Amdro	harvester ants in developed areas; cockroaches in residences
Pyrethrins	Wipe-V	insect repellent on livestock
Pyrethrum	PT-3-6-10	bedbugs in residences; conenose bugs in K-Bar Research Station
Pyrethrum and DDVP (22-dichlorovinyl dimethyl-phosphate)	Wipe-V	biting flies and gnats on livestock
Silica aerogel	Perma-Dust; Dri-Die	cockroaches in Administrative Building and concession Lodge, motel, stores, and quarters; conenose bugs in K-Bar Research Station
Trichloromonofluoromethane, dichlorodifluoromethane, methylene chloride, pine oil, rotenone, and pyrethrins	Wasp-Freeze	wasp and yellow jacket nests
Triclopyr	Garlon-3A	Tamarix control around natural water sources

POTENTIAL PESTICIDE USES

CHEMICAL	EXAMPLE TRADE NAME **	USE
2,4-D	Demise, Weed-B-Gone	herbicide; broadleaf weeds in grass
Acephate (with Experimental Use label)	various	Africanized honey bees; stomach poison
Allethrin and piperonyl butoxide aerosol	various	space treatments for flying insects
Ammonium soaps of higher fatty acids	Hinder	deer repellent
<u>Bacillus thuringiensis</u>	Dipel, Thuricide	webworms
Benzyl diethyl methyl ammonium saccharide	Ro-Pel	gustatory repellent; woodpeckers, gnawing rodents, etc.
Borate wood treatments	Bora-Care, Timbor	wood decay; carpenter ant, termite damage
Boric acid dusts	Perma-Dust, Roach-Prufe	cracks and crevices; carpenter ant galleries
Boric acid baits (liquid and solid; sweet and protein)	Drax	ants, roaches
Carbaryl dust	Sevin	outside pests (carpenter ants, carpenter bees); indoor pests (emergencies: ants, roaches, silverfish)
Carbon monoxide gas fumigation cartridge	Gopher-Gasser	animals in burrows
Chlorpyrifos	Dursban, Empire, Killmaster	carpenter ants, termites inside wood; outdoor pests; indoor ticks/fleas (health emergencies)
Cholecalciferol (vitamin D ³)	Quintox, Rampage,	rodents outside
Clethodim	Select	herbicide; annual or perennial grass in broadleaves
Copper-8-quinolinolate	various	wood preservative: fungus on wood
Diatomaceous earth with or without pyrethrins	Dialect, Diatomite	cracks and crevices; dust applications
Fenoxycarb (IGR)	gustatory inhibitor; Logic, Ultraban, Torus	ants (fire), fleas, roaches
Flea powder (commercial)	various	household pets
Flea soap (commercial)	various	household pets

CHEMICAL	EXAMPLE TRADE NAME **	USE
Fluorodinitrotoluidine	Balan, Benefin	pre-emergent herbicide; sand bur and crab grass
Glufosinate-ammonium	Finale	non-selective herbicide
Glyphosate	Roundup, Kleenup, Rodeo	non-selective herbicide; weeds in pavement cracks, herbaceous and woody weeds
Hexaflumuron (IGR) baits	Sentricon	termites
Hydramethylnon baits	MaxForce; Amdro, Siege, Combat	ants (harvester), roaches, crickets; termites
Hypochlorite (bleach)	Clorox	sanitizer for rodent feces/debris
Linalool (d-limonene)	Demize	fleas, ants
Mercaptans		odorous repellent (skunk odor)
Methoprene (IGR)	Altosid, Pharorid	fleas on household pets, ants
Mustard oil with capsaicin (commercial)	Get-Away	repellent; rodents, deer, rabbits, raccoons, and dogs
Napthalene (commercial)	Hinder, Shoo, Chaperone, PDCB	animal repellents
Paradichlorobenzene (commercial)	Snake-A-Way, Repel, PDCB	animal repellents
Potassium salts of fatty acids (soaps)	Insecticidal Soap	bee colonies, insects on plants
Permethrin	Permanone	fleas in animal burrows; acaricide on clothing
Pyrethrins	Wipe-V, various	flies on horses; contact sprays
Pyrethrum with piperonyl butoxide	various	mothproofing; contact sprays
Resmethrins	various	honey bee nests; space treatments; outside applications
Siduron	Tupersan	herbicide; annual grass in grass
Silica aerogel with pyrethrum	Tri-Die (PT-230), Silikil, Drione	cracks, crevices; insect pathways
Silica gel without pyrethrum	Dri-Die	cracks, crevices; insect pathways; flea control
Thiram	Arasan	gustatory deer repellent
Trichloromonofluoromethane with d-trans-allethrin and phenothrin	Wasp-Freeze	wasp, hornet, yellow jacket nests
Triclopyr	Garlon-3A	woody weeds; Tamarix, Chinese elm
Ziram		deer repellent; fungicide
** SPACE ALLOWS LISTINGS OF ONLY A VERY FEW OF THE MANY COMMON BRAND NAMES		

XII. REFERENCES

Akre, R.D., A. Greene, J.F. MacDonald, P.J. Landholt, H.G. Davis. 1980. Yellowjackets of North America. USDA Handbook #552.

Allen, Lawrence A. Urban Vertebrate Pests (Part I; Rodents, rats and mice). Van Waters and Rogers Pest Control Library, San Mateo CA.

Applied Myrmecology, Westview Press, 5500 Central Ave., Boulder CO 80301; 303/444-3541. Control of pest ants.

Arizona, State of. 1995. Video: A Homeowner's Guide to Safe Honeybee Control. Arizona Department of Agriculture, Agric. Ser., Univ. of Arizona,

Tucson AZ.

Bailey, Vernon. 1971. Mammals of the Southwestern United States. Dover Publications. 409 pp.

Baker, Rex O. and Gerald R. Bodman and Robert M. Timm. 1994. Rodent-proof Construction and Exclusion Methods. In: Hygnstrom, Scott E., Robert M. Timm, and Gary E. Larson, Prevention and Control of Wildlife Damage. Univ. of NE Coop. Exten. and US Dept of Agric., APHIS.

Ball, Jeff. 1988. Rodale's Garden Problem Solver. Rodale Press, Emmaus PA.

Barnes, A.M., L.J. Ogden, and E.G. Campos. 1972. Control of the plague vector, Opisocrostis hirsutus, by treatment of prairie dog (Cynomys ludovicianus) burrows with 2% carbaryl dust. J. Med. Entomol. 9:330-333.

Bat Conservation International, "Suggestions for Building Bat Houses and Attracting Bats", Brackenridge Field Laboratory, University of Texas, Austin, TX 78712.

Beard, M.L., S.T. Rose, A.M. Barnes, and J.A. Monteneri. 1992. Control of Oropsylla hirsuta, a plague vector, by treatment of prairie dog burrows with 0.5% permethrin dust.

Bennett, Gary W., John M. Owens, Robert M. Corrigan. 1988. Truman's Scientific Guide to Pest Control Operations; Purdue University, Edgell Communications.

Benson, Lyman, and Darrow. 1945. A manual of southwestern desert trees and shrubs. Arizona University Biological Science Bulletin, #6, Tucson Arizona.

Bonar, Ronald. The Northern Pocket Gopher: Most of What You Thought You Might Want to Know, but Hesitated to Look Up. US Dept. Agric., Forest Service, Publ. #9524-2807, Missoula Technology & Development Program, Bldg. #1, Missoula MT 599801.

Blair, W. Frank; A. P. Blair; Pierce Brodkorb; Fred R. Cagle; and George A. Moore. 1957. Vertebrates of the United States. McGraw Hill Book Co., New York NY.

Bradley, Joan. 1971. Bush Regeneration: The Practical Way to Eliminate Exotic Plants from Natural Reserves. The Mosman Parklands and Ashton Park Association, Mosman (Sydney), New South Wales.

Burt, William Henry. 1980. A Field Guide to the Mammals of North America North of Mexico. Houghton Mifflin Co., Boston MA.

Byford, James L. 1994. Nonpoisonous Snakes. In: Hygnstrom, Scott E., Robert M. Timm, and Gary E. Larson, Prevention and Control of Wildlife Damage. Univ. of NE Coop. Exten. and US Dept of Agric., APHIS.

CDC. 1977. Histoplasmosis control. US Dept. Health, Educ., and Welfare, Centers for Disease Control, Atlanta, GA.

Christensen, Dr. Chris, A Technician's Handbook to the Identification and Control of Insect Pests, 1983. Pest Control Technology, 4012 Bridge Ave., Cleveland OH.

Cole, M.M., and G.S. Burden. 1978. Fleas (order Siphonaptera) In Bram, RA (ed). Surveillance and collection of arthropods of veterinary importance. U.S. Department of Agriculture, Animal and Plant Health Inspection Service. Handbook # 518.

Communicable Disease Center. 1949. Rat-borne disease prevention and control. Public Health Service, CDC, Atlanta GA.

Cook, J. 1979. Clothes, Moths and Carpet Beetles. TX Agric. Exten. Serv., College Sta. TX.

Costello, D.F. 1966. The world of the porcupine. Lippincott, Philadelphia.

Craft, John A. 1990. Crickets. In: Mallis, A. Handbook of Pest Control, 7th Edition; Franzak & Foster Co., Cleveland OH.

Craven, Scott R. and Scott E. Hygnstrom. 1994. Deer. In Hygnstrom, Scott E., Robert M. Timm, and Gary E. Larson, Prevention and Control of Wildlife Damage. Univ. of NE Coop. Exten. and US Dept of Agric., APHIS.

Davis, William B. and David J. Schmidly. 1994. The Mammals of Texas. Texas Parks and Wildlife Press, Nongame and Urban Program, Austin TX 78744.

Durrant, Stephen. 1952. Mammals of Utah. University of Kansas Publ. Mus. of Nat. Hist., Lawrence KS.

Edwards, Stephen R., Bruce M. Bell, and Mary Elizabeth King. 1980. Pest

Control in Museums: a Status Report. Assn. Systematics Collections, Mus. Nat. Hist., Univ. of Kansas, Lawrence KS 66045.

Ehmann, Norman. Termites, Vol. 7. Van Waters & Rogers Pest Control Library, San Mateo California.

Environmental Sanitation Office, Washington DC. "Ticks and Lyme Disease in NPS"

Florian, Mary-Lou (conservation scientist, British Columbia Provincial Museum). 1986. The Freezing Process - Effects on insects and artifact materials. Leather Conservation News; 3(1):1-13, 17.

Forbes, C.F. and W. Ebeling. 1987. Use of Heat for Eliminating Structural Pests. IPM Practitioner 9(8):1-5.

Frantz, Stephen, 1986. Batproofing Structures with Birdnetting Checkvalves. IPM Practitioner, Vol. 8(9), September: 1-8.

Frazier, D.A. 1976. Insect Stings—A Medical Emergency. J. Am. Med. Assoc. 235(22):2410-2411.

Giles, Robert H. 1969. Wildlife Management Techniques. Wildlife Society, Washington DC.

Girardi, A., K. Hackett. 1982. IPM Binder for Yellowjackets: A Management Strategy, developed for NPS by John Muir Inst. for Environ. Studies., Napa, CA.

Glass, G.E., J. Johnson, G. Hoddenbach, et. al. (in press:), Rodent-proofing and HPS (Hantavirus Pulmonary Syndrome).

Gorenzel, W. Paul and Terrell P. Salmon. Swallows. 1994. In Hygnstrom, Scott E., Robert M. Timm, and Gary E. Larson, Prevention and Control of Wildlife Damage. Univ. of NE Coop. Exten. and US Dept of Agric., APHIS.

Greenhall, Arthur M. and Stephen C. Frantz. 1994. Bats in Prevention and Control of Wildlife Damage, Cooperative Extension Division, Institute of Agricultural and Natural Resources, University of Nebraska, Lincoln. Good details on bat control, a primary reference for bat control programs.

Harmon, James D. 1993. Integrated Pest Management in Museum, Library and Archival Facilities. Harmon Preservation Pest Management, P.O. Box 40262, Indianapolis IN 46240.

_____. 1994. Stepping Lightly. Pest Control Technology, Feb. 1994: 50-56.

_____. 1995. Preserving Artifacts. Pest Control Technology, Jan. 1995: 62-82.

Hall, Raymond. 1946. Mammals of Nevada. University of Calif. Press, Berkeley.

Hedges, Stoy. 1991. Managing Pests Without Pesticides. Pest Control Technology, Jan. 1991: 45-49.

_____. 1991. Field Guide for the Management of Structure-Infesting Ants. Franzak & Foster, Cleveland OH.

_____. 1992. Field Guide for the Management of Structure Infesting Flies. Franzak & Foster, Cleveland OH.

_____ and Mark S. Lacey. 1994. Field Guide to Management of Urban Spiders. Franzak & Foster, Cleveland OH.

Henderson, Robert. 1985. How to Trap a Coyote. Coop. Exten. Kansas State Univ., Manhattan Kansas.

_____ and Clifford W. Spaeth. Managing Predator Problems: practices and procedures for preventing and reducing livestock losses. Coop. Exten. Ser., Kansas State Univ., Manhattan, KS.

_____; Edward K. Boggess; and Robert J. Robel. Understanding the Coyote. Coop. Exten. Ser., Kansas State Univ., Manhattan, KS.

Hoffmeister, Donald F. 1986. Mammals of Arizona. University of Arizona Press and Arizona Department of Game and Fish.

Howard, W.E. 1994. Rattlesnakes. In: Hygnstrom, Scott E., Robert M. Timm, and Gary E. Larson, Prevention and Control of Wildlife Damage. Univ. of NE Coop. Exten. and US Dept of Agric., APHIS.

Hygnstrom, Scott E., Robert M. Timm, and Gary E. Larson, 1994. Prevention and Control of Wildlife Damage. Univ. of NE Coop. Exten. and US Dept of Agric., APHIS.

Jackson, William B. 1990. Rats and Mice. 74 pages. In: Mallis, Arnold. 1990. Handbook of Pest Control. Franzak & Foster Co., Cleveland OH. 1152 pages.

Knight, Dr. James, Controlling pocket gophers in New Mexico; New Mexico State University, Cooperative Extension Service, College of Agriculture and Home Economics and NMSU publication, pp. 1-5, #400-L-2.

_____. 1986. A Humane Method for Removing Snakes from Dwellings. Wildlife Soc. Bull., 14(3):301-303. New Mexico State Univ., Exten. Wildl. Unit, Coop. Exten. Serv., Las Cruces, New Mexico 88003.

Knipe, Theodore. 1957. Javelina in Arizona, A Research and Management Study. State of Arizona, Game and Fish Department, Phoenix AZ; Wildlife Bull. # 2.

Koehler, Philip G.; Richard S. Patterson; and Richard J. Brenner. 1990. Cockroaches. In: Mallis, A. 1990. Handbook of Pest Control, 7th Edition; Franzak Foster Co., Cleveland OH.

Krzyzik, Anthony, December 1989. Birds in Human Modified Environments and Bird Damage Control: Social, Economic and Health Implications. USACERL Tech. Rep. N-90/03, U.S. Army Corps of Engin., Constr. Engin. and Res. Lab. Extensive bird control bibliography.

Kunzmann, Michael R.; Roy Johnson; and Peter S. Bennett. 1987. Tamarisk Control in Southwestern United States: Proceedings of Tamarisk Conference, Univ. of Arizona, Tucson, Sept. 2-3, 1987. Special Report No. 9, Cooperative National Park Resources Studies Unit.

Levy, M.P. 1975. A Guide to the Inspection of Existing Homes for Wood-inhabiting Fungi and Insects. U.S. Dept. Housing and Urban Devel., Washington DC.

Lockard, John R. Bee Hunting. Fur-Fish-Game Book Dept., 2878 E. Main St., Columbus OH 43209.

Lowe, Charles H. 1964. The Vertebrates of Arizona. University of Arizona Press, Tucson AZ.

_____; Cecil R. Schwalbe; and Terry B. Johnson. 1989. The Venomous Reptiles of Arizona. Arizona Game and Fish Department, Phoenix AZ 85023.

Lowney, Martin. In print. Animal damage control pamphlet. US Department of Agriculture-APHIS, Mosely VA.

Ludeman, J. 1954. Here's one expert's opinion on porcupine control. Pest Control Magazine, 22(4):26,28,30,44.

Mace, Alice E. 1985. All About Lawns. Ortho Books, Chevron Chemical Co., 575 Market Street, San Francisco CA 94105.

Mallis, A. 1990. Handbook of Pest Control, 7th Edition; Franzak Foster Co., Cleveland OH.

Mampe, Douglass. 1990. Termites. In Arnold Mallis. Handbook of Pest Control, 7th Edition; Franzak & Foster Co., Cleveland OH.

Marsh, Rex E., Terrell P. Salmon, and Walter E. Howard. 1981. Integrated Management of Rodents and Other Wildlife in Campgrounds. US Department of Interior, Forest Service. 126 pages.

_____, and Walter E. Howard, 1990. Vertebrate Pests, In: Handbook of Pest Control by Arnold Mallis.

_____. 1994. Woodpeckers. In Hygnstrom, Scott E., Robert M. Timm, and Gary E. Larson, Prevention and Control of Wildlife Damage. Univ. of NE Coop. Exten. and US Dept of Agric., APHIS.

Martin, S. C. and R. R. Alexander. 1974. In: Seeds of Woody Plants in the United States, Agriculture Handbook # 450; U.S. Forest Service, Dept. of Agric. Washington D.C.

Mazzotti, Frank J., Joe Schaefer, Craig N. Huegel, and Bill Kern. 1995. Florida Wildlife Resources Handbook. Florida Coop. Exten. Serv., Inst. Food and Agric. Sci., Univ. of Florida and Florida Game and Fresh Water Fish Commission Nongame Wildlife Program, Gainesville Florida.

McClaren, Mitchel P. and Thomas R. van Devenner. 1995. The Desert Grassland. University of Arizona Press, Tucson.

McGavin, George C. 1992. Insects. Smithmark Publishers, New York.

Milne, Lorus and Margery. 1988. Field Guide to North American Insects and Spiders. Alfred A. Knopf, New York.

Moore, Wayne L.S. 1988. Controlling Household Pests. Ortho Books, Chevron Chemical Co., 742 Bancroft Way, Berkeley CA 94710

Morelli, Dave, 1996. Pocket Gopher Control. Wildlife Control Technology: 3(2), March-April 1996.

Norment, Bev. R. 1990. Spiders. In Mallis, A. Handbook of Pest Control, 7th Edition; Franzak & Foster Co., Cleveland OH.

Olkowski, William; Sheila Daar; and Helga Olkowski. 1984. IPM for Weeds and Ground Squirrels on Levees: A Case Study - Part 2. IPM Practitioner, BIRC, Berkeley CA.

_____, Daar, S., and H. Olkowski. 1991. Common-Sense Pest Control. Taunton Press, Newtown, CT.

Parker, T.A., 1990. Hide and Carpet Beetles. In: Handbook of Pest Control by Arnold Mallis. Franzak & Foster Co., Cleveland OH.

Personal reference. Rector, Barron (telephone, 409/845-2755). 1 August 1996. Personal telephone communication with Gerald D. McCrea.

Pest Control and Pest Control Technology, 1982 through 1994. Periodical pest control trade magazines of the National Pest Control Association. GIE Publishers, 4012 Bridge Ave., Cleveland OH 44113.

Pinniger, David. 1990. Insect Pests in Museums. Archetype Publ. Ltd, London WC1H 0PY.

Pinto, Larry. 1990. Occasional Invaders. In: Handbook of Pest Control by Arnold Mallis. Franzak & Foster Co., Cleveland OH.

Pitcairn's, Dr. Complete Guide to Natural Health for Dogs and Cats; Rodale Press, Emmaus PA.

Pratt, Harry D. 1975. Sanitation in the Control of Insects and Rodents of Public Health Importance. United States Dept. of Health, Educ. and Welfare; US Public Health Serv., Cen. for Disease Control, Atlanta GA. 42 pages.

_____, and Robert Z. Brown. 1976. Biological Factors in Domestic Rodent Control. United States Department of Health, Education, and Welfare; US Public Health Service, Centers for Disease Control, Atlanta GA. 307 pages.

_____, F. Bjornson, and Kent S. Littig. 1977. Control of Domestic Rats and Mice. United States Department of Health, Education, and Welfare; US Public Health Service, Centers for Disease Control, Atlanta GA.

Putnam, Stuart E. Jr., Controlling Stinging and Biting Insects at Campsites; ED&T Publ. #2689; USDA, US Forest Service Equipment Development Center;

Putnam, Stuart E. Jr.. Controlling Stinging and Biting Insects at Campsites; ED&T Publ. #2689; USDA, US Forest Service Equipment Development Center; Missoula MT 59801.

Roth, Susan A.; et.al. 1989. Controlling Weeds. Ortho Books, Chevron Chemical Company, Box 5047, San Ramon CA 94583.

Rust, Michael K. 1990. Fleas. In: Handbook of Pest Control by Arnold Mallis, 1990; Franzak & Foster, Cleveland OH.

Salmon, Terrell P. and W. Paul Gorenzel. 1994. Woodrats. In: Hygnstrom, Scott E., Robert M. Timm, and Gary E. Larson, Prevention and Control of Wildlife Damage. Univ. of NE Coop. Exten. and US Dept of Agric., APHIS.

Scott, Harold G. and M.R. Boram. 1968. Rodent-borne disease control through rodent stoppage. Public Health Service, Centers for Disease Control, Atlanta GA.

Simmons, Sewell E.. 1985. Parklands Pest Management. California Dept. of Food and Agric., Sacramento California.

Smith, Cheryl. 1993. The Ortho Home Gardener's Problem Solver. Ortho Books, Chevron Chemical Company, Box 5047, San Ramon CA 94583.

Smith, M.R. 1965. House-infesting ants on the Eastern United States. Tech. Bull. 1326. Agric. Res. Serv. U.S. Dept. Agric., Washington, D.C.

Smith, Robert L. 1992. Venomous Animals of Arizona. University of Arizona Press, Tucson Arizona.

St. Augin, Forrest E. 1990. Mites and Ticks. In: Mallis, A. Handbook of Pest Control, 7th Edition; Franzak & Foster Co., Cleveland OH.

Story, K.O. 1984. Approaches to Pest Management in Museums. Conservation Analytical Laboratory, Smithsonian Institution.

Swann, Donald E., Roy C. Murray, William W. Shaw, and Cecil R. Schwalbe. 1993. Assessment of Animal Damage to Ruins on Tonto and Casa Grande National Monuments. Unpublished contract report from University of Arizona, CPSU, to SOAR, NPS.

Tagg, Martyn D. 1985. Tonto National Monument: An Archeological Survey. Western Archeological and Conservation Center, Tucson, AZ.

Taylor, W.P. 1935. Ecology and life history of the porcupine (*Erethizon epixanthum*) as related to the forests of Arizona and Southwestern United States. Univ. Ariz., Tucson.

Texas A&M and Texas A&M Extension Service, 2401 East Hwy. 83, Weslaco TX 78596. Dr. John G. Thomas, entomologist; Dr. "Stormy" Sparks, Texas A&M Experiment Station, 512/968-5581; Dr. F.G. Maxwell, Dept. Entomol, Texas A&M Univ., College Station TX 77843. Information on Africanized bees.

Texas Rodent and Predatory Animal Control Service, Donald Hawthorne, State Supervisor.

Texas State Department of Health, Austin TX. Information on Africanized bees.

Thompson, S.W. 1975. Snakes. In F. R. Henderson, ed. Handbook on Prevention and Control of Wildlife Damage, Great Plains Agric. Council and Kans. Coop. Ext. Serv., Kansas State Univ., Manhattan.

Timm, Robert M. 1983. Prevention and Control of Wildlife Damage; Nebraska Cooperative Extension Service, Lincoln NE. The older addition. see Hygnstrom, Scott E., Robert M. Timm, and Gary E. Larson, 1994.

_____. 1994. House Mice. In: Hygnstrom, Scott E., Robert M. Timm, and Gary E. Larson, Prevention and Control of Wildlife Damage. Univ. of NE Coop. Exten. and US Dept of Agric., APHIS.

_____. and Walter E. Howard. 1994. White-footed and Deer Mice. In: Hygnstrom, Scott E., Robert M. Timm, and Gary E. Larson, Prevention and Control of Wildlife Damage. Univ. of NE Coop. Exten. and US Dept of Agric.,

APHIS.

Touhey, Dr. John E., Chief, Bureau of Environmental and Occupational Health for San Antonio Metro. Health District, San Antonio TX. Information on Africanized bees.

Tuttle, Merlin D. America's Neighborhood Bats. 1989; Univ TX Press, Austin; 96 pp. Merlin D. Tuttle, founder, exec. dir. Bat Conservation International, Austin, TX.

United States Army, Environmental Hygiene Agency. 1991. Guide to Commensal Rodent Control. US Army Environmental Hygiene Agency, HSHB-RP, Aberdeen Proving Ground, MD.

United States Department of Agriculture, Animal Research Service, Carl Hayden Bee Research Center, Tucson AZ; 2000 E. Allen Road; 602/629-6380. Information on Africanized bees.

_____, Baton Rouge Research Center, Honey Bee Breeding, Genetics and Physiology Laboratory, 1157 Ben Hur Road, Baton Rouge LA 70820; FTS 687-0277, 504/766-6064. Information on Africanized bees.

United States Department of the Interior, U.S. Fish and Wildlife Service, Publication (Resource Publication 143), "House Bat Management", Arthur M. Greenhall, 1982; U.S. Govt. Printing Office, Washington, D.C. 20402.

US Dept. of Interior, National Park Service, Wildlife and Vegetation Division. 1993. Commensal Rodents, An IPM Training Manual. 72 pp.

_____. 1984 and 1994. First and Second Editions, Integrated Pest Management Information Manual. Washington D.C.

United States Dept. of Health, Education and Welfare. 1967. Pictorial Keys to Arthropods, Reptiles, Birds, and Mammals of Public Health Significance. Public Health Service, Atlanta, GA.

United States Navy. Introduction to the Biology of Domestic Rodents. US Navy Disease Vector Control Center, Jacksonville FL.

University of California. Agricultural Sciences Leaflet # 2402 for detailed information on planning a prescribed burn.

Vengris, Jonas and William A. Torello. 1982. Lawns, Basic Factors, Construction and Maintenance of Fine Turf Areas. Thomson Publications, Fresno CA 93791.

Ware, George W. 1988. Complete Guide to Pest Control - With and Without Chemicals. Thomson Publications, P.O. Box 9335, Fresno CA 93791.

Washington State Cooperative Extension. 1987. Aggressive House Spiders. Bulletin # 1466.

Wasser, Clinton H. 1982. Ecology and Culture of Selected Species Useful in Revegetating Disturbed Lands in the West. Publ. FWS/ OBS-82/56. Western Energy and Land Use, Off. of Biol. Serv., US Fish and Wildlife Ser., Washington DC

Welch, Tommy G. 1991. Brush Management Methods. Tex. Agric. Exten. Ser., Tex. A&M, College Station, TX.

Wheeler, Alfred G., Jr. 1990. Bed Bugs and Other Bugs. In: Handbook of Pest Control by Arnold Mallis, 1990; Franzak & Foster, Cleveland OH.

Whiteley, H.E. 1987. Flea-control tips from the experts. Veterinary Medicine, September 1987:913-916.

Whitson, Tom D.; Larry C. Burrill; Steven A. Dewey; David W. Cudney; B.E. Nelson; Richard D. Lee; and Robert Parker. 1996. Weeds of the West (5th edition). Western Society of Weed Science and Western United States Land Grant Universities, Cooperative Extension Services.

Wilson, E.O. and G. Holdobler. 1990. The Ants. Harvard Univ. Press.

Wood, S.F. 1975. Home invasions of cone-nosed bugs (Hemiptera: Reduviidae) and Their Control. National Pest Control Operators News, Vol. 35:16-18.

Yepsen, Roger B. 1984. The Encyclopedia of Natural Insect & Disease Control. Rodale Press, Emmaus PA.

Zycherman, L. A. (ed.) 1988. A Guide to Museum Pest Control. Amer. Inst. for Conservation Hist. and Artistic Works and Assoc. Systematics Collections. Wash., D.C.

XIII. NATIONAL PARK SERVICE IPM VIDEOTAPES

"Crack and Crevice Treatment for Cockroach Management," 13 minutes.

"Integrated Pest Management," 15 minutes.

"Integrated Pest Management; Commensal Rodents," 23 minutes.

"Pesticide Applicator Safety," 17 minutes.

"Structural Inspections -- A way of Managing Wood Inhabiting Insects," 23 minutes.

"Subterranean Termite Biology," 11 minutes.

XIV. AUTHOR OF PLAN

Gerard A. Hoddenbach, Hoddenbach Consulting (March, 1998), P.O. Box 750128, Torrey UT 84775, 435/425-3095, e-mail ipmhelp@color-country.net, is the author of this plan. Information used to develop the IPM Plan comes from on-site visits and interviews with park staff, previous personal experience with pest problems in various National Park Service areas, and a variety of written sources.

INDEX TO PESTS

The following animal and weed pests are included in this Plan for BIBE under the listed headings:

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ACCIDENTAL PESTS

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ANTS

BEDBUGS

BEEES, WASPS, AND HORNETS

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THISTLES (TUMBLEWEED)

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THISTLES (TUMBLEWEED)

ACCIDENTAL PESTS

Description

Many common household and workplace pests which normally live outdoors only inadvertently enter buildings. Although some of these pests survive indoors by scavenging food and finding refuge, many die from starvation or dehydration.

Pest control professionals call pests that accidentally invade structures: "Occasional Invaders", "Perimeter Invaders", "Household Pests" or "Accidental Pests/Invaders" (which is the term used here). This large group of pests contains a wide variety of insects and arachnids such as:

several different kinds of: **ants, cockroaches, crickets, earwigs, mayflies, caddisflies, stoneflies, ground beetles, leaf beetles, lady beetles, various weevils, webworms and tent caterpillars, moths, caterpillars, boxelder bugs, cicadas, centipedes, millipedes, sowbugs, pillbugs, springtails, thrips, ticks, spiders, scorpions, slugs, snails, bees, wasps, snakes and woodrats.**

Most accidental pests enter buildings when outside conditions become too harsh. This may be caused by excessive heat, cold, wet, or dry conditions. Others are attracted to porch lights (or insect prey) at night where they accidentally enter buildings. Except for only a few insects and arachnids that can find food and are able to reproduce inside (i.e., some cockroaches, spiders, etc.), most pest invaders do not survive indoors for more than a few days or weeks. Most can not regulate water loss from their bodies in relatively dryer indoor environment without continual contact with moist soil.

Many of the native accidental pests are widely distributed across the United States. Some of these pests may pose certain degrees of health concern for residents and/or may even cause some structural damage but most demand control because they become nuisances inside structures.

Occurrence in the park

Accidental pests are native insects and arachnids and are typical to the park environment. They

normally live outdoors but, at least seasonally, enter park buildings and become pests. The most troublesome accidental pests reported of in the park are scorpions, centipedes, and conenosed bugs which are described in this section. Ants, bees, wasps, spiders, bats, mice, woodrats, and snakes are described in other sections.

Potential damage and health concerns

Several accidental pests pose health and safety concerns because they carry diseases, sting or bite, damage fabrics, contaminate foods, present an undesirable presence, attract other pests, or create unfounded fears on the part of residents or office workers.

Inspections and monitoring

Because of the recent appearance of Hantavirus in the Southwest, all persons engaged in inspections and monitoring and who might come into contact with rodents or dry rodent debris should wear approved personal protective equipment and follow Centers for Disease Control guidelines for personal safety (Appendix).

The following general guidelines apply to most accidental pests:

- Control actions for accidental pests should never begin with pesticide treatments. These pests come into structures from the outside and controls should begin with thorough inspections to uncover points of entry and sources, kinds, and extent of infestations. There are usually good reasons for most pest infestations which may be an attraction to structures, available entry points, or obtainable food, water, and harborage. Discovering such contributing factors requires a consciousness of pests and their biology, abilities, and habitats.
- Perform a complete inspection of the building's exterior and interior following guidelines noted in Section I of the IPM Plan and in the Appendix. Record findings on appropriate inspection forms.
- Monitor structures for the presence of accidental pests both visually and with sticky traps.
- The number of traps required in a room varies in regard to the kinds of pests present and

severity and location of infestations.

- Number the traps and place them against walls, near doorways, and in hidden areas where pests will encounter them. Frequently check traps and identify all captures. Record the number, location, species, life stage, and time interval over which pests were caught in a journal. Recording capture data on floor plan drawings will point out the areas of greatest pest activity and provide base-line information for post-treatment monitoring.

- One fairly new technique when using flat sticky traps is to place a few traps upside down with the sticky surface separated from the floor by a 1/16 inch spacer (such as a small coin). This tends to increase capture rates for crawling insects which prefer small, dark cracks.

Action thresholds

Action Thresholds for accidental pests are quite subjective and depend on potential damage and health concerns, numbers of pests entering a building, and tolerance levels of the occupants or office workers.

The most important thing to remember when dealing with pests which occasionally enter structures, is that they have discovered a way to enter. Consequently, the mere presence of an accidental pest inside of a structure becomes an Action Threshold to launch inspection and monitoring programs to find and close the access points.

A controlling Action Threshold for accidental pests will vary according to specific hazards or damage to be expected from the pest or tolerance level of occupants, (see references to specific Accidental Pests, as attached).

Non-chemical pest management

All pest management activities should begin, both indoors and outdoors, with non-chemical control measures.

5-Step Control Program

No single pest management method is effective for all accidental pests. However, effective control can usually be had by

following a basic, 5 part approach:

- obtain cooperation of site occupants/workers to allow for a full inspection of structures and their commitment for achieving improved sanitation and effective exclusion.

- carefully inspect the premises visually (possibly day and night) and monitor by examining the contents of sticky traps.

- develop recommendations for non-chemical and, if need be, chemical control options.

- implement treatments and follow-up treatments.

- monitor and evaluate treatment results.

Population reduction. Sticky traps placed along walls act as a form of minor control for some accidental pests inside structures. Remove any remaining pests with a vacuum or by killing them when seen. Remove prey insects. Remove clutter which provides insect harborage. Repair water leaks.

Other. Most accidental pests only require attention during specific times of the year when they are active and abundant; when the season changes, problems often disappear. Using heavy-bodied paints and concentrating on painting cracks can be very effective in sealing insects out. When exclusion is adequate, even established infestations often disappear.

Chemical management

Indoors, good exclusion should always be affirmed before considering the use of a pesticide.

Inside, apply pesticides to cracks and crevices, holes, and other small openings where pests may be a problem. Spray and dust applications of boric acid, Drione, silica aerogel, resmethrin are labeled for such uses.

Outside, resmethrin is labeled for applications in a band around building foundation walls, perimeter flower and/or ornamental plant beds,

perimeter flower and/or ornamental plant beds, unfinished basements, and crawl spaces.

Chemical repellents. A band of silica aerogel placed across door sweeps, in window frame joints and other cracks opening into a structure, and in insect harborage areas effectively repels all invertebrate pests for a number of weeks. After the pyrethrum has degraded, residues of fine silica particles (sand) remain on surfaces and continue pesticidal action.

Precautions. Occupants and employees often ask about Vapona, (No Pest Strip; DDVP), for pest control. Vapona is only effective in enclosed areas (see product label). When the active ingredient combines with air (hydrolyses) to produce acidic fumes which present the potential for human health hazards and serious damage to objects.

DDVP is currently in special review at E.P.A. since it is a dietary carcinogen for rodents and is also considered to be a possible human carcinogen. It is very seldom used in NPS areas.

Fog or spray treatments are sometimes used in rooms to control pests. Although these products may kill exposed insects, the aerosol-sized pesticide droplets do not penetrate cracks and crevices to reach hidden pests. And, they do not correct the basic reasons underlying a pest infestation which are usually poor sanitation or exclusion. It is not safe to breathe aerosol pesticides sprayed in a room. Always read and carefully follow product warnings on labels.

Evaluating treatments

The competence of treatments will be determined through continual post-treatment inspections and monitoring. Treatments are effective when accidental pests are no longer seen inside of a structure or caught on sticky traps.

Treatment evaluations will be used to supply essential information to adjust Action Threshold values, develop more effective management strategies, and demonstrate any apparent needs for new control methods or chemicals.

Chemical alternatives

Allethrin aerosol treatment for flying insects
Boric acid bait (liquid and solid) for ants, roaches, silverfish, and other indoor pests
Boric acid dust for cracks and crevices
Diatomaceous earth
Diatomaceous earth with pyrethrin
Fenoxycarb insect growth regulator for ants, fleas, roaches
Hydramethylnon bait for ants, roaches, and crickets
Methoprene insect growth regulator for fleas, ants
Potassium salts of fatty acids (soaps) for insects on plants
Pyrethrin for contact spray
Resmethrin aerosols for space treatment of honey bees; outside applications
Silica aerogel with or without pyrethrin for cracks, crevices, and pest pathways

Sources of advice, technical information, and supplies

See Appendix listings for equipment and chemical supplies.

National Park Service Videotapes

"Crack and Crevice Treatment for Cockroach Management," 13 minutes.

"Integrated Pest Management," 15 minutes.

"Pesticide Applicator Safety," 17 minutes.

"Structural Inspections -- A Way of Managing Wood Inhabiting Insects," 23 minutes.

Literature

Bennett, Gary W., John M. Owens, Robert M. Corrigan. 1988. Truman's Scientific Guide to Pest Control Operations; Purdue University, Edgell Communications.

Christensen, Dr. Chris. 1983. A Technician's Handbook to the Identification and Control of Insect Pests. Pest Control Technology, 4012 Bridge Ave., Cleveland OH.

Hedges, Stoy. 1991. Managing Pests Without Pesticides. Pest Control Technology, Jan. 1991:

45-49.

Mallis, A. 1990. Handbook of Pest Control, 7th Edition; Franzak & Foster Co., Cleveland OH.

Moore, Wayne LS. 1988. Controlling Household Pests. Ortho Books, Chevron Chemical Co., 742 Bancroft Way, Berkeley CA 94710

Olkowski, William, Daar, S., and H. Olkowski. 1991. Common-Sense Pest Control. Taunton Press, Newtown, CT.

US Dept. of Interior, National Park Service. 1984, 1994. Integrated Pest Management Information Manual, 1st and 2nd Editions.

United States Dept. of Health, Education and Welfare. 1967. Pictorial Keys to Arthropods, Reptiles, Birds, and Mammals of Public Health Significance. Public Health Service, Atlanta, GA.

Ware, George W. 1988. Complete Guide to Pest Control - With and Without Chemicals. Thomson Publications, P.O. Box 9335, Fresno CA 93791.

Yepsen, Roger B. 1984. The Encyclopedia of Natural Insect & Disease Control. Rodale Press, Emmaus PA.

ACCIDENTAL PESTS: CENTIPEDES

Description, distribution, identification

Centipedes are arthropods with one pair of legs on each of 15 or more body segments and antennae containing 14 or more segments. The first pair of appendages behind the head are modified into claw-like jaws and contain venom. Most species are nocturnal.

Several centipede species occur in the Southwest, some of which become quite large and intimidating; however, none are regarded as lethal to humans. Most species live outside under stones and debris and only accidentally invade dwellings.

House centipede. The house centipede (*Scutigera coleoptrata*) is one of the smaller species but may be from 1 to 1-1/2-inch long. This centipede has slender antennae, 15 pairs of long legs (seemingly out of proportion to its body size), and 3 stripes that run the length of its grayish-yellow body. Its legs are banded in white.

The house centipede is common everywhere in the United States and, unlike many other centipedes usually lives its entire life indoors. It frequents dark, moist areas like bathrooms, basements, damp closets, and other seldom occupied rooms where it preys on spiders and insects.

Giant desert centipede. The giant desert centipede (*Scolopendra heros*) and related species in the genus *Scolopendra* live outdoors in Southwestern desert areas and are very large, up to 8 or more inches long.

These are aggressive predators, very strong for their size, and are hard to kill. They are most often seen in on summer nights in desert areas after rains have encouraged prey to come out.

Occurrence in the park

Various kinds of centipedes and other native outdoor pests are found throughout the park and become "accidental pests" when they take up temporary residence inside structures.

Biology

Centipedes are primarily carnivorous. They normally live outdoors in protected situations where they hide and feed on insects or other forms of life. They are attracted to areas with high moisture such as loose bark/boards, rotting logs, areas beneath stones, in trash, piles of leaves, grass clippings, and trash. One species, the garden centipede (symphylid), feeds on and damages plant tissues.

During periods of extended dry weather, centipedes are forced to search out cooler, damper surroundings and may invade structures where they survive on flies, spiders, and other invertebrates. Although centipedes can be found anywhere in a structure, they are usually seen in damp basements, crawlspaces, bathrooms, closets, and near potted plants.

Centipedes kill their prey or protect themselves with pincer-like jaws which inject venom into a victim.

Potential damage and health concerns

Persons are sometimes bitten by centipedes when putting on sweaty or damp clothing that has been lying on floors and has attracted centipedes because of contained moisture. Many people are terrified by large centipedes but these arthropods are not responsible for great damage or health concern.

Pain from the bite of small (1-1/2 inch long) centipedes is reported to be somewhat greater than that of an ant but less than pain from a bee sting; however, some hyper-sensitive persons may be allergic to centipede bites. Even the bite of a giant desert centipede, which is painful and may cause swelling and fever around the sting site, is not usually regarded as serious. When crawling on a person's skin, a large centipede's sharp claws may cause scratches and introduce bacteria (from moist habitats where the insect lives) and cause secondary infections. Always cleanse scratches and bites with antiseptics to reduce the possibility of secondary infections.

Action Thresholds

Finding one or more centipedes indoors in a residence or office will be the Action Threshold

for control.

Outdoors, there is no Action Threshold for centipedes and they will not be controlled except where posing immediate or potential threat to visitors or employees.

Inspection and monitoring

Inspecting and monitoring for centipedes is the same as for insects (see Appendix III). Use a flashlight to carefully examine all likely harborage sites, especially dark closets, damp basements, bathrooms, kitchens, potted plants, areas beneath debris, and baseboard cracks.

Monitor for centipedes by placing sticky traps in likely harborage areas as well as near doorways, open pipe and electrical traces, and on window sills.

Non-chemical management

Centipede controls should concentrate on non-chemical tactics both indoors and outdoors.

Keeping centipedes from entering a structure (exclusion) is the first and most effective indoor control measure. Seal all possible points of access such as cracks in baseboards, holes in masonry, crawlspace doors, and other locations where centipedes might enter. Screen and weatherstrip doors, windows, and vents and be sure that door sweeps are tight. When exclusion is adequate, indoor infestations often disappear.

Indoors, caulk all cracks in walls, baseboards, and open pipe and electrical traces. Practice good sanitation, eliminate boxes and other stored materials that provide harborage. Control other insect pests inside buildings that centipedes feed on. Frequently vacuum closets and other dark areas. Correct conditions causing excessive moisture in basements, crawlspaces, washrooms, and boiler rooms. Stopper sink drains at night. Sticky traps placed along walls act as a form of control for centipedes inside structures. Remove centipedes seen inside a structure with a vacuum.

Outdoor sanitation is important to reduce the possibility for centipedes moving into buildings:

- remove trash and debris and other

harborage such as accumulations of leaves, grass clippings, logs, stones and rocks, etc. from around buildings

- store firewood and lumber off the ground -only bring inside an amount of firewood that will be promptly burned

- install a weed-free barrier strip of gravel around foundations

- in open garages and outbuildings, control the small arthropods that centipedes feed on

- provide adequate ventilation in crawlspaces

- reduce or eliminate moist harborage near structures by repairing leaking pipes and air conditioners, mowing lawns, weeding plant beds, removing wood and grass piles, etc.

- at night, centipedes are often attracted to outdoor lights where they feed on insects. Install yellow or sodium vapor bulbs to make lights less attractive to insect prey. Install lighting out and away from doorways or porches but aimed back to the structure.

Chemical management

Indoors, good exclusion should be assured before considering the use of pesticides. Additional protection can be had by treating harborage cracks and points of entry with boric acid, diatomaceous earth, synergized silica aerogel dusts and sprays, or other chemicals.

A band of synergized silica aerogel placed across door sweeps, in window frame joints and cracks opening into a structure, and in insect harborage areas effectively repels all insects and arthropods for a number of weeks.

Inside, spray and dust applications of resmethrin, or boric acid labeled for use in wall voids, cracks and crevices, along baseboards, and in other harborage.

Outside, resmethrin is labeled for band-applications around building foundation walls, perimeter flower and/or ornamental plant beds, unfinished basements, and crawl spaces. Band applications should only be used in worst-case scenarios and considered as a last resort.

Evaluating treatments

Treatment evaluations will be done by continual inspection and monitoring. Treatments may be considered effective when centipedes are no longer seen inside of a structure or caught on sticky traps.

Treatment evaluations will be used to supply essential information to adjust Action Threshold values, develop more effective management strategies, and demonstrate any apparent needs for new control methods or chemicals.

Chemical alternatives

Allethrin aerosol for flying insects
Boric acid bait for prey of centipedes
Boric acid dust for cracks and crevices
Diatomaceous earth with or without pyrethrin
Fenoxycarb insect growth regulator for
prey of centipedes
Hydramethylnon bait for prey of centipedes
Methoprene insect growth regulator for prey of
centipedes
Potassium salts of fatty acids (soaps) for insects
on plants
Pyrethrin contact spray
Resmethrin aerosol treatment
Silica aerogel with or without pyrethrin

Sources of advice, technical information, and supplies

National Park Service Videotapes

"Crack and Crevice Treatment for Cockroach Management," 13 minutes.

"Integrated Pest Management," 15 minutes.

"Pesticide Applicator Safety," 17 minutes.

"Structural Inspections -- A way of Managing Wood Inhabiting Insects," 23 minutes.

Literature

See Appendix listings for equipment and chemical supplies.

Christensen, Dr. Chris. 10983. A Technician's Handbook to the Identification and Control of Insect Pests. Pest Control Technology, 4012

Bridge Ave., Cleveland OH.

Frazier, D.A. 1976. Insect Stings--A Medical Emergency. J. Am. Med. Assoc. 235(22):2410-2411.

Hedges, Stoy. 1991. Managing Pests Without Pesticides. Pest Control Technology, Jan. 1991: 45-49.

Pinto, Larry. 1990. Occasional Invaders. In: Arnold Mallis, Handbook of Pest Control, 7th Edition; Franzak & Foster Co., Cleveland OH.

BEDBUGS

Description, distribution, identification

A number of different kinds of bedbugs are known to affect man, the most common species being the common bedbug (*Cimex lectularius*). This insect occurs world-wide, feeds on humans, bats, and chickens and is sometimes found in various Southwestern parks.

Adult bedbugs are reddish-brown, flat, wingless (do not fly) insects about 3/16-inch long and 1/8-inch wide. When un-fed they are flat and thin but when fed and full of blood, they are elongated, plump, and reddish.

Occurrence in the park

Bedbugs are often a problem in slightly more than half of the trailer residences used by BIBE seasonal employees. They have not been reported as problems in the concession accommodations but such occurrence is also possible.

Biology

Female bedbugs lay batches of 1 to 5 eggs per day for a 60-day period for a total of about 200 to 500 eggs per female lifetime. The female glues the eggs into cracks and crevices and the eggs hatch in 6 to 10 days. Differing degrees of relative humidity do not effect the development of bedbug eggs; however, the eggs will not develop below 55-F. nor above 98-F.

Young bedbug nymphs require a blood meal between each of 5 molts. Under optimum conditions, well-fed bedbug nymphs can become adults in 35 to 50-days but poorly fed ones may require 150 or more days. There can be as many as 3 to 4 generations of bedbugs per year.

Both adult and nymphal bedbugs feed on human blood; however, household pets and other animals are sometimes parasitized. Bedbugs can only crawl about 8 inches per minute and normally remain as close as possible to their hosts. The insects mainly feed at night; during daytime, they hide in cracks found in bed frames, walls, floors, baseboards, and within bedding and upholstered furniture. Bedbugs prefer wood or paper surfaces over stone or plaster ones.

They are quite hardy insects and can go as long as a year without feeding.

Bedbugs are usually spread by being transported in and introduced from infested luggage, clothing, bedding, and furniture. They can also move between adjoining apartments by way of voids, ducts, and electrical wire and plumbing pipe traces.

Pharaoh ants and Argentine ants are major bedbug predators and have been known to quickly eradicate bedbugs from rooms. Spiders, pseudoscorpions, mites, and reduviids also prey on bedbugs.

Potential damage and health concerns

Bedbugs are not known to transmit disease but bedbug infestations always carry a stigma associated with uncleanness. However, even the most sanitary of homes can experience occasional infestations with these pests if they are accidentally imported on clothing or luggage.

Bedbug bites cause a welt and may become inflamed, itch severely (in sensitive people), and cause dermatitis. Some people react very strongly to bedbug bites and may experience anemia, nervousness, insomnia, general debility, and/or eye disturbances when they have received numerous bites over a long duration.

Bedbug bites do not display a red center and reddish halo surrounding the site of the bite, as is typical of flea bites. The welt from a bedbug bite has a white halo around it and the swelling diminishes in size over a few hours.

Action thresholds

Finding evidence of bedbugs (or related species such as bat bugs) in an occupied structure will be the Action Threshold for control.

Inspection and monitoring

Inspections and monitoring for bedbugs are similar activities.

Large bedbug infestations in structures are often identified by the distinctively sweetish odor produced by the insects. The odor comes from excretions (previous blood meals) which show up

as brownish, yellowish, or black spots on walls near crevices where bedbugs hide. Another good indication of an active infestation is finding small blood spots on bed sheets.

One way to monitor for bedbugs is by sliding a large piece of butcher paper under a bed and then spraying up under the bed springs/frame with a pyrethrin aerosol. Bedbugs will quickly fall out of the bed frame onto the paper.

Carefully examine with a strong flashlight all possible cracks and crevices in the room and especially cracks and joints in beds and furniture. Look for bedbugs, their cast skins, or black or brown bedbug feces. Also look for bedbug signs behind picture frames, posters, or loose wallpaper.

Carefully inspect the attics of buildings suspected to be infested with bedbugs to determine if other parasites (i.e. bat bugs, fleas) that also bite people are the cause of complaints rather than bedbugs.

Non-chemical management

The best prevention and control against bedbugs is good sanitation and housekeeping practices. Frequent, thorough vacuuming (or mopping) of floor cracks often greatly reduces bedbug populations.

Bedbugs often invade homes through second-hand furniture, laundry, visitors' luggage, etc. Thoroughly clean all second-hand furniture before bringing it into the building.

Heat and freezing are good methods for sterilizing articles that can withstand elevated or lowered temperatures. Bedbugs quickly die in temperatures of 113-F. or die in 30 to 60 days when exposed to temperatures lower than 48-F.

Caulk and paint all cracks in bedsteads; caulk wall cracks; launder or dry clean bedding. Seal bed linens in plastic bags after cleaning and before placing them in moving vans. Steam clean second hand furniture before bringing it into the house.

Frequently expose mattresses, springs, bedding, bed slats, and bed frames to sunlight. Wash infested bedding in hot soapy water and dry it in a hot air clothing dryer.

Remove burrowing animal, bat, and bird nests/dens from attics and crawlspaces. Seal openings in the building to prevent the entrance of bird and animal pests.

Chemical management

Apply residual chemicals like pyrethins, silica gel, or diatomaceous earth into all cracks and crevices behind baseboards and in bed frames, wainscot moldings, floors, and other known or suspected harborage areas.

Pyrethrums have limited residual action and must be applied several times at weekly intervals. Retreat areas within 6 days to best control newly hatching bedbugs.

Silica aerogel is one preferred pesticide for bedbugs. Take beds frames apart and treat all cracks, joints, and interior parts. Treat mattresses and box springs (especially folds in fabric), picture frames, moldings, and all cracks and crevices in the room. Make a second pesticide application a week after the first one (when eggs have hatched). Only very light applications of pesticide are required on bedding. Do not use any chemical treatments in the quarters of hospital patients or on bedding used by infants, the elderly, or the infirm. All bedding should be allowed to thoroughly dry before persons sleep on it.

Pyrethrin aerosol fog applications are not usually advisable to treat for bedbugs because the aerosolized chemicals do not effectively penetrate deep into cracks and crevices.

Both silica aerogel and diatomaceous earth are well suited for treating cracks, wall voids, and attics.

Evaluating treatments

Post-treatment inspections and monitoring will determine whether or not treatments have been effective in removing bedbugs.

Treatment evaluations will be used to supply essential information to adjust Action Threshold values, develop more effective management strategies, and demonstrate any apparent needs for new control methods or chemicals.

Chemical Alternatives

Diatomaceous earth with or without pyrethrin
Pyrethrin spray
Silica aerogel with or without pyrethrin

Sources of advice, technical information, and supplies

National Park Service Videotapes

"Crack and Crevice Treatment for Cockroach Management," 13 minutes.

"Integrated Pest Management," 15 minutes.

"Pesticide Applicator Safety," 17 minutes.

"Structural Inspections -- A way of Managing Wood Inhabiting Insects," 23 minutes.

See Appendix listings for equipment and chemical supplies.

Literature

Bennett, Gary W., John M. Owens, Robert M. Corrigan. 1988. Truman's Scientific Guide to Pest Control Operations; Purdue University, Edgell Communications.

Christensen, Dr. Chris, A Technician's Handbook to the Identification and Control of Insect Pests, 1983. Pest Control Technology, 4012 Bridge Ave., Cleveland OH.

Forbes, C.F. and W. Ebeling. 1987. Use of Heat for Eliminating Structural Pests. IPM Practitioner 9(8):1-5.

Moore, Wayne LS. 1988. Controlling Household Pests. Ortho Books, Chevron Chemical Co., 742 Bancroft Way, Berkeley CA 94710

Olkowski, William A.; Sheila Daar; and H. Olkowski. 1991. Common-Sense Pest Control. Taunton Press, Newtown, CT.

Ware, George W. 1988. Complete Guide to Pest Control - With and Without Chemicals. Thomson Publications, P.O. Box 9335, Fresno CA 93791.

United States Dept. of Health, Education and Welfare. 1967. Pictorial Keys to Arthropods,

Reptiles, Birds, and Mammals of Public Health Significance. Public Health Service, Atlanta, GA.

Wheeler, Alfred G., Jr. 1990. Bedbugs and Other Bugs. In: Handbook of Pest Control by Arnold Mallis, 1990; Franzak & Foster, Cleveland OH.

COCKROACHES

Although there are about 55 species of cockroaches in the United States, only a relatively small number of species are regarded as common household pests. The four main pest cockroaches in the Southwest, and which will be described here, are the German, brown-banded, Oriental, and American roaches. All 4 of these species have world-wide distribution.

The importance of cockroach control can not be taken lightly. Cockroaches are said to be the most significant household insect pest to manage and they directly affect more people in this country than any other group of insects. Many urban residents who have fought roaches with insecticides for years are usually very skeptical of ever being able to manage them. It is estimated that, in this country, private homeowners spend over \$15-million per year and commercial pesticide operators spend \$60-million on pesticides to control roaches. Roach control is difficult because 95 or more percent of the roaches in a building must be eliminated or a roach population recovers to pre-treatment levels in just a few weeks. Most management failures occur are because 1 or more key roach habitats were not found and treated. And, German and brown-banded roaches can be continually imported into buildings along with paper items, cardboard boxes, furniture, electrical appliances, and other goods.

Occurrence in the park

Cockroaches are a continual problem in residences and other NPS buildings. Large populations of Oriental roaches infest the sewer system which serves the concession operation.

German cockroach (*Blatella germanica*).

Description. The German roach is more active than other domestic roach species, is the most frequently encountered roach, and is potentially more fecund than other species. Adults are about 1/2 to 5/8 inch in size and light brown to tan in color. The most distinguishing characteristic that identifies them is two dark, parallel stripes running lengthwise along the pronotum. German roaches have wings and can glide (fly) short distances.

Habits. German cockroaches can be found throughout a structure but most commonly in those rooms where people eat and drink. German roaches tend to prefer warm, humid sites (kitchens and bathrooms) where their main harborage is in structural cracks and crevices located near sources of food and/or water. The insects produce aggregation pheromones which attract other roaches into safe and favored sites for feeding and resting.

German roaches tend to remain closer to harborage (10 to 15 feet) than Oriental or American roaches (50 or more feet), and spend 75 percent of their life resting in cracks. Small instar (young, still developing) roaches can use cracks as small as 1/64 inch wide but larger adults require crevices about 3/16-inch wide. Female roaches are usually quite active but gravid females may never leave a crack, even to feed. Males seldom leave deep cracks and nymphs remain in hiding before and during molt. Periods of inactivity tend to reduce the effectiveness of pesticide sprays or baits placed out in open areas of rooms.

Foods and feeding. German roaches prefer foods that are high in carbohydrates such as powdered sucrose, maltose, dehydrated potatoes, and alcohols (especially beer). However, they will feed on almost anything having nutritive value which includes all types of food products as well as soap, glue, paper, and toothpaste.

Reproduction. A female German roach produces 5 to 6, yellowish-brown egg capsules, about 1/4 to 3/8 inch long, during its lifetime (100 to 200 days). Each egg capsule contains about 30 to 40 eggs. Females carry an egg capsule until it is within a couple of days of hatching and then deposit it in a sheltered site. Females are often seen with the egg capsule still attached and protruding from their posteriors.

Varying temperatures and humidity influence the length of time it takes for eggs and young to develop into mature insects but the range is usually from 2 to 7 months. Well-established populations are typically composed of about 75 percent nymphal roaches. A German roach population, given favorable conditions, can increase by at least 2000 percent in 3 months. Serious household infestations can quickly develop after introducing only a few individual

roaches.

Brown-banded cockroach (Supella longipalpa).

Description. Adult brown-banded roaches are about 1/2 inch long, light brown in color, and have two faded, light-brown stripes across the top of their wings. Females are darker than males. Similar to adults, nymphs also have light tan stripes across the back.

Habits. The brown-banded roach is gregarious, but, different from German roaches, shows a preference for high, dry, and warm locations with low moisture such as shelves in closets, behind picture frames and wall hangings; under wall moldings; near appliance motors; and in light switches, closets, and furniture. This roach prefers temperatures around 80 degrees F. and temperatures lower than 75 degrees F. retard its development. Brown-banded roaches are difficult to control because they can occur in so many places within a structure.

Food and feeding. Brown-banded roaches prefer starchy foods like bread crumbs, book sizing, and wallpaper paste but will also feed on and damage a number of other items, even nylon stockings. Brown-banded roaches have lower water requirements than other roaches and can occupy a greater variety of sites in a building.

Reproduction. Brown-banded roach egg cases are small (5/32 to 3/16 inch long), reddish brown, and purse shaped. Unlike German roaches, a female brown-banded roach only carries an egg case for 24 to 36 hours and then deposits it, usually in or under furniture or shelving. The preference for placing egg cases within furniture helps to account for the wide-spread national distribution of this roach.

Females live about 7 months during which time they produce about 14 egg cases, each containing 14 to 18 eggs. Development from the egg to adult is greatly influenced by temperature and averages about 5 months but can vary from 3 to 9 months.

American cockroach (Periplaneta americana).

Description. The American cockroach is the largest of the cockroaches in this country, averaging about 1 1/2 inches long.

The American roach has reddish-brown wings lightly marked with yellow around the perimeters and long antennae (1 to 1-1/2 times the length of the body). Adults have fully developed wings but do not commonly fly. Economically, the American roach is the second-most significant roach in this country (the German roach being the first).

Habits. The American cockroach normally lives outdoors in alleys, lawns, decayed wood, and palm tree fronds but becomes an important structural invader, especially in warmer areas of the country, because it has become so well-established in sewers. After entering structures, the American roach thrives in dark, moist, warm (about 80 degrees F.) sites like kitchens, bathrooms, basements, furnace rooms, steam tunnels, sewers, and crawl spaces. It is not often found on second floor levels of buildings.

American roaches easily enter buildings through sewers and drains when drain traps do not contain water, through open pipe and electrical traces, or under doors. American roaches, however, do not usually range very far (20 yards being an unusual distance) and the site of their entrance can usually be determined by the relative numbers caught on sticky traps. American roaches frequently invade buildings in large numbers following heavy rains or when waste water drainage systems back up.

Food and feeding. The American roach is principally an outdoor species where it feeds on decaying vegetation, leaf litter, wastes, and other dead and decomposing organic matter.

Indoors, American roaches feed on almost all household foodstuffs but foods containing saturated fatty acids increase their feeding activity. Even though these roaches are serious pests in residences, they are even more commonly found in such commercial establishments as bakeries, restaurants, and grocery stores where they live in food storage and food preparation areas, drains, damp basements, and

steam tunnels.

Reproduction. Females produce about 9 to 10, 3/8 inch long, dark reddish-brown egg capsules during their life. Each egg capsule contains about 16 eggs. Usually, the female produces 1 capsule per week until she has placed about 15 to 25 capsules in different locations near food sources. The female deposits the egg capsule soon after it is formed and does not carry it like German roaches. Eggs hatch in about a month and nymphs take from 5 to 26 months to mature, depending on temperature. There is usually only 1 generation of American roaches produced per year but adults can live for up to 3 years. American roach populations tend to cycle with the season and their numbers usually increase about the same time each year.

In many parts of the country, nymphal American roaches begin to hatch during May and June when populations contain about an equal number of adults and nymphs. Their populations tend to reach the greatest numbers between August and November when nymphs outnumber adults.

Oriental cockroach (Blatella orientalis).

Description. Oriental cockroaches are dark, shiny, reddish-brown to black roaches. The females may be as large as 1-1/4-inches long and are slightly more robust than 1 inch long males. Wings on males extend 2/3 to 3/4 the length of the body but female wings are only rudimentary, stubby lobes. Neither sex can fly at any age. The antennae of both sexes are about as long as the body. When disturbed, Oriental roaches seem sluggish and do not appear to move as quickly as do other roaches. Oriental roaches lack the specialized pad on their feet which allows other roaches to climb on smooth surfaces.

Habits. Oriental roaches can survive outdoors in most geographic areas and are found under stones, debris, and leaf litter - even during mildly freezing weather. They mainly enter buildings through sewer drains, under doors, and along pipe and electrical line traces. Oriental roaches have high moisture requirements and are usually only found in the lower areas of a structure such as basements, crawl spaces, and lower wall voids. However, it is not unusual for Oriental

roaches to travel along water pipes and electrical lines and appear in upper floor levels.

Food and feeding. Oriental roaches mostly feed on a wide variety of organic matter. Reducing available food is not usually an effective method for controlling Oriental roaches because they can find so many other, naturally-occurring foods such as dead insects, slugs, and other animals; grass and weeds; bird and animal droppings; and human garbage.

Reproduction. An adult female lives for up to 6 months. During that time she can produce about 8 reddish-brown (which later turn black), 3/8 inch long egg cases, each containing about 16 eggs. The female deposits an egg case in a protected site within about 30 hours of its formation. Eggs take from 1 to 3 months to hatch and development from nymph to adult can range from 7 to 26 months, depending on temperature. Most nymphal roaches become adults during May and June which are peak months when Oriental roaches move indoors.

Populations are cyclic. Adult numbers are highest from spring to late June and nymphal roach numbers are highest between late-July and August. September populations are mostly composed of small to mid-sized nymphs and only contain a few adults. Nymphs that hatch in late fall overwinter and then mature during late spring. These cycles may give false impressions of the effectiveness of control. During late fall, after the natural die-off of adults and populations seem to be controlled, nymphs continue to increase in number in voids and crawlspaces until crowding forces them out into view.

Roach predators

Outside, roaches are preyed on by ants, rats, wasps, toads, beetles, bugs, mantids, dragonflies, cats, scorpions, spiders, lizards, and other small animals. Indoors, the principal roach predators are rats, mice, centipedes, and spiders.

Potential damage and health concerns

Because of their feeding habits and locations where they live, cockroaches (of all kinds) have

the potential to spread many serious diseases, pathogens, and at least one parasite to man. While eating, roaches vomit partly-digested food materials and continually defecate. They commonly forage on kitchen counters after dark where live/dead roaches and roach feces can enter and contaminate human foods.

Roaches that primarily live in sewers or outside on the ground feed on filth and decaying organic matter and have the potential to spread diseases to man. One researcher found that nearly 1/2 of the roaches he studied carried fecal streptococci.

Roaches are also known to be responsible as an important cause of severe cases of human allergies (especially in children).

Disease organisms carried by roaches are many and include Staphylococcus, Clostridium and Salmonella bacteria (food poisoning), and Proteus. Roaches also carry the pathogens that cause bacillary dysentery, typhoid fever, cholera, polio, amebic dysentery, urinary tract infections, diarrhea, and infectious hepatitis. However, the role played by cockroaches as a vector for disease is controversial. For more discussion, see Koehler et. al., 1990

Roaches sometimes invade bedrooms where they climb on sleeping persons and gnaw on eyelashes, eyebrows, fingernails, and calluses on hands and feet or other organic debris in the bed. And, roaches are known to enter the ear canal of sleeping persons which, in some cases, requires medical attention for removal.

Roaches are attracted to electrical switches where they corrode points, set off alarm systems, disrupt cash registers, and cause short circuits in computers. The hard exoskeleton of a roach can scratch sensitive computer heads and disks and roach body fluids can corrode electrical parts.

Roaches feed on and damage paper goods, starchy materials, glues, furniture, clothing, cardboard, molds, sugar, protein, and many other things that supply them with nourishment. However, roaches spoil much more food than they eat with excrement, secretions from scent glands, and regurgitations.

Action threshold

The accepted Action Threshold for roach control is when a number of sticky traps placed in a room capture an average of 2.5 roaches per trap per night. However, a lower threshold (say, 1 to 2 roaches captured over any 24 hour period) might be more appropriate in some cases. This is due to the high reproductive rates of some roaches, significant potentials for health concerns, and recent studies suggesting that 1,000 or more roaches may be present in a structure for every one captured on a sticky trap.

Inspection and monitoring

Inspections and monitoring for roaches are similar (see Inspection and Monitoring Guidelines in the Appendix). Cockroach inspections should determine the kind(s) of roaches present in a structure, the relative size of their population, and the underlying reasons for the problem. Knowledge of pre-treatment and post-treatment population size is necessary to be able to properly evaluate the effectiveness of control.

Use a bright flashlight when inspecting areas to find the focal areas of cockroach activity. Night-time inspections made with a yellow filter covering the inspection light can be very effective. Applying fluorescent sticky labels to suspected harborage sites during daytime inspections will make those sites easier to find after dark.

Sticky traps are the most commonly used method to determine the presence and abundance of roaches in a structure. One study showed that a large number of roaches can be expected to be present in a dwelling for every roach trapped during a 24-hour period. Serious roach problems can exist when more than 1 to 2 roaches are trapped over any 24 hour period.

When placing sticky traps, individually number the traps and note their location in the structure on a floor plan diagram. Analysis of captures will show major roach harborage areas and where to make treatments. The most important data to record for sticky traps is the total number of roaches caught; however, additional information on the presence of egg capsules and immature roaches provides valuable insight into population trends (see sample form at the end of this section). Also record any recommendations for new treatments or changes in Action Thres-

holds, capture of insects other than roaches, evidence that roaches or other insects that have been eaten by rodents, captured rodents, and record any missing traps (lost to vandalism or removed by animals or maintenance workers).

Sticky traps should be repositioned if no roaches are caught after 2 or 3 nights. The number of traps required will vary with the species of roach present and the severity and location of infestations. Use at least 10 sticky traps per 100 square feet of room size but also place 5 traps in each potential area of major activity (under sinks and dish washing machinery, around sources of food, water, warmth, etc.). Some commercially-available sticky traps are supplied with attractive food tablets are usually more effective than unbaited traps. A little peanut butter placed in the center of a sticky trap can also be used as an attractant. Place sticky traps against walls and fixtures and under appliances but not out in the open; and, do not place traps where they will get wet. The best locations for traps are in corners showing signs of roach activity (stains and feces). Leave traps out for 2-3 nights. When roaches are captured on traps, study their position on the trap to indicate the direction from which they entered the trap. Often this information can be plotted to point out major areas of activity. Since some roaches can complete a generation in 4 to 6 weeks, follow-up monitoring is always required.

German and Oriental roaches are attracted to tight, dark spaces such as beneath boards. An effective sticky trap for these species is a standard glue board (as used for mice) placed sticky side down and separated from the floor with 3/16 inch thick spacers (small coin).

Non-chemical management

Prior to control, it is very important to identify the species of roaches present as well as any likely harborage sites. Roaches greatly differ in their habitat preference and in the ways they enter a structure. Knowing the type of roaches present allows for controls to be more specific and effective.

Human residents and office workers commonly become overly depressed when they experience bad roach infestations in their surroundings and sometimes tend to "give up" on controls;

however, "giving up" only allows for development of even larger roach populations. Monitoring which draws an occupant's attention to the presence of roaches or to conditions supporting roach infestations often helps to reduce roach numbers in a residence because it encourages people to practice better sanitation and exclusion.

Effective cockroach control requires a number of things:

- **good exclusion to keep roaches from entering the building.** Check building interiors and exteriors and caulk or seal all cracks and crevices (especially around sinks, cupboards, and baseboards) and other points of possible entry. Install tight door sweeps, caulk and seal all pipe and electrical line traces, install screens on drains, screen air and ventilation ducts, repair torn or loose window screens, repair loose window and door frames, and remove all unnecessary equipment or stored items roaches can hide under.

- **significantly reducing or eliminating food, water, and harborage available to roaches.** Store foodstuffs in tight insect-proof containers. Remove fresh fruit, candy, or other food from office desk drawers. Do not cover shelves with shelf paper (loose paper provides roach harborage sites). Repair all water leaks or sources of water condensation. Make it impossible for roaches to find harborage, soil, or water in or under potted plants kept indoors.

- **practice good sanitation and cleanliness.** Keep garbage cans tightly covered and empty them every evening. Place wet garbage in sealed plastic bags before placing it in garbage cans. Thoroughly clean up all spilled food, water, and crumbs immediately after eating. Do not leave dirty dishes in the sink. If dishes must be left in the sink, immerse them in soapy water. Clean up all pet foods after feeding pets; don't leave pet food dishes out between feedings. Clean all accumulations of food or grease from stoves and kitchen machinery. Frequently clean the crumbs out of toasters. Do not store empty, recyclable aluminum cans or plastic containers indoors.

- do not bring roaches into a structure.

Examine all incoming food, paper bags, cardboard boxes, etc. for roaches and roach egg cases. As soon as such items are emptied, seal them up in plastic garbage bags or properly dispose of them.

- eliminate harborage. Indoors, do not store empty plastic or paper bags in locations (i.e. drawers) where they provide roach harborage. Do not store anything on the floor (including pan lids in the small area usually found between the refrigerator and cupboard or stove) that gives roaches a place to hide. Hang wet mops up by the mop head outdoors. Outside, move stacked firewood, dead wood, debris, branches, stones, etc. away from buildings. If wood stoves are used, store firewood outside on pallets and up off the ground. Bring only small quantities of firewood into the house. Trim trees, bushes, and vines so they do not touch the structure.

Various non-poisonous live traps can be easily made that effectively capture cockroaches. Over 200 roaches per night were captured in one such trap. However, trapping by itself will only slightly lessen cockroach infestations. Effective controls require good exclusion and sanitation, reduction of harborage, keeping roaches from being imported into a building, and, possibly, chemical controls.

- Lightly grease the upper, inner surface (1 to 2 inches below the rim) of a clean, empty gallon can with petroleum jelly. Place a small quantity of an attractive food product in the can such as: potatoes, sucrose syrup, raisins, Coca-Cola, stale beer, fresh bananas, white bread, or even water. Place the can in a dark corner so its outer surface is in contact with 2 walls.

- Place about 1/2 inch of beer or a mixture of 1 part molasses to 10 parts water in a pint jar and locate the jar where roaches can reach it. Insects that enter the jar will drown in the liquid.

- Place an inch of water (maybe with a little detergent added) in the bottom of an empty jar and lightly coat the inside of the jar with peanut butter. Roaches will drown in the water.

Chemical management

The two principal truisms of roach control are:

- The use of pesticides is not a substitute for prevention.

-Pesticides are not a substitute for sanitation.

Chemical controls generally only provide temporary control over roaches. To be effective, pesticides must kill 95 percent or more of the roaches present and follow-up treatments must identify and treat all remaining reservoirs of the insects. Often, the need for roach control outdoors can be just as great as the need for inside control. It is important to seal as many holes as possible roaches might use to enter a building or the insects will continue to enter from the outside after pesticide applications have broken down.

Make chemical applications in harborage areas (cracks and crevices) where roaches live and breed. Effective chemicals for those areas include dusts of silica aerosol, boric acid, and diatomaceous earth. If a pressurized aerosol dust is not available, use a professional hand duster to apply those materials. Boric acid takes from 7 to 14 days to kill roaches (silica aerogel and diatomaceous earth are faster) and all three products remain active in cracks a long time. Currently, roaches do not show resistance to these materials. Other insecticides commonly used by industry include pyrethrins, baygon, and dursban.

Boric acid and hydramethylnon baits are very effective for roach control. Place out 10 or more bait stations in a normal sized kitchen. Some bait stations are backed with sticky tape and can be used on vertical surfaces.

Insect growth regulator chemicals are available either as dusts, baits, or disposable packets that release very small amounts of the material into the air.

Resmethrin-based aerosol sprays are effective for a quick knock-down of large roach populations but do not have very long residual and do not penetrate into cracks very well. Prior to using any space spray, cover or remove all exposed human foodstuffs and pets or other live animals.

Spray the room as you walk out the door. Leave the room closed for 15-30 minutes and thoroughly ventilate the room before re-entering.

Outside, apply residual insecticides into cracks, crevices, open pipe and electrical traces, and weep holes and seal the cracks with caulking. Place hydramethylnon bait stations in attics and crawlspaces or, when roach populations are very high, apply residual pesticide dusts to those areas.

Sewers: The main products used to control roaches in sewers are: boric acid paste, silica aerogel, bendiocarb, chlorpyrifos, and carbaryl dusts. Silica aerogel, used at the rate of 136 grams per manhole in Yakima, Washington, proved very effective and is considerably less toxic than many chemicals.

Evaluation treatments

The effectiveness of roach treatments will be determined through continual monitoring and inspection. Treatments will be considered effective when roaches are no longer found inside structures.

Evaluations of treatments will be used to supply essential information to adjust Action Threshold values, develop more effective management strategies, and demonstrate any apparent needs for new control methods or chemicals.

Chemical alternatives

Allethrin
Boric acid
D-phenothrin
Diatomaceous earth
Fenoxycarb (IGR)
Hydramethylnon
Hydroprene (IGR)
Pyrethrum and pyrethrins
Resmethrin
Silica aerogel with pyrethrin

Sources of advice, technical information, and supplies

National Park Service Videotapes

"Crack and Crevice Treatment for Cockroach Management," 13 minutes.

"Integrated Pest Management," 15 minutes.

"Pesticide Applicator Safety," 17 minutes.

See Appendix listings for equipment and chemical supplies.

Literature

Bennett, Gary W., John M. Owens, Robert M. Corrigan. 1988. Truman's Scientific Guide to Pest Control Operations; Purdue University, Edgell Communications.

Christensen, Dr. Chris, A Technician's Handbook to the Identification and Control of Insect Pests, 1983. Pest Control Technology, 4012 Bridge Ave., Cleveland OH.

Forbes, C.F. and W. Ebeling. 1987. Use of Heat for Eliminating Structural Pests. IPM Practitioner 9(8):1-5.

Hedges, Stoy. 1991. Managing Pests Without Pesticides. Pest Control Technology, Jan. 1991: 451-49.

Koehler, Philip G.; Richard S. Patterson; and Richard J. Brenner. 1990. Cockroaches. In: Mallis, A. 1990. Handbook of Pest Control, 7th Edition; Franzak Foster Co., Cleveland OH.

Moore, Wayne LS. 1988. Controlling Household Pests. Ortho Books, Chevron Chemical Co., 742 Bancroft Way, Berkeley CA 94710

US Dept. of Interior, National Park Service, Wildlife and Vegetation Division. 1984 and 1995. Integrated Pest Management Information Manual, 1st and 2nd Editions.

Ware, George W. 1988. Complete Guide to Pest Control - With and Without Chemicals. Thomson Publications, P.O. Box 9335, Fresno CA 93791.

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Chemical alternatives

Allethrin aerosol for initial knock-down
Boric acid dust, liquid, and solid bait
D-phenothrin (flushing)
Diatomaceous earth with or without pyrethrin in cracks and crevices
Fenoxycarb (IGR) bait
Hydramethylnon bait
Hydroprene (IGR) bait
Pyrethrin aerosol (knock-down)
Resmethrin aerosol for quick knock-down of populations
Silica aerogel with or without pyrethrin for sewers and cracks and crevices

Sources of advice, technical information, and supplies

National Park Service Videotapes

"Crack and Crevice Treatment for Cockroach Management," 13 minutes.

"Integrated Pest Management," 15 minutes.

"Pesticide Applicator Safety," 17 minutes.

See Appendix listings for equipment and chemical supplies.

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Bennett, Gary W., John M. Owens, Robert M. Corrigan. 1988. Truman's Scientific Guide to Pest Control Operations; Purdue University, Edgell Communications.

Christensen, Dr. Chris, A Technician's Handbook to the Identification and Control of Insect Pests, 1983. Pest Control Technology, 4012 Bridge Ave., Cleveland OH.

Forbes, C.F. and W. Ebeling. 1987. Use of Heat for Eliminating Structural Pests. IPM Practitioner 9(8):1-5.

Hedges, Stoy. 1991. Managing Pests Without Pesticides. Pest Control Technology, Jan. 1991: 45-49.

Koehler, Philip G.; Richard S. Patterson; and Richard J. Brenner. 1990. Cockroaches. In: Mallis, A. 1990. Handbook of Pest Control, 7th Edition; Franzak Foster Co., Cleveland OH.

Moore, Wayne LS. 1988. Controlling Household Pests. Ortho Books, Chevron Chemical Co., 742 Bancroft Way, Berkeley CA 94710

US Dept. of Interior, National Park Service, Wildlife and Vegetation Division. 1984 and 1995. Integrated Pest Management Information Manual, 1st and 2nd Editions.

Ware, George W. 1988. Complete Guide to Pest Control - With and Without Chemicals. Thomson Publications, P.O. Box 9335, Fresno CA 93791.

COCKROACH STICKY TRAP MONITORING FORM (EXAMPLE)

BUILDING _____			INSPECTOR: _____				
LOCATIONS			CAPTURES				
DATE	LOCATION	TRAP NO.	ADULTS	IMMATURES	EGG CASES	TOTAL CAPTURES	NOTES

Analysis:

* Infestations composed entirely of German and brown-banded roaches indicates that the insects are not coming in from outdoors.

* Samples which include only American and Oriental roaches indicates roaches are moving into the building from the outside.

* Oriental roaches found on upper floors suggests insects are moving up from the basement or sewer through wall voids or pipe and electrical traces.

* Look at the direction roaches entered a sticky trap and plot those directions back to suspected harborage areas.

* If only roach (or other insect) parts (i.e. legs, antennae, fecal piles) are found on sticky traps, mice are probably eating the captured roaches.

* American roaches in a tight basement suggests insects may be entering through sump pumps located below the basement floor. Check basement floor drains. Ask maintenance to open sumps for inspection; look into lateral lines emptying into sumps and at any water or steam pipes penetrating basement walls. Erosion may be present around pipes or on the earth-side of the basement wall. Apply non-repellent baits or boric acid dust in drains to prevent flushing the roaches into structural interiors.

* Adult roaches can move for some distance from harborage to sticky traps. If only young nymphal roaches are seen on traps, the harborage is probably located close to traps. If roaches in all stages of development are seen on traps (young nymphs to adults), it is almost certain that roaches are breeding on the premises and are not coming in from the outside. Ask long-time residents or cleaning or maintenance personnel about any possible old roach harborage that is now hidden by newly-installed panelling or equipment.

ACCIDENTAL PESTS: CONENOSE BUGS

Description, distribution, identification

Conenose bugs (also known as "kissing" or assassin bugs) belong to the large order known as "true bugs". One member of this group that is most often found indoors is Triatoma sanguisuga, the bloodsucking conenose. The bloodsucking conenose is a medium-sized (3/4 to 1-1/4-inches long), dark brown to black colored bug with reddish-orange or yellowish markings and has a distinctive odor. It ranges over much of the United States including Arizona, Texas, and New Mexico. Other similarly appearing conenoses with overlapping ranges and that may enter structures in the Southwest are Triatoma protracta, Triatoma recurva, and Triatoma rubida.

Occurrence in the park

Conenose bugs, along with a number of other outdoor pests, are considered as "accidental pests" and seldom if ever remain long inside structures. Conenoses are serious seasonal pests in the K-Bar Research Station because they enter the building and bite sleeping occupants. They can also be found in or around all park residences and offices and especially inside structures that do not have good exclusion or are otherwise open to the environment (archeological ruins, historical buildings, outbuildings, etc.).

Biology

In summer, conenose bugs lay eggs that require about 10 days to hatch. Developing young require at least 5 blood meals from hosts during their growth. Young bugs overwinter and molt into adults during the following spring. Two generations per year are possible in warm climates. The normal habitat for conenose bugs is in hollow trees or animal nests where they feed on (suck blood from) vertebrates (raccoons, woodrats, mice, etc.) as well as invertebrates. When conenoses enter structures, they usually do so when wild or domestic mammals also occur in or around crawlspaces or near building foundations. They are often associated with woodrat nests.

Inside, during the day, conenoses may live in cracks, bedding, floors and walls, crawlspaces (rodent nests), and under furniture.

Many of the insects in the true bug group are efficient predators on other insects and may prey on cockroaches and other pests found inside structures. Although conenoses are nocturnal in their habits, they are strongly attracted to light.

Potential damage and health concerns

Because of the recent appearance of Hantavirus in the Southwest, all persons engaged in inspections and monitoring and who might come into contact with rodents or dry rodent debris should wear approved personal protective equipment and follow Centers for Disease Control guidelines for personal safety (Appendix I).

Many insects in the true bug group feed on blood from vertebrates. Conenoses often feed on sleeping humans and can be vectors for various diseases. The bloodsucking conenose has been known to carry equine encephalitis virus; Chagas' disease is also carried by other members of this insect group. Most bites by bloodsucking conenoses are painless but persons bitten often show strong allergic reactions to a bite. A highly sensitive person may suffer anaphylactic shock. Treatment of conenose bites may require consultation by a physician.

Action Thresholds

Finding even small numbers of conenose bugs inside a building used by people such as residences, offices, and research stations will be the Action Threshold for control.

Outdoors, conenoses will not be controlled except where posing an immediate or potential threat to visitors or employees.

Inspection and monitoring

Inspections and monitoring for conenoses (and other insects) are similar activities (see Appendix III). Inspections and monitoring are most productive when performed at temperatures ranging from 60 to 84 degrees F., when conenoses are most active.

Outside, inspection efforts should begin on the exterior of structures to identify all possible structural defects allowing pests to enter: excessive clearance or gaps under doors and around windows, open pipe and electrical traces, open crawlspace doors, exterior wall cracks, etc. Wear heavy gloves when looking under loose boards, rocks, and other debris. Look into crawlspaces for any possible rodent nests.

Inside, use a good flashlight to carefully examine all likely harborage sites, especially dark closets, damp basements, bathrooms, kitchens, bedding, upholstered furniture, floors and walls, ceiling cracks, under furniture, fireplaces, crawlspaces, potted plants, under debris, and baseboard cracks. Also look for excessive clearances around windows, doors, pipe and electrical traces, and other openings which may occur inside the structure.

If approved, places that are difficult to inspect are sometimes treated with a pyrethrin-based aerosol which forces insects out of hiding.

Place standard insect sticky traps every 10 to 20 feet along walls, near doorways, and in areas described above. Also place sticky traps adjacent to the bottoms of doors, near open pipe and electrical traces, and on window sills. Examine traps after a few days. Traps that capture the greater numbers of insects are those that are closest to the places where insects are entering.

Non-chemical management

Keeping conenoses from ever entering a structure (exclusion) is the most effective preventative measure. Seal all possible points of access such as holes and cracks in masonry, cracks around crawlspace doors, chimney flues, etc. Screen and weatherstrip doors, windows, and vents.

Carefully check attics, crawlspaces, and other voids and remove rodent nests. Seal crawlspace doors and other openings to keep wild and domestic animals from getting under structures.

Eliminate all possible outside breeding sites near structures such as trash piles, hollow trees, woodrat and other mammal and bird nests. Practice good exterior sanitation to prevent

attracting vertebrate or invertebrate pests into yards.

Install outside lighting away from doors. If lighting is already near doorways, use yellow or sodium vapor lights to reduce the attraction of bugs at night. Only use exterior lighting for brief periods during seasons when conenoses are abundant.

For indoor control, seal cracks in baseboards, open pipe and electrical traces, and screen chimneys. Conenoses fly at night and are attracted to artificial light; install tight screening on all windows and other openings and vents. Practice good sanitation, eliminate boxes and stored materials that provide harborage. Vacuum closets and other dark areas often. Vacuum up conenoses found inside structures.

If insects can not be kept out of structures, move beds out away from walls, do not let bedcovers touch the floor, place bed legs inside of drinking glasses containing a little water (or coat bed supports with Tanglefoot sticky glue or teflon or fluon paint), and protect sleeping persons with mosquito netting that does not touch the person. A small camping tent with tight zipper closures could also be used inside when other protection was not available.

Chemical management

Indoors, good exclusion should be assured before considering the use of pesticides.

A band of synergized silica aerogel placed across door sweeps, in window frame joints and other cracks leading to the outside, and in insect harborage areas will effectively repel insects for a number of weeks.

Boric acid, diatomaceous earth, and synergized silica aerogel are long-lasting and effective chemicals that can be applied into suspected insect harborage areas.

Various residual pesticides are labeled for use outdoors against pests occasionally invading buildings and can be applied in a band around building foundations, walls, perimeter flower and/or ornamental plant beds, unfinished basements, and crawl spaces. These include resmethrin and synergized silica aerogel applied

around windows, doors, walls, and into cracks.

Evaluating treatments

Continually inspect and monitor for conenoses to verify if exclusion is adequate or chemicals have been effective. Treatments are considered effective when conenoses are no longer seen inside of a structure or caught on sticky traps.

Treatment evaluations will be used to supply essential information to adjust Action Threshold values, develop more effective management strategies, and demonstrate any apparent needs for new control methods or chemicals.

Chemical alternatives

Boric acid
Diatomaceous earth
Resmethrin
Silica aerogel with pyrethrins

Sources of advice, technical information, and supplies:

See Appendix listings for equipment and chemical supplies.

National Park Service Videotapes

"Crack and Crevice Treatment for Cockroach Management," 13 minutes.

"Integrated Pest Management," 15 minutes.

"Pesticide Applicator Safety," 17 minutes.

"Structural Inspections -- A way of Managing Wood Inhabiting Insects," 23 minutes.

Literature

Christensen, Dr. Chris. 10983. A Technician's Handbook to the Identification and Control of Insect Pests. Pest Control Technology, 4012 Bridge Ave., Cleveland OH.

Hedges, Stoy. 1991. Managing Pests Without Pesticides. Pest Control Technology, Jan. 1991: 45-49.

Mallis, A. 1990. Handbook of Pest Control, 7th Edition; Franzak & Foster Co., Cleveland OH.

Olkowski, William; Sheila Daar; and H. Olkowski. 1991. Common-Sense Pest Control. Taunton Press, Newtown, CT.

Pinto, Larry. 1990. Occasional Invaders. In: Arnold Mallis, Handbook of Pest Control, 7th Edition; Franzak & Foster Co., Cleveland OH.

Smith, Robert L. 1992. Venomous Animals of Arizona. University of Arizona Press, Tucson Arizona.

Ware, George W. 1988. Complete Guide to Pest Control - With and Without Chemicals. Thomson Publications, P.O. Box 9335, Fresno CA 93791.

Wheeler, Alfred G., Jr. 1990. Bed Bugs and Other Bugs. In: Handbook of Pest Control by Arnold Mallis, 1990; Franzak & Foster, Cleveland OH.

Wood, S.F. 1975. Home invasions of cone-nosed bugs (Hemiptera: Reduviidae) and Their Control. National Pest Control Operators News, Vol. 35:16-18.

Ware, George W. 1988. Complete Guide to Pest Control - With and Without Chemicals. Thomson Publications, P.O. Box 9335, Fresno CA 93791.

ACCIDENTAL PESTS: SCORPIONS

Description, distribution, identification

Three dozen or more kinds of scorpions occur throughout the Southwest. These are arachnids with 8 legs, a pair of large, claw-like pincers, and a pair of pincers at the mouth. A large bulbous tail segment contains poison glands attached to a terminal stinger.

Occurrence in the park

Various species of native scorpions occur in the park and can be expected around residences, offices, and especially in structures open to the outside environment (archeological ruins, outbuildings, etc.).

Biology

Scorpions are nocturnal predators that search for insects and other small organisms under loose bark/boards, objects lying on the ground, and in wood piles and crumbling stone foundations. Scorpions can live 6 or more months without food or water but they are highly attracted to moisture and are often found in or near crawlspaces, air conditioners, bathrooms, kitchens, basements, and utility rooms. However, heavy rains may force scorpions out of normally dry arroyos to higher ground, during which time they typically enter structures.

After feeding, scorpions may hide for 2 to 3 months. They shun temperatures above 90 degrees F. and during hot summer weather may move into cooler living spaces of buildings.

Female scorpions can produce 32 or more living young per brood and during their development she may carry the young on her back for up to 2 weeks. It requires 3 to 4 years for the young of most scorpions to become mature.

Potential damage and health concerns

Scorpions will sting when crushed or contacted but most species are relatively non-venomous. Although the sting of most scorpions is no more poisonous than that of a bee or wasp, the **bark scorpion** (*Centruroides sculpturatus*) is a poten-

tially lethal species. This species occurs in western New Mexico, Arizona, Mexico, sporadically along the west bank of the Colorado River in California, and possibly in Texas. The bark scorpion has very slender pincers and a small tubercle at the base of the stinger but it is most easily identified by its habits of climbing up walls and trees (not common to most other scorpions).

Although scorpion venom is neurotoxic and can be fatal to young children, the elderly, and the sick, potentially-lethal stings by bark scorpions have only resulted in about 64 deaths in the United States over the last 20 years (about 3 per year). Symptoms of a toxic sting are rapid respiration, salivation, vomiting, epigastric pain, and tenderness but without swelling or discoloration at the sting site. Antivenin for bark scorpion stings is available only at larger medical institutions.

To help prevent scorpion stings:

- Shake out and inspect shoes and clothing before putting them on in the morning.
- Move beds away from walls and do not let bedcovers touch the floor. Scorpions and centipedes cannot climb clean glass. Place crib or table legs in wide-mouth glass jars at night. A commercially available teflon (fluron) paint is available which is so smooth that arthropods can not climb on it.
- Wear gloves when placing hands in areas where scorpions may occur.
- At night, use a flashlight and do not walk barefoot.

Action Thresholds

Finding one or more scorpions in a residence or office will be the Action Threshold for control.

Outdoors, there is no established Action Threshold for scorpions and they will not be controlled except where they pose an immediate or potential threat to visitors or employees.

Inspection and monitoring

Inspection and monitoring for scorpions indoors

is similar to that for insects (see Appendix III). Use a flashlight to carefully examine all likely warm, damp harborage sites, especially dark closets, damp basements, sink cabinets, bathrooms, kitchens, potted plants, areas beneath debris, and baseboard cracks. Look for open cracks and pipe chases that lead into wall voids or crawl spaces. Carefully examine crawl spaces and attics.

Pyrethrin-based aerosols force arthropods out of hiding which can be of help in discovering their presence when inspecting difficult sites.

Place standard sticky traps in likely harborage areas and space them about 10 to 20 feet apart along walls, and especially, adjacent to door bottoms, near open pipe and electrical traces, and on window sills. Examine sticky traps after a few days; the traps with the most scorpions and/or insects are the traps closest to entry sites.

Sometimes scorpions enter houses through drains and occupants find them in bathtubs, sinks or shower stalls. Scorpions can be attracted to damp cloths placed on the floor/ground inside/around a building and then the scorpions can be hand-collected and removed.

Scorpions fluoresce under UV black-light and can be seen from several feet away. They can be expected to be active when air temperatures are 77 degrees F. or more.

Outside, cautiously inspect for scorpions under bark, boards, and stones located near structural foundations. Look for open cracks around foundations and door stoops and look for scorpions behind bird houses, tree trunk wrappings, and under plant mulch.

PRECAUTIONS:

- Use a stick or tool to turn over objects on the ground or first carefully inspect their undersides.
- Wear leather gloves when placing hands into dark, damp areas or holes in the ground.

Non-chemical management

Exclusion. Preventing scorpions from invading a structure (exclusion) is the most effective control measure. Seal all possible points of exterior access such as holes in masonry, crawlspace doors, etc. Install a weed-free barrier strip of gravel or concrete around foundations. Be sure all doors, windows, and vents are screened, caulked, and weather stripped.

Indoors, seal cracks in baseboards, open pipe and electrical traces.

Only bring inside that amount of firewood to be promptly burned.

Sanitation. Practice good interior sanitation, eliminate boxes and other stored materials that furnish harborage to scorpions. Control insect pests inside the building preyed on by scorpions and frequently vacuum closets and other dark areas.

Outside, remove all trash, debris, and other harborage such as leaf and grass piles, logs, stones and rocks, etc. from around buildings. Store firewood and lumber off the ground and as far from buildings as possible. Repair leaky pipes and air conditioners and dry up any moist areas near structures.

Habitat modification. Correct conditions causing excessive moisture in basements, boiler rooms, crawlspaces, and washrooms; increase sub-floor ventilation.

In open garages and outbuildings, control small arthropods that scorpions prey on.

Population reduction. Remove scorpions when they are found inside of buildings with a vacuum or by killing them manually. Sticky traps placed along walls also greatly help to reduce scorpion populations.

Chemical management

A band of synergized silica aerogel will effectively repel most crawling pests for a number of weeks. Follow label directions and apply the pesticide across door sweeps, into cracks and crevices and other insect harborage, and in other cracks leading to the outside.

Boric acid or diatomaceous earth are long-lasting and effective chemicals that can be applied into insect harborage areas.

Various residual pesticides are labeled for use against pests that occasionally invade buildings and include: microencapsulated pyrethrum and activated silica aerogel. Some labels for these chemicals may allow for band-application around building foundation walls, perimeter flower and/or ornamental plant beds, unfinished basements, and crawl spaces to kill or repel insects. Band applications should only be considered in the worst-case scenarios and as a last resort.

Evaluating treatments

The effectiveness of treatments will be shown by the results of periodic inspections and monitoring. Treatments will be considered sufficient when scorpions are no longer seen inside of a structure or caught on sticky traps.

Treatment evaluations will be used to supply essential information to adjust Action Threshold values, develop more effective management strategies, and demonstrate any apparent needs for new control methods or chemicals.

Chemical alternatives

Allethrin aerosol for flying insects
Boric acid bait for prey of scorpions
Boric acid dust for cracks and crevices
Diatomaceous earth with or without pyrethrin
Fenoxycarb insect growth regulator for prey of scorpions
Hydramethylnon bait for prey of scorpions
Methoprene insect growth regulator for prey of scorpions
Potassium salts of fatty acids (soaps) for insects on plants
Pyrethrin contact spray
Resmethrin aerosol treatment
Silica aerogel with or without pyrethrin

Sources of advice, technical information, and supplies

See Appendix listings for equipment and chemical supplies.

National Park Service Videotapes

"Crack and Crevice Treatment for Cockroach Management," 13 minutes.

"Integrated Pest Management," 15 minutes.

"Pesticide Applicator Safety," 17 minutes.

"Structural Inspections -- A way of Managing Wood Inhabiting Insects," 23 minutes.

Literature

Christensen, Dr. Chris. 1983. A Technician's Handbook to the Identification and Control of Insect Pests. Pest Control Technology, 4012 Bridge Ave., Cleveland OH.

Frazier, D.A. 1976. Insect Stings--A Medical Emergency. J. Am. Med. Assoc. 235(22):2410-2411.

Hedges, Stoy. 1991. Managing Pests Without Pesticides. Pest Control Technology, Jan. 1991: 45-49.

Mallis, A. 1990. Handbook of Pest Control, 7th Edition; Franzak & Foster Co., Cleveland OH.

Pinto, Larry. 1990. Occasional Invaders. In: Arnold Mallis, Handbook of Pest Control, 7th Edition; Franzak & Foster Co., Cleveland OH.

Smith, Robert L. 1992. Venomous Animals of Arizona. University of Arizona Press, Tucson Arizona.

US Dept. of Interior, National Park Service. 1984. Integrated Pest Management Information Manual, 1st Edition.

Ware, George W. 1988. Complete Guide to Pest Control - With and Without Chemicals. Thomson Publications, P.O. Box 9335, Fresno CA 93791.

ANTS

Description, distribution, identification

There are over 750 ant species in the United States but only about 30 of them become structural pests and an even smaller number are outdoors pests.

Each species of ant has slightly different biology. Proper identification of problem ants is important when choosing the better control measures. However, because of the large number of different kinds of ants, identification can be difficult. Many pest control texts offer keys to identify ants but it is usually safer to send specimens to a specialist.

A number of easily observable features that can be used to broadly separate ants include the following:

Number of nodes: Ants are divided into 2 major groups according to the number of nodes making up the narrow waist (petiole) between the abdomen and thorax.

Single node: sub-Family Dolichoderinae. Single-node ants generally do not have stingers. A few cause stinging sensations by ejecting irritating fluids from their abdomen; some have strong jaws and a painful bite.

Argentine (Iridomyrmex spp.)
Brown field ant (Formica spp.)
Carpenter (Camponotus spp.)
Crazy ant (Paratrechina spp.)
Field ant (Formica spp.)
Ghost ant (Tapinoma spp.)
Honey/small honey (Prenolepis spp.)
Odorous house (Tapinoma spp.)
Pyramid (Dorymyrmex spp.)
Slave ant (Formica spp.)
Velvety tree (Liometopum spp.)

Two nodes: sub-Family Myrmicinae. Two-node ants generally have stingers and most will inflict painful stings. The major outdoor stinging ant pest in the Southwest is the harvester ant. The imported red and black fire ants are not yet reported in national parks in Texas, New Mexico, or Arizona.

Acrobat (Crematogaster spp.)

Big-headed (Pheidole spp.)
Fire, California and Southern (Solenopsis spp.)
Fire; Red, Black Imported (Solenopsis spp.)
Harvester (Pogonomyrmex spp.)
Little black (Monomorium spp.)
Pavement (Theramoreum spp.)
Pharaoh (Monomerium spp.)
Thief (Solenopsis spp.)

Food Choice: A number of ants are specific in their preferences for food (i.e., sweet, protein, or fatty foods). Most kinds of ants eat both sweets and protein; only some ants eat sweets and fats; and very few ants prefer solely protein foods.

Nesting: Common ants that often nest inside buildings are carpenter, crazy, odorous house, pavement, pharaoh, small honey, and thief ants.

Exotic ants: Ants that are not native to the United States include: argentine, crazy, little black, little fire, pavement, pharaoh, and red and black imported fire ants.

Specific information on a number of ant pests in the park follows:

Harvester ant

Distribution and description. There are about 22 species of native harvester ants; 21 of those species occur in Southern and Southwestern states, and 11 species occur in Arizona. Harvester ants are quite abundant throughout the park.

Harvester ants have two nodes, 1 pair of spines on the thorax, and a stinger. The size of the reddish-black or brownish colored worker ants varies from 1/5 to 3/8 inches long, depending on species. The key distinguishing feature for harvester ants is a long fringe of forward-pointing hairs on the underside of the head, just in back of the mandibles, which ants use to transport food, water, and sand.

Nests. Nests of harvester ants are found outside in open, sparsely vegetated areas. Nests are always fully exposed to sunlight. Ants keep an area of a fairly large size around the ant mound bare of all vegetation. Sometimes harvester ant nests contain more than 20,000 worker ants and

may extend up to 20 feet deep into the soil. Colonies are usually long-lived; some undisturbed nests have been known to have survived for up to 19-years. Usually, the older nests are the larger ones.

Foods and feeding. Harvester ants principally feed on vegetable foods in the form of seeds, although they will eat insects when available.

Habits. These ants establish feeding trails radiating out from the nest for 200 or more feet. Harvester ants cannot usually be managed with attempts to reduce habitat or change environmental conditions. They begin to forage in summer during early morning when ground temperatures reach 70 degrees F.; activity slackens if ground temperatures reach 100 degrees F., but resume again when the ground cools during late afternoon or early evening. During early spring and fall, ground temperatures may only allow ants to forage during mid-day.

Reproduction. Swarming commonly occurs between June and October (mostly from August to September) after rain has softened the ground enough that queens can dig earthen brood cells.

Damages. Harvester ants do not often invade structures but are common pests in agricultural crops and have been known to kill young fruit trees. Sometimes these ants undermine the edges of roadways or walkways and causing edges to fail.

Harvester ants are fierce and readily defend the nest with painful stings. They have the most toxic of all insect venoms which produces a burning pain that may last for hours. Multiple stings by harvester ants can kill young livestock that stumble onto nests and even some human deaths have been attributed to stings. Persons allergic to insect stings can be at the most serious risk.

Field ant

Distribution and description. Field ants are brown, black, red, or various combinations of these colors and about 1/3 inch long. These single-noded ants have a rather long abdomen.

Foods and feeding. Field ants make trails to a food source and feed on nectar, honeydew, and

other insects (especially termites).

Habits. Some species of field ants build large nest mounds from leaves, sticks, and other debris around rocks, plants, and obstructions or may nest in sidewalk cracks along the edges of walls.

Damages. Field ants often enter buildings. They do not sting but contain large amounts of formic acid which may enter the wound made when the ants bite. Pain from the bite, however, does not last long.

Carpenter ant

Distribution and description. Single-node, native carpenter ants live in colonies usually having only one queen but multiple-queened colonies are known. They are found throughout the United States and identified by their large size, evenly rounded thorax, 12 segmented antennae, and a circle of hairs on the posterior portion of the abdomen.

Foods and feeding. Carpenter ants range widely for food. They do not always remain in trails and may travel as far as 100 or more yards from the nest to find food. Natural foods for carpenter ants are sweets (honey dew, plant juices) and protein (such as dead insects).

Habits. Although a few individual carpenter ant workers may be seen during the day, most activity is at night. Indoors, when lights are suddenly turned on about midnight, large numbers of ants may be seen active around food scraps and sources of water. Carpenter ants usually enter buildings under door and window frames, through eaves, along utility wires serving a structure, through plumbing and electrical line traces, and from shrubs or branches touching the structure.

Reproduction. Carpenter ants need a moist, humid environment for their nests which are made by hollowing out galleries in damp or weakened (water damaged) wood. Outside, nests are usually found in rotting fence posts, stumps, old firewood, dead trees, and under stones. In structures, nests may be found in insulation, wood softened by fungal rot, hollow doors, and wall voids. Carpenter ants establish satellite colonies in areas some distance away

from the main colony. Reproductive swarmers (alates) are produced when the colony is from 2 to 5 years old and may appear during any time of the year but, most commonly, between February and June in the West. The presence of alates inside a building is a good indication that a colony is located somewhere within the structure. New colonies are also formed by budding when a group of ants breaks away from a mature colony to form a new colony.

Damages. Carpenter ants invade structural wood that has been damaged by water. Once nests are begun, the ants are capable of invading peripheral, sound wooden members. If colonies persist for a number of years in a building, considerable structural damage may result.

Argentine ant

Distribution and description. Although limited by cold, the Argentine ant is still widely distributed over much of the United States. This is an exotic ant with 1 to 2 nodes on the petiole, depending on species, and a heart-shaped abdomen. The head is large and the ant has very obvious forward-looking eyes which are located close to the base of elbowed antennae. This ant is light to dark brown (some shiny brownish black) color, 1/8 inch long (queen 1/4 inch), and covered with fine hairs. It does not have spines on thorax or a circle of hairs on tip of the abdomen but does have a musty odor when crushed.

Foods and feeding. Argentine ants tend aphids, prey on termites, other ants, housefly larvae, and cockroaches. Outside, the ant feeds solely on liquid foods, sap, and sweet plant secretions. Indoors, it seeks out meats and sweets.

The Argentine ant establishes well-defined trails from the colony to distant food sources.

Habits. The Argentine ant is an aggressive, competitive, ant and usually becomes the most abundant species in an area by out-competing other ants. The Argentine ant has no natural enemies and it contends with and even preys on southern fire and other ants when inhabiting the same territory. It is attracted to lights at night.

Argentine ants overwinter deep in soil or in

buildings near sources of heat. It seldom nests indoors but is a major pest in the home (around baseboards, windows, and water pipes) where it seeks sweets or escape from outside conditions that may be too wet or dry.

Reproduction. Argentine ants nest outdoors in moist situations (refuse piles, holes in trees, under stones and concrete, in beehives, and sometimes under loose pieces of insulation that cover the foundation). Colonies have several queens per nest and nests are usually large (to 30,000 individuals) and quite mobile. Several colonies often congregate during the fall of the year into communal, over-wintering sites and then divide again in springtime. Argentine ants mate within the nest and swarms are rarely seen.

Damages. The Argentine ant has no public health importance; it does not attack humans, carries no known diseases, and does not sting but may pinch the skin with its mandibles.

Odorous house ant

Distribution and description. The odorous house ant occurs widely in the United States from sea level to over 10,000 feet in juniper, sagebrush, pinon-juniper, pine-riparian, riparian, and aspen habitats. It is a native, trailing, and single-node species. It is recognized by its uneven-shaped thorax, 12 segmented antennae, no circle of hairs on the posterior abdomen, and a bad odor (putrid, rotten-coconut odor) when crushed. This ant is dark reddish brown to black, 2 to 3 mm long, and about the same size as (and often confused with) Argentine ants. However, different from the Argentine ant, the odorous house ant is darker in color and the petiole and node are hidden by the frontal part of its overhanging abdomen.

Foods and feeding. The odorous house ant primarily feeds on sweets (derived from aphids) but also some protein (dead insects). The ant establishes obvious trails leading to food sources.

Habits. Odorous house ants usually become indoor pests at the beginning of the rainy season when the plant leaves are washed clean and then again late in the year after the leaves have fallen. At both of these times aphids and honeydew are reduced. Do not allow vegetation

to touch buildings.

The odorous house ant frequently invades houses but does not sting.

Reproduction. This species has multiple queen colonies and it nests mainly indoors, although it may also nest outdoors. Indoors, nests are usually located in walls and under floors, especially around heat sources. Outdoors, nests are shallow and located under boards or stone. Some nests are found in wood where ants have taken over abandoned termite tubes. Mating usually takes place in the nest and swarms are seldom seen. New colonies are often formed by budding, when a group of ants leave the main colony to establish a new colony.

Damages. The odorous house ant is the second-most important ant pest in households, only surpassed by the Argentine ant. Bites and stings of odorous house ants may cause allergic reactions or rashes in some persons.

Pavement ant

Distribution and description. The exotic pavement ant mostly occurs in urban areas and throughout the United States.

This ant is about 1/8 inch long and has a body covered with thick, stiff hairs (setae). It has a 2 segmented petiole, 12 segmented antennae, and 2 small spines on the top rear of the thorax. This ant is light to dark brown, blackish, or brownish-black in color with pale-colored legs and antennae. The abdomen is dark colored (usually solid black). The pavement ant is unique in having easily visible, parallel lines (really, parallel furrows) on the head and thorax.

Foods and feeding. The pavement ant is a scavenger and does not have specific preference for foods. It usually seeks sweet and greasy materials but also feeds on dead insects.

Pavement ants mainly forage at night on well-established trails that sometimes range 30 or more feet across yards and into structures.

Habits. Pavement ants are rather slow moving. Their colonies can be as large as 30,000 individuals.

Outside, nests are usually located next to, under or at the edge of sidewalks and pavement cracks, next to buildings stones, in driveways, foundations, woodwork and masonry, and under thick mulch. They are also commonly found in lawns.

Inside, ants may nest in wall voids, bath trap areas, and crevices. They are frequently found in basements and slab-on-grade homes.

Outside, nest entrances are usually marked by a small crater. Inside, the nest entrance displays sawdust or similar-appearing materials (sand, insect parts, etc.) dumped into the room area.

Pavement ants are most active in summer but it is not unusual to find them indoors during winter. They enter homes through heating ducts, cracks in slab, and other open areas.

Although the pavement ant does not compete very well with native ants in rural areas, the distribution of pavement ants seems to be increasing.

Reproduction. Winged reproductive ants are present all year but swarms usually occur in late-spring. Swarms can occur at any time of year in heated structures and large swarms may, actually, originate inside structures.

Damages. Workers bite or sting but these ants are not as aggressive as fire ants. Pavement ants frequently become pests in gardens and are attracted to eggplants, peanuts, and strawberries.

Velvety tree ant

Distribution and description. The velvety tree ant is a common native ant in the Southwest where it ranges from sea level to 6000 feet in sagebrush, ponderosa, pine-riparian habitats.

This is a small (1/8 to 1/4 inch long), 2-tone colored ant with a glistening, velvety black abdomen, brownish-black head, and red thorax. When crushed, it produces a putrid, rank odor similar to that produced by the odorous house ant.

Foods and feeding. The velvety tree ant moves in obvious trails from the colony to food sources; trails can be 200 or more feet long. It is

attracted to sweets and protein, tends aphids for honey dew, and eats other insects.

Habits. The velvety tree ant is usually crepuscular or nocturnal in habits. It forms large colonies, usually outside under rocks or in the trunks of living or dead trees (usually in upper parts of pine trees) along stream banks. This ant is a common pest to fishermen, picnickers, and children.

When this ant gains access into roofs (via vegetation ladders) it constructs nests inside of foam roof coverings.

Reproduction. The velvety tree ant is thought to breed in July and gravid females, ready to initiate new nests, are found in August.

Damages. This ant invades and damages foam roofs which eventually causes leaks.

This is a very aggressive and pugnacious ant. It does not sting but it does bite and then injects poison into the wound. Bites cause severe stinging sensations and are painful.

Thief ant or Grease ant

Distribution and description. The native thief ant is a more common pest in the eastern and central part of the country; however, it is also found in the Southwest in riparian, pinon-juniper, pine-riparian, sagebrush, and disturbed areas.

This two-node ant has an uneven shaped thorax, 10 antennal segments ending in a 2 segmented antenna club, and a stinger.

Although thief ants resemble fire ants in size and by having 2 nodes on the petiole, thief ants are easily recognized. They are one of the smallest ants (workers may only be 1/16 inch long) and are yellow to dirty-brown in color with a smooth to shiny but hairy appearance. Thief ants are sometimes also confused with pharaoh ants because of size and color, but the thief ant has a 2-segmented club on the end of its antennae, while the pharaoh ant has a 3-segmented club. All other light-colored ants in the United States are larger than the thief ant.

Foods and feeding. Thief ants are very diverse, omnivorous feeders. They establish definite trails

from nests to feed on larvae of host ants, seeds, and honeydew; but, they prefer grease and high protein foods (meats, cheese, grains, fats, live or dead insects). They do not eat sugar.

Habits. The thief ant usually nests inside in wall voids, cracks, cupboards, etc, but will also nest outside. Outdoors, it usually forms colonies in bare soil, under rocks, logs or debris, and often near the nests of other species.

Thief ants are a frequent nuisance invader in residences. Their trails are often seen near sinks and cupboards containing food items or water.

The thief ant rarely stings. Its colonies may contain up to 2,000 individuals.

Thief ants are predators on other ant colonies. They invade or rob other ant nests of larvae, pupae, and food and may actually take up living in the nests of other species.

The small size of thief ants allows them to enter food containers other ants can not. Cracks and crevices must be kept as clean as possible and tight seals (gaskets) must be used on stored foods. Their small size also helps thief ants to escape detection, and they may be present in packaged food stuffs without ever being recognized as ants.

Reproduction. Thief ants swarm and establish new nests in late spring or early summer. Alates and brood are present all summer-long in a multiple-queened colony. It does not bud to form new colonies but the 1/6 inch long queen often carries one or more workers along on the mating flight to help initiate a new colony.

Damages. Thief ants can be very destructive of wood, paper, glue, and other organic materials and present health hazards where they are attracted to food stuffs. Large numbers have been known to kill small chickens but, because of their small size, thief ant bites are not usually serious.

Thief ants are the intermediate host of poultry tapeworm. They are persistent, nuisance pests and difficult to control.

Occurrence in the park

Various kinds of native and exotic ants occur throughout the park. Most indoor ant pest problems arise when the insects enter offices, residences, and concession facilities.

Native harvester ants commonly occur in the park and nests may pose stinging hazards where located near visitor-use areas, along trails, and in horse corrals.

Action thresholds

Thresholds for actions to control ants vary greatly in regard to sites where ants are found, kind of ants present, and people's general tolerance of ants. Generally, the observation of ants, ant trails, or suspicion of ant nests (especially carpenter ants) located inside a building, residence, or office will be the Action Threshold for controlling ants.

The Action Threshold for harvester ant colonies is finding ant mounds in areas frequently used by visitors or staff and which could result in stinging occurrences.

Inspection and monitoring

Failing to identify pest ants is the first, and most common, reason for ant control failures. Knowing the kind of ants present furnishes knowledge on where and how to look for problem areas and how to correct them. The second most common reason for failures in ant control is incomplete inspections (both exterior and interior) that fail to identify points of entry and nest locations.

Inspecting and monitoring for harvester ants is easy because they are outdoor pests that usually produce very evident nest mounds or by their obvious presence on the grounds. Periodically count and map the locations of colonies which occur in visitor use or other developed areas (i.e., backyards, campgrounds, near residences, tables, signs, trails, etc.).

It is more difficult to inspect and monitor for other kinds of ants which may or may not be entering structures from the outside. First, determine if the problem ants have nocturnal or diurnal habits and then conduct inspections at the appropriate

time of day/night. Indoors, place sticky traps in areas frequented by ants to detect their presence. Definite ant trails can be encouraged by placing out small amounts of food to attract ants.

Inspection and monitoring methods for carpenter ants must be very thorough and can also beneficially be used to monitor for other ant species.

For carpenter (and other) ants, it is best to begin with a detailed exterior inspection of a structure to find where ants are entering.

- walk around structures (day and/or night) looking for ant trails and places where ants enter. Visually track foraging ants back to their nests. It can take a great deal of time to find carpenter ant nests which can be 300 or more feet from a structure, in wood piles or rotten stumps.
- periodically monitor for ants with sticky traps placed around building exteriors.
- bait ants with honey, dead insects, or pieces of meal worms and follow ants carrying food back to the nests.
- examine shrubs, trees, and other vegetation to determine if ants are tending aphids or using vegetation as an access to buildings.
- look for ants next to and under sidewalk edges, foundations, expansion joints, mulch, rocks and logs, and structural siding.

Look for places on the building near foundations, fascia, and soffits that may show peeling paint or signs of fungus/mold. Do not confine inspections to the building. Use binoculars to see if ants are trailing down wires or off shrubbery onto the structure. Ants tend to follow edges, grooves, and crest lines, a behavior called structural guideline orientation.

One key to locating carpenter ant colonies inside a structure is finding any locations that show excessive moisture. Begin inspections in basements and crawlspaces. Inspect areas around the bath trap and interior voids for ants. Ask occupants about plumbing leaks during the past several years and use a moisture meter to search for sources of moisture in walls, floors,

ceilings, foundations, etc. Use sticky traps baited with a few grains of sugar to determine areas of major ant concentration. Look for small piles of "sawdust" (frass) under wooden moldings or beams. Ask occupants whether firewood is stored inside the building.

Look for ants and trails along interior baseboards and under the edges of carpets (pull up small areas every 3 or so feet with needle nosed pliers). Especially look for ants under carpets located near sliding glass doors.

In uncarpeted rooms, shine a light under the bottom edges of the baseboard and slowly move a knife blade or spatula along in the crack to chase foraging ants into the open.

Carefully inspect sub-slab heating ducts and heating registers. Use a mirror to look into ducts for ants or piles of soil/frass.

Ants often move through plumbing, drain pipe, and electrical line traces that penetrate the slab. In commercial buildings, swarms often move up through walls and into false ceilings and fluorescent ceiling lights.

To best locate ant trails and be able to follow them, put small amounts of peanut butter and mint jelly on 16 or more (per residence) white, index cards. A day or so before making the inspection, locate the cards throughout the building and in outdoor areas where the occupant has seen ant activity. During the inspection, estimate the number of worker ants on each card, follow ant trails and record other information on an inspection diagram. This survey will show good locations for placement of poison bait stations.

If approved, use pyrethrum flushing sprays to force ants out of hiding along baseboards and other cracks.

Non-chemical management

Ants are one of the more difficult structural pests to control. They commonly occur in all habitats, are small enough to enter through minute cracks, and readily communicate the locations of food to the rest of the colony. Ant problems should always be a signal that pest exclusion is not adequate. An effective ant control program

depends on improved exclusion, finding ant nests, meticulous sanitation, and persistence.

Cultural. Do not allow harvester ant mounds to build up in heavily used visitor-use areas. Remind visitors, especially children, to not sit or stand on harvester or field ant mounds.

Exclusion. The basic recommendation for controlling ants inside a building is to concentrate on exclusion rather than eradication. Prevention is the best method for keeping ant problems from occurring or recurring.

Do not place emphasis on controlling foraging ants. Only 5 to 10 percent of the total number of worker ants present in a nest forage at any given time. Concentrate treatments on nests where most of the ants and queen are located; queen ants of various species can produce workers faster than insecticides kill them.

If ants are in lines leading to food, do not remove the food source until the hole(s) used by ants to enter has been sealed. Ants are easier to kill while still in lines when following chemical scent-trails than when aimlessly wandering in search of their entrance point. Apply a small amount of pyrethrum or silica aerogel into the hole or crack from which ants are emerging and seal it closed with caulking. Then, immediately mop up ants with a sponge and soapy water or spray them with soapy water.

Once most of the ants are killed, caulk all possible entry points and correct any contributing conditions by repairing water leaks, eliminating moist wood, improving sanitation, enhancing crawlspace ventilation, etc.

In an emergency and for temporary closure, holes where ants are entering a structure can be filled with petroleum jelly. Close and mark those holes as soon as ants are seen entering a structure. The longer ants are allowed to enter, the harder they are to control. For longer term exclusion, apply boric acid or silica aerogel into holes and then carefully caulk and seal them and all other cracks and crevices in the structure. Heavy body paint is an effective sealing material for interior wall cracks.

Install permanent sticky barriers (Stickem, Tanglefoot, Sticky Stuff) or super-smooth teflon (fluon) paint barriers around the legs of

free-standing tables, and bottoms of cabinets, etc. Sticky barriers are long-lasting when protected from dust with a cover. Teflon barriers are effective until the paint surfaces are scratched or covered with grease or dust.

Sanitation. Remove all sources of food and water available to ants. Repair plumbing leaks, insulate cold water pipes to prevent condensation, thoroughly clean and keep all kitchen surfaces dry, frequently sweep/vacuum floors to eliminate food scraps, seal foods in ant-proof containers, etc.

Thoroughly rinse out all empty cans and other food containers before placing them in the trash; clean meat and fast food wrappings in dish water before discarding. Separate organic wastes from other wastes before placing organic materials in trash cans with tight-fitting lids. Raise outside garbage cans up on legs and check to see that can bottoms do not have holes that allow ants to enter.

Habitat modification. Maintain a weed-free zone around structures and prevent trees and shrubs from touching buildings. Do not stack firewood next to buildings. If firewood becomes ant-infested, do not treat it with insecticides, remove or discard it. If ants are infesting indoor ornamental flower pots, periodically flood the pots with water to force ants out; keep water collection trays under flower pots free of excess water. Where needed, apply Tanglefoot sticky barriers and approved ant baits.

Indoor Ants, Nesting Inside: If ants are nesting indoors, quickly improve sanitation practices. Make determined efforts to find and eradicate nests in the structure through use of chemical injection or ant baits. Treat voids, cracks, and areas where ants are found with boric acid dust or silica aerogel and then caulk and seal the cracks.

The most common entry place for ants which nest inside structures is in the cracks between the foundation and sill plate.

Carpenter ant control requires prompt correction of any conditions contributing to the infestation. Repair water leaks and replace wet, damaged wood. Ventilate attics and crawlspaces. Correct the grade around the structure.

Indoor Ants but Nesting Outside: Invasion of structures by sweet-eating ants is usually a seasonal event that begins when rain washes honeydew off tree leaves or vegetation becomes bare in the fall. Harvester ants in the South and West only rarely enter structures and only do so when the ants can not find appropriate food outside.

If the ants are not nesting indoors, find and seal (caulk) all structural entry points; remove outdoor nesting and food sources (old wood, shrubs, food sources, honeydew producers, etc.); use approved chemicals which may include boric acid dust, silica aerogel dust, or pyrethrin to treat cracks, crevices, holes, etc. or hydramethylnon or boric acid bait stations to destroy nests.

To prevent the likelihood of carpenter ants making nests near a structure, remove all dead wood, tree limbs, stumps, and other wooden debris from the yard and from under the building. Stack firewood up off the ground and as far away from the structure as possible. Trim tree or shrubbery limbs touching the structure.

Outdoor Ants: First, monitor ants by visually counting and marking the locations of colonies. If you have difficulty finding nests, set out non-poisonous bait stations to attract ants and then follow the ants back to the nests; then, apply approved pesticides to the nests. Improve outside sanitation practices.

As a last resort in extreme cases, pesticide barrier treatments around building exteriors may be needed. Confer with the appropriate IPM Coordinator if this seems to be needed.

Sometimes, sticky barrier pastes are helpful to temporarily keep ants from moving onto outdoor tables, chairs, plants, wires, etc. However, the pastes deteriorate quickly during warm weather and must be frequently replaced. Teflon (fluon) paints are more long-lasting.

Chemical management

Various pesticides are registered for ants and people often simply spray ants when they see them but this practice only kills a few worker ants and does not control the source of the problem. And, the loss of worker ants sometimes stimulates colonies to divide (bud). To be effective,

pesticides which contain an insect growth regulator (i.e., fenoxycarb, methoprene, sulfluramid) or a slow-acting stomach poison must be used in ways that reach and affect a majority of the workers in the colony and/or queen ant.

Boric acid and hydramethylnon are two, effective, slow-acting stomach poisons. A number of hydramethylnon formulations are effective for outdoor harvester ant colonies; other formulations are labeled for indoor use and attract sugar or grease-eating ants (Argentine, cornfield, little black, odorous house, and pavement ants).

Boric acid dusts for cracks and crevices and boric acid baits (sweet or protein) are both available. Toxic baits currently available for carpenter ant control are not considered effective by most pest control technicians.

Carpenter ants nesting inside of structures may require drilling into ant galleries or interior wall voids for application of boric acid, silica aerogel, or chlorpyrifos products. In a worst-case scenario, an outside barrier treatment is sometimes necessary to keep ants from entering structures; silica aerogel is highly repellent to insects and long-lasting when placed in cracks.

Velvety tree ants live outdoors. A number of effective pesticides are available for treating outside vegetation to kill both ants and aphids that attract ants. Other pesticides are available as barrier treatments around buildings in worst-case scenarios. Do not use boric acid products on vegetation; it kills plants. Insecticidal soap is generally an effective control for insects on plants and does not normally harm the plant. Read labels before applying pesticides to plants.

Thief ant nests are difficult to locate but, when found, should be treated with approved pesticides. Carefully apply pesticides into voids, cracks, and crevices, especially concentrating on kitchen areas. Effective sprays and dusts include silica aerogel, boric acid, pyrethrins, chlorpyrifos, carbaryl, and bendiocarb. Boric acid baits are available but, to be effective, have to be more attractive to ants than other available food sources.

Evaluating treatments

Treatments will be evaluated by continual inspection and monitoring. When ants are no longer found inside structures, treatments will be considered effective.

Evaluations of treatments will be used to supply essential information to adjust Action Threshold values, develop more effective management strategies, and demonstrate any apparent needs for new control methods or chemicals.

Chemical alternatives

Allethrin aerosol for flying insects
Borate wood treatment for carpenter ants
Boric acid bait (liquid and solid)
Boric acid dust for cracks and crevices
Diatomaceous earth with or without pyrethrin
Fenoxycarb insect growth regulator
Hydramethylnon bait
Methoprene insect growth regulator
Potassium salts of fatty acids (soaps) for ants on plants
Pyrethrin contact spray
Resmethrin aerosol treatment
Silica aerogel with or without pyrethrin

Sources of advice, technical information, and supplies

See Appendix listings for equipment and chemical supplies.

National Park Service Videotapes

"Crack and Crevice Treatment for Cockroach Management," 13 minutes.

"Integrated Pest Management," 15 minutes.

"Pesticide Applicator Safety," 17 minutes.

"Structural Inspections -- A way of Managing Wood Inhabiting Insects," 23 minutes.

Literature

Applied Myrmecology. 1990. Westview Press, 5500 Central Ave., Boulder CO 80301; 303/444-3541. Deals exclusively with control of pest ants.

Hedges, Stoy A. 1991. Managing Pests Without Pesticides. Pest Control Technology, Jan. 1991: 45-49

_____. 1991. Field Guide for the Management of Structure-Infesting Ants. Franzak & Foster, Cleveland OH.

Mallis, Arnold, 1990. Chapter 12, Ants; revised by k.D. Haack and T.A. Granovsky, In Handbook of Pest Control; Franzak & Foster, Cleveland OH.

Olkowski, W., Daar, S., and H. Olkowski. 1991. Common-Sense Pest Control. Taunton Press, Newtown, CT.

Smith, M.R. 1965. House-infesting ants on the Eastern United States. Tech. Bull. 1326. Agric. Res. Serv. U.S. Dept. Agric., Washington, D.C.

U.S. Department of the Interior, National Park Service. 1984, 1994. First and Second Editions, IPM Information Manual. Washington DC.

Wilson, E.O. and G. Holdobler, 1990. The Ants. Harvard Univ. Press.

BEES, WASPS, AND HORNETS

Description, distribution, identification

A variety of stinging Hymenopteran insect pests commonly occur throughout the country and include both social and solitary insects.

Social insects include honey bees, bumble bees, paper wasps, hornets, and yellow jackets. Social bees and wasps live in colonies and are responsible for most stinging incidents.

Solitary bees and wasps include sweat, leaf-cutter, and digger bees; carpenter bees; mud daubers; digger wasps; and tarantula killers. Solitary bees and wasps do not live in colonies, seldom sting people, and are not usually very aggressive.

Honey bees (*Apis mellifera*) range in color through various shades of yellow, black, or brown; they are about 2/3 inch long, have a pollen basket on the rear legs, and their body is covered with light-colored hairs.

Honey bees show elaborate social divisions in the nest and construct uncovered/open combs in sheltered sites (holes in walls, trees, rocks, buildings, or under rock overhangs, or in structural voids). Their nests may contain 60,000 to 80,000 individuals at full strength. The European (often, domestic) honey bee is still the more common honey bee over most of the United States, and is not particularly aggressive or defensive of its nest. The European honey bee, however, is very susceptible to varroa and tracheal mites which have recently appeared and are killing many bee colonies. The numbers of honey bees seasonally found in dry desert areas can vary by 10 or more times, depending on annual rainfall patterns.

Africanized honey bees (AHB) are less susceptible to varroa and tracheal mites than European honey bees, are less selective for locations of a nest site, and are much more aggressive nest defenders. AHB will place nests in the same locations as do European honey bees, but will also use holes in the ground, culverts, pipes, covered water meters, overturned flower pots, etc.

Bumble bees (*Bombus* spp.) are closely related

to honey bees but are larger (about 1-inch long), robust, social, black and yellow colored bees with a hairy abdomen. The abundance of hair on the top of the abdomen and color readily distinguishes bumble bees from similar-sized, shiny black carpenter bees. Although there are about 57 species of bumble bees in North America, the golden northern (*Bombus fervidus*), golden-orange (*Bombus borealis*), and Sonoran (*Bombus sonorus*) bumble bees are probably the more common species found in the Southwest.

Only fertilized queens over-winter. During early spring, the queen will build a nest in a hole in the ground and provision it with pollen and nectar. When the eggs hatch, young which become workers assist the female in enlarging the nest. By the end of summer, a nest may contain up to 400 worker bees. Male and female bumble bees capable of reproducing are produced during late summer; they leave the nest, mate, enter hibernation, and become active during the following season.

Solitary bees belong to one of a number of different families which contain numerous genera and species. In the Southwest, solitary bees include insects like yellow-faced bees (Family Colletidae, *Hylaeus* spp.); green metallic bees (Family Halictidae, *Agapostemon* spp.), mining or digger bees (Family Andrenidae, Subfamily Anthrophorinae; *Andrena* and *Anthophorah* spp.), clarkia bee (Family Melittidae, *Hesperapis* spp.), leafcutting bees (Family Megachilidae, *Megachile* spp.), mason bees (Family Megachilidae, *Osmia* spp.), and sweat bees (Family Halictidae, various genera). Insects from the different families are best identified by a specialist who is able to compare subtle differences in wing venation. Identification to the genus and species level can be quite complex.

Life cycles of solitary bees may be very complicated and differ greatly among various families and genera. In general, solitary bees feed on nectar and the females provision their larvae with nectar and pollen during egg laying. Some species are very specific as to the kind of flowers they use. Some species may become exceptionally numerous in a relatively small area only when certain cacti or flowers are available.

A female solitary bee usually digs a simple nesting burrow or series of branching burrows

(some species dig burrows communally) a few inches deep in the soil. Pithy stems, dead wood, and clay (mason bees) are also used for nesting. Some species prefer to nest together in large numbers in specific soil types, such as the sides of a clay or sand embankment (Anthophora) and sometimes dig burrows into archeological adobe ruins. Other species prefer to build burrows in meadows, gardens, and lawns; still others prefer to build burrows in abandoned fields, or bare soil. The female places nectar and pollen in the completed burrow, lays an egg(s), and closes the burrow. Larvae mature within a month or so and emerge as adults. The life history of many of these bees is still not fully known but many solitary bees are highly beneficial insects because they pollinate plants.

Paper wasps (umbrella wasps; Polistes spp.) are red or dark brown in color and can be identified by their long, rear legs which hang down and trail during flight. Paper wasps are attracted to warmth and often place their nests under building eaves and in other locations that are protected from light and weather. Nests are single-combed, umbrella-shaped, flat and are not covered with an exterior, protective, paper-like envelope like hornet nests. The nests (which may be basketball-size or larger) are found in cool and protected places from late-May to early June when day and night temperatures are warm. At maximum size, nests usually contain less than 250 insects, are readily visible, and are normally attached under overhangs. Paper wasps are not normally aggressive except when they feel the need to protect the nest. Aggressive behavior, however, tends to increase during late season when most human stinging incidents occur.

Yellow jackets (Vespula spp.; Dolichovespula spp.) are 1/2 inch or more long and distinguished from other social wasps by their distinctive coloration of alternating yellow and black bands (some species may show white or red colors) and their nests are always built in protected places (abandoned rodent burrows, decayed tree stumps, and holes in buildings). The nests reach maximum size (3,000 to 10,000 workers) by late July to late September. Yellow jackets are extremely aggressive.

Bald faced hornets (Dolichovespula maculata) are much larger (to 3/4 inch long) and huskier

wasps than yellow jackets. They are mostly black with indistinct whitish stripes on the body and a whitish face. Hornets are normally not aggressive unless their nest is threatened. The nests are usually placed in areas exposed to the elements and commonly found under structural roofs or in vegetation. The nests are typically pear-shaped, the larger end being at the top, and are covered with an outer sheath. Nests may only contain 100 to 700 workers.

Mud dauber wasps. Mud daubers (Subfamilies Trypoxyloninae and Sphecinae) are solitary wasps and are identified by their long, slender shape (1/2 to 1 inches long), very long and slender abdomen, and dark blue or black color with pale markings and metallic luster. These wasps build tube-like mud brood chambers in sheltered places inside garages, sheds, or under eaves and porches. People often fear mud daubers because of their resemblance to paper wasps; but, mud daubers do not defend their nest and rarely sting. Mud daubers are beneficial because they eliminate spiders and insect pests found around structures.

Digger wasps (Scolia spp. and Campsomeris spp.) are long, robust, hairy wasps with light-colored bands and areas of red and yellow. They have a 1 inch wide wingspan and appear during early mornings when they may be seen flying over and digging holes in lawns while searching for or covering up beetle grub prey. The female stings a beetle larva, constructs a cell around it, and lays an egg on the larva. The lone, developing wasp larva feeds on the beetle larva and overwinters in the burrow as a pupa.

Tarantula hawks (Pepsis spp.) are identified by their blue or black bodies; black, blue, red, yellowish, or orange-colored wings, and size (1 to 1 3/4 inches long). They show erratic movements, darting into and out of cover and by constant wing twitching. Tarantula hawks prey on tarantulas and are usually seen flying close to the ground looking for prey.

Carpenter bees (Xylocopa spp.) are large (1/2 to 1 inch long), shiny black, solitary bees that are sometimes seen slowly flying around wooden moldings or beams or entering holes in wood. Females excavate a 4 to 6 inch long egg gallery in wood where she lays eggs and provisions the burrow with food for the larvae. Galleries may be

re-used in subsequent years and have been known to extend as far as 12 feet. Young emerge in early summer.

Occurrence in the park

Honey bees, solitary bees, bumble bees, hornets, wasps, yellow jackets, and similar insects are native species and occur throughout the park. They are attracted to flowering plants, heavy vegetation, disturbed soil, poor grade around structures, garbage cans, and water leaks. Paper wasps and yellow jackets can be found anywhere in the parks but become common pests when they establish nests around residences, in water control boxes in the ground, and under buildings.

Biology

Life histories and habits of wasps and bees vary considerably. Although honey bee colonies may use a nest site for a long time (up to 30 years), bumble bees, wasps, hornets, and yellow jackets construct new nests each year. All these insects are opportunists and will use holes in structures or rocks as nesting sites.

Foods and Feeding: Many social wasps prey on small insects (flies, caterpillars and beetles) which they feed to larvae. Adult wasps feed on carbohydrates or sugars (flower nectar, tree sap, fruits, honey dew, etc.) but also scavenge human foods from garbage cans. In general, solitary wasps prey on spiders and insects.

Honey bees and bumble bees feed on flower nectar, pollen, and honeydew and are sometimes attracted to garbage. Most solitary bees feed on nectar and pollen.

Predators: A number of birds prey on honey bees and wasps. Skunks can seriously damage honey bee colonies.

Potential damage and health concerns

Female bees and wasps will only sting to protect the nest or young and males do not sting at all. Very few stinging incidents occur when honey bee swarms (formed after nest division) are found hanging on trees or buildings.

Human stinging incidents are usually worse during rainy seasons and during late-summer to fall when nests are more vulnerable. However, both visitors and employees can accidentally disturb bee and wasp nests located in the ground, on vegetation or structures, or close to trails and visitor-use facilities. These nests continually pose various degrees of hazard. Stings are very painful and some people are so afraid of being stung they may injure themselves (or cause an automobile accident) trying to escape flying bees and wasps. A percentage of people are highly allergic to stinging insects and may become very ill or die from only a single sting.

Wasps and bees are seldom responsible for direct structural damage; however, when nests become established inside of building walls, entire sections of the wall may have to be removed to extract colonies or abandoned nests. Predators (including woodpeckers) often subsequently cause direct and serious damage to walls when trying to reach insect combs or larvae.

Yellow jacket problems often seem to appear almost overnight during late summer (after July) when the size of insect populations and activity peak, usually after the first frost and when prey items or food are no longer available. Yellow jackets are very aggressive insects, especially when protecting the nest. The act of stinging in most bees and wasps causes release of airborne aggression pheromones (odors) that further enrage the colony. Unlike honey bees, wasps do not have a barbed stinger and an individual can sting a number of times. Nests may be located in holes/voids in buildings, shrubs, under eaves, etc. but are also found in the ground or in the roots of dead/rotten trees.

Paper wasp nests are commonly located under building eaves and in other partially-hidden locations where people may inadvertently come into close contact with the insects and be stung. During fall, some species of male paper wasps fly to the highest available and preferred site for mating (i.e. towers, buildings, etc.) where they attract females with sex attractants (pheromones). Groups of females arrive, find males, mate, and hibernate in the sites chosen by males. Such aggregations of wasps sometimes occurs in locations where people

come into contact with the insects and are stung. **Bald faced hornets** seldom impact people because nests are usually located high up in trees or shrubs. Hornets, however, can be very aggressive should their nest be disturbed. Nests on buildings, in low shrubs, and sheds always pose hazards to persons passing by.

Currently, **honey bees** of the European genotype do not pose serious hazard to visitors. Although honey bee venom is relatively toxic to man and a number of persons are highly allergic to it, honey bee aggressiveness is confined to nest protection, they do not protect their nest out very far (usually, out to a distance of 10 to 20 yards), and a relatively small number of worker bees respond to disturbances. However, honey bee aggressiveness tends to increase when temperatures are lower than 56 degrees F.

The **AHB** is much more defensive of its nest and may protect it out to a distance of 150 or more yards. And, ten or more times as many AHB workers will respond to disturbances than do European honey bees. Various persons in Central America who initially survived a serious AHB attack have been reported to die within a year or two following the attack because of kidney and liver problems. AHB are established in the park and could pose threats to humans should nests become established near visitor use areas. To date, there have been no AHB problems in the park.

Some **solitary bees** damage adobe walls, soft wood, and foam roofs when excavating nesting burrows. Lithurge apicalis, Family Megachilidae, a common leaf-cutter bee over much of northern New Mexico is one of these and nests in decaying or rotting wood (i.e. damaged portions of roofs, etc.). Larvae developing in the burrows subsequently attract woodpeckers which may do extensive damage. Various species of solitary bees such as digger bees (Anthophora spp.), alkali bees (Nomia nevadensis angelesia), green metallic bees (Agapostemon virescens), and great golden digger wasps (Spex ichneumoneus) prefer to nest in soil and clay banks and sometimes may dig nest burrows in archeological adobe walls.

Other solitary bees may dig nests in trails and frighten visitors using trails. Solitary bees are not normally known to be aggressive and leaf-cutter

and most other solitary bees only sting when a victim touches the bee (while brushing the bee off) or has come into the line of travel of bees flying to/from a nest. The pain from stings of most solitary bees is usually mild. Approaching a nesting aggregation of digger bees, however, may result in very painful stings.

Bumble bees. Very few people are stung by bumble bees; however, bumble bees will actively defend a nest which can be well-hidden in the ground and not easily detected until stepped on. Bumble bees do not have barbed stingers and can sting repeatedly. Persons disturbing a nest can receive a rather large number of stings and the bees will chase people for a distance of 300 or more yards. Although bumble bee stings are painful and the bees invoke fear because of their size and noise, relatively fewer bumble bees are present in any given nest to attack a person than are present in honey bee and wasp nests.

The presence of **mud dauber** brood chambers is undesirable and can cause damage to painted/finished structural surfaces. Abandoned brood chambers attract carpet beetle infestations due to remnant scraps of protein in the form of dead spiders and insects.

Digger wasps do not attack people and rarely sting. Persons have been known to safely walk among them as they fly over lawns.

Tarantula hawks are beneficial insects but will sting if provoked; great care should be used around them since the sting can be very painful.

Carpenter bee holes can seriously damage decorative structural wood members and developing larvae in the galleries may attract woodpeckers. Subsequent damage by woodpeckers can be even more serious than that caused by the bees. The female carpenter bee rarely stings; male carpenter bees do not sting.

Action thresholds

Active paper wasp, hornet, yellow jacket, honey bee, or solitary bee nests will be removed or controlled when located close to areas of high-use or otherwise pose threats to visitors or employees or when damaging resources.

Immediate control action will be undertaken for severe yellow jacket problems, when 10 or more yellow jacket foragers visit an open garbage can within 10 minutes. Changes in this Threshold may be made after records of yellow jacket visits are correlated with the numbers of reported stinging incidents.

Any carpenter bee activity seen in or near buildings or historical structures will be the action threshold for corrective and/or preventative control measures.

Inspection and Monitoring

Inspections for honey bees and other stinging insects will determine the presence and kind of insects, locations of nest sites and available harborage, relative abundance, and structural deficiencies or habitat conditions supporting or attracting the pests.

Watch for bees and wasps that may be entering holes and cracks in structures. Sometimes wasp and bee nests inside of walls can be located by use of a stethoscope.

Watch for honey bees within a 3 mile radius of open water sources. Most worker bees only fly 1/2 to 1 mile from the nest to water but some may fly as far as 3 miles. The maximum foraging distance for honey bees is about 6 to 8 miles.

Develop an ability to "beeline" (see Lockard in reference section), and follow flying bees from flowers or water to their nest. If bees cannot be followed, triangulate two or more compass azimuths from different locations.

Periodically through the season, monitor the number, relative size, and aggressiveness of paper wasp, yellow jacket, hornet, and honey bee colonies. Closely watch honey bee colonies for any sudden or unusual changes in aggressive behavior which could indicate "Africanized" traits. Inspect for and monitor for sensitive areas where AHB could establish colonies. AHB more readily nest in the ground, pipes, holes, etc. than do European honey bees.

Suspected sudden increases in the numbers of bees present during any given season or year are best tested when 3 or more years of base-line data are had. Compare suspected unusual

number of bees present with previous, average numbers. Base-line information on the numbers of bees present during specific seasons can also be developed with random transect counts of individual foraging bees on flowers. Maintain records of the numbers, times, and locations of honey bee swarms.

Non-chemical management

Exclusion: Thoroughly seal all cracks and holes 1/8 inch or larger in diameter that lead into voids in residences, garages, outbuildings, crawlspaces, etc.

Fans or air curtains can be used to exclude flying insects.

Habitat in visitor-use areas highly attractive to nesting solitary bees can be covered with plastic during the short nesting period.

Sanitation: Repair and control all water leaks; bees must have water to survive. Remove unnecessary sources of open water. The numbers of bee colonies present in an area can become quite large (10 or more times normal) when water is available to them.

Keep areas clean; remove or tightly cover empty containers, pipes, and culverts; remove any old or abandoned bee equipment (colony boxes); exclude bees from trash containers and frequently wash garbage cans; remove attracting food materials (rotting fruit, cold drink cups); remove piles of dead limbs and other vegetation; cover stacks of pipe and lumber; modify picnic and outdoor tables and chairs so as to not expose open pipe ends.

Encourage residents to tie up household garbage tightly in plastic bags before placing it in collection cans or dumpsters.

Habitat modification: Remove all debris, piles of lumber, or other potential nest sites from around buildings and areas of human use. Prune any thick vegetative growth that may harbor nests.

Remove all needless sources of open water (faucet drips, leaking pipes, etc.) which attract honey bees (they use water to cool their nest)

and wasps. Fill depressions (such as water catchments on trails) that attract bees and wasps.

Study the habits of solitary bees and modify their preferred nesting locations by moistening the soil if insects are attracted to dry locations, covering compacted or hard soil with loose sand, or paving trails with soil-cement materials.

Population reduction: Controls taken against the nests of most stinging insects are best done at night when the insects are not active. Scout the nests by day to reduce the needs for illuminating the colony at night with a flashlight, as light tends to aggravate the insects. If a light must be used at night, illuminate the nest from the rear to prevent disturbing the colony and so insects will not be attracted to the light. After removing a nest, carefully clean any attracting odors and pheromones from the site (soap, ammonia, etc.) to keep insects from returning.

Various possible non-chemical controls include:

- Soapy water spray (1 part dish soap in 16 parts water; i.e., 1 cup of dish soap in 1 gallon of water) removes the waxy coating from an insect's body and the reduced water surface tension drowns insects. Use a strong stream of soapy water from a high-pressure pumper to destroy the combs of honey bees and kill the insects.
- Carbon dioxide fire extinguishers, large vacuum cleaners, hot air, and agricultural flamers have been used to destroy stinging insects nests, depending on site location and local conditions.
- Hymenopterous insects are easily killed by heat. Cover a hornet nest, swarming honey bee colony, or AHB swarm trap with a plastic tarp and then expose the tarp to intense sunlight to cause a build up of heat.
- Large, shop vacuums can be used to catch and remove colonies and swarms.

Attempts to lessen wasp problems during the spring by reducing the numbers of insects present during fall are not effective, as natural rates of over-winter mortality for fertilized queens are likely to be about 99.9 percent. Focus control efforts to the springtime when queens can be attracted to pollen and nectar traps.

Other non-chemical control of wasp numbers in an area might include the following:

- All beverages sold by concessionaires for take-out should be supplied with a plastic lid and straw.
- Move dumpsters and trash barrels away from doorways and other high traffic areas. Fit dumpsters and trash barrels with tightly closing lids. Frequently pick garbage up, continually check cans for gaps and holes and keep cans clean. Use garbage liners.
- Remove stumps, dead limbs, hollow trees that serve as potential nesting sites.
- Remove plants that attract wasps and bees including those vulnerable to scale or aphid attack (indicating a source of honeydew).
- Traps: use sticky traps or jar traps baited with meat or sweets for wasps.

Capture bee swarms by placing an open cardboard box under a limb supporting the swarm. Make 3 cuts in one side of the box and fold the flap out so as to make a door with a "landing pad". Strike the limb supporting the bees sharply with a stick so the bees will fall into the box. Cover the box and move back from the site to allow any flying bees to enter the box through the prepared door. When it is dark, close the box and remove it. Bees in an enclosed container can easily be killed by placing the container in strong sunlight.

Kill (by swatting) any carpenter bees seen burrowing into wooden structural members. Keep holes in structures plugged and painted so as to not be attractive to female carpenter bees.

AHB may swarm 3 or more times during a season and migratory swarms can fly 10 miles before settling down into a nest. Swarming bees are usually relatively gentle; however, keep people away from AHB swarms and only collect swarms at night when the entire colony is settled. Never try to remove swarms alone; always have 2 or more trained professionals present when monitoring or controlling AHB colonies. Complete bee suits should be worn when working with bees. Never allow spectators near AHB operations.

Chemical management

Repellents: Diluted ammonia, sometimes used as a disinfectant in trash cans, dumpsters, outdoor tables, etc., is said to also repel wasps and bees. Beekeeper supply houses sell foul-smelling chemicals used by beekeepers to drive bees out of hive boxes before harvesting honey.

Aerial wasp and hornet nests and combs (in trees, under eaves, etc.) are effectively treated with aerosol wasp "freeze" spray but some sprays are not very effective on honey bees. Honeybees are susceptible to resmethrin which chemically combines with combs and prevents future re-establishment. Regardless of the product used, always have a second, back-up container available. Other chemical options, that may or may not be approved, depending on circumstance, include: dichlorfos, diazinon, carbaryl; acephate, chlorpyrifos, and bendiocarb.

African honey bees. Some agencies are experimenting with acephate to destroy AHB colonies. Bees are attracted to a sweet bait and then the bait is amended with poison. Acephate used for this purpose is only available under a special, experimental label for honey bees. Extreme care must be taken to not affect non-target, European honey bees (domestic) or other organisms.

Bumble bee nests. Locate the nest site and inject the nest with a resmethrin spray and follow up with residual dusts. If nest entrance cannot be located, spray the area suspected to contain the nest with wettable insecticide powder to help prevent your being stung

while looking for the actual entrance hole. If bumble bees are nesting in a wall void or attic, use the same chemical treatments as for honey bees in wall voids or attics.

Hornet nests. Hornet nests have only one entrance on the bottom. Treat nests by spraying a chemical pesticide directly into the entrance hole to kill the guard insects. After treating the entrance, treat the nest interior with a desiccant or pesticidal dust (bulb duster with a 12 inch extension wand). Leave the nest in place for 24 hours to assure all returning worker wasps are killed. Treat the nest again should the nest remain active. Pyrethrin and aerosol "freeze" chemicals provide quick knockdown and residual control for hornets.

Paper wasp nests. Treat the area surrounding an entrance of wasp and yellow jacket nests in structural voids with resmethrin (or other approved chemicals) to disorient insects. Then, insert a treatment tube into the nest and thoroughly apply residual pesticide dusts or aerosols. Plug the nest entrance with steel wool and dust the area surrounding the plug with residual pesticide to kill any returning workers. If the entrance hole being used by the wasps can not be found, use a stethoscope to listen through the wall for nest activity and drill a hole through the wall and inject pesticide aerosol or dust directly into the colony.

Carpenter bees. Inject residual pesticide dusts or sprays into carpenter bee burrows to kill the larvae and then seal the hole with a pesticide-impregnated plug or caulking. Paint over caulked burrows to keep from attracting other carpenter bees.

Evaluating treatments

Continually monitoring honey bee, wasp, and hornet colonies after treatment will demonstrate the efficacy and longevity of treatment.

Treatment evaluations will be used to supply essential information to adjust Action Threshold values, develop more effective management strategies, and demonstrate any apparent needs for new control methods or chemicals.

Precautions

Each AHB colony behaves differently and behavior also differs in relation to weather conditions or season. Some AHB colonies may aggressively defend a nest when threats are 100-150 yards away and often 10-times or more AHB bees will attack as do European honey bees. Disturbed AHB nests may remain agitated for 1 to 2 hours and may chase people for a distance of up to a quarter of a mile.

Be especially wary of any bee colony on dreary, rainy days, if the colony is located in a low-lying area, or during cool weather.

Unaware persons have mistakenly approached an AHB colony and quickly received 400 to 500 stings. Often, 500 or more stings can be lethal, especially in the old, the very young, the infirm, or those unable to flee. Persons receiving 15 to 25 or more stings should always seek medical assistance since potential reactions can later develop, including kidney failure. Allergic persons can die from only a single sting. Obvious systemic allergic reactions require immediate medical attention. Encourage allergic persons to consult their doctors for information and to carry proper medications.

Destroy all colonies of aggressive wasps, hornets, yellow jackets, bees, or other stinging insects which could possibly endanger the public or employees with physical or mechanical means (heat, vacuum, freezing, etc.) or with properly approved pesticides. The US Department of Agriculture, Agricultural Research Service should be asked about possible benefits and drawbacks for placing Africanized honey bee swarm capture traps in the park.

Chemical alternatives

Allethrin aerosol treatment for flying insects
Pyrethrin spray for wasps
Resmethrin spray for outside space treatment of honeybee and bumble bee nests
Silica aerogel with or without pyrethrin for tunnels of carpenter bees and solitary bees
Wasp freeze chemicals (without CFC's) for wasp nests

Sources of advice, technical information, and supplies

National Park Service Videotapes

"Integrated Pest Management," 15 minutes.

"Pesticide Applicator Safety," 17 minutes.

"Structural Inspections -- A way of Managing Wood Inhabiting Insects," 23 minutes.

See Appendix listings for equipment and chemical supplies.

Literature

Akre, R.D., A. Greene, J.F. MacDonald, P.J. Landholt, H.G. Davis. 1980. Yellowjackets of North America. USDA Handbook #552.

Arizona, State of. 1995. Video: A Homeowner's Guide to Safe Honeybee Control. Arizona Department of Agriculture, Agric. Ser., Univ. of Arizona, Tucson AZ.

Bitner, Ron. Information on leaf cutter bees. Route 4 Box 58-J, Caldwell ID 83605, 208/467-3314.

Frazier, D.A. 1976. Insect stings - a medical emergency. J. Am. Med. Assoc. 235(22): 2410-2411.

Girardi, A., K. Hackett. 1982. IPM Binder for Yellowjackets: A Management Strategy, developed for the NPS by John Muir Inst. for Environ. Studies., Napa, CA.

Landolt, Peter J. and Hal C. Reed, US Department of Agriculture, ARS Laboratory, Gainesville FL. Consultants to NASA on late-summer swarming wasp control (traps) to protect space crafts.

Lockard, John R. Bee Hunting. Fur-Fish-Game Book Dept., 2878 E. Main St., Columbus OH 43209.

McGavin, George C. 1992. Insects. Smithmark Publishers, New York.

Milne, Lorus and Margery. 1988. Field Guide to North American Insects and Spiders. Alfred A.

Knopf, New York.

Moore, Wayne LS. 1988. Controlling Household Pests. Ortho Books, Chevron Chemical Co., 742 Bancroft Way, Berkeley CA 94710.

Olkowski, William; Sheila Daar; and Helga Olkowski. 1991. Common-Sense Pest Control. Taunton Press, Newtown, CT.

Putnam, Stuart E. Jr.. Controlling Stinging and Biting Insects at Campsites; ED&T Publ. #2689; USDA, US Forest Service Equipment Development Center; Missoula MT 59801.

Smith, Robert L. 1992. Venomous Animals of Arizona. University of Arizona Press, Tucson Arizona.

Texas A&M and Texas A&M Extension Service, 2401 East Hwy. 83, Weslaco TX 78596. Dr. John G. Thomas, Entomologist; Dr. "Stormy" Sparks, Texas A&M Experiment Station, 512/968-5581; Dr. F.G. Maxwell, Dept. of Entomology, Texas A&M Univ., College Station TX 77843.

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Texas, State of; Department of Health
Touhey, Dr. John E., Chief, Bureau of
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USDA-ARS Baton Rouge Research Center,
Honey Bee Breeding, Genetics and Physiology
Laboratory, 1157 Ben Hur Road, Baton Rouge LA
70820; FTS 687-0277, 504/766-6064.

USDA-ARS Carl Hayden Bee Research Center,
Tucson AZ; 2000 E. Allen Road; 602/629-6380

US Dept. Health, Educ. and Welfare. 1967.
Pictorial Keys to Arthropods, Reptiles, Birds, and
Mammals of Public Health Significance. Public
Health Service, Atlanta, GA.

U.S. Dept. of Interior, National Park Service.
1984, 1994. First and Second editions of the NPS
Integrated Pest Management Information Manual.

SAMPLE STINGING INSECT - DATA MONITORING FORM

Date: _____ Filed by: _____

1. Where in park did sting occur?
2. What was victim doing when stung (walking on trail, throwing trash away, sitting at table, other?)
3. How many times was victim stung?
4. Location of sting on victim's body?
5. What was the reaction to the sting? (pain and redness, swelling in area of sting, swelling of limbs, nausea, respiratory distress, other)
6. What was follow-up treatment? (application of gel, ice, referral to doctor)
7. Did victim receive printed materials on stings?

SAMPLE STINGING INSECT MONITORING FORM

Date: _____ Map Reference: _____ Recorder: _____

EVENT:

1. Time, weather (overcast, bright, windy), and temperature when stinging incident occurred:
2. Specific park location where sting occurred (picnic area, path, recreation area, forested area, other):
3. Species causing the sting (yellowjacket, wasp, European honey bee, Africanized honey bee, etc.; who/how identified?) and behavior:
4. Activity of victim when stung (walking on trail, throwing trash in can, sitting at table, other):
5. Number of times victim was stung:
6. Location of stings on victim's body:
7. Victim's physical reaction to stings? (pain and redness, excessive swelling in area of sting, swelling on limbs, difficulty swallowing, difficulty in breathing, nausea, disorientation, etc.):
8. Was the victim treated (application of ice, referral to doctor, self-treatment, etc.):
9. Had the victim received printed or posted information on the presence of, or precautions against, stinging insects in the park:

OBSERVED FOOD AND WASTE MANAGEMENT PRACTICES

1. Are concessions providing lids/straws for beverage containers?
2. Are garbage containers tight against bees and wasps?
3. Are garbage cans overflowing because of infrequent pickup?
4. Are the insides (including bottom under the plastic liner) of the garbage cans clean?
5. Are there enough garbage cans?
6. Are external garbage spills cleaned up or hosed down?
7. Are management practices creating puddles of water which attract bees and wasps?

MONITORING

1. Counts of yellowjackets, bees, or wasps visiting garbage cans during a 10 minute interval (identify specific cans on an attached map):
2. Presence of active stinging insect nests in the area (identify locations on an attached map):

EMPLOYEE COMMENTS AND RECOMMENDATIONS: _____

DEER

Description, distribution, identification

White-tailed (*Odocoileus virginianus*) and mule deer (*O. hemionus*) are both found throughout much of North America; both species occur in Big Bend National Park.

Deer are even-toed ungulates that can weigh up to 400 pounds, depending on species and location. The tail is the easiest identifying feature to distinguish white-tailed and mule deer. Mule deer have a tail that is either black-tipped or black on top and white-tailed deer have a broad tail that is even-colored on top and white below. Male deer of both species begin to produce antlers during late spring; antlers are fully formed by late fall and are shed in mid-winter.

Occurrence in the park

Deer are common native animals in the park. They are attracted to developed areas, residences, and campgrounds where they scatter garbage and create general nuisances. Deer potentially pose safety hazards to people who, attempting to feed them, approach too closely.

Biology

Deer frequent forest edges and thrive in agricultural areas interspersed with riparian habitat. They are most active during early mornings and late evenings. Deer have a home range of several hundred acres, but the size of that area varies with season, sex, and habitat quality.

Foods and feeding. Deer are browsers that mostly feed on leaves, stems, and buds of woody plants. Preferred plant species varies greatly, depending on region and availability. Forbs, when present, are a favored food during spring and summer. Fruits and nuts are also seasonally important but grasses are relatively unimportant.

Reproduction. Deer breed from October to January with peak activity in November, depending on latitude. Most fawns are born during May and June, and adult females usually produce a single fawn but some

produce two young.

Potential damage and health concerns

Deer cause damage to a wide variety of crops and may permanently disfigure trees, nursery stock, and ornamentals.

Deer-vehicle accidents on highways are the cause of severe vehicle damage and human injury or death. People attempting to feed deer, or otherwise closely approach the animals, are sometimes injured when deer kick or butt them.

Deer harbor a number of diseases common to humans (i.e., Lyme disease and, very rarely, rabies) and livestock and may become aggressive towards humans during rut or in search of food.

Action thresholds

Frequent or costly damage to ornamental plants or other cultural or natural resources, threats of human injury, or noticeable numbers of deer found around visitor use areas will be the action threshold for deer control.

Inspection and monitoring

Inspection and monitoring techniques for deer are similar. Frequently count deer at night with a spot light and keep the counts separated as to individuals of different sexes, ages, sizes, colors, or other clearly identifiable characteristics. After a given number of samples are made (all the animals do not frequent a given area at the same time), the total of the maximum number of animals seen in each group will provide a minimum estimate of the number of animals present.

Non-chemical management

LEGAL. Deer are protected year-round in all states, except during legal harvest in hunting seasons. In cases of severe or persistent damage, states may issue special depredation permits to allow deer to be taken at times other than the legal hunting season. Regulations vary on the disposal of dead carcasses. Control of deer damage can be a difficult social, political, biological, and logistical problem; planning should always

involve state wildlife agencies.

Although fencing (temporary electric fences and permanent woven-wire fences) is expensive, it usually remains the most effective and long-term method to exclude deer. Net wire fences should be 8 feet high and topped with barbed wire. Electric fences should be made of 6-strands spaced 10-inches apart with the bottom strand 8-inches off the ground. Individual trees/plants can be encircled with hardware cloth or poultry netting. Vexar seedling protectors are effective for small trees and are relatively inexpensive compared to fencing costs.

Scare devices, repellents, live-trapping, and shooting are other methods used in deer control. Scare devices are most effective when actions are taken at the first indication of a deer problem and before behavioral feeding patterns become established. Repellents are often used on ornamental plants and various commercially-available ones include:

Thiram (Arasan), a taste repellent and available as an aerosol spray; one application is reported to last 6-months.

Ziram, a fungicide ordinarily used for plant diseases.

BGR (Big Game Repellent, Weyerhaeuser Co., registered by McGlaughlin, Gormley, and King Co., Minneapolis, MN. This repellent was cooperatively developed by the US Fish and Wildlife Service and is made from fermented eggs.

Repel (Leffingwell Chemical, Brea, California) contains paradichlorobenzene.

Hinder, ammonium soaps or higher fatty acids, is said to be effective for 5 to 7 days when sprinkled on plants. A 20 percent solution of egg mixed with water is reported to be just as effective as some commercial repellents.

Ro-Pel, benzyldiethyl methyl ammonium saccharide, is an extremely bitter substance and can be applied to many materials or plants.

Bottled hot sauce has even been used by

some on plants.

Tests of repellents by Colorado State University found coyote urine and BGR to be the best dilute repellents. Chicken egg solutions, Hinder, and thiram were intermediate in effectiveness.

Gustatory repellents that reject deer because of bitter taste should be applied to trees and shrubs during the dormant period; new growth which appears after treatment is unprotected. Area repellents that are applied near plants repel deer by odor but are usually less effective than contact repellents. Consult manufacturers for specific information on repellents.

Live-trapping by means of a clover trap or drop-net or capture of deer with immobilizing drugs are effective ways to remove small populations of animals. These techniques, however, are very labor-intensive and must be coordinated with state Fish and Wildlife agencies.

Regardless of the method used to lessen the number of deer present in an area, it is usually necessary to reduce a population by at least 60 percent each year prior to reproduction. When animals are live-captured and released, some tagged animals have been known to return to point of capture from a distance of 20 or more miles.

Promising research is underway on the use of chemosterilant and immunocontraception to slow deer reproduction, but these methods are best suited for urban parks and refuges.

Chemical management

Toxicants and fumigants are not used in deer control.

Evaluating treatments

Periodic monitoring of deer (nighttime, spotlight census) will provide information on the effectiveness of previous treatments.

Evaluations of treatments will be used to supply essential information to adjust Action Threshold values, develop more effective management strategies, and demonstrate any apparent needs for new control methods or chemicals.

Chemical alternatives

Publications, P.O. Box 9335, Fresno CA 93791.

There are no chemical toxicants registered for deer. A number of repellents are labeled for deer.

Ammonium soaps of higher fatty acids
Benzyl-diethyl methyl ammonium saccharide
Capsaicin-based products
Fermented eggs (BGR, Big Game Repellent)

Sources of advice, technical information, and supplies

National Park Service Videotapes

"Integrated Pest Management," 15 minutes.

See Appendix listings for equipment and chemical supplies.

Literature

Craven, Scott R. and Scott E. Hygnstrom. 1994. Deer. In Hygnstrom, Scott E., Robert M. Timm, and Gary E. Larson, Prevention and Control of Wildlife Damage. Univ. of NE Coop. Exten. and US Dept of Agric., APHIS.

Hart, Rhonda Massingham. Deer Proofing Your Yard & Garden. Storey Communications, Schoolhouse Road, Pownal VT 05261.

Simmons, Sewell E.. 1985. Parklands Pest Management. California Dept. of Food and Agric., Sacramento California.

Thompson, Dan; Lowell Miller; and Brad Johns at Pennsylvania State University are researching immunocontraception methods as a means to control deer.

Timm, Robert M. 1983. Prevention and Control of Wildlife Damage; Nebraska Cooperative Extension Service, Lincoln NE.

US Dept. Agric., APHIS, Denver Wildlife Research Center, Bldg 16, Federal Center, PO Box 25266, Denver CO 80225-0266; 303/236-7874. Repellents, information.

Ware, George W. 1988. Complete Guide to Pest Control - With and Without Chemicals. Thomson

FLEAS

Description, distribution, identification

There are approximately 1,600 different flea species; about 95 percent of those species occur on mammals and about 5 percent of those species on birds. About 120 of those species transmit plague and less than 20 species bite humans. Although fleas occur world-wide, they are rarely found at altitudes above 5,000 feet.

Taxonomic keys for identifying fleas are available in most pest control and parasitology texts; however, flea identification is difficult and must be done with a microscope. Fleas collected off pets or from households should be sent to a specialist or public health agency for identification.

Occurrence in the park

Most park residents keep pets and frequently experience flea problems in their residences.

The cat flea (Ctenocephalides felis) and human flea (Pulex irritans) are expected to be found in the park if imported on furniture or clothing. Other fleas that may be found in the park are the dog flea (C. canis), Oriental rat flea (Xenopsylla cheopis); northern and other rat fleas (Nosopsyllus fasciatus, Leptopsylla spp.), mouse flea (Ctenopsyllus segnis); bird flea (Echidnophaga gallinacea), western chicken flea (Ceratophyllus niger), European chicken flea (Ceratophyllus gallinae); and squirrel flea (Orchopeas howardii).

Biology

Flea biology can be very complex. For the sake of simplicity, only the basic biology of the cat flea is outlined here. For specific information on other kinds of fleas, refer to standard reference texts on parasitology or pest control.

The peak season for flea development is from May to September and this is usually the time residents usually begin to call for help.

CAT FLEAS. Cat fleas are the most important and common household flea in this country. This is because cat fleas have a preference for

domestic dogs and cats, feed on a variety of wild animals, bite humans, have an ability to survive in a wide range of environmental conditions, and can live on rodents when other hosts are not present.

Cat fleas and dog fleas are often found jointly, are similar in appearance, and are often confused with one another. Adult cat fleas are about 1/8-inch long, have sucking mouthparts, and exclusively feed on the blood of a host animal.

Cat fleas produce about 20 eggs per day for up to 3 weeks and infestations can build up rapidly. If there were 25 female fleas on a pet, one could expect as many as 500 eggs per day to drop from the pet onto carpets, rugs, bedding, chairs, etc.

Adult female fleas begin to lay from 4 to 8 eggs at a time about 2 days after their first blood meal; egg-laying peaks by about the fourth day and lasts for about 10 days. Cat flea eggs are round, light colored, and about 1 mm in diameter.

Eggs are laid on the host and then fall to carpet. Flea larvae hatch in 2 to 14 days and begin to feed on organic debris on the floor. Larval cat fleas are about 1/8-inch long and have chewing mouthparts. They feed on a variety of materials including adult flea excrement and other organic debris. Flea larvae are strongly attracted to moisture but are very susceptible to heat, sunlight, and low humidity. Larval development takes about 10 days in 50 percent relative humidity but only 5-days in 90 percent humidity.

When flea larvae mature, they spin sticky silken cocoons among carpet threads and then pupate in the cocoon. Although the pupae complete development and molt into adults while still inside the cocoon, emergence must be stimulated by direct pressure on the cocoon, activity by animals or humans near the cocoon, response to increased temperature, etc. Most adult fleas emerge from cocoons in about 10 to 14 days but can remain inactive in the cocoons (waiting for a host) for up to 1-year if a catalyst for emergence is not present. This is why cat fleas become common summertime pests when occupants return home from a vacation.

Flea larvae are not evenly distributed within an

infested house. The numbers of flea larvae in any given area are influenced by activity of pets and humans; humidity, temperature (sunlight), and moisture; available food; adult flea feces in the area; and fleas originating from wild animals (animals nesting in crawl spaces, chimneys, etc.). Concentrations of flea larvae are found in the areas which are most suitable for flea development and where pets (or wildlife) spend most of their time.

DOG FLEA. The dog flea is found in all parts of country except the Rocky Mountain and Intermountain regions. It is a less common and less important household pest than is the cat flea.

Dog fleas are mostly abundant during warm, summer months and prefer to feed on dogs, cats, and people but will also feed on other animals.

HUMAN FLEA. The human flea is primarily a parasite on pigs but alternately feeds on people, domestic animals, poultry, skunks, badgers, foxes, wild animals, and some farm animals. Unlike cat, dog, and other fleas, the human flea does not have spines.

NORTHERN RAT FLEA. The northern rat flea is widely distributed in Europe and America and is a parasite on exotic house mice, Norway rats, black rats, and man. Exotic mice and rats do not commonly occur in the park but this flea could be imported along with household goods. Larvae of the northern rat flea spend more time in the nest of the host and less time on the host than do other fleas.

ORIENTAL RAT FLEA. The Oriental rat flea is the principal vector for bubonic plague and is found throughout the United States except in some Rocky Mountain and Intermountain states. This flea is only occasionally found in buildings and is most common in seacoast towns. The Oriental rat flea has a wide range of hosts which include: Norway, cotton, and roof rats; house mice; man; cottontail rabbits; California ground squirrels; and prairie dogs. Developing Oriental rat flea larvae do not require a blood meal. Adult fleas spend more time on the hosts than do most other fleas.

STICKTIGHT FLEA. Sticktight fleas are pests predominately in Southern and Southwestern

states. They are found on poultry (around the eyes and comb) but may also be found on some wild birds, cats and dogs (along the edges of the ears), rats, horses, and embedded in the skin of persons handling live poultry.

CHICKEN FLEA. The Western chicken flea is only found in western United States but other kinds of chicken fleas are more widely distributed. The chicken flea is a common parasite on domestic fowl and wild birds but also attacks dogs, cats, rabbits, rats, other mammals, and humans.

SQUIRREL FLEA. Squirrel fleas occasionally leave squirrel nests in attics and hollow trees and bite man.

Potential damage and health concerns

Domestic pets can suffer severe skin irritations from flea bites and scratching. Fleas are readily spread from one animal to another, including man, and can be responsible for a range of maladies. One of these is flea allergy dermatitis, caused when irritating flea saliva is injected into an animal's skin. One study found that many persons develop allergic responses from inhaling house dust contaminated with flea body parts.

A characteristic flea bite shows as a central, small red spot at the point penetrated by the mandibles and surrounded with a red, flushed ring ("halo"). Flea bites seldom produce much swelling, while bedbug bites produce a large weal-like bump that usually lasts a few hours.

Fleas are important vectors for a number of serious diseases and parasites including bubonic plague, murine typhus, tularemia, and tapeworms. Although chicken fleas may transmit plague to man, cat and dog fleas are not often associated with plague transmission. Keep rodents from spreading into campground or residences to reduce the potentials for fleas and disease.

Action thresholds

Human occupants/workers bitten by fleas will be the Action Threshold for controlling fleas in households, offices, or work sites. Simply finding fleas on pets will not be a standard for initiating flea control in structures but will serve as an

incentive to advise residents about fleas and flea management methods.

Inspection and monitoring

Because of the recent appearance of Hantavirus in the Southwest, all persons engaged in inspections and monitoring and who might come into contact with rodents or dry rodent debris should wear approved personal protective equipment and follow the Centers for Disease Control guidelines for personal safety.

The most common errors in performing flea inspections and monitoring are: failing to properly identify the flea species, failing to locate the source of the problem, and failing to determine if fleas in the structure are coming from wild animals.

Identify Fleas. Collect fleas causing problems and properly identify them. Various methods can be used to capture fleas for identification purposes.

Place damp paper towels out overnight near pet resting areas and the next day examine folds in the towels and areas beneath the towels for fleas.

Another kind of flea trap can be made at home by leaving a shallow pan of water out overnight placed immediately below an illuminated low-wattage light bulb.

Comb pets over a white surface with a commercial flea comb.

Some persons wear white pants when inspecting for fleas. White socks should be pulled over the cuffs. The inspector should slowly walk around in the room to attract fleas. Fleas jumping up onto the white fabrics can be easily seen and captured.

Specific Sources of Fleas. Look under furniture cushions and in cracks and crevices for granular, salt and pepper-like materials which confirm major sites of flea infestation. The "salt" is flea eggs, empty egg cases, and shed larval skins. The "pepper" is dried blood flakes and dark feces of adult fleas.

Determine the areas in a room or yard suspected

of harboring major flea activity by watching the habits of the family pet and its resting places and travel routes. A stuffed chair favored by a pet can be a flea breeding focal point.

A flea requires relatively large amounts of blood each day to survive and it defecates about 4-times its weight during every 7-minute period while feeding. Thus, feeding activities produce significant amounts of sign in those areas where fleas are concentrated.

Fleas cannot live on lawn detritus since grass does not contain blood nor can fleas survive in sunlit or dry micro-habitats with low relative humidity. Likely outdoor areas supporting development of flea larvae are shaded places, protected from wind, having moist soil, and frequently visited by host animals.

Wildlife Sources of Fleas. Identify any probable wildlife vectors that might bring fleas into a structure and study their travel and loafing habits. Look for bird and mammal nests in unscreened chimneys and vent pipes; inspect crawlspaces and attics.

General flea management programs

Fleas in a household. An effective flea control program requires, more than anything else, good cooperation from the occupant. It also demands good sanitation, proper and precise use of insecticides, and effective control of fleas on pets.

Flea management on pets. When initiated before the flea season, the following flea control preventive measures for pets should reduce the needs for toxic control.

- Establish only one sleeping area for a pet and choose a place that can be easily cleaned. Keep the pet bedding filled with fresh cedar chips, which tend to repel fleas and other parasites. Frequently wash pet bedding in hot, soapy water.
- Carefully vacuum pet loafing and sleeping areas every 1 to 2 days. Flea eggs, larvae, pupae, and adults become concentrated in carpets and pet bedding. While only about 25 percent of the larvae in a carpet can be removed by vacuuming, 30 to 60 percent of

the eggs can be picked up and about 95 percent of the adult fleas can be removed. This is because vacuuming stimulates fleas to emerge from cocoons. Be careful that fleas captured in a vacuum bag are not re-introduced into the house. The paper vacuum bag should be removed after each use and the opening taped. Dispose of the bags in outside trash receptacles or burn the bags.

- Regularly (daily, if possible) groom pets with a special flea comb to remove fleas from the fur. Drop captured fleas in warm soapy water and flush them down the toilet; wash combs in soapy water. Regularly shampoo pets with Safer's Flea Soap. Periodically dust pets with low-toxicity diatomaceous earth to kill fleas and larvae. Massage eucalyptus oil into the animal's skin or use herbal shampoos (from pet stores); these help to repel fleas. Do not use any chemicals, oils, or soaps on animals showing raw skin or open sores.

- Healthy dogs and cats usually do not have severe flea problems. Feed pets nutritious, well-rounded diets which incorporate whole grains, vegetables, and lean meats rather than commercial pet food. Fleas tend to prey and remain on sick or poorly nourished animals.

Flea collars are not effective when they are the only flea control measure used and may irritate animals and expose children, veterinarians, adults, and others who handle pets to residual pesticides. Different brands of flea collars can be impregnated with carbaryl, DDVP, propoxur (Baygon), chlorpyrifos (Dursban), or naled (Dibrom). If you must use a flea collar on a pet, only do so for brief periods of time and store the collar at other times in an airtight bag. Remember, adult fleas spend 95 percent of their time detached from the animal - that is, in carpets, furniture, and maybe, even on the owner's clothing.

Cats dusted with residual pesticides ingest poisons when they lick their fur. If pesticides are used on pets, protect yourself by using gloves and ensure there is adequate airflow. Use a face mask and only use pesticides for a short period of time.

Systemic medication (lufenuron; "Program", Ciba-Geigy) is available with a veterinarian's prescription. This is reported to prevent fleas on dogs 6 weeks old or older. The drug is given in tablet form to the pet once a month. Consult with your veterinarian for other similar medication suitable for cats. Medications for pets do not have EPA registration and do not require NPS approvals for use.

Non-chemical management

Exclusion. Good preventive and wildlife control measures are necessary when structural flea infestations originate with wild animals.

Screen vents, crawl spaces, and chimneys with 1/4 inch mesh hardware cloth to keep wild animals from entering. Prevent animals from using electrical and telephone lines or nearby bushes and trees to gain access to structures.

Sanitation. To eliminate fleas and flea harborage in a home, provide occupants information on cleaning methods, check lists of areas to be cleaned/vacuumed, and ways to dispose of contaminated vacuum bags.

Request occupants thoroughly vacuum all parts of the house (rugs, furniture cracks and crevices, drapes, etc.) once or twice a day with an industrial-strength vacuum for an entire month. This helps to remove sources of food for fleas, large numbers of flea eggs, and kills many flea larvae and adult fleas. Vacuuming also tends to align carpet fibers which helps insecticides to penetrate. A vacuum beater bar attachment makes a vacuum more effective in removing flea eggs and larvae. If a pet will tolerate it, vacuum the pet as a means to try to remove fleas from the fur.

Shampoo or steam-clean carpets. Remove rugs from public use areas. Wash wood and tile floors with detergent. But, do not clean floors or remove residues immediately following application of a residual pesticide. Doing so will reduce the pesticidal effects.

Remove clutter, old boxes, debris, etc. that provide shelter to fleas. Place stored items

on pallets or shelves up off the floor.

Wash pet bedding in hot soapy water and/or destroy all old, infested pet bedding. Keep pets outdoors. Establish appropriate pet grooming, washing, and feeding procedures to keep pets free of fleas. Limit a pet's contact with other animals, especially wildlife.

Remove vegetation near to or touching the structure.

Habitat modification. If possible, lower the relative humidity inside buildings below 50 percent.

Population reduction. Fleas are very susceptible to high temperatures. Flea eggs are killed when exposed to 46 degrees F. for 10 days or 37 degrees F. for 5 days; larvae fail to develop at temperatures below 55 degrees F, or above 95 degrees F. At 80 to 90 degrees F., larvae can mature in 4 to 8 days but maturation takes 26 to 36 days at 60 degrees F. All adult fleas emerge from the cocoon within 4 weeks at 90 degrees F. and within 20 weeks at 52 degrees F. At 95 degrees F. and 100 percent relative humidity, only 10 percent of the unfed adults emerging from cocoons will survive for 10 days but adults can survive 40 days at 60 degrees F.

Cars and recreational vehicles may be overlooked during flea treatment but can be a source for fleas and eggs that move back into the home. If cars are treated with volatile pesticides, pesticide odors are intensified inside the car by excessive heat (sunlight). However, fleas have rather low heat tolerance (can be killed around 130 degrees F.). Parking a tightly closed, infested car in the sun should produce enough heat inside the vehicle to kill fleas in all stages of development.

Chemical management

It is not unusual to have to resort to pesticides to correct flea infestations. The most common errors in chemical flea management are failing to gain complete cooperation of the occupants; failing to use proper chemical application

techniques and proper rates of pesticide product; failing to adequately treat outdoor areas where fleas live; and failing to control fleas on rodents or wildlife that may be associated with the structure (in chimneys or crawlspaces). Follow pesticide label directions for proper application methods for chemicals.

A pet must be treated by a veterinarian and the outdoor areas used by the pet must be treated with an insecticide on the same day that the structure is treated. Sometimes, an entire yard must be treated. If a pet cannot be taken to a veterinarian, methoprene is the only insect growth regulator (IGR) labeled for animals.

Rat or feral animal control programs must not "orphan" fleas (i.e., killing rodents without first controlling their fleas) or the fleas may attack other animals. Prior to initiating rodent or other wild animal controls, it is desirable to treat the wild animals (through use of dusting stations) and their nesting areas for fleas.

Insect growth regulators (IGR's) are chemicals that interrupt the growth stages in insects. IGR's are very helpful in pest control and their effects are long-lasting; however, IGR's take a long time to act since they only effect immature stages, many of them break down in light, and most can not be effectively used outdoors.

Evaluating treatments

The effectiveness of treatments will be determined through continual monitoring and inspection. Treatments will be considered effective when fleas are no longer found inside structures.

Evaluations of treatments will be used to supply essential information to adjust Action Threshold values, develop more effective management strategies, and demonstrate any apparent needs for new control methods or chemicals.

Chemical alternatives

Boric acid dusts for cracks and crevices.
Diatomaceous earth dust.
Diatomaceous earth dusts with pyrethrins.
Fenoxycarb insect growth regulator.
Flea powder with pyrethrin (commercial brands) for pets.

methoprene insect growth regulators. Insect growth regulators (IGR's) are chemicals that interrupt the growth stages in insects. IGR's are very helpful in pest control and their affects are long-lasting; however, IGR's take a long time to act since they only effect immature stages, many of them break down in light, and most can not be effectively used outdoors. Other pesticides recommended for interior use include diatomaceous earth dusts, pyrethrum (with piperonyl butoxide) and resmethrin aerosols.

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Chemical alternatives

Carbaryl dust (consult with Cluster IPM Coordinator prior to use)
Diatomaceous earth with or without pyrethrin
Fenoxycarb insect growth regulator
Flea powder with pyrethrin (commercial) for pets
Flea soap with pyrethrin (commercial) for pets
Linalool (d-limonene)
Methoprene insect growth regulator
Pyrethrin contact spray
Resmethrin aerosol with or without pyrethrin for cracks and crevices

Sources of advice, technical information, and supplies

National Park Service Videotapes

"Crack and Crevice Treatment for Cockroach Management," 13 minutes.

"Integrated Pest Management," 15 minutes.

"Pesticide Applicator Safety," 17 minutes.

See Appendix listings for equipment and chemical supplies.

Literature

Barnes, A.M., L.J. Ogden, and E.G. Campos. 1972. Control of the plague vector, Opisocrostis hirsutus, by treatment of prairie dog (Cynomys ludovicianus) burrows with 2% carbaryl dust. Jour. Med. Entomol. 9:330-333.

Beard, M.L., S.T. Rose, A.M. Barnes, and J.A. Monteneri. 1992. Control of Oropsylla hirsuta, a plague vector, by treatment of prairie dog burrows with 0.5% permethrin dust.

Christensen, Dr. Chris, A Technician's Handbook to the Identification and Control of Insect Pests, 1983. Pest Control Technology, 4012 Bridge Ave., Cleveland OH.

Cole, M.M., and G.S. Burden. 1978. Fleas (Order Siphonaptera) In Bram, RA (ed). Surveillance and collection of arthropods of veterinary importance. U.S. Department of Agriculture, Animal and Plant Health Inspection Service. Handbook 518.

Hedges, Stoy. 1997. Attacking Fleas on All Fronts. Pest Control Technology, 4012 Bridge Ave., Cleveland OH. July 1997.

Pitcairn's (Dr.); Complete Guide to Natural Health for Dogs and Cats; Rodale Press.

Rust, Michael K., Fleas. In: Handbook of Pest Control by Arnold Mallis, 1990; Franzak & Foster, Cleveland OH.

U.S. Department of Health, Education and Welfare. 1967. Pictorial keys to arthropods, reptiles, birds, and mammals of public health significance. US Dept. Health, Educ. & Welf., Washington, DC.

US Dept. of Interior, National Park Service. 1984, 1995. Integrated Pest Management Information Manual, First and Second Editions.

GARDEN PESTS

Description, distribution, identification

Succulent garden plants attract a wide variety of arthropod pests (see the list of more common garden pests at the end of this file). The sheer number of pests which can affect garden crops makes it impossible to describe treatments for individual pests in this section. Rather, this section presents basic information on garden practices that minimize the occurrence of pests or that reveal the presence of pests early enough for selected controls to be effective before infestations become too severe.

There are more than 10,000 species of arthropod pests in this country which are pests on garden plants and probably 76,000 or more additional species considered to be beneficial species. At the ratio of about 1 pest species per 8 beneficial species, effective pest management depends on:

- a good knowledge of pests, plants, and pest life cycles and the use of effective physical and mechanical pest management methods.
- being able to recognize and preserve beneficial insect predators (see listing at the end of this file) by reducing the use of chemical pesticides.

Occurrence in the park

Biology

Garden pests show extremely diverse biology. However, the vast majority of garden pests can be placed into one or more of the following categories depending on how they feed on plants (some pests may occur in more than one category):

- pests that chew above ground plant parts
- pests that suck juices from plants
- pests that feed on below ground plant parts
- pests that bore into plants

Potential damage and health concerns

Garden pests weaken the overall health and appearance of garden plants and injure the crop. Some garden pests become numerous enough to leave the garden and affect other, adjacent plants.

Action thresholds

The Threshold for management actions to control garden pests will be plants damaged by pests or the potential for pest infestations to spread into adjacent areas where they can not be tolerated.

Inspection and monitoring

Inspection and monitoring methods for garden pests are similar.

Carefully examine entire plants (or a representative sample of the leaves, twigs or stems of plants) for pests and record the incidence and kinds of pests or damaged plants. Examine plants at night with a light to find nocturnal pests. Continually monitor every growth cycle of garden plants and watch for slow grow or discolored or damaged leaves.

Some plants are more attractive to specific pests than other plants. Gardeners often closely watch susceptible plants ("trap plants") as an early warning of the presence of pests.

Non-chemical pest management

Garden pests must be accurately identified before considering management actions. Some easily seen, beneficial arthropods can be confused with similar-appearing pest species. Some serious garden pests are so small they are easily missed with casual observations.

The best measures to prevent insect pests in gardens are to:

- Take adequate preventive measures.

Practice companion planting. Insect pests are not usually a problem when desirable plants are surrounded by plants insects do not like.

Plant resistant strains of plants that are adapted to specific local climate and growing

conditions and that are resistant to disease and pests. Avoid planting cultivars that are susceptible to aphids, adelgids, and phylloxerans.

Provide proper conditions (soil fertility and organic content, soil pH, irrigation, and shade) to encourage the growth of healthy plants. Healthy plants are more resistant to disease and pests. Annually rotate crops to preserve the availability of soil nutrients.

Encourage natural predators and parasites. Release lacewings, ladybird beetles, syrphid flies, predaceous midges, and aphid mummies in the garden. Include flowering, nectar-producing plants in the garden to attract adult predatory insects, bees, and birds. Provide suitable habitat to support predators.

Birds are important predators on insects and a list of birds that are important predators on insects and garden pests is included at the end of this file. The presence of birds can be enhanced by installing stations where they can find sunflower seeds, suet mixes, water, nest boxes, and cover and roost sites.

Some people construct a 6 to 8 foot wide fenced-in area ("chicken lane") around the garden. Chickens are released in the enclosed lane around the garden and eat all the green vegetation and insects. The barren, pest-free border around the area greatly lessens insect pests in the garden.

Maintain good environmental sanitation in the garden. Keep the landscape clean by removing pest hiding places. Rake up clippings and plant debris which give pests protected locations for over-wintering. Remove weedy growth located near gardens that supports cutworms, slugs, and snails. Frequently wash off garden plants with a hose to remove aphids, mealybugs, and spider mites.

Provide barriers between pests and plants. These may be:

- floating row covers, made from light-weight synthetic fabric that allows the passage of sunlight and water but protects the plants from aphids, cucumber

beetles, flea beetles, and whiteflies. Drape the fabric over the garden before the emergence of seedlings.

- place collars made from bottomless paper cups, milk cartons, or cans around plants to protect plant stems from cutworms, root maggot flies and other pests.

- place sticky barriers around plant stems to stop slow moving ants, snails, beetles and crawling insects.

- place copper barriers (1 to 3 inches wide) around plants to keep snails and slugs from climbing on plants.

- use netting to cover plants and provide protection from birds and flying insect pests.

- fence the garden to exclude vertebrate predators.

Place sticky traps, pheromone traps, and black light traps in the garden to capture flying and crawling pests. Bury pieces of potato in various locations in the garden for a week or two. When the potato pieces are removed from the ground, wireworms that have been feeding on the potato will also be removed.

Following harvest in late fall, remove or burn all garden debris. Then, till the soil 6 to 8 inches deep and allow birds to feed on any exposed garden pests for 2 to 3 weeks. Till the garden again, but only 2 inches deep, and allow birds feed again for another week. Cover the garden with about 4 to 6 inches of protective mulch for the winter. Cultivate the garden again in the spring. Tilling and sanitation are very beneficial practices for gardening. These processes interrupt the life cycle of insect pests and expose underground grubs, eggs, and pupae to cold temperatures and predation and prevent pests from overwintering in the soil or garden debris.

● Frequently monitor the garden

Begin monitoring plants for pests early in the

growing season. Use a standardized system to record observations. Record the presence of aphid parasites and pest predators. Learn to quickly recognize the early stages of plant diseases.

● Promptly take control actions to selectively remove pests.

Establish threshold levels that define when and where specific management actions will be taken to control garden pests.

Use mechanical and cultural insect controls, whenever feasible. Light reflected from aluminum foil or white plastic mulch in newly planted areas will confuse aphids and prevent them from landing on plants. Crush aphids with the fingers when infestations are not too extensive. Keep aphid-tending ants from being able to climb on plants by placing sticky substances on plant stems or bone meal or crushed charcoal barriers around plants. Destroy ant colonies located near gardens. Eliminate plants that are alternate hosts for insect pests.

Watch for and hand-pick pests from plants (especially large slow-moving pests like Colorado potato beetle, snails, and tomato hornworms). Begin early in the season (before pest number increase) using a flashlight and black light at night to locate and remove nocturnal insect pests from plants (some tomato hornworms fluoresce in the dark).

When necessary, only spot treat plants with insecticidal soap, summer oils, or other approved insecticides. Spot treatments are less likely to kill biological control agents than widespread spraying. It is not wise to try to kill all insect pests in the garden with pesticides (even those having relatively low-toxicity, such as diatomaceous earth, rotenone, sabadilla, and pyrethrum). Such action also kills the insect predators that prey on pest species.

Use dormant and superior horticultural oils to suffocate overwintering stages of insects on plants (such as scale and spider mite eggs). Dormant oil is applied to the stems of large perennial plants during the winter. Some gardeners even mix dormant oil with

insecticidal soap or insecticidal soap and alcohol. Superior oils are less viscous, lighter, and some products can be applied to plant foliage and stems during the summer. Horticultural oils can be effective for controlling whiteflies without harming beneficial insects.

Repellents. There are no dependable repellents available for garden pests; however, bone tar oil, ashes, and a number of other materials with repellent qualities are commonly used. One recipe for an pesticide-free garden pest repellent that can be sprayed onto plants is:

Mix 4 cups of bone meal, 2 cups of gypsum, 2 cups of Epsom salts, 1 cup of wood ashes, 1 cup of lime, 1 tablespoon of baking powder, and 4 tablespoons of Diaperene baby powder into a bucket full of dry peat moss. Spread the peat moss along the rows of garden plants and flowers.

Some gardeners find old-fashioned scarecrows and plastic snakes and owls are of help in repelling birds. Moving decoys are always more effective than static ones.

Population reduction. There are many predatory organisms available to help control garden pests, which include beneficial plant diseases, bacteria and fungi that specifically affect pests, amphibians (frogs and toads), and reptiles (lizards and snakes). Some gardeners erect bat houses near gardens to help reduce the presence of flying, nocturnal insects (especially mosquitoes).

Chemical management

There are many pesticides commercially available for controlling garden pests. The following are labeled products which have a relatively low toxicity.

Insecticidal soap. Soap effectively kills most soft bodied insects (aphids, mealybugs, spider mites), adult Japanese beetles and a number of other garden pests, is biodegradable, and is not toxic to beneficial organisms.

Diatomaceous earth (DE). DE is a safe, non-poisonous, effective, easy to apply, broad spectrum, mechanical insecticide that kills all arthropods. The sharp edges on DE crystals scratch the outer skeletal covering of arthropods, which causes water loss and desiccation. Use the natural-grade variety of DE, formulated for gardens, and do not use the type of DE used as a filter medium for ponds or pools. DE can be applied to plant foliage either as a dust (to control flea beetles and ants) or a water-mixed slurry. DE can also be scattered around the bases of plants to control crawling squash bugs, slugs, and snails.

Sulphur. Finely ground sulfur dust applied to plant foliage is an effective pesticide for mites.

Botanical poisons. Various non-selective botanical pesticides are available for controlling garden pests and some can be toxic to humans. Botanical pesticides tend to decompose rapidly in the soil into harmless compounds. Commonly used botanical pesticides include: false hellebore (a dry botanical powder), pyrethrum (for controlling most garden pests; has low residual), rotenone (use products having more than 1 percent concentration of active ingredient), ryania (derived from the root of a tropical shrub), quassia (for aphids, caterpillars, soft-bodied pests) sabadilla dust (for aphids, caterpillars, and beetles), neem oil, and others.

Synthetic pesticides. There are a large number of synthetic pesticides available for controlling garden pests. Synthetic pesticides are generally not selective and also kill non-target organisms. Those products which have low-toxicity and are usually approved for use by NPS include: pyrethrin, resmethrin (provides good control of garden pests; some micro-encapsulated formulations have long residual effects), allethrin, fenoxycarb (insect growth regulator), hydramethylnon (slow-acting stomach poison), and silica aerogel (sand) with pyrethrin additive.

Biological controls. A number of biological control agents are available to control garden pests. These products are included under the chemical classification because they are labeled by EPA as pesticides. A number of

commonly used biological products include *Bacillus thuringiensis* (BT; for lepidopterans and a few other insects), *Bacillus popilliae* (for Japanese beetle grubs), *Bacillus tenebrionis* (for Colorado potato beetles and elm leaf beetles), and *Nosema locustae* (for grasshoppers).

Note, BT is lethal to most caterpillars (including hornworms, cabbage worms, and beneficial species) and is available as a spray or dust.

Parasitic nematodes are available commercially. These organisms search out and kill soil-dwelling grubs, carpenter worms, and mole crickets. Choose an appropriate nematode strain for specific pests.

Evaluating treatments

Continual inspection and monitoring for garden pests and pest damage will provide information regarding the effectiveness of treatments.

Evaluations of treatments will be used to adjust Action Threshold values, develop more effective management strategies, and demonstrate the apparent need for new control methods or chemicals.

Chemical alternatives

Allethrin
Bacillus thuringiensis
Bacillus tenebrionis
Bacillus popilliae
Benzyldiethyl methyl ammonium saccharide
(gustatory repellent)
Carbon monoxide gas cartridge (for burrowing rodents)
Diatomaceous earth
Fenoxycarb
Glufosinate ammonium (non-selective herbicide)
Glyphosate (non-selective herbicide)
hydramethylnon
Insecticidal soap
N,N-diethyl-m-toluamide (personal insect repellent; DEET)
Nosema locustae
Parasitic nematodes
Potassium salts of fatty acids (insecticidal soap)
Pyrethrin
Pyrethrum

Resmethrin
Silica aerogel with pyrethrin
Sulphur dust
Trichloromonofluoromethane (for wasp nests)

Sources of advice, technical information, and supplies

See Appendix listings for equipment and chemical supplies.

National Park Service Videotapes

"Integrated Pest Management," 15 minutes.

"Pesticide Applicator Safety," 17 minutes.

"Self Help Pest Management", 24 minutes.

Literature

Arnett, Ross H. 1985. American Insects. Van Nostrand Reinhold, New York.

Baker, Jerry. 1988. Garden Line Series: Baker's Dozen (Tips, Tricks, and Good Advice). American Garden Institute, Wixom MI 48393.

Furniss, R. L. and V. M. Carolin. 1977. Western Forest Insects. Misc. Publ. #1339, U.S. Dept. of Agric., Forest Service.

Mother Earth News (periodical magazine). P.O. Box 70, Hendersonville, NC 28793; 704/693-0211.

Olkowski, William, Sheila Daar, and Helga Olkowski. 1991. Common-Sense Pest Control. Taunton Press, Newtown, CT 06740.

Ortho Books Editorial Staff. 1987. Controlling Lawn and Garden Insects. Chevron Chemical Company, San Francisco CA 94105.

Simmons, Sewell E. 1985. Parklands Pest Management. California Department of Food and Agriculture, Sacramento, CA 95814.

EXAMPLES OF COMMON GARDEN AND FIELD PESTS

DIPTERA cabbage maggot carrot rust fly currant fruit fly hover flies leaf miners Mediterranean fruit fly pepper maggot robber flies tachinid flies	HOMOPTERA aphid blue sharpshooter citrus mealybug longtailed mealybug red banded leafhopper scales spittlebug tree hopper whitefly	THYSANOPTERA thrips	NEUROPTERA lacewing
HYMENOPTERA ants braconid wasp yellow jacket bumblebees honeybee	ORTHOPTERA field cricket Jerusalem cricket mole cricket snowy tree cricket grasshoppers katydid preying mantis	HEMIPTERA assassin bug boxelder bug eggplant lace bug harlequin bug leaf-footed bug minute pirate bug negro bug stink bugs squash bugs tarnished plant bug	NON-INSECTS centipede millipede opossum raccoons rodents and gophers skunks slugs and snails spider mites
COLEOPTERA asparagus beetles bean weevil cabbage curculio fig beetles flathead appletree borer flea beetles grape colaspis ground beetles June or May beetles Mexican bean beetles pecan weevil potato stalk borer rove beetles sap beetles shothole borer soldier beetles Southwest corn borer tiger beetles vegetable weevil			
LEPIDOPTERA artichoke plume moth beet armyworm cabbage looper codling moth corn earworm cotton square borer cutworms diamond back moth fall army worm fall or garden webworm forest tent caterpillar fruit tree leaf roller grapeleaf skeletonizer grape root borer imported cabbage worm orangedog orange tortix parsleyworm peachtree borer potato tuberworm pyramidal fruitworm redhumped caterpillar saltmarsh caterpillar spring cankerworm strawberry crown moth tomato hornworm walnut caterpillar whitelined sphinx moth yellownecked caterpillar yellow woolly bear zebra caterpillar			

CLASSIFICATION OF GARDEN PESTS BY DAMAGE DONE TO PLANTS

<u>PESTS THAT CHEW ABOVE GROUND PLANT PARTS</u>			<u>PESTS THAT SUCK JUICES FROM ABOVE GROUND PLANT PARTS</u>		
armyworm	cricket	leaf skeletonizer	aphid	mite	tarnished plant bug
bagworm	curculio	leaf-tier	chinch bug	psyllid	thrip
bee	cutworm	sawfly	lace bug	spittlebug	treehopper
billbug	earwig	snail and slug	leafhopper	squash bug	whitefly
blister beetle	flea beetle	springtail	mealybug		
bollworm	fruitworm	webworm			
budworm	grasshopper	weevil			
true bugs	hornworm				
cankerworm	leafminer				
caterpillar	leafroller				

<u>PESTS FEEDING ON PLANTS BELOW GROUND</u>			<u>PESTS THAT BORE INTO PLANTS</u>		
billbug	root aphid	symphylan	apple maggot	corn earworm	plum curculio
corn root aphid	root borer	white grub	bark beetle	European apple sawfly	spruce budworm
corn rootworm	root maggot	wireworm	carpenterworm	mellonworm	tomato fruitworm
onion maggot	rootworm		cherry fruitworm	Oriental fruit moth	various other borers
woolly apple aphid			codling moth	pickworm	white pine weevil
nematode					
root weevil					

IMPORTANT PREDATORS ON GARDEN PESTS

PREDATOR	PREYS ON (BENEFITS)
BIRDS	
BLACKBIRD (RED-WING)	general insect feeder
BLUEBIRD	feeds on 80% of the pest insects such as bark insects and insect eggs
BUSHTIT	aphids, beetles, and leafhoppers
CARDINAL	
CATBIRD	
CHICKADEE	bark insects
CREEPER	bark insects
CROW	insect borers
FINCH, PURPLE	
FLYCATCHERS	
GOLDFINCH	in summer 50% of the diet of this bird is insects
GROSBEAK	potato beetles, grasshoppers, caterpillars, and bees
JAY, (STELLER'S)	bees and wasps
JUNCO	feeds on insects during summer
HAWKS	small mammals and mice
KINGBIRD	insect borers
KINGLET	aphids, scales, and small insects
MARTIN	flying insects
MOCKINGBIRD	60 percent of this bird's is insects, grasshoppers, and beetles

PREDATOR	PREYS ON (BENEFITS)
INVERTEBRATES	
ANTS (various)	some ants are pests (tend aphids); fire ants prey on most agricultural invertebrate pests
BEES (BUMBLE, HONEY)	important as crop pollinators
BEETLE, LADY	aphids, mealybugs, scales, leafhoppers, and spider mites
BEETLES (beneficial)	aphids, cankerworms, caterpillars, slugs, and snails
BUG (BIG-EYED)	aphids, blister beetles, leaf hoppers, and spider mites
BUGS (predaceous)	general insect feeders
CENTIPEDES	general insect feeder
DAMSEL FLY larvae (ant lion)	crawling insects
FLIES (FLOWER, HOVER)	aphids, mealybugs, and small insects
FLIES (ROBBER)	white grubs, grasshopper eggs, flying insects
FLIES (Tachinid)	caterpillars, sawflies, beetles, grasshoppers, and bugs
LACEWING (larvae, adults)	aphids, mealybugs
MANTIS, PREYING	general insect feeder
MEALYBUG DESTROYER	mealybugs
SCORPIONS	general insect feeder
SPIDERS	general insect feeder
WASP (Braconid)	aphids, caterpillars
WASP (chalcid, Ichneumon)	lay eggs in many pest species
WASP (MUD DAUBER)	spiders, crickets, cicadas, flies, leafhoppers
WASPS (YELLOW JACKET)	caterpillars, small insects
	caterpillars, small insects

AN EXAMPLE INFORMATION TABLE THAT COULD BE DEVELOPED FOR CONTROLLING GARDEN PESTS

PEST	DAMAGE	NON-CHEMICAL ALTERNATIVES	CHEMICAL ALTERNATIVES
ANTS	Disturb plant roots with tunnels; encourage and spread aphids (to obtain honeydew) and cause mold and fungus, mealy bug, and scale problems; plants near ant hills may be damaged or killed. Re-seed areas made bare by ants after ants have been controlled. Ants overwinter in soil and garden trash.	Use sticky materials (Tanglefoot or Stick-Em) around plant stems/tree trunks. Sprinkle steamed bone meal around ant mounds. Eliminate aphids, whiteflies, soft scales, mealybugs, and leafhoppers that attract ants by producing honeydew. Spray full strength vinegar where ants are normally seen. Place cinnamon sticks 4 feet apart around plants; sprinkle ground cinnamon on ground. Sprinkle pepper (cayenne or black) in areas used by ants. Cucumber peelings and citrus peelings are thought to be toxic to ants; regularly replace peeling silvers when they dry up. Mix 1/4 cup sugar, 1/2 cup sorghum molasses, and 1 package dry yeast; pour into jar lids, place in areas where ants seen. Place a few spoonfuls honey in open plastic bag and leave the bag out overnight in ant areas; dispose of captured ants the next day or so; after about 6-days, ant colonies will be depleted of workers.	Spot treat nests with boric acid, andro, or fenoxycarb (IGR) baits.
APHID, NAKED	Suck plant juices (especially on new growth) and cause yellowed, curled, and distorted leaves; affect garden vegetables, harden buds, disfigure flowers, stunt plants; cause plant wilt/death, exude honeydew; spread viral plant diseases. Eggs laid in fall, hatch in spring; overwinter as egg.	Cultural control: Cover planting beds with fabric row covers. Aphid numbers increase with increased nitrogen fertilization; don't over-fertilize plants. To control aphids in peach orchards, keep area free from preferred host plants (plantain, bindweed, lamb's quarters <Amaranth>). Interplantings of garlic, chives, coriander, anise, pansy, petunia, alliums, pennyroyal, spearmint, tansy, painted daisy may help to reduce infestations. Monitoring: A trap crop of nasturtiums will attract early infestations. Mechanical control: Sanitation: aphids overwinter in litter. Hand pick or crush aphids. Aphids are attracted to yellow; fill yellow dishes or pans with slightly soapy water and place them near infested plants. Paint boards yellow, coat with sticky Tanglefoot. Place aluminum foil sheets or mulch around plant bases to cause light reflections that keep winged forms from landing. Blend equal parts of green onions and water and spray on roses to discourage aphids. Ferti-Lome dormant oil spray. Apply superior-grade oil spray just before budbreak. Dust plants late in evening (to protect beneficial insects) with diatomaceous earth. Apply Tanglefoot bands to trees and plants. Spraying infested plants with a strong jet of water to wash aphids off but this may also cause them to spread to other plants. Biological control: Encourage predators like hoverfly larvae, lacewings, aphid lions, ladybugs, soldier bugs, damsel flies (lacewings), bigeyed bugs, pirate bugs, spiders, assassin bugs, syrphid flies, gall midges, braconid wasps. Rear beneficial insects by placing aphid-infested foliage in plastic bag, when predators emerge place them on plants with small painbrush. Collect as many fuzzy looking aphids as possible; mix in a blender with a little water; strain through coffee filter; add a little liquid soap; spray on plants.	Apply insecticidal soap to plants every 2-3 days until ants are controlled. Make 2 applications of pyrethrum 3 to 4 days apart. Also: pyrethrin, resmethrin, rotenone, diazinon, malathion, sevin, dimate 4E (agricultural formula for green bug aphids).
BEAN BEETLE	Adults and larvae chew holes in bean pods and eat the seeds. Bean beetles spend the winter in rubbish. The insects appear from late March to June and 2 weeks later lay eggs on the undersides of leaves. 1 to 4 generations per year, depending on climate.	Monitoring: Check undersides of leaves for larvae, eggs (orange clusters), adults. Cultural control: Sanitation, destroy crop residues after harvest. Plant nasturtium/garlic. Plant/harvest beans as early as possible. Plant potato/nasturtium every 3rd row between beans or a clove of garlic in every bean hill. Mechanical control: Frequent hand picking usually sufficient in North. Spun-bonded row cover may be helpful. Use diatomaceous earth against larvae. Biological control: In South, may introduce <i>Pedobius foveolatus</i> , a small parasitic wasp. Encourage the presence of preying manitises in the garden.	Rotenone or pyrethrin.
CORN EARWORM	Light gray-brown moth; occurs throughout US. Prevents corn pollination and stunts developing corn ears; a major pest. Also will damage tomato leaves and buds, peppers, squash, peas, potatoes, lettuce, beans, and cucumbers. The larvae are 1-1/2 inches long, white, green, or red with spines. Up to 7 generations per year; pupae overwinter in soil. Cannot withstand severe winters. Controls must be initiated early in the season as earworms are difficult to control after they enter the ears.	Monitoring: Check the topmost, upright leaves of young corn plants twice a week. Light traps used by commercial growers to monitor presence. Pheromone traps can be used. Smartweed is a trap crop. Intercrop with soybeans to attract Trichogramma wasps. Cultural control: Choose corn varieties with tight husks to minimize damage. Mechanical control: Use blacklight traps for adults. Lights placed in fields may prevent egg laying. Deeply spade garden in fall to expose the larvae to cold. Remove infested fruits and vegetables that fall to the ground and continually clean up all garden debris. Plant hybrid, resistant corn early in northern areas. Plant corn varieties that mature at different times during the season and plant corn varieties with heavy silk (Country Gentleman) because corn pollen and silk attracts predatory minute pirate bugs. Handpick corn earworms. Suffocate larvae by applying 20 drops of mineral oil, mineral oil and BT, or light horticultural oil and BT with a medicine dropper to the corn silk just inside each ear 3 to 7 days after the silk appears and continue applications until the silk wilts and starts to turn brown. Biological control: Spray plants with BT or BT mixed with light horticultural oil every 3 to 5 days if holes or worms are found during inspections. Or, sprinkle newly emerged corn silks with BT and put a few drops of mineral oil on the browning silks a few days later. Treat plants with trichogramma, Elcar (a viral insecticide). BT will kill 40 to 60 percent of the earworms, enough to protect tomatoes, beans, and lettuce but not enough for use on corn. The effectiveness of BT can be increased by dusting corn silks early and then again every few days until the silks turn brown. Minute pirate bug (<i>Orius spp.</i>), Trichogramma wasp, Tachinid flies, and lacewings are effective insect predators. Flycatchers, barn swallows, downy woodpecker, sparrows, blackbirds, grackles, phoebes, moles, and toads are effective vertebrate predators.	Pyrethrin (2 sprays 3 to 4 days apart), rotenone, sevin, carbaryl, and acephate on ornamentals.

JAVELINA

Description, distribution, identification

Javelina (also known as collared peccary; Tayassu tajacu) are medium- to large-sized, even-toed, hoofed, pig-like animals, often called by many "the wild pigs of the New World". They are primarily tropical and sub-tropical animals with their northern distribution generally limited to the Lower Sonoran zone. Javelina are most abundantly found in West Texas, southern New Mexico, and Arizona habitats which contain abundant Opuntia spp. (prickly pear cactus).

Javelina have a combined head and body length of about 35 inches; they stand about 2-feet tall at the shoulder and weigh up to 50 pounds. They have long, coarse, bristly hair of a mixed black and gray color, 3 toes on each hind foot, and have upper tusks that point downward.

Javelina do not develop a woolly, protective undercoat during winter, they have a thin hide, and do not develop thick fat reserves. Consequently, climate (more than topography or vegetation) limits javelina distribution. Southern and southeast Arizona are prime winter habitats for javelinas.

Occurrence in the park

Javelina are native animals that occur throughout the park but become nuisances in developed areas when they spread garbage or, in a few cases, attack people trying to feed them.

Biology

Habitats. Javelina live in brushy, semi-desert habitats along cliffs and among cacti, oaks, chaparral, and mesquite thickets. In much of the Southwest, they range in areas from 1,200 to 6,000 feet in elevation. They usually do not stray far from waterholes and use rocky ravines for travel routes.

Biology. Javelina are mostly active during the morning and late afternoon. They are inactive (huddle together in protected areas) during cold weather. Javelina search out shade during intense mid-day summer heat.

Javelina are usually found in herds containing

about 9 animals. Herds may be slightly smaller during winter months (December through March). However, herds can vary in size from as many as 25 animals to as few as 2 animals. Javelina occupy only a limited home range (about 640 acres) and wander within an area having a radius of less than 3 miles.

Javelina are territorial and do not move between different bands. Each band has a specific area of activity with feeding and sleeping areas never far apart. Javelina produce rather evident piles of scat that are associated with scent-marking of the outer home range boundaries. Scat piles are usually located close to and just outside of bedding sites (they do not defecate in the den).

The density of javelina in any given sized area of optimum habitat may vary considerably over only very short distances.

Foods and feeding. Javelina are omnivorous. They feed on nuts, mesquite beans, berries, fruits, cacti, grubs, bird eggs, and, where in contact with man, on human garbage or hand-outs.

Reproduction. Young female javelina are about 8 to 9 months old when they reach sexual maturity. Javelina are believed to be able to breed all year and gestation is about 5 months long. Litters usually average about 2 but may contain as many as 5 young. The young are able to follow the mother just one day after birth. Javelina young show a high mortality rate (about 80 percent) from birth to maturity. Teams of two or more coyotes, working together, are the principal source of mortality for young javelina; bobcats and mountain lions rank second to coyotes as predators.

Potential damage and health concerns

Javelinas are considered to be beneficial animals because they do not compete with grazing animals for food and their feeding preferences (Opuntia) help to limit the natural spread of prickly pear cactus.

Javelina, however, quickly become accustomed

to humans and will closely approach people to beg for food hand-outs. This can result in persons being bitten or otherwise injured by the animals.

Javelina overturn garbage cans, root in the ground, expose garbage, and generally become nuisances.

Action thresholds

Herds of javelina causing resource damage or otherwise creating nuisance or safety problems will be the Action Threshold for control. Control will usually be the live-capture and removal of entire herds of animals for release in other areas.

Inspection and monitoring

Inspecting for and monitoring javelina are similar. Because of their communal habits, the numbers of javelina in an area can be determined by searching out and counting herds in any given area. This is done by walking up sand covered washes and counting fresh javelina tracks that cross the washes. Herds use washes and canyons as major pathways and all animals in herd usually cross a wash within an area of only a few yards.

The number of animals in any given herd is determined by counts of the number of individual animal tracks.

Non-chemical management

Exclusion. Exclusion is the best method for keeping animals from upsetting garbage cans, entering gardens, etc.

Sanitation. Preventing park visitors from feeding wild javelina and assuring visitors, employees, and concessionaires are careful with garbage helps to reduce resources available to animals.

Store garbage in metal or sturdy plastic containers with tight-fitting lids and place the cans on racks. If lids do not fit tightly, wire or tie them down or use commercially designed, pest-proof cans.

Habitat modification. As possible, remove sources of food, water (leaking pipes, man-

caused depressions, etc.), or shelter available to javelina.

Repellents: There are no dependable repellents for javelina. However, various non-chemical scare-tactics have been tried to keep nuisance animals out of areas: tying dogs in the yard, lights, radios, scarecrows, plastic or cloth streamers, aluminum pie pans, plastic windmills, etc. Any or all of these may have temporary effectiveness, but, in most situations, do not provide adequate long-term protection.

Population reduction. Javelina are native game animals. Consult with the state fish and game department for regulations which protect the animals. Population reductions are best done by live-trapping entire herds in corrals made with fence wire.

Live-captured javelina will be transported at least 10 miles away from point of capture for release. Before release, animals will be marked by paint or other suitable means and marked animals that return will be destroyed. Park personnel will take all possible precautions against disease transmission or personal injury during trapping, cage handling, transport, marking, and release.

Chemical management

There are no known chemical repellents or toxicants labeled for javelina.

Evaluating treatments

Periodic inspection and monitoring will show whether javelina are present in an area.

Periodic evaluation of the success of javelina control programs will be used to provide information for adjusting Action Thresholds, developing more effective management strategies, and demonstrating any apparent needs for new control methods.

Chemical alternatives

There are no chemical toxicants or repellents labeled for javelina.

Sources of advice, technical information, and supplies

National Park Service Videotapes

"Integrated Pest Management," 15 minutes.

See Appendix listings for equipment and chemical supplies.

Literature

Blair, W. Frank; A. P. Blair; Pierce Brodkorb; Fred R. Cagle; and George A. Moore. 1957. *Vertebrates of the United States*. McGraw Hill Book Co., New York NY.

Burt, William Henry. 1980. *A Field Guide to the Mammals of North America North of Mexico*. Houghton Mifflin Co., Boston MA.

Davis, William B. and David J. Schmidly. 1994. *The Mammals of Texas*. Texas Parks and Wildlife Press, Nongame and Urban Program, Austin TX 78744.

Knipe, Theodore. 1957. *Javelina in Arizona, A Research and Management Study*. State of Arizona, Game and Fish Department, Phoenix AZ; Wildlife Bull. # 2.

Lowe, Charles H. 1964. *The Vertebrates of Arizona*. University of Arizona Press, Tucson AZ.

MICE AND WOODRATS

Numerous kinds of native, white-footed mice (Genus, Peromyscus) occur in the United States. In general, these (as well as other mouse-like rodents) are small, primarily nocturnal mammals with rather poor eyesight, similar diets, and high fecundity. Recently, various species Peromyscus were implicated as carriers of the Sin Nombre Hantavirus, most notably the deer (P. maniculatus), cactus (P. eremicus), and brush mouse (P. boyleyi). These 3 closely related species have very similar appearance, biology, and habits and are difficult for lay persons to separate.

Eight or more kinds of native woodrats (Neotoma spp.) occur in this country and the different species are likewise difficult to separate. Woodrats are also nocturnal animals but are 2 to 3 times larger than white-footed mice and produce fewer young. Woodrats are known to carry Hantavirus, but at much lower frequencies than white-footed mice.

Sin Nombre Hantavirus is a serious respiratory disease initially appearing in the Four Corners Region of Arizona, New Mexico, Utah and Colorado, but which has since been found nation wide. Various names have been used for this disease, the last ones being Muerto Canyon Hantavirus, Sin Nombre Hantavirus, and Hantavirus Pulmonary Syndrome (HPS). HPS will be the name of the disease used here.

Description, distribution, identification

Deer mice (Peromyscus maniculatus)

Considerably more biological information is available for deer mice (P. maniculatus) than other kinds of mice. Since deer mice are so frequently encountered in buildings (Glass et. al., in press) and their biology is so similar to other closely related species, they are used here as a "model" to describe the general biological characteristics of other small, native, mouse-sized rodents.

Deer mice are small mice with large ears, white feet, and white bellies. They show a distinct separation of color between the upper and lower portions of their brownish back. Their tails are also sharply bi-colored and usually as long as

the combined head and body length.

Although deer mice have a greater tendency to store foods than house mice, the nests, droppings, and other signs of deer mice are similar to those of house mice.

Deer mice are the most widely distributed and abundant mammal in North America. They occupy nearly every dry-land habitat ranging from deserts to grasslands and occur over most of the United States.

Woodrats (Neotoma spp.)

Woodrats are found from low, hot, dry deserts to rocky slopes above timberline; however, within that range, they are usually restricted to specific habitat types. The woodrats most common in and around the park include the whitethroated woodrat Neotoma albigula, southern plains woodrat (N. micropus), and Mexican woodrat (N. mexicana). These animals have a hairy tail, soft, fine fur, large ears, and are light in color. Exotic (Old World) rats are similar in size but have long, scaled tails, rougher fur, small ears, and are dull-gray to brownish black in color. A characteristic woodrat nest is a mound of sticks and rubbish placed in a rock crevice, around the base of a shrub, in an attic, or beneath a building.

Occurrences in the park

Various species of native mice and woodrats occur throughout the park and the animals are common nuisances and health-related pests when they enter residences, warehouses, offices, or other structures.

Some park staff members are concerned about acquiring HPS as a result of accidental exposure to rodents or rodent debris in their residences or during the course of performing their official duties.

Biology

Deer mice

Mice select home ranges providing them harborage (shelter), nesting, and secure travel lanes (runs and runways). They occupy a home range which can vary in size from 1/3 to 4 or more acres. One reason for the great variance in

the estimated size of the home range is because some deer mice may move 200 or more feet each day between their nest and a food source.

Summer population density of deer mice can reach 15 to 20 or more animals per acre in good, outside environments; however, population size is quite cyclic, varies greatly in number during the summer, and is balanced by rates of natural and annual mortality, which may range from 63 to 99 percent. Deer mice seldom live in the wild longer than 3 months during summer.

When food is not limited, large mouse populations develop where harborage and food are available such as in: piles of refuse or stored items, hollow walls, garbage areas, and old buildings. Population size always becomes greatest during the fall.

Mice are abundant around most structures (Glass et. al.) and tend to move indoors during late season when cooler weather makes outdoor habitat less hospitable (i.e., less food and fewer available nesting sites).

Mated pairs and family groups usually nest together during the breeding season but individuals surviving the winter may take new mates in the spring. Whenever a mate dies, a new mate is quickly found. Deer mice do not hibernate but become torpid for short times when winter temperatures fall below 59 degrees F.

Foods and feeding. The need for food greatly influences how far a mouse will move each day. Exposure to predation during feeding activity selects for larger populations to be located as close as possible to a continual source of food and suitable habitat.

Deer mice are primarily seed eaters but will also take nuts, fruits, roots and larger insects (i.e., grasshoppers, moths, and caterpillars), fungi, green vegetation, snails, centipedes, and small birds and mammals. When food is abundant during fall, mice store food in caches near their nesting sites.

In general, mice require only about 1/10 ounce of food and less than 1/10 ounce of water per day to survive; larger rodents can survive on as little as 8/10 ounce of food and 1/2 ounce of water per day. Elimination or

reduction of food, water, or harborage stresses a population and threatens its existence.

Reproduction. Outdoors, mice build nests at ground level under shrubs, boards, logs, tree roots, and in other rodent burrows. Nests are typically made of stems, twigs, leaves, grass roots and fibrous materials but may also be lined with fur, feathers, and shredded cloth. Sometimes deer mice nest in above ground sites such as a hollow logs, fence posts, unoccupied buildings and vehicles.

Reproduction in deer mice is characterized by early sexual maturity, a short gestation period, post-partum breeding, a short time between litters, and large litter size. More typically, breeding occurs continuously from spring through fall with a short lull during summer. Although some female deer mice can remain continuously pregnant from April through October, for practical purposes, reproduction in a population is normally completed by July. However, in warmer regions and inside buildings, mice can reproduce year-round.

High reproductive rates adapt rodents to rapid population growth and quick recovery should their numbers be reduced by pest control programs, predators, or adverse weather conditions.

During the breeding season, female deer mice come into heat every fifth day until impregnated. The gestation period is usually 21 to 23 days but may be as long as 37 days in nursing females. Females usually bear 3 to 5 young (as many as 8) per litter and a single female can wean up to 35 young per year if food is abundant. There may be from 2 to 4 or more litters per year, depending on species and climate. Young are weaned when 2 to 3 weeks old and become sexually mature about 7 to 8 weeks of age. Young born during spring and summer often breed during that same year.

Predators. Nearly all mammalian carnivores, raptors, and snakes prey on deer mice.

Woodrats

Woodrats are semi-arboreal, agile rodents that

are active all year. They can easily climb rock faces and jump from limb to limb like squirrels. These animals generally are solitary except when mating or rearing young.

Woodrats are sometimes called packrats because of their habits for "stealing" small shiny objects (spoons, bottle caps, etc.) and moving those items into their nest.

Woodrats construct a nest of sticks and limbs. Freshly injured tree bark and freshly cut branches are good signs of wood rat activity.

Foods and feeding. Food is determined by local condition but woodrats are primarily vegetarian. The animals are reported to eat green vegetation, seeds, nuts, acorns, fruits, fungi, and cacti. When woodrats nest in buildings (commonly in attics and crawlspaces), they may be attracted to available human foods, but usually continue to also feed outside.

Reproduction. Woodrats are not highly prolific. The animals can breed as early as January and as late as October but the season usually only lasts from May through August. Commonly, 1 to 5 litters of 2 to 3 young are born per adult female per year. The young require 2 months to reach maturity and annual increases or decreases in population size are not great.

Predators. Woodrats are preyed on by many predators including coyotes, foxes, bobcats, badgers, weasels, snakes, and raptors.

Potential damage and health concerns

Various park employees are concerned about the possibility of acquiring HPS as a result of accidental exposure to rodents or rodent debris found in their residences or work places.

Deer mice and woodrats frequently enter residences, office buildings, and other structures that are not properly rodent-proofed. The animals will build nests, store enormous amounts of food (acorns, nuts, seeds, etc.) in hollow walls and voids, and damage museum items, upholstered furniture, mattresses, clothing, leather and paper goods, as well as other materials. Rodent food caches and dead rodent carcasses attract

a variety of pests, including insects which feed on human foods and dead animals. Often, other rodents, trying to reach the food caches, cause additional damage.

Deer mice

Deer and other small mice can be responsible for increased rates of deterioration to historical and modern buildings when they burrow around foundations. Their digging loosens soil, increases soil permeability, and enhances erosion. Deer mice are attractive to predators which cause additional damage by enlarging mouse burrows trying to catch prey.

Deer mice and other rodents damage gardens and ornamental plantings when they dig up seed or graze on plants.

Parasites harbored by deer mice include helminths, arthropods, fleas, tapeworms, pinworms, flukes, mites, and lice. Diseases spread by mice include salmonellosis, leptospirosis, trichinosis, and typhoid. Deer mice are resistant to but vector sylvatic plague, tularemia, and tick-borne rickettsioses (as Rocky Mountain spotted fever and Q-fever) but rarely carry adiaspiromycosis or coccidioidomycosis. Deer mice (and some other rodents) are the principal vectors of the recently identified HPS which is transmitted to humans through contact with mouse nests and dried mouse feces, urine, and body fluids.

Woodrats

Woodrat nests can be a source of many parasites which may affect man, most notably conenose bugs which can be a vector for Chagas' and other diseases. Woodrats can also be an important vector for other diseases, including plague and tularemia.

Although their role of transmitting disease to man is reportedly minor, dead and dying woodrats should not be handled with bare hands.

Action thresholds

Summer reproduction may allow small mouse-sized rodent populations to increase by 25 or more times, even after allowing for expected rates of natural mortality, which commonly

eliminates 90 or more percent of the young before reaching maturity. The rate of increases for woodrat populations is much slower.

The following, "working" thresholds are offered as Action Thresholds to justify control until further information is developed by the park staff:

Outside Locations (i.e., near buildings or historic structures or damage to vegetation, etc.). Large mouse populations can seriously damage native and ornamental vegetation and their burrows are detrimental to the stability of foundations and walls. However, the ubiquitous occurrence, natural fecundity, and small size of mice makes them difficult to control in outdoor environments. The Action Threshold for mice in outdoor locations is:

- Capture of 30 or more mice in 100 trap nights around structures.
- Significant numbers of rodent burrows in, under, or adjacent to 10 or more percent of building walls or foundations.
- Excessive damage to any structure or cultural resource at any time of the year.

The Action Threshold for woodrats in outdoor locations will be any significant damage to structures or cultural resources by the animals or their nests.

Inside Structures. Inside the Visitor Center, residences, or other occupied buildings, evidence of only a single mouse or woodrat is the Action Threshold to justify control. This is because mice are prolific and the presence of rodents in buildings poses potential for contamination, disease, and damage to personal belongings and historical resources.

Action Thresholds for Rodenticides. No Action Threshold is offered for use of rodenticides inside of structures; it is undesirable to use poisons inside of buildings (especially buildings containing museums and curatorial storage areas). Poisoned animals that die in inaccessible areas create odors and dead carcasses attract insect pests.

Where, through monitoring and evaluation, physical and mechanical methods of control for outdoor rodent populations are not found to be

adequate and Action Thresholds are still exceeded, approval will be requested for rodenticides through appropriate NPS channels.

Inspection and monitoring

Because of the recent appearance of Hantavirus in the Southwest, all persons engaged in inspections and monitoring and who might come into contact with rodents or rodent feces or debris should wear approved personal protective equipment and follow Centers for Disease Control guidelines for personal safety.

A rodent inspection of a building should provide at least 3 valuable pieces of information:

- . extent and severity of infestation,
- . location of rodent harborage and activity and travel areas,
- . the safest and most appropriate control strategies.

Effective rodent inspections require a good familiarity with and ability to identify potential structural entry points as well as signs of rodents which may be: droppings and urine stains, sounds, burrows and nests, seed caches, odors, runways, tracks and rub marks, and gnawing damage.

Exterior inspections. Identify and document all possible rodent entry points (pipes, wires, duct traces, torn screens, etc.) both outside and inside of buildings.

Locate primary zones of rodent activity (harborage, feeding, and activity areas). Document spilled foods, weeds and tall grass next to buildings, piles of junk or debris, loosely covered garbage containers, shrubs and trees that touch or overhang buildings, faulty door sweeps, open pipe and electrical traces, etc.

Document any signs of rodents such as tracks, odors, sounds, droppings, damage, etc.

Interior inspections/monitoring.

Systematically examine all portions of the building including locker rooms, rest rooms,

kitchens and lunch rooms, boiler and furnace rooms, storerooms, offices, attics, and roofs.

Look for any source of food and water available to rodents and which may come from snacks eaten by staff at desks, crumbs, empty aluminum cans for recycling, dead insects on sticky traps, bars of soap in restrooms, bad garbage management, broken packages in food storage cabinets, open drains or leaking pipes, etc.

Search out available rodent harborage inside or behind machinery (kitchen appliances, water coolers, etc.), and in such places as employee lockers, improperly stored boxes and items on floors.

Monitor for rodents by periodically examining and documenting conditions in the same areas and for the same things as watched for during inspections. Monitoring, however, also requires snap, live, or sticky traps, and non-poisonous tracking boards be placed throughout buildings in likely rodent harborage and captures periodically counted. Glass et. al. (in preparation for publication) found tracking powder stations to be more effective in monitoring for the presence of mice in structures than bait stations or snap traps.

Careful monitoring will provide information on the actual occurrence and possible increase or decrease of rodent populations.

Non-chemical management

Legal status. Deer mice and woodrats are considered native, non-game mammals in some states and receive whatever protection as is afforded such species by state or local laws. It is usually permissible to control these rodents when necessary, but if in doubt, check with state wildlife agencies.

Control programs. All successful rodent control programs address 7 critical elements:

- thorough inspections that identify species involved, key harborage sites, locations where rodents obtain food and water, and factors encouraging rodent build-up. Until it is learned why rodents

are present and how they enter, controls can not be effective;

- good sanitation practices which deny rodents food and harborage;

- effective exclusion gained by sealing all potential entry points rodents can use to enter structures; this also includes closing external burrows next to buildings;

- ectoparasite control, if needed;

- effective and safe means for reducing rodent populations. This is best accomplished with snap and other traps placed every 10 linear feet along interior walls, every 20 linear feet along exterior walls, both inside and outside of all exterior doors, and in attics and crawlspaces;

- regularly monitoring areas after control for evidence of rodent activity and sanitation; asking residents or workers where they see rodents;

- evaluating control data to be assured programs have been effective.

Exclusion. Rodent-proof construction (exclusion) is the best and most permanent method for preventing rodents from entering buildings. A recently completed study on the effects of rodent exclusion in buildings in 3 national park areas, co-authored by Hoddenbach (Glass, et. al., in press), was supported by the Center for Disease Control and Prevention. That study showed rodent-proofing to be a highly effective method (90 percent control) for preventing small rodent infestations in structures. It also showed maintenance crews with no specialized training can follow recommendations of an IPM specialist and successfully perform rodent-proofing repairs with only standard construction methods and materials. Data not presented in the study suggested the average cost for labor and materials to rodent-proof structures 10 or more years old varied from \$2,000 to \$2,500 per residential structure or house trailer.

Good exclusion demands all exterior and interior openings larger than 1/4 inch (for

mice) and larger than 1/2 inch (for woodrats) be sealed with, respectively, at least 1/4 inch or 1/2 inch sized-mesh hardware cloth, metal flashing, or durable caulking. Chimneys should be closed after use or covered with hardware cloth or chimney covers. Hardware cloth (with edges buried several inches below the soil line) is used to exclude rodents from building/trailer foundations and to protect newly seeded garden plots.

Sanitation. Store foodstuffs (dry pet food, grass seed, groceries, etc.) in plastic, glass, or metal, rodent-proof containers. Do not store packaged food materials on the floor. Do not store snack foods in desk drawers. Keep stoves, floors, counter-tops, and areas around coffee stations clean of crumbs and food particles. Do not leave dirty dishes in the sink. Store empty aluminum cans for recycling outside and in a covered container. Remove the trash from buildings every night. Frequently clean the bottoms of trash cans under the plastic liners.

Habitat modification. Rodent damage can be reduced in unoccupied buildings by removing or limiting harborage and available nesting sites. Remove mattresses and padded cushions from furniture; store them on edge, separated from one another, off the floor. Store boxes and other materials off the floor on pallets or shelves. Remove drawers in empty cupboards or chests and re-insert them upside-down to keep animals from nesting in them.

Electronic repellents. Ultrasonic and electromagnetic rodent control devices are not known to be successful for keeping rodents out of structures.

Population reduction. Mouse-sized (for mice) and rat-sized (for woodrats) snap traps are the most effective way to control rodents inside structures. Both white-footed mice and woodrats are relatively easy to capture. For best results, several traps should be set, even when only a single animal is believed present. Automatic or multiple capture traps can catch a number of rodents in a single setting and are also effective, as are sticky (glue) traps. Frequently check traps and dispose of dead or captured animals so the bodies do not cause odors, become food for remaining

rodents, or attract insects.

Frequently vary the kind of traps used and the type of bait used on traps. Different kinds of traps (and different baits) have specific characteristics and sometimes capture animals that can not otherwise be caught.

Seasonality for controls. During mid- to late-summer, natural increases in population size forces young rodents to find an unoccupied home range. The biology of mouse reproduction emphasizes the benefits to be had with aggressive winter and early spring control programs while population numbers are still low. To be effective and offset natural rates of reproduction in mice, direct controls (trapping or poison) must remove 80 or more percent of the adults from a population both before (early spring) and throughout the reproductive period.

Woodrats do not reproduce as fast as do mice; however, winter and early spring controls, before birth of the young, is still the most effective means for reducing population size.

Chemical management

A number of anticoagulant and other poisonous baits are effective on rodents. Poison baits, however, are not recommended by NPS for use inside occupied structures. It may seem easy to put a high reliance on poison baits but baits, alone, will not control domestic rodents, are dangerous to use, and often cause secondary pest problems.

The high rate of reproduction in mice can replace many losses caused by poisons.

Rodents must feed on some toxic baits for a number of days before the bait become effective. Such baits may only make animals sick or become repulsive to the rodents if lethal amounts are not consumed. However, newer, single-dose rodent baits are reportedly more effective.

Rodents may show behavioral avoidance towards eating some baits or even develop resistance to or become tolerant of multiple-dose baits. Although rodent resistance has

not yet appeared in single-dose baits, some researchers predict it will.

Toxic baits (or rodents killed by baits) can poison children, pets, and other animals. Rodents often move and store poisons in hidden places (even kitchen toasters) where poisons may be found and eaten by other animals.

Poisoned animals commonly die in walls and other structural voids and cause long-lasting bad odors, attract insects, and become food for other rodents.

Deer mice tend to carry off and store more poisonous bait than do house mice. For that reason, ground meal or paraffinized wax bait blocks (which cannot be easily carried off) are more effective for deer mice than seed or pelletized baits.

Repellents. Moth flakes or moth balls, which are sometimes used as rodent repellents, are illegal to use for rodent control because E.P.A. has not registered them for such purposes. These materials are also hazardous to human health and their vapors can seriously damage some objects.

Evaluating treatments

Continual monitoring with traps, glue boards, and direct observations will determine if rodent populations have been eliminated.

Evaluations of treatments will be used to supply essential information to adjust Action Threshold values, develop more effective management strategies, and demonstrate any apparent needs for new control methods or chemicals.

Chemical alternatives

Benzyl-diethyl methyl ammonium saccharide
gustatory repellent

Although many commercial toxicants are available for rodent control, none are recommended by NPS for use inside structures.

When circumstances demand, cholecalciferol (Vitamin D³) may be a relatively low-risk rodenticide and approved for use on outside

populations. Rodents are one of the few animals that can not tolerate Vitamin D. When ingested by them, it mobilizes calcium from the bones into the bloodstream and produces hypercalcemia and heart failure.

Whenever rodenticides are used, it is imperative that poisons only be placed in sealed bait boxes to protect non-target animals and humans. Bait boxes are available from pest control supply companies.

Sources of advice, technical information, and supplies

National Park Service Videotapes

"Integrated Pest Management," 15 minutes.

"Pesticide Applicator Safety," 17 minutes.

"Integrated Pest Management; Commensal Rodents," 23 minutes.

"Self Help Pest Management", 24 minutes.

See Appendix listings for equipment and chemical supplies.

Literature

Baker, Rex O. and Gerald R. Bodman and Robert M. Timm. 1994. Rodent-proof Construction and Exclusion Methods. In: Hygnstrom, Scott E., Robert M. Timm, and Gary E. Larson, Prevention and Control of Wildlife Damage. Univ. of NE Coop. Exten. and US Dept of Agric., APHIS.

Glass, G.E. et. al. (in press) Rodent-proofing and HPS (Hantavirus Pulmonary Syndrome).

Jackson, William B. 1990. Rats and Mice. In: Mallis, Arnold. 1990. Handbook of Pest Control. Franzak & Foster Co., Cleveland OH.

Marsh, Rex E., Terrell P. Salmon, and Walter E. Howard. 1981. Integrated Management of Rodents and Other Wildlife in Campgrounds. US Department of Agriculture, US Forest Service.

Pratt, Harry D. 1975. Sanitation in the Control of Insects and Rodents of Public Health Importance. US Dept. Health, Education, & Welfare; US

Public Health Service, Centers for Disease Control, Atlanta GA.

_____ and Robert Z. Brown. 1976. Biological Factors in Domestic Rodent Control. US Dept. of Health, Education, and Welfare; US Public Health Service, Centers for Disease Control, Atlanta GA.

_____, F. Bjornson, and Kent S. Littig. 1977. Control of Domestic Rats and Mice. US Dept. Health, Education, and Welfare; US Public Health Service, Centers for Disease Control, Atlanta GA.

Salmon, Terrell P. and W. Paul Gorenzel. 1994. Woodrats. In: Hygnstrom, Scott E., Robert M. Timm, and Gary E. Larson, Prevention and Control of Wildlife Damage. Univ. of NE Coop. Exten. and US Dept of Agric., APHIS.

Scott, Harold G. and M.R. Boram. 1968. Rodent borne disease control through rodent stoppage. US Department Health, Education, and Welfare; US Public Health Service, Centers for Disease Control, Atlanta GA.

Simmons, Sewell E.. 1985. Parklands Pest Management. California Dept. of Food and Agric., Sacramento California.

Timm, Robert M. 1994. House Mice. In: Hygnstrom, Scott E., Robert M. Timm, and Gary E. Larson, Prevention and Control of Wildlife Damage. Univ. of NE Coop. Exten. and US Dept of Agric., APHIS.

_____ and Walter E. Howard. 1994. White-footed and Deer Mice. In: Hygnstrom, Scott E., Robert M. Timm, and Gary E. Larson, Prevention and Control of Wildlife Damage. Univ. of NE Coop. Exten. and US Dept of Agric., APHIS.

US Dept. of Interior, National Park Service. 1984, 1994. Integrated Pest Management Information Manual, First and Second Editions.

***** Additional information follows on Rodent Control, Trapping, and Rodent-Proofing. This information is included as a reference for developing informational handouts.**

INDOOR RODENT CONTROL GUIDELINES

In nature, rodents are not pests, rather, they are important parts of the ecosystem. When they enter structures, however, rodents contaminate food, cause structural and property damage and transmit diseases. Control of rodents in structures REQUIRES A DETERMINED EFFORT AND GREAT ATTENTION TO DETAIL.

RECOGNIZING RODENT INFESTATIONS:

Rodent infestation is verified when finding droppings, fresh gnawing, finely shredded paper or fibrous nesting material, food or seed caches in structures. Mice also emit a characteristic (easily recognized) musky-like odor; rodents may sometimes be seen during daylight hours.

RODENT DAMAGES: Rodents can harbor parasites that affect man and rodents can carry 200+ pathogenic micro-organisms which including those that contaminate food and vector HPS, typhus, plague, tularemia, Rocky Mountain spotted fever, relapsing fever, dysentery and other diseases. Rodents damage furniture, mattresses, clothing, papers, etc. when making nests. They chew into food containers and the urine, feces, hair, etc. they deposit is said to contaminate 10 times more foodstuffs than they eat. Rodent feces attract other mice and pests. Rodents invade attics and structural areas and gnaw on walls, cables, wires (many structural fires are caused by rodents that gnaw on electrical wires).

THRESHOLD FOR CONTROL: Even one mouse in an occupied building warrants control: mouse populations develop rapidly, pose great potential for contamination and property damage, and rodent odors/traces attract other pests.

RODENT FACTS:

Mice mostly feed on cereal grains but eat almost all human foods; they are sporadic feeders, only nibbling small bits of food here and there. Mice can run on horizontal cables/ropes; jump 12 inches up from the floor onto a flat surface; squeeze through 1/4 inch diameter holes. Females can produce as many as 20 young per season, some of which mature within 30 days and produce young. Deer mice are mostly active at night; have a home range of 1/3 to 4 acres; they do not hibernate but are less active in

winter.

CONTROLLING RODENTS: Effective rodent control **REQUIRES** integrating 4 **NECESSARY STEPS:** (1) **MONITORING;** (2) **SANITATION;** (3) **EXCLUSION;** and (4) **POPULATION REDUCTION.**

Of these, EXCLUSION has proven to be the most effective; but must also be combined with increased sanitation and monitoring programs.

MAJOR MISTAKES:

- DO NOT under-estimate the severity of a rodent infestation either in the numbers of animals present or size of area(s) infested.
- DO NOT use too few traps or an insufficient number of trap stations; place traps along walls.
- DO NOT fail to remove dead animals; these become food for remaining rodents and insect pests.

MONITORING: Continually monitor and inspect for mice and for possible locations where they can enter a building. Watch for rodent sign (gnawing, nests, feces). Vacuum up old rodent feces and sign to be able to recognize new infestations and to be able to determine if populations are increasing, decreasing, or static. Use a flashlight to inspect, even during daytime.

SANITATION: Mice survive in very small areas and with very limited shelter and food (they only require about 1/10 ounce of food and water per day) and are very difficult to eliminate even with good sanitation practices. However, good sanitation is always a BOTTOM LINE AND BACKBONE for rodent control.

- Sanitation must include both the outside and inside of affected structures.
- Reduce and eliminate ALL available food and water; store all foodstuffs and pet food in plastic, glass, or metal rodent-proof containers; keep garbage cans tightly covered; take garbage out every night; promptly remove uneaten pet/bird food; check for and remove foods stored in desks or cupboard drawers; continually clean up all crumbs, do not leave left-over food or dirty dishes out; keep outside garbage covered and remove it at least twice a week.

- If possible, maintain an 18 inch wide, vegetation-free zone around buildings. Trim the bottom out of shrubs or other ground-hugging plants to eliminate rodent harborage. Trim any plants that touch or overhang the structure back 3 to 4 feet from the building. Clean up all outside and inside clutter or litter.

- Outside, store firewood and other items on pallets located at least 15 feet from the house.

- Set landscaping rocks or logs 1/3 to 1/2 their depth into soil to discourage rodents from burrowing beneath them.

- Mice will make nests in anything that does not move. Continually rearrange furniture, boxes, clothing, etc. to discourage nest development.

- Don't keep empty aluminum cans inside; don't store paper sacks or other items where they will provide shelter for mice.

- Don't take food into rooms other than the kitchen; crumbs attract mice.

- Store everything off the floor to reduce rodent harborage and so you can easily inspect for and trap rodents. Raise hollow-base furniture off the floor to be able to inspect under it.

- Clean up all uneaten pet food as soon as animals finish eating.

- Repair all water leaks.

- Keep the stove top clean; frequently clean under top of stove and behind and under the stove and it's drawers. It only takes a very small amount of grease to feed a mouse. Frequently check under the refrigerator for rodent sign, clean lint from cooling coils, and drain (or clean) the drip pan.

- Remove the bottom or lowest drawers from kitchen cabinets and the stove to inspect for rodent debris; clean those areas well. These are good trapping sites.

- Be sure rodents are not imported into buildings from the outside with boxes, groceries, or other materials brought in.

- Trim the bottom out of shrubs and other ground-hugging plants near structures to

eliminate rodent harborage. Trim plants touching or overhanging a structure back 3 to 4 feet from the building.

- Frequently check under the refrigerator for rodent sign, to see if lint should be cleaned from cooling coils, and to drain the drip pan.

EXCLUSION: Mice can enter a hole 1/4 inch diameter; squirrels/rats a 1/2 inch hole.

- Rodents are attracted to outside doors, especially those with lights above them that entice insects. **DO NOT LEAVE DOORS OPEN and BE SURE DOOR SWEEPS FIT TIGHTLY!** Check around doors before entering from the outside. Move lights away from house and out onto poles that shine back onto the building from a distance. Use yellow lights, which attract fewer insects.

- Repair all loose, poor-fitting, or damaged doors, screens, windows. Be sure all screens are intact; only use metal window screening. Carefully check all door bottoms, sides, and tops for holes and gaps 1/4 inch or larger. Be sure doors and screens have self-closing springs and doors have good sweeps.

- Caulk or screen holes around heaters, water pipes, electrical wires, appliances, under sinks or those that enter through the foundation with 1/4 inch hardware cloth.

- Regularly inspect building exteriors from roof to foundation. Carefully check eaves, siding, soffits, cornices, foundations, etc. and caulk or seal all holes 1/4 inch or more in size.

- Screen all chimneys, vents, and open pipes with 1/4 inch hardware cloth. However, regularly check any screened chimney for build-ups of carbon and ash on the screen and to be sure the chimney draws properly. Automatic, self-closing chimney vents are also commercially available.

- Eliminate all access to interior dead spaces (voids), cracks, crevices, other openings where rodents can hide, enter, or leave a room, building, or equipment.

- Install buried "L-shaped" hardware cloth along the bottoms of foundations or pour "L-shaped" concrete curtain walls along foundations for an even more permanent solution.

HOUSE TRAILERS: House trailers are difficult to rodent-proof because of construction methods and materials used. Check for the following items, along with other things noted in the "SANITATION" and "EXCLUSION" sections.

- Trailer skirting must be tight everywhere and protected at the bottom with an "L"-shaped piece of 1/4 inch hardware cloth which extends up the side of skirt from the ground 5 to 6 inches and which extends underground and out from the skirt for 5 to 6 inches. Cover the wire with 1 to 2 inches of soil or rocks to keep it tight. An even longer-lived solution is to pour "L" shaped concrete curtain walls along the foundations.

- Water heater cabinets must be tight so rodents can not enter through pipe and electrical traces leading to areas within the trailer structure. Walls between the water heater cabinet and the bathroom and kitchen must be rodent-proof.

- The furnace, furnace cabinet, and chimney openings through the ceiling must not have gaps.

- All bathroom and kitchen pipe, drain, and propane/utility service line traces must be tightly caulked.

- All openings around clothing washer bibs or electrical circuit breaker boxes must be tightly sealed.

- Be sure the flap on the clothing dryer vent and kitchen vent close tightly when not in use.

POPULATION REDUCTION:

Trapping

Neither trapping nor poisoning, alone, will completely control rodents (good exclusion and sanitation are also necessary). However, traps are the preferred and safest method of rodent control inside buildings.

Traps offer proof of the removal of rodents and make it possible to accurately count the number of animals killed. This allows for better program monitoring.

Traps reduce the potential of odor and fly and carpet beetle problems which can develop if poisoned rodents die in walls or inaccessible

places.

Poison bait

It may seem desirable to rely on poison baits as a quick, easy control for rodents. However, poison baits, used as the only control, will never remove all rodents from a building and poison baits have many serious drawbacks.

- Mice will move and store poison baits in hidden places (even in kitchen toasters) where the bait may be found by other animals or humans. Toxic baits (or rodents killed with baits) can cause poisoning in children, pets, and animals.

- Often, rodents must feed on toxic baits for a number of days (they eat very little at any one time) before the baits are effective and sometimes will not eat certain baits.

- Poisoned animals dying in walls or hidden areas in the structure cause long-lasting bad odors, attract insects, or become food for other rodents.

- Rodents have been known to become resistant to some toxic baits.

- Poison baits present a number of problems surrounding the disposal of old or contaminated baits.

USE OF POISONOUS BAITS IN NPS AREAS REQUIRES NPS APPROVAL. CONSULT WITH THE CLUSTER INTEGRATED PEST MANAGEMENT COORDINATOR FOR ASSISTANCE AND COUNSEL.

Predators (cats/dogs)

Dogs and cats may kill some mice but do not offer effective control in most instances; it common to find mice living in close association with dogs/cats. Dogs/cats sometimes bring sick or dead rodents home for their owner to dispose of and pets can acquire plague from sick rodents. Also, feeding pets may increase rodent numbers when rodents can obtain food from pet dishes or pet feces.

Sound/electronic devices

Mice are easily frightened by strange and unfamiliar noises but will become accustomed to

regular or repeated sounds. There is NO EVIDENCE ultra-sonic or other electromagnetic sounds force rodents out of buildings or are otherwise effective for pest control.

RODENT TRAPPING GUIDELINES

Various kinds of traps for rodents are available and include snap traps (both mouse- and rat-size), glue boards (sticky traps), and multiple-capture live traps. Choose the right kinds of traps and keep them in good condition.

General

- Recent cases of HPS, caused by contact with dried rodent urine, feces, and liquid discharges require the U.S. Centers for Disease Control guidelines must be followed when trapping rodents. Wear rubber gloves when handling traps, rodents, or when cleaning up rodent feces or debris. It is always best to disinfect both the captured rodent and trap with Lysol or Clorox before handling them. Spray an approved disinfectant (household bleach mixed 1 to 10 with water or Lysol, as per label directions) on both captured rodent and trap and allow them to soak for 15 minutes before handling. Dispose of dead rodents in a tied plastic bag placed in an outside garbage can. To clean traps for re-use, dip them in a solution such as diluted Lysol or dimethyl dibenzyl ammonium chloride. Double rinse the traps after disinfection. Contact the State Department of Health, Vector Control Division, or CDC (800/532-9929) for more information.

- Rotate traps by leaving them baited but unset for 1 to 2 days; then, set them again for a few days; then, leave them unset again for a few days.

- Don't put out traps that repel rodents. When storing, setting, or otherwise handling traps, do not let them become tainted by odors of pesticides or other repellents (i.e., tobacco or odors from dogs/cats).

Snap traps

- Do not use traps that are not physically able to hold rodents. Springs should be strong and firm; trap bases should not be warped (tipping traps

frighten rodents).

- Be sure trigger mechanisms operate smoothly at the slightest touch (professional Victor brand <M7-M325> traps have adjustable triggers and can be set to varying sensitivity). Only if needed, lightly oil working parts of traps but only use mineral or inorganic oils.

- One researcher found traps with enlarged trigger pans captured 17 percent more mice with 14 percent less bait stealing than regular-sized triggers. Trigger pans can be enlarged by attaching a wire screen, thin piece of metal, or stiff cardboard to the trigger. Trim the enlarged trigger pans to be 1/4-inch smaller than the trap bail. Some argue, however, expanded triggers cause traps to release too early, when a rodent is only close to a trap, and reduce trap success.

- Traps with enlarged bait pans, properly placed in rodent run-ways, do not need bait; however, bait always adds to trap success.

Multiple capture traps

Food and pharmaceutical industries are the larger users of multiple capture traps because their regulations permit use of enclosed rodent traps in establishments but prohibit the use of rodenticide baits.

Ketch-All (Kness Mfg.Co.), Victor Tin Cat (Woodstream Corp.), Mouse Master (Dura-Built Products) are 3 major brands of multiple catch traps manufactured in U.S. One brand has not been consistently shown to be better than another. The Center for Disease Control (CDC), however, does not recommend using live capture traps for rodent control in areas where HPS is known present.

Ketch-All is the brand that has been used longest and is commonly called the "wind-up" mouse trap. **Tin Cat** is a low profile trap that uses double treadle doors without a winding mechanism. **Mouse Master**, most recent multiple catch trap, is a modified version of the Ketch-All.

- Don't over-wind the various models of wind-up traps; a forceful impact by the rotor may kill or hurt animals and result in odors or insect problems if traps are not frequently checked. Trap success is found better when captured rodents remain alive as long as possible.

- Service and clean traps regularly with a nylon scrub brush, rag, or putty knife. Some pest control technicians use a non-stick food spray on the interior bottom of live traps to make it easier to remove dead mice and debris. Disinfect traps after use with a viricide, such as lysol or dimethyl dibenzyl ammonium chloride. Double rinse traps in water after disinfection.

- Carry tools for minor trap repair: putty knife, pliers, long thin screwdriver, and a small vial of light pharmaceutical-grade mineral oil (no odor) or cooking or mineral oil; do not over-oil traps.

TRAP PLACEMENTS:

- **USE ENOUGH TRAPS.** Place at least 2 traps at each trap station and place trap stations 6 to 10 feet apart along walls and in areas where mouse activity is high. The home range of a house mouse is seldom more than 20-feet in diameter (its home range should be thought of as a sphere radiating out for 10 to 15 feet in all directions - to the sides, above, and below). Deer mice range over larger areas but close placement of traps is not detrimental.

- Set traps along routes leading from harborage to feeding areas. Rodent feeding stations are often found in room corners making those good places to trap.

- Place traps along rodent runways. These are identified when finding feces, smears, tracks, and other sign. Or, sprinkle light patches of tracking flour, talc, or dust on the floor or a cardboard base to be able to see where mice are most active.

- Construct barriers (or, "bottlenecks") which force mice to run along walls or through narrow passages and cross over traps. Place traps parallel with and touching walls with triggers pointed in opposite directions or place traps perpendicular to walls with the triggers pointed toward the wall.

- Place traps in concealed locations where mice are normally found rather than where the traps are easiest for you to reach or see. Darkened corners, runways along walls, pallets, behind appliances and objects, inside suspended ceilings are good places. If possible, put traps behind objects or place concealing shields over

traps to make sets more attractive to mice. Low profile Tin Cat traps can be placed under pallets or equipment and in ceiling voids.

- Place traps on both sides, both inside and outside, of exterior doors. Place traps near utility openings in walls and other possible rodent entry locations.

- Force mice to explore their territories by continually changing the habitat as much as possible. Move furniture and equipment; use objects to create runways, funnels, and wings which force mice into traps. However, do not change habitat when attempting to trap rats.

- Nail traps to vertical surfaces if these surfaces are used by mice. For pipes, attach an adjustable-radiator hose ring to the trap bottom with a screw and attach the trap to the pipe with the radiator hose or simply attach the trap to the pipe with duct tape.

Baits

- Keep traps with different baits close together and keep good records of the most effective baits.

- The most common bait for traps is peanut butter placed on the center of the trap pan and sprinkled with rolled-oats (or, peanut butter pre-mixed with oats). When using peanut butter on the trigger, smear a little on the underside of the trigger to make it more difficult for mice to remove.

- Tie nut meats, seeds, or dried fruit (especially, raisins) to the center of the pan. Fresh pecans and other nutmeats are good baits. Pierce the nut with the protrusion of the trigger or drill through the nut and tie it onto the trigger. Some technicians say that mice prefer fresh pumpkin seeds over many other baits.

- Cotton tied to triggers is a good bait to attract female rodents which are attracted to the fabric as a source for nesting material. Cotton is especially good in areas where foods for rodents are abundant and reduce the attraction of baits.

- Small, softened pieces of hard chocolate candy (i.e., Tootsie Roll) make good and durable bait when hardened. Similarly, fresh black gum drops are good bait and can be pushed or tied

onto triggers.

- Tie small pieces of hickory smoked bacon to triggers with a strong thread, string, dental floss, or light wire.

- Melt cheese onto the trigger with a kitchen match. Do not use a cigarette lighter because the fuel leaves a repellent odor.

Bait stealing

When bait is stolen and animals are not caught on a trap, place baited traps on patches of tracking powder. Tracks seen in the powder over the next few days will show whether ants, cockroaches, or rodents are stealing baits.

TRAPPING METHODS

- Make maps of trap locations and list counts of animals captured, by trap number, on the maps and on trapping logs. Other data recorded on the trapping log should include dates of inspection and relative trap success rate (number of animals captured divided by total number of traps set for a specified number of days). This information will help keep track of the activity of individual traps and will help if someone else has to pick the traps up. Summarize trapping records every week or so to see if rodent populations seem to be changing. Relocate or delete trap stations where rodents are not caught. Closely examine and carry out preventive structural maintenance in areas where traps always catch rodents.

- Trap intensively with a large number of traps in areas showing rodent activity (fresh droppings). On the average, only 50 percent or less of even professional trap sets are successful. If mice are active in an area and traps fail to catch the rodents after several days, move the traps a few feet, disrupt harborage by moving objects around, replace traps with different or new traps, and check to see that traps all work properly.

- Move traps to new areas every 2 weeks; some trappers suggest moving traps more frequently. This encourages mice to investigate the area more and may bring bait odors into closer contact with mice (mice have only small home ranges). The first area trapped can be re-trapped after a lapse of a couple of weeks.

- Trap success can be increased if rats are exposed to unset traps for several days before actual trapping begins. Alternate placement of set and unset baited traps. For smart rats, bait unset traps for several nights to allow animals to become familiar with the traps and a regular source of food. Then, set traps. After a few nights, leave baited traps unset again.

- Maintain good public relations by picking up trapped animals as soon as possible. In areas used by the public, place covers over trap stations to hide dead animals.

- Do not place traps above food or food handling areas. Do not use traps where they can harm pets or children.

RODENT/PEST PROOFING GUIDELINES

Although indoor rat infestations are nearly always quickly noticed, mouse infestations can become established rather inconspicuously and quickly develop into rather large populations. The most common error in mouse control is in underestimating either the size of the mouse population or extent of the infestation.

Sealing entrances against rodent invasion always seems to have lower priority than trapping the animals, increasing sanitation, or reducing interior mouse harborage and food. However, rodents (especially deer mice) cannot be effectively controlled in structures until all access to the outside is denied.

The goal in rodent-proofing is to physically prevent rodent penetration. In no instance should openings be left larger than 1/4-inch for mice or 1/2-inch for rats.

SPECIFICATIONS FOR RODENT RESISTANT MATERIALS:

SOLID METAL MATERIALS:

- Sheet metal: 24 gauge or heavier; galvanized metal.

- One successful technician recommends tin coated steel called "tyrne" sheet metal; it is soft and bendable (annealed) and can come

coated with rosin so can be painted. It is extremely animal resistant.

- Aluminum coil stock: is soft and easily shaped and excludes birds, bats, and squirrels (if they are not too aggressive); rodents can easily chew through aluminum if there is an accessible edge.

SCREENING MATERIALS:

- Expanded metal. Use 28 gauge or heavier, galvanized or non-rusting, expanded metal. This material is like very heavy-duty hardware cloth and is difficult to work with.
- Perforated metal. Use 24 gauge or heavier, galvanized or non-rusting, perforated metal. This material is also somewhat difficult to work with.
- Metal window screening. Metal window screens do not provide adequate rodent proofing; plastic window screening provides no protection at all.
- Hardware cloth. Use 19 or heavier gauge, galvanized, 1/4 inch or smaller sized mesh for mice. Use 16 gauge, welded-at-each-joint, 1/2 inch by 1/2 inch, galvanized-after-welding hardware cloth for rat-sized rodents. This is very strong material and can last 10 to 20 years because of the heavy zinc coating.

WEATHER STRIPPING: Weather stripping comes in many forms and is used to seal small spaces between movable parts, such as between doors and frames.

- Compression seals are usually made from felt or foam and sponge compounds and are not very resistant to gnawing pests. Compression seals are suitable for non-uniform gaps and are inexpensive and easy to install; however, they are less durable than various other kinds of weather stripping.
- "Bump-type" seals include vinyl tubular gaskets with or without reinforcing molding and are backed with vinyl, felt, wool pile, or foam strips. These are unobtrusive and also suitable for non-uniform gaps. Heavy duty styles seal better.
- Metal tension strips come in a variety of designs in brass, bronze, and aluminum wafer-like strips. These are not difficult to install but are not suitable for non-uniform gaps. They are

permanent, tight, and unobtrusive.

- Interlocking seals are made in two pieces and form a double seal on door jambs, door bottoms, and windows. These are relatively expensive and probably require a carpenter to install them. They are not suitable for non-uniform gaps but they are permanent, highly effective, and unobtrusive.

- Door bottom or threshold seals are compressible rubber or vinyl seals that fit on door bottoms or thresholds. These are relatively expensive and somewhat difficult to install properly. They are suitable for uneven gaps. Gustatory repellents or flashings can be applied to plastic or rubber door seals to keep rodents from chewing on them.

- Door sweeps include felt, vinyl, and stiff bristle sweeps inserted in a metal holder and which seal door bottoms. These are suitable for slightly uneven gaps, moderately priced, and easy to install but they are very visible. Sweeps with slotted screw holes can be readjusted as the sweep wears. Automatic door sweeps are available that drop to seal when the door closes but require professional installation.

- Garage door strips are mostly used on overhead garage doors and usually have a wide rubber or plastic gasket which is compressed under weight of the garage door. These are moderately priced and easy to install unless they interfere with the locking mechanism. They are suitable for somewhat uneven gaps and are durable. However, they are susceptible to being gnawed by rodents. Gustatory repellents may be applied to rubber door seals to keep rodents from chewing on them.

FILLER MATERIALS:

- Lath screen/metal (galvanized, light gauge) is a light-gauge, metal, screening which is attached over wooden walls before applying plaster. This wire is very soft and, as a filler material, can be wadded up and easily pushed into even very odd-shaped holes. After forcing lath screen into holes slightly expand the sharp edges to fill the cracks and dig into edges of the hole. Be careful of sharp edges when handling this material. Lath screen is very rodent proof and, being galvanized, does not rust or bleed through caulking.

- Steel wool: If steel wool is used, use 00 size material. This is a good filler for small holes but it rusts and cannot be used where water is present. Always caulk over steel wool to seal it.

- Stainless steel mesh does not rust and is a commonly available material (as pot scrubber pads) that excludes rodents but is somewhat harder to work with than steel wool.

- Copper mesh excludes rodents but aluminum and plastic screening do not. One commercial copper copper product, "Stuff-It", is available from various pest control supply houses and the manufacturer reports it to be rodent-proof when used as directed.

MORTAR/CAULKING: Use the best available caulking in colors to match the structure.

- Oil-resin based caulking is preferred by some because it is long-lasting (1 to 4 years) and has superior smoothing qualities even in cold weather (latex caulking freezes). Although easy to apply and inexpensive, oil-resin caulking may discolor/shrink or poorly adhere to porous (brick) surfaces, requires paint thinner for cleanup, and cures slowly. Oil-based caulking is adequate for filling small holes and cracks not subject to stress (i.e., between wooden frame and siding).

- Latex caulking may be either acrylic or vinyl caulking. Acrylic latexes are good for non-moving joints, last longer, and have better weathering characteristics but are more expensive than vinyl latexes. Both are easy to apply, quick curing, do not stain or bleed, clean up with water, and durable (3 to 10 years). They have good adhesion and shrinkage, during curing, is minimal.

- Butyl caulking is slow curing but very good for gaps between metal and masonry and for joints up to 3/4 inch wide and 3/8 inch deep. Butyl caulking is slightly more durable than latex but is harder to apply. Butyl, however, has good resistance to shrinking, excellent adhesion, and is good for use below ground level. It is flammable when wet and requires paint thinner for clean up.

- Elastomeric sealants include silicones, urethanes and others which are best for joints subject to movement (between masonry and wood or metal siding). Silicones can be used in

cracks even larger than 1 inch wide and 1/2 inch deep and are quite durable (up to 20 years). Elastomeric sealants cure rapidly, are waterproof, remain flexible in a range of temperatures, and show excellent resistance to shrinking and good adhesion on most materials. However, only certain formulations can be painted, they are more expensive than other caulking, and require solvents for clean up.

- Asphalt sealant is a tough caulking that repels rodents. It requires mineral spirits for clean up and thinning. It stays flexible between expanding and contracting surfaces; resists oil, grease, salt, and heavy traffic; and sets up tack free in about 30 minutes.

- Roof cement (in caulking tubes) is softer and thinner than canned roofing cement and easier to apply. The best types contain fiber; try various brands to find one that works best.

- Roof cement (in a can) is waterproof and pasty and sticks to nearly everything (wet or dry) as long as the items are not dusty. It is available in 1 and 5 gallon cans. This is good for cementing around chimneys and sealing chimney caps since it expands and contracts with changing temperatures. Roof cement lasts twice as long as mortar when applied to clean, dry surfaces. Roofing cement is relatively inexpensive, compared to other types of adhesives.

- Cement and mortar are excellent barriers to wildlife but are not practical for most situations because they harden so slowly and require excessive time for mixing and clean up. Cement is good, however, for larger jobs (steps, sidewalks, tuck pointed foundations, chimneys, and barriers around slabs and sidewalks). Mortar is a mix of several materials designed to be an elastic spacer for ceramics (bricks), it is not as hard as cement, weathers faster, and is not a substitute for cement. The best mixes for cement are 1 part cement to 3 parts sand or richer. For concrete, use 1 part cement to 2 to 4 parts sand or richer.

OTHER KINDS OF MATERIALS

- Building materials such as brick and tile or cinder or glass block are effective. Glass and cinder blocks, however, have hollow centers and may require installation of a cap to keep animals from moving up from the ground and through the

void. Spanish tiles require plugs to seal the open tile ends and exclude birds and rodents.

- Wood can be effective if there is no gnawing edge (butt, joint, hole, or other surface break where rodent can start to gnaw); use the best grade of wood available.

- Fit door bottoms with a metal channel and metal kick plates.

- Plug holes for utility traces passing through masonry walls with concrete; use sheet metal or hardware cloth for traces through wooden walls.

- Cover floor drains with heavy metal mesh; leaving no openings larger than 1/4 inch. Floor drains that have dried up because of non-use can be routes of entry for pests. Pour water into the traps and put 1 or more tablespoons of cooking oil in the drains to reduce water evaporation losses (one test showed no water loss after 1 month compared to 40 percent water loss for drains without oil).

- Fit sliding doors with rubber guards or brush-type gaskets that fit tightly on both sides of the rails.

- Design rodent guards for utility lines. Use a flat or funnel-shaped guard for single vertical lines next to buildings. Multiple vertical lines require more elaborate guards. Protect horizontal lines with 18 inch radius disk guards set far enough away from buildings so animals cannot jump to roofs. Be cautious in the installation, however, for if not properly placed, the guards can damage the insulation of electrical cables.

MONITORING

Continue to periodically inspect, monitor, and re-evaluate rodent-proofing and condition of structures.

The probability of a building becoming re-infested is directly proportional to the size of external rodent populations.

- Pay special attention to the condition of exterior vegetation, doors, windows, foundations and vents, meter boxes, loading platforms, etc. Be sure possible pest entryways were not overlooked in the original surveys.

- Check that doors (especially screen doors) and windows are not propped open.

- Check to see that new modifications to the structure have not damaged previously-installed rodent proofing (trucks may have backed into building, new construction, etc.).

- Assure that pests are not being imported into the building from the outside along with supplies and materials.

RATTLESNAKE

Description, distribution, identification

At least 13 different kinds of rattlesnakes occur in Western North America. Eleven of those species can be found in Arizona, 8 in Texas, and 7 in New Mexico. Some states have laws protecting rare species (4 species are protected in Arizona) and/or even require collecting permits for taking other species.

Rattlesnakes (Genera Crotalus and Sistrurus) are stout-bodied reptiles with triangular-shaped heads that are distinctly wider than their necks. They have vertical pupils, a rattle on the end of the tail, and are variously colored, usually in dark crossband patterns. Rattlesnakes have venomous fangs in the upper jaw that fold back into the mouth. These snakes are called pit vipers because they possess 2 heat-sensitive "pits" on the face, which are used to locate warm-blooded prey.

Occurrence in the park

Various kinds of rattlesnakes occur throughout the park and appear from time to time in visitor-use or residential areas.

The Western diamondback (Crotalus atrox), rock (C. lepidus), black-tailed (C. molussus), Mojave (C. scutulatus), prairie rattlesnakes (C. viridis), and massasauga (Sistrurus catenatus) are the more common kinds of rattlesnakes expected. Except for the prairie rattlesnake, which ranges over nearly the entire Western United States, the other species show local to wide occurrence from southern California through central Texas.

Biology

During winter (November through February or March as shown by studies in southern Arizona), many species of rattlesnakes hibernate in established, sometimes long-lived, communal dens. Dens are usually natural caves, holes, and crevices where snakes can escape winter weather. It is not uncommon for various other kinds of non-poisonous snakes to also occupy dens along with rattlesnakes. During springtime, the locations of den sites may sometimes be discovered when seeing rattlesnakes (and other

snakes) sunning on rocks around crevices.

Rattlesnakes are cold-blooded vertebrates with little resistance to high, daytime temperatures. They are generally active at night during summertime, but may also be seen during early mornings as they move to a protected place (burrow, deep shade) to escape the heat. About sundown, when temperatures are cooler, rattlesnakes emerge from hiding. During cooler spring and fall weather, rattlesnakes are may be active most of the day.

Foods and feeding. Rattlesnakes prey on a wide variety of small, ground-dwelling animals which includes rodents, rabbits, lizards, and birds.

Reproduction. Rattlesnakes breed during spring and fall. They do not lay eggs but bear 4 to 24 (or fewer) living young (6 to 8 inches long) during late summer. When born, the young possess venom and are fully capable of killing prey. Young do not remain with the female and most species become fully mature within 2 or 3 years.

Predators. Natural predators of snakes include mammalian carnivores, owls, and raptors.

Potential damage and health concerns

Rattlesnakes do not damage park resources; however, they do pose potential for causing human psychological trauma and/or poisonous bites. Lethal rattlesnake bites, however, are not common. Arizona is a state that supports an extremely large number of rattlesnake species; however, even in that state the number of reported deaths from rattlesnake bites has not exceeded two deaths per year since 1929. Yet, the number of rattlesnake bites per year in Arizona as well as in other Southwestern states has increased through the years because of larger human populations and increased contact with snakes during recreational activities.

Action thresholds

The observation of a single poisonous snake in a residential, visitor-use, or other area of human activity will be the Action Threshold for Control.

Inspection and monitoring

When snakes are suspected of being inside buildings, thoroughly examine the exterior foundation, crawlspace doors, basement screens, door sills, vents, etc. to find small cracks and holes (larger than 1/4 inch) where they might gain entrance. Carefully examine the many interior hiding places a snake could use.

To inspect for snakes outside, turn over rocks, flat boards, and other debris lying on the ground. Look for snake trails in dust and soft soil. Carefully search for snakes at night with a floodlight. Be sure to wear leather boots while inspecting and/or monitoring for poisonous snakes.

Non-chemical management

Legal. Various species of rattlesnakes in many states are protected by State or Federal law and specific kinds of permits may be required to collect or kill the animals. Check with the state Division of Wildlife Management before taking control actions.

The first step in snake management is to identify the reptile. Many non-poisonous, beneficial snake species are often mistaken for rattlesnakes.

An effective fence that excludes most kinds of poisonous snakes is 36 inches high, made from 1/4 inch mesh hardware cloth, and with the bottom buried several inches in the ground. It is best to place supporting fence posts inside the area to be protected so snakes cannot climb them. Gates must fit tightly. Keep the fence free of weeds and debris.

Snakes suspected of being inside or under structures can be captured by at least 2 kinds of traps.

- Place large (6 inch X 12 inch) glue boards along walls. To release captured snakes unharmed, pour a little cooking oil on the captured animal to soften the glue and the snake will be able to work its way loose.
- Place hardware cloth funnel traps along long drift fences or walls.

It is recommended for employees to only use commercially manufactured equipment for live-

capturing, marking, transport, handling, or releasing of venomous snakes. Staff should be trained in the use of commercially manufactured, professional, long-handled snake capturing tongs, available from pest control equipment suppliers. To transport poisonous snakes, place the animals in a tight, solidly constructed container fitted with a double interior screen; a tight, locking lid; and clearly mark the outside of the container with warnings about the contents. To prevent overheating and killing snakes, keep the container out of direct sunlight. Similarly, do not place a container containing snakes in an environment where it might freeze.

Employees will have the option of destroying poisonous reptiles if it determined that the animals cannot be safely captured or released.

Sanitation and habitat modification. Brush, wood, and rock piles; old lumber; and other materials lying on the ground give snakes a place to escape from the heat of the sun. Eliminating areas that provide shade to snakes in, around, and adjacent to residences and campgrounds will lessen the likelihood for snakes in the area.

Eliminate food and cover by closely mowing lawns and fields.

Good sanitation and effective rodent control around structures makes areas less attractive to snakes.

Behavior modification. Signing in some parks which provides diagrams of snakes and courteously asks people to not intrude into a rattlesnakes' domain (or otherwise warn persons about the presence of poisonous snakes) have proven effective in reducing the incidence of snake bite. One park uses a very effective sign that is worded: "Respect the rattlesnakes' right to privacy. Please stay on the trail."

Population control. The preferred control for poisonous snakes will be capture of the animal and removal from the immediate surroundings or killing them, depending on circumstances. If snakes are released unharmed, release points should be far enough distant and isolated so snakes will not likely come in contact with people. If

release points are not on park property, contact land owners for permission before making releases.

Chemical management

Repellents. Commercial snake repellents have not proven very effective in the past, but one company has recently introduced a new product, Snake-A-Way. It is registered for rattlesnakes and checkered garter snakes, but is apparently not effective against most other species of snakes.

Toxicants. There are no toxicants registered for snake control.

Evaluating treatments

Snake control methods will be judged effective when snakes are safely removed from areas of human use and monitoring and inspection show snakes are no longer found in areas of human use.

Evaluations of treatments will be used to supply essential information to adjust Action Threshold values, develop more effective management strategies, and demonstrate any apparent needs for new control methods or chemicals.

Chemical alternatives

There are no toxicants registered for control of snakes. Sometimes, poisonous gas fumigation has been required for entire buildings which removes snakes as well as all other pests but does not correct the original problems. Repellents used against snakes include:

Naphthalene and sulfur repellent (around buildings).

Sources of advice, technical information, and supplies

National Park Service Videotapes

"Integrated Pest Management," 15 minutes.

See Appendix listings for equipment and

chemical supplies.

Snakebite

Information on snakebite treatments and sources for antivenin. **Texas** (El Paso) Poison and Drug Information Center, 915/533-1244; **New Mexico** (Albuquerque) Poison and Drug Information Center, 505/843-2551; **Arizona** (Phoenix) Poison and Drug Information Center, 602/626-6016 or Samaritan Regional Poison Center, 602/253-3334.

Literature

Byford, James L. 1994. Nonpoisonous Snakes. In: Hygnstrom, Scott E., Robert M. Timm, and Gary E. Larson, Prevention and Control of Wildlife Damage. Univ. of NE Coop. Exten. and US Dept of Agric., APHIS.

Howard, W.E. 1994. Rattlesnakes. In: Hygnstrom, Scott E., Robert M. Timm, and Gary E. Larson, Prevention and Control of Wildlife Damage. Univ. of NE Coop. Exten. and US Dept of Agric., APHIS.

Knight, James E. 1986. A Humane Method for Removing Snakes from Dwellings. Wildlife Soc. Bull., 14(3):301-303. Also: New Mexico State Univ., Exten. Wildl. Unit, Coop. Exten. Serv., Las Cruces, New Mexico 88003.

Lowe, Charles H.; Cecil R. Schwalbe; and Terry B. Johnson. 1989. The Venomous Reptiles of Arizona. Arizona Game and Fish Department, Phoenix AZ 85023.

Marsh, Rex E. and Walter E. Howard, 1990. Vertebrate Pests, In: Handbook of Pest Control by Arnold Mallis, 1990.

Mazzotti, Frank J., Joe Schaefer, Craig N. Huegel, and Bill Kern. 1995. Florida Wildlife Resources Handbook. Florida Coop. Exten. Serv., Inst. Food and Agric. Sci., Univ. of Florida and Florida Game and Fresh Water Fish Commission Nongame Wildlife Program, Gainesville, Florida.

Simmons, Sewell E.. 1985. Parklands Pest Management. California Dept. of Food and Agric., Sacramento California.

Thompson, S.W. 1975. Snakes; in F. R. Henderson, ed. Handbook on Prevention and Control of Wildlife Damage, Great Plains Agric. Counc. and Kans. Coop. Ext. Serv., Kansas State Univ., Manhattan.

RINGTAIL CATS

Description, distribution, identification

Ringtail cats (*Bassariscus astutus*) are animals with soft, bushy pelage; long, slender bodies; pointed fox-like faces; large eyes; prominent ears; banded/ringed tails; and semi-retractable claws. The combined head and body length averages about 14 to 16 inches and animals have a 14 to 27 inch long tail. Females are slightly smaller than males. The long tail with whitish and blackish-brown rings is the key characteristic for identifying ringtails; raccoons have shorter tails and a black face mask; a coatimundi has an extended snout and its tail is indistinctly ringed.

Ringtail cats mainly occur in Upper and Lower Sonoran habitats. They are found at elevations from near sea level to about 6,500 feet statewide in Arizona, New Mexico, most of Utah, southern Nevada, southern and northern California, and southwestern Texas.

Occurrence in the park

The abundance of many vertebrate pests in the park, including ringtails, tends to cycle with weather conditions. From time to time, ringtails invade structures and introduce fleas, move into campgrounds and upset garbage containers, eat domestic pet foods, and otherwise become pests.

Biology

Ringtails are mainly found near sources of water in chaparral-like habitat with rocky ridges and cliffs.

They readily adapt to people and are easily tamed; miners once brought ringtails into their cabins to catch rodents. Ringtails are excellent climbers and den in hollow trees, under rock piles, in dry crevices, and in unused buildings. Population densities of 5 to 10 animals per square mile are considered high.

Foods and feeding. Ringtail cats are partially colonial, nocturnal animals. They feed on mice, woodrats, birds, lizards, insects, cactus fruit, apples, pears, and

other plants. They are very susceptible to dehydration and establish dens no further than 1/4 mile from water.

Reproduction. Although breeding habits of ringtails are poorly known, females probably mate in February or March and bear 2 to 4 young in late May to early June. Young emerge from dens when they are about 2 months old and forage with the mother. They leave the mother when 5 to 6 months old.

Predators. Ringtail predators are the larger carnivores like coyotes, foxes, and bobcats.

Potential damage and health concerns

Ringtails prey on rodents and greatly enlarge rodent burrows when excavating prey.

Ringtails often make dens in structural attics and become pests by: introducing parasites, odors, noises, chasing rodents, and accumulating nesting materials and spoiled and moist foods (especially fruits). It is quite common for ringtail urine and liquids from their food to soak through nests and into attic floors; liquids can soak through attic floors and damage articles stored in lower living quarters.

Action thresholds

Ringtails that damage desirable cultural or natural resources or personal possessions, excavate burrows in historic or archeological areas, interfere with desired aesthetic values, or attract undesirable predators will be the Action Threshold for ringtail control.

Inspection and monitoring

Because of the recent appearance of Hantavirus in the Southwest, all persons engaged in inspections and monitoring and who might come into contact with rodents or dry rodent debris should wear approved personal protective equipment and follow Centers for Disease Control guidelines for personal safety.

Inspection and monitoring methods are similar.

Examine the exteriors of buildings to find possible entry points for ringtails. Inspect attics

and similar hiding places for animals, nests, or caches of fruits and other foods. Conduct nighttime census with spot lights. Dust areas around openings into attics or other voids with flour and check them later for tracks.

Non-chemical management

LEGAL. Ringtails are protected in most states as furbearers and permits may have to be obtained before managing the species.

Good exclusion is the best preventative measure to keep ringtails out of attics and other structures. Be sure all possible holes 2 inches or more in diameter, that could serve as an entrance for animals, are adequately sealed.

Reduce an area's capacity to support ringtails by removing brush, debris, or other harborage that attracts them or animals they prey on.

Live-trapping with cage or foot-hold traps, Conibear traps and snares are effective non-chemical controls for ringtails. Cage traps must be extra long models or a ringtail's tail will keep the trap door from closing and allow the animal to escape. If animals are to be released, transport them at least 35 miles away to lessen the likelihood of their return.

Ringtails are normally difficult to find at night but, where detected, shooting (if permitted) is effective for lowering population numbers.

Chemical management

There are no toxicants registered for the control of ringtails.

Evaluating treatments

Treatment efficacy will be shown when ringtails no longer enter structures or when the numbers of ringtails or ringtail tracks seen over given periods of time are fewer.

Evaluations of treatments will be used to supply essential information to adjust Action Threshold values, develop more effective management strategies, and demonstrate any apparent needs for new control methods or chemicals.

Chemical alternatives

There are no toxicants or repellents labeled for ringtails.

A number of products are labeled for control of fleas which may be present in ringtail dens located in structures.

Fenoxycarb (IGR) for fleas.
Flea powder with pyrethrin for fleas
Hypochlorite (household bleach) sanitizer
Methoprene (IGR) for fleas
Pyrethrum for fleas
Silica aerogel with pyrethrin for fleas

Sources of advice, technical information, and supplies

National Park Service Videotapes

"Integrated Pest Management," 15 minutes.

See Appendix listings for equipment and chemical supplies.

Literature

Blair, W. Frank; A. P. Blair; Pierce Brodtkorb; Fred R. Cagle; and George A. Moore. 1957. *Vertebrates of the United States*. McGraw Hill Book Co., New York NY.

Burt, William Henry. 1980. *A Field Guide to the Mammals of North America North of Mexico*. Houghton Mifflin Co., Boston MA.

Davis, William B. and David J. Schmidly. 1994. *The Mammals of Texas*. Texas Parks and Wildlife Press, Nongame and Urban Program, Austin TX 78744.

Lowe, Charles H. 1964. *The Vertebrates of Arizona*. University of Arizona Press, Tucson AZ.

SKUNKS

Description, distribution, identification

There are 4 kinds of skunks in most parts of the Southwest and which also occur in the park: the spotted skunk (Spilogale putorius); striped skunk (Mephitis); hooded skunk (Mephitis macroura); and hog-nosed skunk (Conepatus leuconotus).

Skunks are members of the weasel family. They are small, cat-like, mostly nocturnal, carnivorous mammals with an assortment of black and white markings.

The **striped skunk** is about the size of a house cat and has prominent, lateral white stripes down otherwise jet black fur and is the most commonly abundant of the 4 species. This is the skunk that is most commonly found in urban areas and near open spaces, washes, and canals.

The **spotted skunk** is smaller and has white spots and short, broken white stripes on a black coat.

Hooded skunks are about the same size as striped skunks but have a unique ruff of fur on the neck and a long tail.

The snout of the **hog-nosed skunk** is long and hairless and its entire back and tail are white. Only the lower sides of its belly are black.

Occurrence in the park

Skunks are not a major problem in the park but are sometimes attracted into campgrounds and residence areas where they disturb garbage cans, dig under structures, introduce fleas, and cause bad odors.

Biology

Burrows. Skunks excavate holes in the ground for their dens or to capture prey. They do not hibernate but remain relatively inactive during winter and do not often leave the den during intensely cold weather.

Habits. The average number of skunks in an area is highly variable and depends on available resources but may range from 9 to

37 skunks per square mile. The average diameter of a skunk's home area is usually from 1/2 to 1 1/2 miles, but during the breeding season, animals may travel 4 to 5 miles per night. Life expectancy is about 3 years but 10 year-old striped skunks are known in the wild.

Foods and Feeding. Skunks are opportunists and feed on a large variety of items including mice, birds, eggs, insects, carrion, and some vegetable matter. They are often attracted to campgrounds and residential areas by garbage, pet food, and available shelter.

Reproduction. Skunks are usually sexually mature within a year and breed from February to March. In April or May, 2 to 5 young are born; they are weaned when about 2 months old. Young stay with the mother until fall.

Predators. Natural predators on skunks are most of the larger carnivores.

Potential damage and health concerns

Skunks dig burrows under structures for denning. The dens have very disagreeable odors, especially when occupied by several animals, during breeding times, or when an already inseminated female fights off the advances of a second male. Skunks sometimes dig holes in lawns to capture immature insect prey.

All skunks have the ability to produce a nauseating, defensive odor from anal glands. They can accurately eject their defensive material for distances of 10 to 12 feet, less accurately to 20 feet.

Skunk dens can be as a source of parasites (mostly fleas) which can be transmitted to humans. Baylisascaris columnaris, a common roundworm carried by skunks and closely related to B. procyonis (carried by raccoons), when transmitted to humans or wildlife can potentially cause central nervous system damage.

The striped skunk is a principal vector for rabies. Rabid skunks appear unduly nervous, are found active during the daytime, salivate excessively,

and usually show little fear of man.

Action thresholds

Finding nuisance skunks in developed areas (campgrounds and residential areas), skunks known to cause damage to structures or resources, or skunks acting as if they may be infected with rabies will be the Action Threshold for controlling skunks.

Inspection and monitoring

Inspecting and monitoring for skunks are similar. Examine holes under structures to determine if they have a characteristic skunk odor. Place flour or talc tracking patches in front of holes and analyze footprints. Use a spotlight at night and count animals.

Non-chemical management

Exclusion. Good exclusion is of the greatest importance for keeping skunks from entering crawlspaces beneath buildings. Repair and close all openings along foundations. Screen subfloor ventilation holes and wooden deck bottoms with hardware cloth wire mesh.

To keep an animal denning under a building from being able to return to its den, install a swinging 1/2 inch mesh hardware cloth door, hinged at the top, over the hole used by the animal. Dust the ground in front of the hole with flour or talc to show whether the animal has left the hole. Once it is known that the animal is no longer under the structure, seal the hole it was using with 1/4 inch mesh hardware cloth (to exclude smaller animals) and cover that with 1/2 inch hardware cloth mesh. Or, install a durable metal or wooden barrier over the hole.

Sanitation. Properly dispose of garbage and other food sources that attract skunks. Keep tight-fitting lids on garbage cans and/or use animal-proof cans.

Remove unused pet food and water bowls at night. If pet food is stored outside, be sure it is placed in animal-proof containers. Frequently harvest produce from gardens and pick up windfall and over-ripe fruits.

Remove any debris or piles of material from around buildings which could serve as skunk harborage or feeding areas.

Population Reduction. Skunks are listed as furbearers and are protected in some states by game laws. Other states regard skunks as predatory animals and allow reasonable measures of control to alleviate animal-caused damage. Check with the State Game and Fish Department before destroying or releasing skunks.

Skunks are usually live-captured in box traps; however, leg-hold and Conibear traps are also effective if traps can be protected so as to not injure humans or other wildlife. Place traps in areas of greatest skunk activity or near suspected entry points. Do not place traps under a building or deck (removal of the trap will most often result in the trapper being sprayed by the skunk). Use raw whole egg, peanut butter, sardines, raw chicken, or pet food as bait in traps.

Skunks are nocturnal in their habits; using a floodlight at night to shoot skunks can be an effective control.

The preferred measure for controlling skunks and other larger mammals is by live-capture in a cage trap. Humane destruction of trapped animals is most desirable; however, if for some reason captured animals will be moved and released outside the park, prior arrangement must be made with state Game and Fish, U.S. Forest Service or other land owners/managers. Animals will be moved no less than 20 miles distant for release. Before release, animals will be marked by paint or other suitable means. Marked animals that return will be destroyed. Park personnel will take all possible precautions against disease transmission or personal injury during trapping, cage handling, transport, marking, and release.

Other. Various commercial chemical preparations are available to remove skunk odors from materials.

Chemical management

Toxicants. There are no registered toxicants for

skunks.

When ignited, gas cartridges made with sodium nitrate and charcoal release carbon monoxide; they are the only currently registered den fumigants and are reported to be about 70 percent successful for killing skunks in enclosed dens. Do not use this material under buildings.

Evaluating treatments

Continuous inspection and monitoring will provide information as to the effectiveness of the management program.

Treatment evaluations will be used to supply essential information to adjust Action Threshold values, develop more effective management strategies, and demonstrate any apparent needs for new control methods or chemicals.

Chemical alternatives

Repellents and fumigants that, if approved, could be used for skunks include:

Carbon monoxide gas cartridges to kill skunks in holes; not to be used near occupied structures.

Mustard oil and capsaicin gustatory repellent.

Various pesticides are labeled for fleas which may come from skunk dens located under structures.

Fenoxycarb (IGR) for fleas.
Flea powder with pyrethrins
Hypochlorite (household bleach) sanitizer.
Methoprene (IGR) for fleas.
Pyrethrum contact sprays for fleas.
Silica aerogel for fleas.

Sources of advice, technical information, and supplies

National Park Service Videotapes

"Integrated Pest Management," 15 minutes.

See Appendix listings for equipment and chemical supplies.

Literature

Commercially marketed skunk odor deactivators are available from (see Sources in Appendix):

Bramton Co.
Drs. Foster and Smith Inc.
Fritsche, Dodge & Olcott Inc.
G.G. Bean Co.
J. Norris Corp
Neutron Industries
R.C.F. Developments Inc.

Other references

Giles, Robert H. 1969. Wildlife Management Techniques. Wildlife Society, Washington DC.

Hygnstrom, Scott E., Robert M. Timm, and Gary E. Larson, 1994. Prevention and Control of Wildlife Damage. Univ. of NE Coop. Exten. and US Dept of Agric., APHIS.

Marsh, Rex. E. and Walter E. Howard, 1990. Vertebrate Pests, In: Handbook of Pest Control by Arnold Mallis, 1990.

Simmons, Sewell E.. 1985. Parklands Pest Management. California Dept. of Food and Agric., Sacramento California.

Timm, Robert M. 1983. Prevention and Control of Wildlife Damage; Nebraska Cooperative Extension Service, Lincoln NE.

Ware, George W. 1988. Complete Guide to Pest Control - With and Without Chemicals. Thomson Publications, P.O. Box 9335, Fresno CA 93791.

SPIDERS

Description, distribution, identification

Spiders (arachnids) are 8-legged invertebrates with a body made up of only two sections, the cephalothorax (combined head and thorax) and abdomen. Spiders have eight or fewer eyes.

Many different kinds of spiders occur in the United States and greatly differ in size and color. All spiders are predators and rarely become problems in buildings that do not also have insect infestations to attract spiders.

Two pest spiders of health concern, and commonly found in the Southwest, are the black widow (Latrodectus) and brown recluse spiders (Loxosceles).

Black widow spider. Five species of Latrodectus occur in this country. The adult, female black widow spider is about 1/2 inch long. She has a shiny black abdomen, and the underside is usually decorated with red or yellow-red markings in an hour glass pattern. Male black widow spiders are about half the size of the female and streaked with red, white, or yellow, and are not dangerous to man.

Brown recluse spider. About 50 species of Loxosceles are known in the Western Hemisphere. These spiders are about 1/4 to 1/2 inch in diameter and mostly dusky-tan or brown in color and most show a violin-shaped pattern on the top of the cephalothorax. The most distinctive identification character for these spiders is the presence of 3 pairs of eyes.

Occurrence in the park

Most spiders are native arthropods and are expected to be found in or around park residences, offices, especially structures openings to the outside environment (archeological ruins, historical buildings, outbuildings, etc.).

Black widow spiders are mostly found around the

exteriors of residences. Brown recluse spiders occur in the park but have not been a serious problem.

Biology

Black widow spider. The female black widow spider is primarily nocturnal and rarely leaves the irregular, wispy, scaffold-like web; she has poison glands and fangs for killing insect prey and her venom can be dangerous to humans. Black widows, however, are quite timid and usually make no effort to bite, even when provoked. Most black widow bites come about when the spider is accidentally squeezed against a person's body but can also occur if the spider builds webs in folds of clothing, shoes, and beneath objects. The black widow bite is quite poisonous (systemic, neurotoxic), painful, and can result in death. Antivenom almost immediately removes the pain and reactions of a bite.

Black widows are normally outdoor spiders found in holes and voids, rodent burrows, plant detritus, and behind or under rocks or materials stacked against walls. They enter structures when exclusion is not adequate.

Most black widow spiders over-winter as immature individuals and develop into adults during spring and then die in late summer or fall. Some female black widows, however, have been known to live for up to 3 years. The black widow is quite prolific and lays a total of 9 egg sacs (each containing from 200 to 400 eggs) during her lifetime. Young spiders mature in about 4 months and disperse by ballooning on webs on air currents.

Brown recluse spider. The brown recluse spider is normally a nocturnal, outdoor spider but may take up living inside structures. Brown recluse spiders have higher moisture requirements than many other spiders and mostly confine themselves to moist cracks, caves, or beneath items stored on the floor or ground.

The brown recluse is not aggressive but will

bite if squeezed against a person's skin. Bites most often occur when putting on shoes or clothing. The bite causes a severe, long-lasting, and disfiguring wound but is seldom lethal.

Although brown recluse spiders construct fine and irregular webs, they commonly leave them to search for prey.

The female produces 1 to 5 silken, off-white colored egg cases, each containing from 30 to 50 eggs, during her lifetime. Young spiders normally require about a year to mature after which they may live for 2 to 5 years.

Outside, brown recluse spiders are typically found around rocks, piles of debris, in utility boxes, under bark, etc. Inside, they are found in undisturbed areas, commonly in boxes, among papers, in seldom-used clothing and shoes, in corners, under tables and chairs, in crevices along baseboards, doorways, and window moldings.

Predators. The principal predators of spiders are mud dauber wasps, birds, rodents, and other predatory insects.

Potential damage and health concerns

Although black widow and brown recluse spiders can be harmful to man, other kinds of spiders should be regarded as beneficial predators on insects.

Black widow spider. The severity of a black widow spider bite depends on the amount of venom injected, the age and condition of both the victim and the spider, the part of the body bitten, the degree of immunity of the victim, and the treatment given. Bites are rarely fatal in strong, healthy adults but young children and elderly can be vulnerable. Persons with high blood pressure may be at risk of a stroke if bitten.

Brown recluse spider bites are not painful at first and are rarely lethal but do cause severe tissue breakdown which results in long-lived wounds and festering sores. Secondary

infection after a brown recluse spider bite always presents a potential for gangrene; skin grafts are sometimes required to close brown recluse spider wounds.

If bitten by a spider, carefully capture it in a bottle, add alcohol, and take it to a specialist for identification.

Action thresholds

Spiders are usually of serious concern to homeowners even though very few spiders are poisonous. The presence of spiders and the fears occupants have for being bitten are sufficient reasons to warrant a control program in a household.

Inspection and monitoring

Because of the recent appearance of Hantavirus in the Southwest, all persons engaged in inspections and monitoring and who might come into contact with rodents or dry rodent debris should wear approved personal protective equipment and follow the Centers for Disease Control guidelines for personal safety.

Indoor sites to check during inspection and monitoring are little-used, cluttered storage areas, such as, closets, attics, and door and window casings. Outdoors, check small crevices and corners around foundations, wood piles and sheds.

Black widow, recluse and various other spiders are nocturnal. If possible, schedule inspections for nighttime and use a flashlight both indoors/outdoors. Wear long sleeves, long pants, socks, gloves. Avoid placing hands into dark places. Look for silky egg cases about 1/3 inch in diameter, loose irregular webs, or cast skins. The cast skin of a brown recluse spider is fragile but the characteristic violin markings remain on the cephalothorax.

Place sticky traps in brown recluse spiders habitat.

Non-chemical management

Outside. Spiders require a ready supply of insects to survive. Houses infested with flying insects that are attracted to lights often harbor spiders. To reduce the numbers of insects attracted to a structure and lessen spider problems, minimize or shield lights or install lighting (yellow bulbs) that does not attract insects. If possible, eliminate outdoor lighting close to a structure, especially near doorways.

Keep weeds trimmed and remove debris, lumber, scrap, rubbish, and leaf litter from around foundations, caulk entry holes, install tight screens and door sweeps.

Stack firewood, brick, and stone piles away from buildings. Inspect firewood, laundry, outdoor furniture, flowers, etc. for spiders and egg sacs before bringing them inside.

Keep grass mowed very short next to buildings; install an 18-inch wide barrier of vegetation-free gravel around buildings. Keep trees and shrubs trimmed back at least 12 inches away from walls.

If possible, allow outside store rooms to freeze during winter. Summertime temperatures in uncooled storage rooms are usually high enough (120-F. for 1/2 hour) to kill spiders.

Periodically sweep webs off structural exteriors with a garden hose.

Indoors. Assure good housekeeping practices. Regularly vacuum all cracks and crevices, floors, walls, baseboards, and dark corners to destroy webs and egg sacs (use leather or rubber gloves when working in spider harborage). Carefully clean bedrooms, closets, and storerooms used by children.

Do not leave clothing or bedding, boxes, or piles of paper on the floor.

Use a fly swatter or a vacuum to remove live spiders and webs and egg sacs.

Repair any holes in door and window moldings large enough to admit spiders; caulk all

openings around water pipes and electrical lines. Be sure screens on doors and windows are intact and tightly fit.

Repair all exterior and interior water leaks. Ensure attics, crawl spaces, and other enclosed areas are adequately ventilated and are not moist. Excessive humidity encourages insect pests that spiders eat.

Chemical management

Pesticides are effective on spiders when directly applied to the pest, but pesticides are not normally used for spider control because of difficulties in getting chemicals into secluded spider harborage. Also, spiders do not pick up pesticides very well (they walk on hairs on their feet and do not directly contact surfaces), they do not ingest pesticides during grooming, and they live in webs which are above and rarely contact surfaces treated with residual chemicals.

For serious black widow or brown recluse problems, thorough pesticide applications may be necessary. Carefully apply silica aerogel, boric acid, or resmethrin into cracks and crevices of interior baseboards, dressers, cabinets, and other furniture. Make similar treatments in attics and crawlspaces and, especially, areas with high moisture (bathrooms, kitchens, washer and dryer areas). If the crawlspace is relatively dry, residual dusts are more effective; if wet, a crawlspace should be treated with non-residual contact insecticides. After treatments, inform occupants on ways to reduce moisture in the crawlspaces or spider problems will quickly reappear.

Large areas with a substantial brown recluse spider infestation may require a more aggressive treatment. Confer with your park cluster's IPM Coordinator, if such is the case.

Many web-building spiders recycle their silk (eat old webs); light pesticidal dust applications to webs can be an effective control for those species.

Schedule follow-up inspections for 2 or more weeks after treatment, monitor the results, and

retreat, where necessary.

Evaluating treatments

Post-treatment inspections and monitoring will determine whether or not treatments have been effective.

Evaluations of treatments will be used to supply essential information to adjust Action Threshold values, develop more effective management strategies, and demonstrate any apparent needs for new control methods or chemicals.

Chemical Alternatives

Various pesticides can be used to control insects spiders feed on (see appropriate sections). Pesticides that are sometimes used against spiders include:

Allethrin aerosol
Boric acid dust for cracks and crevices
Diatomaceous earth with or without pyrethrin
Pyrethrin contact spray
Resmethrin aerosol
Silica aerogel with or without pyrethrin for cracks and crevices

Sources of advice, technical information, and supplies

National Park Service Videotapes

"Crack and Crevice Treatment for Cockroach Management," 13 minutes.

"Integrated Pest Management," 15 minutes.

"Pesticide Applicator Safety," 17 minutes.

See Appendix listings for equipment and chemical supplies.

Literature

Akre, R.D. and E. P. Catls. 1990. Spiders. Wash. State Coop. Exten. Serv.

Bennett, Gary W., John M. Owens, Robert M. Corrigan. 1988. Truman's Scientific Guide to

Pest Control Operations; Purdue University, Edgell Communications.

_____ and RE Williams. 1989. Spiders. Exten. Bull E-72, Purdue Univ. Coop. Exten., West Lafayette, IN.

Christensen, Dr. Chris. 1983. A Technician's Handbook to the Identification and Control of Insect Pests. Pest Control Technology, 4012 Bridge Ave., Cleveland OH.

Gladney, W.J. 1972. Controlling The Brown Recluse Spider. Div. Agric. Univ. Arkansas; Agr. Expt. Bull. #711.

Harmon, James D. 1993. Integrated Pest Management in Museum, Library and Archival Facilities. Harmon Preservation Pest Management, P.O. Box 40262, Indianapolis IN 46240.

Hedges, Stoy. 1991. Managing Pests Without Pesticides. Pest Control Technology, Jan. 1991: 451-49.

_____ and Mark S. Lacey. 1994 Field Guide for the Management of Urban Spiders. Franzak & Foster, Cleveland OH.

Hite, J.M., W.G. Gladney, J.L. Lancaster, and W.H. Whitcomb. 1996. Biology of the Brown Recluse Spider. Div. Agric., Univ. Arkansas, Agr. Expt. Bull. #711.

Moore, Wayne L.S. 1988. Controlling Household Pests. Ortho Books, Chevron Chemical Co., 742 Bancroft Way, Berkeley CA 94710

Norment, Bev. R. 1990. Spiders. In Mallis, A. 1990. Handbook of Pest Control, 7th Edition; Franzak & Foster Co., Cleveland OH.

Olkowski, William, Daar, S., and H. Olkowski. 1991. Common-Sense Pest Control. Taunton Press, Newtown, CT.

Smith, Robert L. 1992. Venomous Animals of Arizona. University of Arizona Press, Tucson Arizona.

United States Dept. of Health, Education and

Welfare. 1967. Pictorial Keys to Arthropods, Reptiles, Birds, and Mammals of Public Health Significance. Public Health Service, Atlanta, GA.

US Dept. of Interior, National Park Service. 1984, 1994. Integrated Pest Management Information Manual, First and Second Editions.

Ware, George W. 1988. Complete Guide to Pest Control - With and Without Chemicals. Thomson Publications, P.O. Box 9335, Fresno CA 93791.

Washington State Cooperative Extension. 1987. Aggressive House Spiders. Bulletin #1466.

TICKS

Description, distribution, identification

A large number of different kinds of ticks occur in the United States; however, very few species become structural pests and only about 11 species are of major importance in the spread of diseases.

Hard ticks (Family Ixodidae) are tear-drop shaped ticks with a hardened top plate and their mouth parts are visible from a dorsal view.

American dog tick (Dermacentor variabilis).

This tick is normally found in wildlands east of the Rocky Mountains and in a few far western states. It can occur around homes and be a vector of Rocky Mountain spotted fever, St. Louis encephalitis, tick paralysis, and tularemia. The American dog tick does not survive well indoors.

Black legged tick (Ixodes scapularis) and Western black legged tick (I. pacificus). The black legged tick is common in the Southeast (South Carolina, Georgia, etc.) and the Western variety in California and various parts of the Rocky Mountains. Although these ticks normally occur in the wildlands, they are often found around homes and can be a vector of Lyme disease and tick paralysis.

Brown dog ticks (Rhipicephalus sanguineus) occur throughout the world wherever dogs are found (including kennels and yards around veterinarian offices). This tick prefers warm, dry locations where dogs live and does not do very well outdoors and; it is the tick species most commonly found indoors. Female ticks climb upwards where they deposit eggs in cracks and crevices near wall hangings, on ceilings, roofs, etc. Following hatching, young ticks migrate down walls to attach to a dog. The brown dog tick can live as long as 1-1/2 years without feeding and dogs can become infested with ticks in a structure long after the departure of dogs previously living there. This tick rarely attacks humans; but, it can be a vector of Rocky Mountain spotted fever, tick paralysis, tularemia, and human babesiosis.

Deer tick (Ixodes dammini). The deer tick occurs in Eastern and Midwestern parts of

the country and the western deer tick, Ixodes pacificus, in the Western United States). These ticks can transmit human babesiosis, Lyme disease, tularemia, and encephalitis.

Ground hog ticks (Ixodes cookei) are mainly found in groundhog dens under buildings in New England and are a primary vector of one form of encephalitis. However, a number of closely related species which also carry encephalitis occur in rodent dens in various parts of the West. Ground hog ticks often invade structures through cracks and attack man; it can be a vector of Powassan encephalitis and human babesiosis.

Lone star tick (Amblyomma americanum).

This tick, generally found in southern states, has spread into Missouri and to the Atlantic coast. All stages of this tick attacks rabbits, dogs, and large mammals. Lone star ticks can not survive indoors but can transmit Q-fever, Lyme disease, Rocky Mountain spotted fever, tick paralysis, and tularemia.

Rabbit tick (Haemaphysalis leporispalustris).

Can spread Rocky Mountain spotted fever and tularemia to rabbits and subsequently infect humans.

Rocky Mountain spotted fever (wood) ticks (Dermacentor andersoni) are found in many western states and are a major vector of Rocky Mountain spotted fever, Colorado tick fever, encephalitis, and may transmit tick paralysis. The Rocky Mountain wood tick does not survive well indoors.

Soft ticks (Family Argasidae) are "raisin-shaped" ticks with longitudinal lines and its mouth parts which are located under its head are not visible from a dorsal view. Soft ticks are mostly found in protected places such as animal nests and burrows.

Fowl ticks (Argas persicus) occur throughout the United States but are more common in warmer climates. This tick moves into buildings from outdoor nests of wild birds and poultry houses and will readily feed on man during the night.

Pigeon ticks (Argas reflexus) occur throughout the United States but are more common in warmer climates. This tick

moves from outdoor pigeon nests (especially nests near windows and air vents) into dwellings where it will feed on man during the night.

Relapsing fever ticks (Ornithodoros hermsii) tick commonly infest chipmunk and rodent nests in Western mountainous areas (above 3,000 feet). Persons living in cabins infested by rodents may be at risk of contracting relapsing fever.

Spinose ear ticks (Ornithodoros megnini), present in the Southwest, attach to the ears of domestic animals, and sometimes children, and may remain attached for months before dropping off to molt. Ornithodoros ticks, in general, can harbor and transmit leptospirosis, rickettsial diseases, Q fever, tularemia, and viral encephalitis.

Taxonomic keys to identify ticks are available in most pest control and parasitology texts; however, tick identification is difficult and must be done with a microscope. Ticks collected off pets or from households should be sent to a specialist or public health agency for identification.

Occurrence in the park

Many park residents keep domestic pets (cats and dogs) and sometimes experience tick problems in the home during the peak tick season (May to September). Ticks which probably occur and could cause problems in park residences are the brown dog tick, fowl tick, and pigeon tick.

Biology

Ticks are parasites that suck blood from mammals, birds, and reptiles. They have four distinct life stages: egg, larva, nymph, and adult.

Hard ticks

Most species of hard ticks live in outdoor environments and show a wide variance in life cycles, even for tick species within a single genus. In general, adult ticks usually mate while on the body of a host animal. Following mating, adult females feed only once on the host and then drop to the ground where they lay a large number of eggs. Depending on environmental

conditions, the eggs hatch in 2 weeks to several months. Larval ticks are adapted to withstanding long periods of time without feeding because of the difficulty in finding a suitable host. The first larval stage of ticks emerging from the eggs are known as "seed ticks" and only have 6 legs. Soon after hatching the seed ticks climb up into vegetation to watch for a host (persons or animals) passing close enough by so they can become attached (a behavior known as "questing"). One research (Phillip, 1953) noted that ticks are attracted to animal odors up to distances of at least 50 feet and ticks tend to collect along game trails. The questing instinct helps to explain why in homes ticks are found crawling up walls, drapes, and furniture, and are often found outside in cracks and crevices under shingles and in sidings and window and door moldings.

After feeding on a host, most species of seed ticks drop to the ground where they shed their skin and become 8 legged nymphs. After attaching to and feeding on a host, a nymph molts into an adult tick. Some species of hard ticks may remain on a single host but other species move between a number of different hosts. Ticks that move between three hosts are of the greatest importance as disease carriers.

Soft ticks

Most kinds of soft ticks hide in bird or mammal nests or roosting areas or cracks and crevices during the day (where females lay eggs) and roam around at night to search out a host. Following each feeding on a host, adult female soft tick usually deposits a batch of eggs. The larvae become very active in their nocturnal search for a host. Following each feeding, the larvae molt through a series of up to 4 nymphal stages (instars). Soft ticks are called "multi-host ticks" and must periodically feed on blood during their entire life. Some adult ticks may live as long as 3 to 4 years.

The biology of individual tick species can be rather complex and reference to standard parasitology or pest control texts should be made for information on specific kinds of ticks.

Potential damage and health concerns

Both hard and soft ticks can be responsible for

transmitting to man and domestic animals a number of serious viral, protozoan, and bacterial diseases (see above) and tick bites are an irritating annoyance and discomfort. The act of feeding causes ticks to exude body fluids that can contaminate a bite with disease organisms. Secondary infections sometimes follow the scratching of bites and can be responsible for blood poisoning, especially when the head of the tick is torn off and left in a wound.

Picking ticks off dogs by hand is potentially dangerous. Body secretions from infected ticks can be transferred to the hands and introduced into the eyes and mucous membranes and cause disease. Forceps should be used to remove ticks from animals and ticks removed should be killed in isopropyl alcohol.

Action thresholds

Human occupants or workers bitten by ticks will be the Action Threshold for initiating tick management in households, offices, and work sites. Simply finding ticks on pets, however, will not identify the need to initiate tick control in a structure but will serve to indicate the need to advise residents about the methods for managing ticks on pets.

Inspection and monitoring

Because of the recent appearance of Hantavirus in the Southwest, all persons engaged in inspections and monitoring and who might come into contact with rodents or dry rodent debris should wear approved personal protective equipment and follow the Centers for Disease Control guidelines for personal safety.

Inspection and monitoring for the presence of ticks use similar methods.

An inspection of a residence for ticks should concentrate on searching for them around the edges of carpets, on walls and drapes and furniture, under shingles, and in cracks and crevices of window and door moldings.

Outside, ticks can be collected by dragging a cotton, muslin, or flannel cloth over infested areas. This will also reduce the number of ticks present in a yard. The drag should be a piece of

fabric about 36 inches square and with one edge attached to a stick. Slowly drag the fabric across vegetation and examine the fabric for captured ticks. More ticks can be caught by dragging after an isolated rain shower. Ticks retreat into the soil for protection from their questing locations on vegetation when temperatures are 86 degrees F. or less or when the humidity is less than 30 percent.

Carbon dioxide dry ice traps may be used to attract and capture ticks and can be a more productive monitoring method than a tick drag. A dry ice trap can be made by placing dry ice in the bottom of an open can and then submerging the can up to its rim in the ground. Indoors, dry ice can be placed in a shallow, open can and the can placed on top of an insect sticky trap. Ticks, attracted to the emitted carbon dioxide, fall into the can or become attached to the sticky trap and can be collected for identification. Dry ice traps should be left out for a number of days.

Wildlife sources

Identify any probable wildlife vectors that might bring ticks into a structure and study the travel and loafing habits of both wild and domestic birds and animals. Look for bird and mammal nests in crawlspaces and attics and inspect chimneys and vent pipes.

Submission of ticks for testing

It is necessary to identify ticks to be able to verify tick infestations since both clover or bird mites resemble immature brown dog ticks.

Place live ticks in a clean, dry vial, and close the vial tightly. Put the vial(s) in a clean plastic bag with damp (not wet) paper towel and seal the bag. This will allow enough moisture to enter vial so ticks will survive.

Place dead ticks in a vial containing a 70 percent solution of isopropyl alcohol and seal the vial to prevent leakage.

When submitting ticks to public health offices for identification, include the following information: collector's name and address, where the ticks were found (if different from address), date when found, and whether ticks were biting a person or not.

Send ticks to the Texas Department of Health, Vector Control Program, for identification and analysis of disease infection.

Non-chemical management

Exclusion. Good exclusion and wildlife control measures are necessary to prevent ticks from moving into buildings.

To keep ticks associated with birds, rodents, and other wild or domestic animals from entering structures, screen all vents and crawl spaces with 1/4 inch mesh hardware cloth and install commercial chimney covers. Place rat guards over electrical and telephone lines and trim nearby bushes and trees to keep animals from gaining access to roofs. Caulk and seal all cracks and crevices (especially in floors and walls) where ticks could enter.

When engaged in outdoor activity during the tick season, use protective clothing (i.e., mosquito netting, long sleeved shirt with a collar, hat, long pants, and tuck the bottoms of pant legs into the socks).

Sanitation. Eliminate ticks and tick harborage in a home by providing occupants information on proper cleaning methods, a list of specific areas to be cleaned or vacuumed, and ways to dispose of material collected in vacuum bags.

Occupants of infested residences should thoroughly vacuum all parts of the house (rugs, furniture cracks and crevices, drapes, etc.) once or twice a day with an industrial-strength vacuum for an entire month. This helps to remove tick eggs and larvae and kills many adult ticks. Vacuuming also tends to align carpet fibers which helps insecticides to penetrate. A vacuum beater bar attachment makes a vacuum more effective in removing ticks.

Shampoo or steam-clean carpets. Remove rugs from public use areas. Wash wood and tile floors with detergent. However, do not clean floors or remove residues immediately following application of a residual pesticide. Doing so will reduce the pesticidal effects.

Remove clutter, old boxes, debris, etc. that

provide shelter to ticks. Place stored items on pallets or shelves up off the floor.

Regularly clean or destroy pet bedding; regularly vacuum pet resting areas. Regularly examine, clean, and groom pets. Remove ticks with forceps from pets every 3 days during the tick season.

Wash pet bedding in hot soapy water and/or destroy all old, infested pet bedding. Keep pets outdoors. Establish appropriate pet grooming, washing, and feeding procedures to keep pets free of ticks. Limit a pet's contact with other animals, especially wildlife.

Habitat modification

Remove vegetation near to or touching the structure and along pathways and roadsides. Keep commonly used pathways through vegetation opened wide and keep vegetation cut short. This doesn't kill ticks but it lessens the possibility the ticks will have a site from which to quest for hosts (people or pets). When walking, avoid touching vegetation located at the edges of pathways. Mowing and burning of vegetated areas is helpful to temporarily lower tick populations but must be continually repeated.

Trim lawns and weeds to the lowest acceptable minimum height to create a drier and most hostile habitat for tick larvae and to discourage use by wild rodent hosts. Rake up leaf litter. Remove any debris that might harbor rodents.

Prevent birds from roosting or nesting on buildings and promptly clean up bird droppings and nesting sites.

Persons engaged in outdoor activities where they might come into contact with ticks should examine their body a number of times each day and take a hot shower on returning home.

Inside, lower the relative humidity inside buildings below 50 percent if possible.

Regulatory.

Enforce strict leash and pet confinement regulations to prevent the spread of brown

dog ticks between animals. Fence yards to keep dogs and wild animals from bringing in infestations from other areas.

Prohibit the presence of pets in hotels or living areas. Never allow tick-infested pets to enter a residence.

Chemical management

Non-chemical management methods can be effective for most kinds of ticks but pesticides are usually needed to treat brown dog ticks when they infest a structure. Pyrethrins are effective against brown dog ticks; however, the label must list proposed application sites and methods of use. Pesticide dusts are more effective than sprays in crawl spaces.

When using pesticides to treat for brown dog ticks, it is important that the dog, yard, and all areas used by the dog (including vehicles, other structures, and crawl spaces under buildings) are all treated at the same time. The owner or a veterinarian should treat the animal, not a pest control applicator. Usually a second thorough pesticide treatment of all those same areas is required a month after the initial application. The second treatment is needed to kill any tick larvae or nymphs which hatched after the initial application.

Personal repellents. Commercial insect repellents, applied to the body and clothing, can be very helpful in repelling ticks before they attach. DEET (N,N-diethyl-3-methylbenzamide or N,N-diethyl-m-toluamide) is one commonly used personal repellent but can sometimes cause medical problems for people using it.

NPS guidelines state that personal insect repellents purchased by the government for distribution to and use by personnel (including Volunteers in Parks and other volunteers, visitors or other persons) or used on livestock owned or rented by the government must be approved through the 10-21A process and reported on pesticide use logs.

However, insect repellents personally purchased by employees or visitors for application to their body or clothing do not require approval nor reporting. Health and safety information concerning different concentrations of personal

repellents and recommended application methods are available from park and park Cluster IPM Coordinators.

Some of the recommendations for using personal repellents against biting insects include:

- Carefully follow label directions when using repellents.
- Use the lowest effective concentration of DEET possible and do not reapply repellent to the body unless absolutely necessary. One application should last 4 to 8 hours and additional applications do not increase efficacy or duration of the chemical.
- Be aware of the concentration of DEET in products you buy. It is wise to avoid repellent brands with high percentages of DEET even though lower concentrations (15 percent) of DEET must be applied more frequently.
- When possible, only apply personal repellents to the clothing and not to the skin. If applied to the skin, use DEET sparingly and only apply it on exposed skin. Be very careful when applying DEET around the eyes, in elbow creases, and to the back of knees or groin. When returning indoors, wash DEET off the skin. A 20 to 30 percent concentration of DEET applied to the outer clothing is thought to be about 90 percent effective in preventing tick attachment.
- Do not use DEET in squirt bottles
- Do not use any insect repellents on broken skin (old insect bites), cuts, or scratches.
- Be very careful when applying insect repellents to infants and children; they show the greatest incidence of serious reactions. Only use lower concentrations (15 percent or less) on infants or children, do not spray children or infants repeatedly or over long periods of time, and do not use excessive amounts of repellent on children or infants. Do not apply repellents to the hands of children or infants because they may place their hands in their mouth and eyes.
- Jackets and pants impregnated with DEET are commercially available and are reported to

provide good protection; however, follow label instructions carefully and always wear impregnated apparel on top of other clothing to prevent concentrated DEET from coming in contact with the skin.

- If you or a child develops a rash while using a repellent, immediately discontinue use of the repellent. Although severe reactions (i.e., breathing difficulties and seizures) are extremely rare, such reactions require immediate medical attention. If a skin reaction occurs, wash all residual DEET off the skin with soap and water and treat an eye contamination with prolonged flushing with a sterile eye wash or clean water. If irritation persists, consult a physician and show the label of the repellent used to the doctor.

- Do not use DEET when spraying pesticides; DEET increases the rate of absorption of chemicals into the skin.

- Do not inhale or ingest repellents nor get them into the eyes.

Evaluating treatments

The effectiveness of treatments will be determined through monitoring. Treatments will be considered effective when ticks are no longer found inside structures.

Treatment evaluations will be used to supply essential information for adjusting Action Thresholds, developing more effective management strategies, and demonstrating needs for new control methods or chemicals.

Chemical alternatives

Boric acid dust for cracks and crevices
DEET repellent (up to 30 percent concentration)
Diatomaceous earth with or without pyrethrin
Permethrin repellent (for clothing)
Pyrethrin spray
Resmethrin aerosol
Silica aerogel with or without pyrethrin for cracks and crevices

Sources of advice, technical information, and supplies

National Park Service Videotapes

"Crack and Crevice Treatment for Cockroach Management," 13 minutes. Describes locations and methods where pests should be treated.

"Integrated Pest Management," 15 minutes.

"Pesticide Applicator Safety," 17 minutes.

See Appendix listings for equipment and chemical supplies.

Bennett, Gary W., John M. Owens, Robert M. Corrigan. 1988. Truman's Scientific Guide to Pest Control Operations; Purdue University, Edgell Communications.

Chandler Asa C. and Clark P. Read. 1961. Introduction to Parasitology. John Wiley and Sons, New York.

Christensen, Chris. 1983. A Technician's Handbook to the Identification and Control of Insect Pests. Pest Control Technology, 4012 Bridge Ave., Cleveland OH.

Environmental Sanitation Office, Washington DC. "Ticks and Lyme Disease in NPS"

Levy, Craig. AZ Department of Health Services, Div. of Disease Prevention, Phoenix AZ. Conducts tick surveys and will identify any ticks submitted. Include the location where ticks were found or travel history of the collector (if the location is not known), host animal (if known), date, collector's name and phone number.

Phillip, C.B. 1953. Tick Talk. Scientific Monthly, Volume No. 1.

St. Augin, Forrest E. 1990. Mites and Ticks. In: Mallis, A. Handbook of Pest Control, 7th Edition; Franzak & Foster Co., Cleveland OH.

United States Department of Agriculture. 1989. Management of the Lone Star Tick in Recreational Areas. USDA-Agricultural Handbook No. 682. Available through DPMLAC, 202/427-5365.

Ware, George W. 1988. Complete Guide to Pest Control - With and Without Chemicals. Thomson Publications, P.O. Box 9335, Fresno CA 93791.

VULTURES

Description, distribution, identification

The turkey vulture (Cathartes aura) commonly occurs over much of the United States, Mexico, and into South America. This is one of the larger North American birds of prey (26 to 32 inches long and up to 5 pounds in weight) and may have a wingspan 6 foot wide. The bird is brown to black in color and has an unfeathered, red head and a long tail which extends past the legs during flight.

Occurrence in the park

Turkey vultures are common birds around BIBE and they invade the Rio Grande Campground in numbers where they beg for and scavenge food from campers.

Biology

Habits. Turkey vultures tend to be communal in habit; they usually migrate, roost, eat, and fly to food in social groups.

Foods and feeding. Turkey vultures have a well-developed sense of vision and smell. They principally feed on carrion (dead animals) but also will take some vegetable and plant matter. Vultures can be found anywhere a possible food source is available.

Reproduction

Turkey vultures usually lay 2 eggs (ranging from 1 to 4 eggs) between March and July in sheltered areas such as caves, cliffs, and even in abandoned buildings. The eggs hatch in about a month and young vultures require an additional 2 to 3 months in the nest before they are mature. Turkey vultures can live for 16 or more years.

Potential damage and health concerns

Turkey vultures become a general nuisance problem in areas also used by people. The birds produce copious (and bad smelling) manure which presents health, safety, and sanitation concerns and droppings deface structures, vehicles, and facilities (picnic tables, rest rooms, camp fire stand, etc.). Turkey vultures are

attracted to and sometimes physically damage property like window caulking, roof shingles, upholstered cushions, and protective covers in boats and cars.

Action thresholds

The Action Threshold for control will be any nuisance, public health and safety concerns, or property damage created by vultures when in association with people.

Inspection and monitoring

Inspection and monitoring for turkey vultures are similar activities. Slowly walk through areas suspected of containing birds and count the numbers of vultures present. Take note of any possibly different age and size groups. Record what the birds are feeding on or doing. Record any direct or indirect damage caused by birds.

Non-chemical management

Note: Turkey vultures are native, migrating birds and protected by Federal law. They cannot be managed without the proper permit from the U.S. Fish and Wildlife Service.

Vultures do not normally frequent areas where people are present but do so when they have learned that food is available in those areas. Harassment of vultures by whatever means possible to drive them away from areas they have learned to depend on must be constant to break the learned habits of adult birds which subsequently teach those same habits to their developing young. From 2 to 3 weeks of active harassment may be necessary to successfully remove birds.

Begin harassment at dusk when vultures fly to their roosts and continue harassment throughout the day.

Repellents

Helium filled, mylar balloons can be placed as a visual deterrent in trees that vultures use for roosting sites.

There are indications that bald and golden eagles prey on (or, harass) vultures. Suspend images replicating eagle shapes and colors

(kites, balloons) from tree limbs to try discouraging vultures from using certain areas. Similarly, wind-activated models of raccoons, dogs, or other predators on the ground may be other visual repellents that can be tried.

Propane cannons or bird control pyrotechnics have been used to disperse vultures from feeding and roosting areas.

The presence of dead vultures in affected areas seems to repel vultures. Vulture models and/or taxidermied vulture skins might be tried in some locations.

Exclusion

Turkey vultures can be prevented from roosting on roof edges by stretching a wire or 40 pound test monofilament fishing line about 8 inches above and along the roof peak and other perching sites. If metal wires are used they can be electrified with an electric fence energizer.

Prevent vultures from nesting in abandoned buildings or attics by closing all openings with hardware cloth.

Sanitation. Remove all food sources that are available to vultures. Encourage campers to practice good sanitation, keep all food materials locked up, and to not feed birds. Be sure garbage cans have tight-fitting lids and cans are frequently emptied and cleaned.

Population reduction. With proper permits, turkey vultures can be trapped and removed from areas; however, unless killed, the birds will probably return because of their good homing and orientation instincts.

Shooting individual vultures eliminates birds that are habituated to specific food sources or roosting areas. Vultures appear to learn quickly and, where they are habituated to an area and fail to respond to other harassment, often favorably respond when a few of their members are killed. The benefits derived from killing a few vultures may, in the long-run, be better for a given population of birds than a continued dependence on food sources of human origin.

Chemical management

There are no chemical toxicants or repellents

labeled for vultures.

Evaluating treatments

Treatments will be evaluated through continual inspection and monitoring of vulture activity. When vultures no longer are pests, treatments will be considered effective.

Treatment evaluations will be used to supply essential information to adjust Action Threshold values, develop more effective management strategies, and demonstrate any apparent needs for new control methods.

Chemical alternatives

There are no toxicants or repellents labeled for vultures.

Sources of advice, technical information, and supplies

National Park Service Videotapes

"Integrated Pest Management," 15 minutes.

See Appendix listings for equipment and chemical supplies.

Literature

Krzyzik, Anthony, December 1989. Birds in Human Modified Environments and Bird Damage Control: Social, Economic and Health Implications. USACERL Tech. Rep. N-90/03, U.S. Army Corps of Engin., Constr. Engin. and Res. Lab. Extensive bird control bibliography.

Lowney, Martin. In print. Animal damage control pamphlet. US Department of Agriculture-APHIS, Mosely VA.

Mazzotti, Frank J., Joe Schaefer, Craig N. Huegel, and Bill Kern. 1995. Florida Wildlife Resources Handbook. Florida Coop. Exten. Serv., Inst. Food and Agric. Sci., Univ. of Florida and Florida Game and Fresh Water Fish Comm. Nongame Wildl. Program, Gainesville Florida.

Udvardy, Miklow D.F. 1977. Field Guide to North American Birds (Western Region). Alfred A. Knopf, New York.

WEEDS: INTRODUCTION

Description, distribution, identification:

Weeds are usually broadly described as plants which are growing in locations where they are not wanted - or - as plants interfering with management objectives for a given site. Weeds can be plants of many different kinds but fall into one of the following general growth categories:

Annuals. Plants that complete their life cycle (germination to seed production) in less than 1 year, grow fast, reproduce by seed, spread rapidly, are easiest to control, and are persistent because of abundant seed production.

Winter Annuals. Plants that germinate in late summer or fall, grow rapidly until the first frost, go into a partial resting phase during winter, resume growth in the spring, and produce seeds which remain dormant during spring; the older plants die during early summer.

Summer Annuals. Plants that germinate in the spring (when soil temperatures are 60 to 65 degrees F.), show peak growth during hot weather, produce seed and then die in the fall; seeds lie dormant during winter. Summer annuals are generally not shade-tolerant.

Biennials. Plants that require 2 seasons to complete their life cycle, live for 1 to 2 years, usually have a fleshy tap root, and reproduce by seed.

Perennials. Plants that live 2 or more years and reproduce either by seed or vegetatively (usually a more important role than reproduction by seed).

Simple Perennials. Plants that normally reproduce by seed but can produce new plants from cuttings.

Creeping Perennials. Plants that

reproduce by creeping roots, stolons, rhizomes, or by seed.

Many common weeds are aggressively-invading, exotic plants which were either accidentally introduced into this country or imported for specific ornamental or utilitarian purposes. However, nearly any plant can be considered a weed, depending on its location and affect on the environment or appearance. Native and exotic weeds, alike, are usually plants which are better adapted to survive in overly dry or overly wet, unshaded, disturbed, or otherwise hostile locations.

The abilities weeds have for out-competing other plants can be many:

- Some weeds absorb minerals, nutrients, and water from the soil more efficiently than do competing plants.
- The roots of some weeds grow so fast they remove nutrients (especially when only available in limited amounts) from the soil before slower-growing plants can. And, increased rates of above ground growth may allow them to seize and dominate all available space and light.
- Some weeds secrete growth-inhibiting substances from their roots and/or leaves which are toxic to sensitive, competing plants. This is called allelopathy.
- Many weeds have been accidentally or purposely introduced into a locality where the natural mechanisms for their control (specific herbivores, pests, climate, etc.) do not exist.
- Adaptations, as noted above, allow weeds to be healthier, more hardy, produce more seed, and be better able to resist disease, pests, or hostile conditions than other plants.

Potential damage

Excessive or unusually vigorous weed growth damages archeological ruins,

walkways, and roadways and reduces habitat for native wildlife, limits recreational use, presents an untidy appearance, causes human allergic reactions, produces toxins or thorns causing safety hazards, provides fuels that support wildland fires, displaces native vegetation, and harbors rodent or pest populations which may support diseases or cause other problems.

The mere presence of weeds continually contributes to transport of a large number of seeds by wind, water, animals, people, equipment/ vehicles, etc. into other areas of the park. And, some weeds produce enormous numbers of seeds that can remain viable in the soil for decades before conditions encourage germination.

It is the policy of the National Park Service to eliminate all exotic weeds, if possible.

Action thresholds

Weedy growth found to be damaging cultural or natural resources, exotic to the area, or presenting health and safety hazards will be the Action Threshold justifying control measures.

Inspection and monitoring

Inspection and monitoring techniques for weed species are similar. Periodically visit sites or walk along roadways and record weed growth and distribution. This is sometimes better accomplished during the blooming period (when plants are easier to recognize). Record locations, relative numbers or percent of ground covered, and growth stages for weeds. Also record data for any small, slowly expanding populations that, with only slight changes in environmental conditions (i.e. drought or fire), might rapidly increase.

If plants can not be identified in the park, place a representative sample of the seed head or flower, stem, leaves, and underground parts in a sealed plastic bag and send the sample to the local county cooperative extension service. A

collection of properly identified weeds should be kept in the park herbarium.

To determine the average percent of weed cover in an area, randomly throw a 3-foot square grid onto a lawn or field area and count the numbers of squares showing weeds. Twenty or more of such samples should provide sufficient comparative data.

Non-chemical management

In any given situation, the effectiveness of non-chemical weed control depends on a manager's ingenuity, knowledge of weed growth patterns, the reproductive potential of specific weeds, and weed competition with desirable plants. One of the more important questions before considering control is to ask why weeds occur and if there other similar or nearby sites without weeds. Many common weed problems occur because of supportive conditions caused by overgrazing, overuse, clear-cutting, improper mowing of road edges, rain water run-off from roads, importation by vehicles, and/or repeated use of herbicides. Attempting to control weeds under such circumstances is very difficult and expensive. Long-term weed growth in an area, for instance, has probably produced innumerable seeds that can remain viable in the soil for decades. Sometimes, when costs and other rationale are considered, it is found that a greater percentage of weeds can be tolerated than at first thought.

The first step in effective weed control is to identify target weeds so proper management methods can be applied. Following identification, alternative control methods include physical, mechanical, cultural, biological, and chemical techniques. Regardless of the management method(s) selected, actions should always coincide with the time period(s) when weeds are in their most vulnerable stage and most susceptible to attack. The most important, effective, and longest-term weed management is had by cutting or killing weeds before

they produce mature seeds.

Physical and mechanical weed control includes such activities as mowing or cutting, hand pulling, burning or flaming, disking or plowing, mulching, etc. Often, physical and mechanical controls do not require any more time than spraying of herbicide, do not present the hazards surrounding use and storage of toxic chemicals, and do not require NPS approval.

Manual controls such as hoeing, digging, pulling, cutting, girdling, and burning are designed to prevent seed production, prevent seed germination, and to destroy top growth when the plant is least able to recover. Mowing may be used to stress taller weed plants (prevent nutrients moving to the roots) while decreasing competition to shorter, desired plants. Disking can be used to prevent seed production, encourage seed germination, dry out vegetation before root establishment, and change soil conditions (reduce compaction which favors some weeds). Burning suppresses broad-leaf weeds and shrubs and favors grasses. Mulching prevents weed seed germination.

These are desirable and relatively selective techniques; however, most aggressive weeds tend to sprout from root stocks following mechanical controls and, at least for some sites, inaccessibility or logistical hazards may limit the efficacy and safety of control efforts (i.e. steep slopes). Other disadvantages of physical and mechanical weed controls may include:

Mowing does not quickly kill many weeds and, if not done when plants are small, can result in a large amount of flammable and unsightly rubbish which must be removed. Continual cutting, however, will over time exhaust nutrients stored in the plant roots and ultimately kill the plant.

Hand pulling weeds allows for control of weeds before they bloom; however, small pieces of roots are almost always left in the soil and these can sprout to produce

new weed plants.

Heat. In some situations, physical or chemical removal of undesired plants will not be practical and could result in additional damage to either natural or cultural resources. In these cases, one can utilize an agricultural burner to apply heat to the plants. Research has shown that many plants can be successfully destroyed, and their regeneration prevented, through the application of this technique. Since the correct procedure requires that plants not actually be ignited, it is not necessary to comply with the planning requirements of NPS-18. However, if this technique is incorrectly applied, there is potential to cause an accidental wildfire. Consequently, one must assure that qualified suppression resources are immediately available prior to employing this treatment. For definitions of the terms "qualified suppression resources" and "immediately available", consult NPS-18 regarding the former and the park fire management officer about the latter.

The application of heat is most effective while plants are still small. Similar to mowing, considerable dead plant debris may be left after large plants are flamed. The use of heat is labor-intensive and, for sizeable areas, presents problems surrounding the uniformity of treatment and transport of equipment unless tractor-mounted flamers are used. Disturbance of soil surfaces by tractors or heavy equipment is not desirable in many NPS areas and further encourages weed invasion.

Controlled burning of entire fields can only be done when plants are large enough and stems are dry enough to carry fire. These conditions are usually only present after weed seeds have matured and are in the soil. Burning weeds poses a number of safety hazards and is not very selective.

Disking and plowing require heavy equipment and damage soil surfaces (detrimental in archeological areas) which

causes increased rates of wind and water erosion and renewed weed invasion.

Mulching (with ground up tree bark, weed fabric, or plastic sheets) is only practical for small, selected sites (i.e. around trees, specific archeological sites) and is not an efficient method for larger areas.

A somewhat new strategy in weed control is that found in the Bradley method ("artificial selection" against weeds) for eliminating exotic or unwanted plants. Although Bradley uses the same physical and mechanical control alternatives as noted above, it does so in a very persistent, long-term manner. Bradley advises to not attempt clearing weeds from large areas at one time - this only produces large stretches of bare, open soil that further encourages weed recolonization. Bradley recommends the removal of weeds from only relatively small areas (no larger than can be effectively and methodically covered) about once a month throughout the growing season. Weeds occurring singly or in groups of 4 or 5 plants are mechanically removed and then native vegetation is allowed to re-establish before the control areas are expanded. Areas containing solid weed infestations are not worked until native vegetation has reappeared right up to the weed line. Continually work the weed patches but only along the edges so as to form small clearings of less than 6 feet in diameter where native vegetation can re-establish.

The Bradley method would be effective for small, decorative areas in front of or around buildings and along high-use trails and could be easily combined with selective chemical spot-treatments (use of a wick applicator).

Chemical management

Today, most weed control is done with hormone-like, organic chemicals (herbicides). Controlling weeds with chemicals typically seems easier, quicker,

more efficient, and more economical than physical or mechanical controls.

However, chemical weed control does have many associated problems. It is not usually as selective as physical/mechanical methods, can damage desirable plants, and leave long-lasting chemical residues in the soil or otherwise introduce them into the environment. Chemical weed control requires specific knowledge to be able to select proper herbicides. And, it may stimulate plants to develop herbicide resistance, cause secondary pest weed problems, and pose a variety of health hazards and logistical problems for applicators.

Increased selectivity for chemical applications with basal bark, stump, and wick applications are preferred methods for managing weeds in NPS areas.

When it is not practical to control weeds by cutting stems and treating them with herbicides, it may be necessary to broadcast or use chemicals over a wide area. Even though wide area treatments can be effective, the use of relatively short-residual, chemicals - without making accompanying physical changes in the habitat (or otherwise altering conditions supportive of weeds) - only results in the undesirable need to repeatedly apply and depend on chemical treatments. Requests for use of chemical herbicides should be accompanied with program designs describing how long-term weed control will be achieved without a dependence on herbicides (by changing environmental conditions, increasing plant competition, reducing moisture or light, etc.).

Pre-emergent herbicides are chemicals applied to soils to keep weed seeds from germinating. Post-emergent herbicides are applied to actively growing plants following germination and can be either selective chemicals (affecting only specific kinds of weeds) or non-selective chemicals (killing all plant life). Pre-emergent herbicides are usually applied over general areas. Post-emergent herbicides are best used as spot treatments which

only contact a target weed and can be done through pin-point applications with a brush, wick, or controlled spray.

Annual grassy weeds. Pre-emergent herbicides (such as pendimethalin) are usually effective for controlling annual grassy weeds. These chemicals are normally applied 10 to 14 days before weed seed germination (usually about the time lilacs bloom). Note that pre-emergent herbicides should not be used as panaceas, but rather they should be applied as spot treatments for the management of especially injurious plants, such as sandbur. See additional comments on this subject under the description of chemical management of sandbur.

Post-emergent chemical control (as glyphosate, siduron, and clethodim) of grassy weeds is most effective when applied early in the growing season while plant tissues are rapidly dividing and before plants mature and produce seed.

Perennial weeds. Chemical control of perennial weeds, however, is more effective at the end of the growing season when nutrients produced by the plants are being translocated from the leaves for storage in the roots. Depending on the type of weed, chemicals commonly used against perennials include glyphosate, 2,4-D, and triclopyr.

Contact your park Cluster Office IPM Coordinator for information regarding the specific herbicides available that best fit your weed control needs.

Evaluating treatments

Continued monitoring and inspection will show if plants have been effectively controlled.

Evaluations of treatments will be used to supply essential information to adjust Action Threshold values, develop more effective management strategies, and

demonstrate any apparent needs for new control methods or chemicals.

Chemical alternatives

2,4-D - for broadleaf weeds in grass
Clethodim - selective against grasses
Benefin - pre-emergent
Glyphosate - non-selective herbicide
Pendimethalin - pre-emergent herbicide
Siduron - for annual grass in grass
Triclopyr - for woody plants

New product: Glufosinate-ammonium (Roussel Uclaf Corp.). Finale Weed and Grass Killer (may be a possible alternative herbicide for glyphosate).

* In Texas, 2,4-D is a state limited use herbicide. The applicator must be certified to use it.

Sources of advice, technical information, and supplies

National Park Service Videotapes

"Integrated Pest Management," 15 minutes.

"Pesticide Applicator Safety," 17 minutes.

See Appendix listings for equipment and chemical supplies.

Literature

Bradley, Joan. 1971. Bush Regeneration: The Practical Way to Eliminate Exotic Plants from Natural Reserves. The Mosman Parklands and Ashton Park Association, Mosman (Sydney), New South Wales.

Olkowski, William Daar, S., and H. Olkowski. 1991. Common-Sense Pest Control. Taunton Press, Newtown, CT.

Roth, Susan A.; et.al. 1989. Controlling Weeds. Ortho Books, Chevron Chemical Company, Box 5047, San Ramon CA 94583.

Simmons, Sewell E.. 1985. Parklands Pest Management. California Dept. of Food

and Agric., Sacramento California.

Smith, Cheryl. 1993. The Ortho Home Gardener's Problem Solver. Ortho Books, Chevron Chemical Company, Box 5047, San Ramon CA 94583.

University of California. Agricultural Sciences Leaflet #2402 for detailed information on planning prescribed burns.

U.S. Dept. of Interior, National Park Service. 1984, 1994. Integrated Pest Management Information Manual, First and Second Edition.

Vengris, Jonas and William A. Torello. 1982. Lawns, Basic Factors, Construction and Maintenance of Fine Turf Areas. Thomson Publications, Fresno CA 93791.

Ware, George W. 1988. Complete Guide to Pest Control - With and Without Chemicals. Thomson Publications, P.O. Box 9335, Fresno CA 93791.

Wasser, Clinton H. 1982. Ecology and Culture of Selected Species Useful in Revegetating Disturbed Lands in the West. Publ. FWS/OBS-82/56. Western Energy and Land Use, Office of Biol. Serv., US Fish and Wildlife Ser., Washington DC.

POTENTIAL VEGETATION CONTROLS

PLANT CHARACTERISTICS						USE CONTROL
NAME/TAXON	EXOTIC/ NATIVE	REPRODUCTION	TYPE	ROOT	BLOOM	NAME
Bermuda grass <u>Cynodon dactylon</u>	E	Stems, rhizomes, seed	Warm season perennial	Fibrous		Root control; do not allow e to grow in moist shade; F. post- Use post-mulch (stolon) Hard pl. mow, dk Remove Berms time

PLANT CHARACTERISTICS						POSSIBLE CONTROL ALTERNATIVES	
NAME/TAXON	EXOTIC/ NATIVE	REPRODUCTION	TYPE	ROOT	BLOOM	MECHANICAL	HERBICIDE
Bufflegress <u>Pennisetum ciliare</u>	E	Seed, self-fertilizing	Warm season perennial	Fibrous		Hot ground fires reduce density for 1 to 3 years but increases productivity solarization under plastic mulch sets plants back Hand pull; disk	Glyphosate
Cheatgrass <u>Bromus tectorum</u>	E	Seed	Summer or winter annual	Fibrous	Spring	Disking Burning	Glyphosate
Cholla cactus <u>Opuntia</u> and various spp.	N	Seeds, cuttings	Perennial	Fibrous	Early spring to summer	Cutting, pulling Burning Disking	2,4-D Glyphosate
Crabgrass <u>Digitaria</u> spp.	E	Seed, stems	Annual	Fibrous		High mowing retards	Clethodim Glyphosate
Johnson grass <u>Sorghum halepense</u>	E	Rhizomes, seed	Perennial, allelopathic	Fibrous		Prevention Mowing 6 to 9 times Flaming Fungi	Clethodim Glyphosate
Mesquite <u>Prosopis juliflora</u>	N	Seeds, roots	Perennial	Branching	Early spring (April)	Mechanical control with a brush cutter slows growth but causes the plant to root sprout	Glyphosate Triclopyr 2,4-D
Mullein <u>Verbascum thapsus</u>	E	Seeds	Biennial	Tap	Summer	Cut flower stalks Disking Flaming before flowering Bradley method	Glyphosate 2,4-D
Pavement crack weeds (various)	E & N	Seeds, stems, rhizomes	Various: Annual and perennial	Fibrous to deep tap roots	Various	Cutting Mulching Flaming Caulking cracks	Clethodim Glyphosate 2,4-D Triclopyr
Puncturevine <u>Trifolium terrestris</u>	E	Seeds	Summer annual	Tap	Summer	Mulching Cut plants before flowering Do not allow bare spots	2,4-D Glyphosate

PLANT CHARACTERISTICS						POSSIBLE CONTROL ALTERNATIVES	
NAME/TAXON	EXOTIC/ NATIVE	REPRODUCTION	TYPE	ROOT	BLOOM	MECHANICAL	HERBICIDE
Quackgrass <u>Agropyron repens</u>		Seed, rhizomes	Perennial, allelopathic	Fibrous but deep		No effective Repeated disking	Clethodim Glyphosate
Right of Way weeds (various)	E & N	Seeds, stems, rhizome	Annual and perennial	Fibrous to deep	Various	Cutting, disking before flowering Flaming	Clethodim Glyphosate Triclopyr 2,4-D
Saltbush (Atriplex) <u>Atriplex canescens</u>	N	Seeds	Perennial	Deep	Spring to summer	Mowing slows growth	Glyphosate 2,4-D Triclopyr
Sandbur <u>Cenchrus incertus</u>	N	Seed, stems, roots	Warm season annual	Fibrous	Mid- to late summer	Mulching Cut young plants	Glyphosate Pendimethalin
Tamarix <u>Tamarix aphylla</u>	E	Seed, cuttings, roots	Perennial	Deep, branching	Spring	Cutting only slows growth, stimulates sprouting Hot multiple burning gives some control Shade inhibits Grubbing	Glyphosate Triclopyr 2,4-D
Thistle, Canada <u>Cirsium arvense</u>	E	Seed, roots	Perennial	Deep tap	Late summer	Persistent mowing/cutting	Glyphosate 2,4-D
Thistle, Russian <u>Salsola iberica</u>	E	Seed	Annual	Fibrous	Summer	Flaming, disking before flowers appear Exclusion (fences)	Glyphosate 2,4-D
Thistle, yellow star <u>Centaurea solstitialis</u>	E	Seed	Annual	Fibrous	June to September	Cut plants before flowering Pulling when numbers small Disking Flaming	Glyphosate 2,4-D

*** ANNOTATE ON THE CHART ANY CONTROL ACTIONS TAKEN, WHEN TAKEN, AND SUCCESS RATES TO MAKE CHART MORE USEABLE IN THE FUTURE

WEEDS: MISCELLANEOUS

Description, distribution, identification

A large number of weeds occur in the parks. Many of these weeds are exotic but both native and exotic weeds can infringe on native vegetation, damage natural or cultural resources, and create an unsightly appearance. Although it is the policy of the National Park Service to eliminate exotic plants, this may not be economically (or, logistically) feasible for some wide-spread weed problems. Concentrated efforts to control weeds are usually directed towards those high-profile plants causing evident problems. This section identifies a number of miscellaneous weeds which have been identified as problems for park management in Texas, New Mexico, and Arizona. Other problem weeds are described under separate headings (i.e., Bermudagrass, Johnsongrass, mesquite, saltcedar, and thistles).

Buffleggrass (*Pennisetum ciliare*) is an exotic, invading perennial grass with a fibrous root system. The plant is self-fertilizing and sets seed all year long in lower elevation Sonoran sites (below 2,000 feet). The dense top growth of buffleggrass produces more fine fuels than do similar native grasses. When the leaves of buffleggrass dry during the fall, the plant can support potential recurrent wildfires destructive to native desert shrub communities. The Mexican government is encouraging use of buffleggrass for revegetation projects in northern Mexican states and plants are coming into the United States along the international border.

Cheatgrass (*Bromus tectorum*). Cheatgrass, also known as downy brome, is an exotic annual or winter annual, invading grass that can grow to be 30 inches tall. The plants are covered with soft hairs in all stages of growth. Mature, hanging seedheads may be up to 6 inches long. Cheatgrass is widely distributed in this country and is common along

roadsides, in open fields, pastures, rangelands, and cultivated crop areas.

Cheatgrass seedlings produce roots at much cooler soil temperatures (late winter and early spring) than many native perennial seedlings. This allows cheatgrass to outcompete other perennial grasses by taking up available moisture before the other plant species can get their roots into the soil profile. Cheatgrass matures rather quickly and dry plants become a fire hazard.

Cheatgrass reproduces by seed which usually germinates in the fall. When moisture is insufficient, germination may be delayed until winter or spring. Because of its life cycle, cheatgrass becomes a common weed in lawns.

Cholla cactus. Cholla cactus is a generalized term for a variety of perennial, native species of *Opuntia* spp. These are upright, branching plants and, typical of cactus, covered with sharp spines. Cholla are very drought-resistant and cold-tolerant plants which invade disturbed areas. Cholla have a fibrous root system that does not grow very deeply into the soil. Plants produce seeds but can also sprout from cut crowns or plant parts. The roots of cholla cactus may be responsible for various degrees of damage to unexcavated archeological resources.

Crabgrass. Large crabgrass (*Digitaria sanguinalis*) and smooth crabgrass (*Digitaria ischaemum*) occur in the Southwest. Smooth crabgrass is smaller in size than large crabgrass but both species turn purplish in color during the fall and then become brown after the first hard frost. Crabgrass is an exotic, spring or summer annual grass which invades lawns and cultivated fields over much of the West. It can grow to be 2 feet in height.

Crabgrass is an aggressive plant which outcompetes turf grass. It grows rapidly from spring through summer and can, within a single season, significantly reduce turf density.

Crabgrass reproduces both by seed and rooting stems (stolons). Seeds require light to germinate and sprouts are most often found early in the year in bare or thinning areas of the turf.

Pavement weeds. Weeds found in sidewalk and roadway cracks may be of many different kinds but are in one of the following categories: winter annuals, summer annuals, perennials, or biennials. For a description of these plant types, see the section WEEDS: INTRODUCTION. Some weeds found in pavement cracks reproduce solely by seed and others from rhizomes (underground stems) and/or from stem or root cuttings.

Puncturevine. Puncturevine (Tribulus terrestris) is a common, exotic summer annual that occurs in cultivated fields and waste places. The leaves are 1 to 2 inches long and made up of 5 to 8 pairs of leaflets covered with silken hairs. Prostrate, trailing stems grow from a deep tap-root and can extend out from the plant for 6 to 8 feet as dense mats that choke out other plants. A network of fine rootlets branches from the tap root and allows the plant to survive drought.

Puncturevine develops bright yellow flowers during summer which develop into clusters of hard, sharp burs. The mature burs are sharp enough to puncture bicycle tires and are spread by animals, vehicles tires, shoes, etc. Seeds can remain viable in the soil for 4 to 5 years which makes control difficult.

Quackgrass. Quackgrass (Agropyron repens) is a common, exotic, and coarse-textured, cool season, aggressive, perennial grass. The leaves are often constricted near the tips. The presence of quackgrass is a good indication of hard pan soils. Quackgrass has been reported to adapt to moist soils in cool temperate climates and now commonly occurs over much of North America.

Quackgrass shows rapid growth during spring and fall and its erect stalks can become 1 to 3 feet tall by the end of the

growing season. The plant reproduces by seed but also by "creeping", underground, yellowish-white stems (rhizomes) which are somewhat fleshy. The sharp-pointed rhizomes can grow at a rate of 5 or more feet during a year, are able to penetrate hard soils, and quickly invade adjoining areas. Quackgrass roots are usually a foot or more deep and are thought to secrete toxic substances (allelopathic) which helps the quackgrass eliminate other plant competitors. Quackgrass seeds may remain viable in the soil for up to 14 years. Quackgrass is listed as a noxious weed in the Federal Seed Act.

Sandbur (long spine sandbur, burgrass, or grassbur). Sandbur (Cenchrus longispinus and the similar species field sandbur (Cenchrus incertus) are warm season, exotic, annual, branching grassy weeds (but which sometimes overwinter as a short-lived perennial). The leaf blades are yellowish-green, about 2 to 5 inches long and 1/4 inch wide. Immature plants are often purplish with flattened stems. Sandbur may grow to 3 feet tall and spreads horizontally forming dense mats. The spikes, about 1 to 3 inches long, produce clusters of burs with stiff, sharp, spreading spines.

Sandbur is a weed through most of this country and grows in fields, pastures, and waste areas, generally in sandy or gravelly soils. It invades lawns, orchards, gardens, and unmaintained areas. Sandbur roots are fibrous and stem branches sometimes produce reproductive nodes where they touch the soil. Flowers appear from July through September and are quickly followed with sharply pointed straw-colored seed burrs which are spread from area to area by animals.

Occurrence in the park

These exotic plants occur widely throughout the park but become problem weeds when they invade developed areas, lawns, or pavement cracks, invade natural areas, out-compete desirable plants, or otherwise interfere

with management objectives for specific sites.

Action thresholds

Action Thresholds will be reached whenever any weed species are observed to be causing damage to resources. Weeds described in this section are all vigorous competitors, rapidly spread and overtake desired vegetation, or damage resources.

Inspection and monitoring

Inspection and monitoring techniques for weed species are similar. Periodically visit sites and record the distribution of plants and relative size and growth. Be sure to record data on small, slowly expanding populations because slight changes in environmental conditions (such as drought or fire) detrimentally affecting desirable plants can produce conditions allowing weed populations to rapidly expand.

Regularly inspect paved surfaces and associated plantings for disturbances (cracks, exposed earth, accumulations of debris, dead cover plants) which could encourage or support weed growth.

To determine the average percent of weed cover for any given area, randomly throw out a 1 meter grid having 100 sub-divisional units and count the numbers of squares having weeds. Twenty or more samples from various parts of the area should provide adequate data for comparative purposes.

If you cannot identify specific weeds, place a representative sample of the seed head or flower, stem, leaves, and underground parts in a sealed plastic bag and send the sample to the local county cooperative extension service. A collection of properly identified weeds should be kept in the park herbarium.

Take considerable efforts to identify any newly appearing weeds in the area to be assured they will not cause future

management problems. Any new plants found in the area and recognized as Noxious Weeds by the state or county and which do not otherwise commonly occur in the area should be reported to the county extension agent or state weed control supervisor.

Non-chemical management

Preventing the establishment of weeds is the most important measure for weed control. This is done by preventing, if possible, weed seeds from being transported into an area and becoming established, keeping weeds from going to seed, and limiting the spread of perennial plants which reproduce vegetatively.

Established ornamental plantings.

Preventing weed invasion is always easier than trying to control weeds after they appear. Use good cultural practices in lawns and ornamental plantings which include regular soil testing, proper timing for fertilization and liming, proper mowing height and timing, and adequate but not excessive irrigation. Frequent shallow irrigation lessens the vigor of turf grass roots and encourages weed germination. Continually remove debris and heavy thatch from lawns and reduce soil compaction with core aeration.

New ornamental plantings. When planting or renovating sites, plant them with only species adapted to local environmental conditions and, as possible, species which are resistant to diseases and insects. Fall is the best time to renovate cool-season grasses and spring is the best time to renovate warm-season grasses.

Pavement cracks. To control weeds in pavement cracks, repair any surface defects and remove accumulated organic debris and weed growth from the cracks before filling the cracks with mortar, tar, caulking, etc. which prevent new weed establishment. Sometimes, however, persistent weeds will even grow through the material used to fill cracks and will have to be removed again. When feasible, covering weeds in cracks for a few days

during summer with plastic mulch (1.5 to 4 mil thickness) will kill weeds like pigweed, crabgrass, foxtail, quackgrass, thistles, and bindweed.

The agricultural burner is a good mechanical alternative for herbicides for weeds in cracks and usually presents little fire hazard. Flame is not applied to burn weeds (incinerate them) but, rather, to cause permanent wilt which kills the plants by expanding and rupturing plant cells, coagulating protoplasm, deactivating enzymes, and removing cellular liquids. Although only 113 to 140 degrees F. is needed to accomplish most plant cell thermal death, many dry seeds are tolerant of high temperatures and require prolonged exposure. However, too much heat applied to plants can stimulate growth from remaining roots. Only a brief contact with heat (i.e., a light "searing" or wilting, to 140 degrees F.) is needed to kill or severely damage plants. Plants are most susceptible as young seedlings (1 to 2 inches tall) and while in the 3 to 5 leaf stage. Broad leaf weeds are more susceptible to heat than grasses.

When grasses are about 1-inch tall, a protective sheath develops around the leaf and protects growing points from heat and allows tillers to re-sprout. Flaming grass plants will not kill them but, applied during early season, heat severely sets plants back and limits their seasonal growth potential.

Natural areas. Preventing weeds from invading wild areas (roadsides, unkept fields, trails, etc.) is very difficult. Climate, herbivores, man-caused or natural disturbances to the soil, wide variations in available moisture, importation by vehicles or wind or water run-off, improper use of herbicides, and many other factors reduce the health and vigor of native vegetation and create conditions suitable for colonization by weeds.

As possible, control of weeds in natural areas is necessary to prevent dispersal of weeds into developed areas. Non-

chemical controls which prevent the development of weed seeds include mowing, cutting, hoeing, hand pulling, burning or flaming, disking or plowing, mulching (plastic sheets) etc. However, some of these controls can be counter-productive because they may invite renewed weed growth by disrupting the soil, scattering seeds, or leaving live root parts in the soil.

The best methods for weed control in wild areas are those that do not alter soil surfaces but selectively reduce the viability of weeds by decreasing stored energy reserves in the roots and preventing seed formation. Such control requires good knowledge of the weeds present and their phenology in the area as well as careful timing of selected and specific weed control measures. And, different control techniques are usually required for different plant habitats. Plastic mulching may be feasible in some sites. Flaming (agricultural torch) or burning often stand out as the most practical and least disruptive techniques for controlling weeds in natural areas; however, they pose significant hazards for initiating destructive wild fires unless preventive measures are taken.

Bradley method. For a description of the Bradley method ("artificial selection" against weeds) for eliminating exotic or unwanted plants in natural areas, see the section WEEDS: INTRODUCTION. Various physical/mechanical means of weed control might be incorporated into the Bradley method for small, decorative areas (in front of/around buildings and along high-use trails or roadways) and the Bradley method but could also be easily combined with selective chemical spot-treatments (using a wick applicator).

Following are general guidelines for specific weeds identified in the park:

Bufflegrass. Hot ground fires remove buffleggrass top growth and reduce buffleggrass density for 1 to 3 years following a burn. However, buffleggrass production is reported to be slightly

higher in the years following fires. Covering buffleggrass with a plastic tarp (solarization), similar to fires, sets plants back and helps to temporarily retard plant expansion.

Cheatgrass. The principal method to reduce seed production or prevent establishment of cheatgrass is by increasing the health and density of neighboring plants, making them better able to out-compete cheatgrass.

In areas already dominated by cheatgrass, repeated disking (2 to 3 times a year) of areas where sufficient nutrients and moisture are available can reduce cheatgrass density enough that perennial grasses and broadleaves can become established. This technique is widely used in lawn management.

Although cheatgrass is tolerant of fire, fire may sometimes be a preferred control method. Cheatgrass should be burned before the plants turn red in the fall and before the seed heads shatter; burning at other times of the year is not effective. A slow, hot fire is most desirable for removing ground litter. If feasible, re-plant burned sites to native grasses and plants during the following fall or cheatgrass will increase to pre-burn levels within 2 to 3 years.

Crabgrass. High mowing greatly retards crabgrass growth but if monitoring shows an increase in crabgrass, plan to apply a pre-emergent herbicide early during the next spring.

Seal cracks and joints in pavement with tar (or, other material) to prevent an accumulation of organic debris providing a seed bed for crabgrass and other plants.

Pavement crack weeds. To control weeds in pavement cracks, repair any surface defects and remove accumulated organic debris and weed growth from the cracks then fill the cracks with mortar, tar, caulking, etc. to prevent weed establishment. Sometimes, however, persistent weeds that grow up through

the material used to fill the cracks will have to be removed again. When feasible, cover weeds in cracks for a few days during summer with a sheet of plastic (1.5 to 4 mil thickness). This kills such weeds as pigweed, crabgrass, foxtail, quackgrass, thistles, and bindweed.

The agricultural burner is a good mechanical alternative for herbicide for the control of weeds in cracks and usually presents little fire hazard. Flame is not applied to burn weeds (incinerate them) but, rather, to cause permanent wilt and kill the plants by expanding and rupturing plant cells, coagulating protoplasm, deactivating enzymes, and removing cellular liquids. Although only a light "searing" or wilting (113 to 140 degrees F.) is needed to cause the death of most plant cells, many dry seeds are tolerant of high temperatures and require prolonged exposure. However, too much heat applied to plants can stimulate regrowth of remaining roots. Plants are most susceptible to heat when they are young seedlings (1 to 2 inches tall) and in the 3 to 5 leaf stage. Broad leaf weeds are more susceptible to heat than grasses.

When grasses are about 1 inch tall, a protective sheath develops around the leaf. The sheath protects growing points from heat and allows tillers to re-sprout. Flaming grass plants will not kill them but, applied during early season, heat severely sets plants back and limits their seasonal growth potential.

Puncturevine. Establish a healthy environment for desirable plants so they will be able to outcompete puncturevine. Keep bare spots filled in or covered with mulch. Mulching prevents new puncturevine seedlings from developing. Chop puncturevine plants off before the flowers mature to prevent seed formation.

Quackgrass. Because of its extensive network of branching rhizomes, there are no effective non-chemical controls for quackgrass. The underground stems are so tough and branching they can rarely

be dug out. Although plants can be individually removed, severe quackgrass infestations usually requires an entire area (even an entire lawn) be killed and replanted. The best preventive method against the invasion of quackgrass is to maintain the health and density of perennial grasses so they can out-compete quackgrass.

Repeated disking during hot, dry weather exposes and kills most quackgrass rhizomes but any remaining pieces will sprout. Areas must be thoroughly raked after disking.

Fire is not an effective control for quackgrass and only increases its vigor and stand density.

Sandbur. To help prevent sandbur infestations, improve soil conditions with additions of organic matter which encourage strong competing plants. The root system of sandbur is weak and young plants can be easily removed by shallow cultivation. Plastic mulching discourages sandbur growth.

Chemical management

Chemical herbicides have many disadvantages but are many times the only practical solution for weed problems. The first step in any weed control program is to identify the plants so that weakness in their physiology or life cycle can be capitalized on for maximum effect.

Pavement crack and other weeds. In general:

Annual grasses and weeds. Apply pre-emergent herbicide during late winter or early spring or apply glyphosate when weeds are actively growing.

Spot-treat grassy weeds in pavement cracks with glyphosate or herbicidal soaps (with a controlled spray or wick application) while plants are still small and actively growing. Repeat applications in 6 to 8 weeks, as needed. For difficult to control weeds, repeat applications every

10 days until control is obtained.

A relatively new pre-emergent herbicide is available and may be approved by NPS, AgrEvo's Finale Weed and Grass Killer (glufosinate-ammonium). This material is described as causing a buildup of ammonium in plants and kills weeds in a few days. The active ingredient is reported to quickly break down in the soil into carbon dioxide.

Broad leaf weeds. Spot-treat broad leaf and perennial weeds with glyphosate, triclopyr or 2,4-D. The best control is had when plants are young or actively growing and before seed set. Treat plants during the spring or fall. Do not allow plants to set seed.

Weeds with hairy leaves are harder to control. If a herbicide will not adhere to the leaf surface (such as with wild violet), use a mixture of turfion and 2,4-D.

Pre-emergent pendimethalin is effective for treating crabgrass areas during early spring before plants sprout.

Minimize all herbicide contact with other plants.

Buffleggrass. Apply glyphosate or other non-selective herbicide to plants during the period of summer growth.

Crabgrass. Apply a pre-emergent herbicide like pendimethalin during early spring and from 10 to 14 days before weed seeds germinate (generally before lilacs bloom and during forsythia bloom). Pre-emergent herbicides should only be applied to areas with well-established plants and must be soaked with water (rain or irrigation) within 3 to 5 days after application. Glyphosate and clethodim can be used in post-emergent and non-selective spot-treatments for individual plants during the period of summer growth.

Cheatgrass. Apply glyphosate at 1 pound per acre while plants are actively growing during spring or right after new seedlings emerge in the fall. Following death of

mature plants from herbicide treatments, burn the site; after new seedlings emerge, re-apply glyphosate.

An application of atrazine at a rate of 0.5 to 1 pound per acre in the fall and before the rains come will kill germinating seeds for up to 12 months. After the application, wait until the next fall to re-seed the area.

Four-wing saltbush. Cut saltbush stems in the fall before the seeds are dropped and treat the stumps with triclopyr (glyphosate may also be effective on cut stumps). Plants may have to be treated for 2 to 3 consecutive seasons for complete control. Treat young seedlings with 2,4-D or glyphosate.

Puncturevine. Spot-treat with 2,4-D or glyphosate. Apply pre-emergent pendimethalin herbicide during early spring before puncturevine seeds germinate.

Quackgrass. There are no selective pre-emergent or post-emergent controls for quackgrass. However, individual plants can be spot-treated with glyphosate or clethodim. Control of minor quackgrass infestations can be had by applying glyphosate at a rate of 3 pounds per acre when quackgrass stems are in the boot stage of flowering; make a second application 30 days later. Ideally, the first application should be made prior to tilling the ground and the second application made a few weeks after tilling. The first application kills existing weeds and the second application kills emerging seedlings which were dormant in the soil. Two years of applications are recommended.

Clethodim is a post-emergent systemic herbicide used against annual and perennial grasses among broadleaves. It does not persist in the soil (half-life of 1.7 days in sandy loam in natural sunlight) nor seem likely to threaten ground or surface water, presents no unacceptable human health hazards, and only poses minimal risk to avian, aquatic, and mammalian

wildlife. Clethodim penetrates the plant cuticle and causes a cessation of plant growth soon after its application. Subsequent rainfall does not reduce its activity. Apply clethodim when plants are 4 to 8 inches tall and reapply if regrowth occurs.

Control of major quackgrass infestations often requires all the plants in an entire area to be killed with a non-selective herbicide (like glyphosate) and the area then re-planted with desired vegetation.

Other chemicals often used to control quackgrass include terbacil and dichlobenil.

Sandbur. Spot-treat persistent plants with glyphosate. Apply pre-emergent pendimethalin during early spring before sandbur seeds germinate. Based on experience at Guadalupe Mountains National Park, pendimethalin can be expected to provide about 70 to 75 percent control of sandbur. Therefore, to eliminate that species, one should plan on augmenting a pendimethalin treatment with an agricultural burner or possibly a spot treatment with glyphosate. Plan on several seasons of effort, with an emphasis on monitoring, to achieve the desired effect.

The science of chemical weed management is constantly changing. For current recommendations, contact your park Cluster IPM Coordinator or county extension agent.

Evaluating treatments

Periodic monitoring for weeds will provide information on the effectiveness of previous treatments.

Treatment evaluations will be used to supply essential information to adjust Action Threshold values, develop more effective management strategies, and demonstrate any apparent needs for new control methods or chemicals.

Chemical alternatives

2,4-D
Clethodim
Glyphosate
Pendimethalin
Triclopyr

* In Texas, 2,4-D is a state limited use herbicide. The applicator must be certified to use it.

Sources of advice, technical information, and supplies

National Park Service Videotapes

"Integrated Pest Management," 15 minutes.

"Pesticide Applicator Safety," 17 minutes.

See Appendix listings for equipment and chemical supplies.

Literature

Bradley, Joan. 1971. Bush Regeneration: The Practical Way to Eliminate Exotic Plants from Natural Reserves. The Mosman Parklands and Ashton Park Association, Mosman (Sydney), New South Wales.

Mace, Alice E. 1985. All About Lawns. Ortho Books, Chevron Chemical Co., 575 Market Street, San Francisco CA 94105.

McClaren, Mitchel P. and Thomas R. van Devener. 1995. The Desert Grassland. University of Arizona Press, Tucson.

Olkowski, William; Daar, S.; and H. Olkowski. 1991. Common-Sense Pest Control. Taunton Press, Newtown, CT.

Roth, Susan A.; et.al. 1989. Controlling Weeds. Ortho Books, Chevron Chemical Company, Box 5047, San Ramon CA 94583.

Simmons, Sewell E.. 1985. Parklands Pest Management. California Dept. of Food and Agric., Sacramento California.

Smith, Cheryl. 1993. The Ortho Home

Gardener's Problem Solver. Ortho Books, Chevron Chemical Company, Box 5047, San Ramon CA 94583.

University of California. Agricultural Sciences

Leaflet # 2402 for detailed information on planning prescribed burns.

US Dept. of Interior, National Park Service, Wildlife and Vegetation Division. 1984 and 1995. Integrated Pest Management Information Manual, 1st and 2nd Editions.

Vengris, Jonas and William A. Torello. 1982. Lawns, Basic Factors, Construction and Maintenance of Fine Turf Areas. Thomson Publications, Fresno CA 93791.

Ware, George W. 1988. Complete Guide to Pest Control - With and Without Chemicals. Thomson Publications, P.O. Box 9335, Fresno CA 93791.

Wasser, Clinton H. 1982. Ecology and Culture of Selected Species Useful in Revegetating Disturbed Lands in the West. Publ. FWS/ OBS-82/56. Western Energy and Land Use, Off. of Biol. Serv., US Fish and Wildlife Ser., Washington DC.

Whitson, Tom D.; Larry C. Burrill; Steven A. Dewey; David W. Cudney; B.E. Nelson; Richard D. Lee; and Robert Parker. 1996. Weeds of the West (5th edition). Western Society of Weed Science and Western United States Land Grant Universities, Cooperative Extension Services.

Yepsen, Roger B. 1984. The Encyclopedia of Natural Insect & Disease Control. Rodale Press, Emmaus PA.

BERMUDAGRASS

Description, distribution, identification:

Bermudagrass (*Cynodon dactylon*) is an exotic, wiry, perennial, warm-season turf grass which occurs in many warmer parts of the West and Southwest. Its leaves are normally smooth with a conspicuous ring of white hairs at the junction of each node. Above-ground stems (stolons) are scaly, somewhat flattened, and bear at each joint a dead, blade-like sheath which resembles a "dog's tooth". The underground stems (rhizomes) are hard, scaly, and sharp enough to penetrate the root mass of other plants. Bermudagrass may easily be confused with large crabgrass. A number of varieties are used for ornamental turf or pasture grass.

Occurrence in the park

Bermudagrass has begun to invade various river banks in the park.

Biology

Bermudagrass is one of the fastest growing and fastest spreading of many southern turf grasses and one that quickly invades and becomes a weed in locations where it can grow, normally in moist flower beds and sites adjacent to lawns. However, Bermudagrass is also quite drought-resistant.

Bermudagrass reproduces by means of rhizomes and stolons which branch out for several feet around the parent plant. Adventitious roots which form new plants are produced at every node. Bermudagrass also reproduces by seed.

Bermudagrass does not tolerate shade, poor drainage, or high soil acidity. It grows best when average daily temperatures are around 75 degrees F.; it stops growing if temperatures fall below 60 degrees F., and turns brown when temperatures drop below 50 degrees F. Although the top foliage is killed by frost, the plant will re-sprout from rhizomes as soon as the soil warms up again. Bermudagrass is fairly resistant to diseases and insects.

Potential damage and health concerns

Bermudagrass is an aggressive, invading grass that quickly spreads and dominates space and light to out-compete more desirable plants. It is a very troublesome weed where winters are not severe enough (freezing temperatures) to kill roots and rootstocks. More recently, Bermudagrass is becoming established in colder regions of the West.

Action thresholds

The Action Threshold for control of Bermudagrass is reached where monitoring shows the plant to be encroaching on native vegetation or otherwise affecting cultural or natural resources.

Inspection and monitoring

Inspection and monitoring techniques for weed species are similar. Periodically visit sites and record Bermudagrass growth and distribution. Be sure to record data on small, slowly expanding populations which could rapidly enlarge with only slight changes in environmental conditions (moisture, drought, fire, etc.).

If you can not identify weeds, place a representative sample of the seed head or flower, stem, leaves, and underground parts in a sealed plastic bag and send the sample to the local county cooperative extension service. The park staff should maintain a collection of properly identified weeds in the park herbarium.

An estimated average percent of weed cover in an area can be determined by randomly throwing a 1 meter grid containing 100 sub-parts onto a lawn or other field area and counting the numbers of squares containing weeds. Sufficient comparative data should be provided by sampling grids that make up about 20 percent of the area in question.

Non-chemical management

Preventing the establishment of Bermudagrass is the best measure. Once Bermudagrass is established, it is very difficult to control.

Shade inhibits growth of Bermudagrass. Roots and rhizomes are killed (after disking) when

exposed to sunlight and desiccation. Bermudagrass can also be killed by solarization: tilling the ground lightly, irrigating, and then covering Bermudagrass with a black plastic mulch.

Hand pulling will remove individual plants but to be effective should extract as much of the rootstock as possible. Small pieces of root left in the ground will produce new plants.

The spread of Bermudagrass can be limited by disking plants twice (once during spring and again during early summer). Disking and chopping exposes and causes the top layer of soil to dry out and lessens sub-surface spread of Bermudagrass. Be sure to clean equipment thoroughly after cutting Bermudagrass to prevent the distribution of under-ground stems.

If possible, change the Ph of soils in which Bermudagrass is growing.

Chemical management

Three non-selective herbicides often used to control Bermudagrass include clethodim, glyphosate, and siduron. Clethodim is a post-emergent systemic herbicide used against annual and perennial grasses among broadleaves. It does not persist in the soil (half-life of 1.7 days in sandy loam in natural sunlight) nor seem likely to threaten ground or surface water, presents no unacceptable human health hazards, and only poses minimal risk to avian, aquatic, and mammalian wildlife. Clethodim penetrates the plant cuticle and causes a cessation of plant growth soon after its application. Subsequent rainfall does not reduce its activity.

Glyphosate is a non-selective herbicide.

Siduron has a higher LD₅₀ value than glyphosate.

Spot-treat individual plants with glyphosate or clethodim early in the growing season when plants are actively growing and runners are 3 to 6 inches long. Repeat applications if regrowth occurs.

Evaluating treatments

Periodic monitoring for Bermudagrass will provide information on the effectiveness of

previous treatments.

Treatment evaluations will be used to supply essential information to adjust Action Threshold values, develop more effective management strategies, and demonstrate any apparent needs for new control methods or chemicals.

Chemical alternatives

Clethodim
Glyphosate
Siduron

Sources of advice, technical information, and supplies

National Park Service Videotapes

"Integrated Pest Management," 15 minutes.

"Pesticide Applicator Safety," 17 minutes.

See Appendix listings for equipment and chemical supplies.

Literature

Mace, Alice E. 1985. All About Lawns. Ortho Books, Chevron Chemical Co., 575 Market Street, San Francisco CA 94105.

Olkowski, William; Sheila Daar; and Helga Olkowski. 1991. Common-Sense Pest Control. Taunton Press, Newtown, CT.

Simmons, Sewell E.. 1985. Parklands Pest Management. California Dept. of Food and Agric., Sacramento California.

Valent Agricultural Products, 800/6-VALENT. Information on clethodim.

Vengris, Jonas and William A. Torello. 1982. Lawns, Basic Factors, Construction and Maintenance of Fine Turf Areas. Thomson Publications, Fresno CA 93791.

Whitson, Tom D.; Larry C. Burrill; Steven A. Dewey; David W. Cudney; B.E. Nelson; Richard D. Lee; and Robert Parker. 1996. Weeds of the West (5th edition). Western Society of Weed Science and Western United States Land Grant Universities, Cooperative Extension Services.

JOHNSONGRASS

Description, distribution, identification

Johnsongrass (*Sorghum halepense*) is an exotic, perennial grass introduced from southern Europe as a forage plant and which is now found in most Western states. Johnsongrass has erect stems and can grow to 8 feet tall. The leaf blades, which may be an inch wide, are flat and smooth with evident brittle, whitish-colored midveins. A similar plant which can be mistaken for Johnsongrass, shattercane (*Sorghum bicolor*), may be a cross between cultivated sorghum and Johnsongrass.

Occurrence in the park

Johnsongrass occurs as an exotic plant on various open ranges in the park.

Biology

Johnsongrass grows in open ground and fields and becomes a serious weed in waste places and along roadsides. It is winter-hardy and survives in areas where soils do not freeze at least 18 to 24 inches deep. It is a major noxious weed and vigorous competitor for any available moisture, light, nutrients, and space.

Johnsongrass has large, scaly, fleshy, and creeping rhizomes and, once established, spreads by both rhizomes and seed. Plants can produce as many as 5,000 ancillary buds on the rhizomes during a single season, each of which can develop into a new plants during the next season. Johnsongrass seeds are transported by wind, water run-off, and through bird and animal manure and remain viable in the ground for up to 20 years.

Potential damage and health concerns

Johnson grass is an aggressive invader species that can quickly spread and displace more desirable plants. It is an allelopathic weed which releases substances into the soil that harm or limit the growth of other plants. When stressed by frost or desiccation, Johnsongrass produces hydrocyanic acid which can be toxic to livestock. Johnsongrass is listed as a noxious weed by the Federal Seed Act.

Action thresholds

The Action Threshold for control of Johnson grass will be reached when the plant becomes a significant weed problem or affects cultural or natural resources.

Inspection and monitoring

Inspection and monitoring techniques for weed species are similar. Periodically visit sites and record Johnsongrass growth and distribution. Be sure to record data on small, slowly expanding populations which could rapidly expand after slight changes in environmental conditions (i.e. drought or fire).

If you can not identify weed plants, place a representative sample of the seed head or flower, stem, leaves, and underground parts in a sealed plastic bag and send the sample to the local county cooperative extension service. The park staff should maintain a collection of properly identified weeds in the park herbarium.

An estimated average percent of weed cover in an area can be determined by randomly throwing a 1 meter grid containing 100 sub-parts onto a lawn or other field area and counting the numbers of squares containing weeds. Sufficient comparative data should be provided by sampling grids that make up about 20 percent of the area in question.

Non-chemical management

The best strategy to manage Johnsongrass is to prevent its establishment.

Mowing Johnsongrass 6 to 9 times during the summer and before seed set tends to diminish root reserves and may ultimately kill the plant.

Flaming Johnson grass with an agricultural torch controls the plant when a number of treatments are made over a season or two.

Do not allow disturbed soils to remain open to colonization by Johnson grass.

Cultivation that cuts rhizomes into small pieces and scatters them encourages rhizome buds to sprout. Thoroughly clean equipment after cutting

Johnsongrass to prevent rhizome distribution.

Three fungi that attack Johnson grass and may help in control are Spacelotheca cruenta, Spacelotheca holci, and Helminthosporium spp.

Chemical management

Three chemicals commonly used against Johnson grass are clethodim, glyphosate, and pendimethalin.

Clethodim is a post-emergent systemic herbicide used against annual and perennial grasses among broadleaves. It does not persist in the soil (half-life of 1.7 days in sandy loam in natural sunlight) nor seem likely to threaten ground or surface water, presents no unacceptable human health hazards, and only poses minimal risk to avian, aquatic, and mammalian wildlife. Clethodim penetrates the plant cuticle and causes a cessation of plant growth soon after its application. Subsequent rainfall does not reduce its activity.

Glyphosate is a non-selective herbicide that rapidly dissintegrates in the soil.

Spot-treat plants with glyphosate or clethodim after plants are 18 inches tall and before the seed heads form. Retreat any plants that sprout.

Evaluating treatments

Periodic monitoring of Johnson grass will provide information on the effectiveness of previous treatments.

Treatment evaluations will be used to supply essential information to adjust Action Threshold values, develop more effective management strategies, and demonstrate any apparent needs for new control methods or chemicals.

Chemical alternatives

Clethodim
Glyphosate
Pendimethalin

Sources of advice, technical information, and supplies

National Park Service Videotapes

"Integrated Pest Management," 15 minutes.

"Pesticide Applicator Safety," 17 minutes.

See Appendix listings for equipment and chemical supplies.

Literature

Olkowski, William; Sheila Daar; and Helga Olkowski. 1991. Common-Sense Pest Control. Taunton Press, Newtown, CT.

Simmons, Sewell E.. 1985. Parklands Pest Management. California Dept. of Food and Agric., Sacramento California.

Vengris, Jonas and William A. Torello. 1982. Lawns, Basic Factors, Construction and Maintenance of Fine Turf Areas. Thomson Publications, Fresno CA 93791.

Whitson, Tom D.; Larry C. Burrill; Steven A. Dewey; David W. Cudney; B.E. Nelson; Richard D. Lee; and Robert Parker. 1996. Weeds of the West (5th edition). Western Society of Weed Science and Western United States Land Grant Universities, Cooperative Extension Services.

MESQUITE

Description, distribution, identification

Three closely related and intergraded varieties of mesquite occur in the Southwest, honey mesquite (Prosopis glandulosa), velvet mesquite (Prosopis velutina), and western honey mesquite (Prosopis glandulosa var. torreyana).

Honey mesquite (Prosopis glandulosa) occurs in Texas, from eastern New Mexico to Kansas, and in southeastern Colorado.

Western honey mesquite (Prosopis torreyana) occurs in New Mexico, West Texas, and southern Arizona.

Velvet mesquite (Prosopis velutina) is mostly found in southern and central Arizona, southwestern New Mexico and northern Mexico.

Mesquite is a deciduous, thorny shrub or small leguminous tree that is native to tropical and subtropical regions of the Western Hemisphere, Africa, Middle East, and India. It can become a tree up to 30 feet high with a 4 foot diameter trunk.

Occurrence in the park

Mesquite is a native plant that occurs throughout the park. It becomes a problem along roadsides where the thorns puncture vehicle tires. Excessive growths of mesquite in the campground periodically have to be trimmed.

Biology

Mesquite is an aggressive plant that can grow on a variety of soils on even very dry sites. Uncontrolled growth leads to impenetrable, thorny thickets. It is considered to be an undesirable plant because of its ability to out-compete other plants for available soil moisture and light and because of mesquite's high reproductive rate.

Mesquite flowers open from mid-March thorough May in the Southwest and seed pods ripen from August to September. If weevils that infest seeds pods do not kill the seeds, dry mesquite seeds can remain viable in the soil for several years but

must be scarified to encourage sprouting. Fresh seeds promptly sprout without scarification.

Potential damage and health concerns

Excessive or unusually vigorous growth of mesquite hides (or damages) archeological ruins, damage walkways and roadways, may reduce desired habitat for some wildlife species and create habitat for others, limits recreational use, provides fuel to support wildland fires, displaces other native vegetation, and harbors rodent or other pest populations that may support diseases or cause other problems.

Mesquite is an invading plant which alters the desired appearance of some historic landscapes. Mesquite limbs bear spines (up to 3 inches long) and thickets prevent visitor use.

Action thresholds

Mesquite which alters the desired appearance of historical landscapes or otherwise interferes with management objectives for specific areas will be an Action Threshold for control.

Inspection and monitoring

Inspections and monitoring are performed by walking through areas suspected of being infested with mesquite. Plot the locations, numbers, growth stages, and density of plants on maps.

Non-chemical management

After identifying mesquite as a target weed, there are only two principal methods of control: physical removal and control with herbicides. For maximum impact, all control actions should coincide with the period of greatest plant susceptibility.

Attempts to physically or mechanically remove mesquite by cutting, hand pulling (small plants), burning, flaming, disking, plowing, mulching, etc. usually only ultimately result in stimulating mesquite roots to re-sprout or stimulating plants to become increasingly bushy from additional top growth. However, hand and power grubbing are effective when the plants are cut below the lowermost bud. Efficacy is 100 percent when the bud zone is removed. Use native plant seed to

revegetate the pits made when excavating mesquite buds; this will help to prevent colonization by weedy species.

For detailed information about the manufacturers of mechanized equipment (one is called the "Brush Boss") which can cut mesquite below the bud zone, contact Dr. Barron Rector, Associate Professor and Extension Range Specialist, Texas Agricultural Extension Service, at Texas A&M University; his phone number is 409/845-2755.

Chemical management

Fort Bowie National Monument and a number of other NPS areas have obtained 90 or greater percent control over mesquite by cutting the plants at ground level and immediately treating the stumps with 18 percent glyphosate.

Triclopyr is also effective on mesquite. The Texas Agricultural Extension Service reports about 95 percent control by using the "streamline" method of application.

Root-kill in mesquite with 2,4-D and 2,4,5-T is erratic, generally poor, and greatly affected by existing soil moisture, temperature, and physiological and phenological conditions of the plants.

Factors that influence the activity of soil-active herbicides, like tebuthiuron, are moisture (rain) following applications, plant growth forms, and soil texture.

Multi-stemmed mesquite plants are more difficult to control with herbicides than single stemmed ones.

Evaluating treatments

Periodic monitoring of mesquite will provide information on the effectiveness of previous treatments.

Evaluations of treatments will be used to supply essential information to adjust Action Threshold values, develop more effective management strategies, and demonstrate any apparent needs for new control methods or chemicals.

Chemical alternatives

Glyphosate
Triclopyr

Sources of advice, technical information, and supplies

National Park Service Videotapes

"Integrated Pest Management," 15 minutes.

"Pesticide Applicator Safety," 17 minutes.

See Appendix listings for equipment and chemical supplies.

Literature

Benson, Lyman, and Darrow. 1945. A manual of southwestern desert trees and shrubs. Arizona University Biological Science Bulletin, #6, Tucson Arizona.

Martin, S. Clark and Robert R. Alexander. 1974. In: Seeds of Woody Plants in the United States, Agriculture Handbook # 450; U.S. Forest Service, Dept. of Agric. Washington DC.

Personal reference. Rector, Barron (telephone, 409/845-2755). 1 August 1996. Personal telephone communication with Gerald D. McCrea.

Welch, Tommy G. 1991. Brush Management Methods. Tex. Agric. Exten. Ser., Tex. A&M, College Station, TX.

Whitson, Tom D.; Larry C. Burrill; Steven A. Dewey; David W. Cudney; B.E. Nelson; Richard D. Lee; and Robert Parker. 1996. Weeds of the West (5th edition). Western Society of Weed Science and Western United States Land Grant Universities, Cooperative Extension Services.

TAMARIX

Description, distribution, identification

There are 75 or more species of saltcedar (Tamarix spp.) native to North Africa, the Mediterranean region, and Pakistan. Early in the 1900's, about 7 to 8 of those species were introduced into the United States and Canada as ornamentals and to control stream-bank and wind erosion. At least 2 of the introduced species, saltcedar (Tamarix ramosissima) and smallflower tamarisk (Tamarix parviflora), have become naturalized in this country and are widespread.

Tamarix (saltcedar) is a small tree or shrub that can become 20 feet tall. It has reddish-brown bark and small, scale-like leaves. The flowers are pink to white and borne in finger-like clusters. Tamarix rapidly colonizes and invades disturbed habitats, and when moisture is sufficient, forms exceptionally dense stands. Under optimum growth conditions, a desert riparian area can be converted into an impenetrable Tamarix thicket in less than 10 years. Each plant can produce about 1/2-million seeds per season.

The athel tree (Tamarix aphylla) is another and larger species in the Genus Tamarix but rarely becomes a problem. This large-sized evergreen is used as an ornamental, for shade, and as a windbreak. It produces flowers but only sterile seeds. Athel is only propagated through transport and burial of broken limbs, which most often occurs during storms or floods.

Occurrence in the park

Tamarix is a very abundant exotic plant along the Rio Grande which also invades isolated seeps and springs.

Biology

Aspects concerned with the biology of Tamarix and which also deal with possible means of control include the following.

Cutting. Cutting Tamarix plants above ground level stimulates vigorous sprouting from the

crown. Freshly severed stems and shoots will readily root in moist soil but rapidly lose the ability to sprout when becoming dry and brittle.

Any severe degree of trauma (fire, drought, chemicals, cutting, etc.) greatly increases flowering, seed production, and the number of stem cuttings available to colonize new areas. At least 75 percent of the foliage of a Tamarix plant must be removed to merely slow down its growth. Up to 50 percent of the Tamarix cuttings made by beaver are reported to root and initiate new plants. ✕

Fire. Tamarix is not killed by fire and vigorously regrows after being burned. Although up to 90 percent of the plants may rapidly recover after being burned, fire reduces biomass and may help keep stands from reaching and persisting as mature communities. After a thicket burns, however, native riparian vegetation not adapted to fire is usually replaced by Tamarix.

Growth. Seedlings require saturated soil during the first 2 to 4 weeks and grow very slowly; gradually receding moisture levels provide optimum seed bed conditions. Plants germinating in July may be 3 feet tall within a year but growth rates of as much as 12 feet per year are reported. Although some plants produce flowers and seeds in the first growing season, most plants require 3 to 4 years of growth before flowering. Tamarix is insect pollinated; the plants do not self-fertilize. Some plants may live in the wild for 50 to 100 years.

Light. Tamarix requires considerable light for best growth. Dense shade, as found under abundant willow growth, inhibits Tamarix flowering and greatly reduces its growth. Tamarix out competes willows in full sunlight.

Moisture. Tamarix does not depend on a year-round supply of ground water (it is a facultative phreatophyte) and can grow in nearly all substrates and its roots can penetrate the soil 30 or more feet deep.

Available water enhances its potential for growth. Tamarix dies if water is suddenly removed from the root zone.

The size and bulk of Tamarix is regulated by the availability of moisture. However, the availability

of nutrients regulates how bulk in the plant is apportioned between roots and shoots. Very dense stands of Tamarix can develop where the water table lies from 3 to 18 feet below ground. In areas with a high (less than 4 feet to water) water table, Tamarix plants branch profusely just below the ground surface and form bushy plants. In lower water tables (about 18 feet to water), plants form open shrublands and are usually spaced about 10 to 18 feet apart.

Flooding. Although flooding and scouring may kill 50 percent or more of the Tamarix plants present, drowning is not an effective control. Tamarix is considerably more resistant to drowning than other riparian species and can tolerate complete immersion for up to 100 days (which drowns other competing vegetation and allows Tamarix to spread as waters recede).

Seeds. A mature Tamarix tree produces prodigious numbers of small seeds which can be dispersed by the wind for distances up to about 10 miles. The seeds have no specific dormancy or light requirements but will only germinate on moist soil. However, once seeds germinate, the seedlings are very resistant to drying and are highly adaptable to conditions found at the micro-site and this helps Tamarix out-compete other riparian species.

Soil salinity. Tamarix can tolerate high soil and water salinity (from 652 to 15,032 ppm) and adapts to such conditions by excreting salt from openings in its scale-like leaves. The salt excreted by Tamarix kills or limits the growth of other competing grasses and seedlings.

Potential concerns

Tamarix is a very aggressive plant that quickly forms dense colonies to dominate sites. Tamarix crowds or shades out and inhibits growth of native species like cottonwood and willow.

Tamarix transpires enormous amounts of water from ditches, springs, ground water, etc. One report estimated a 100 percent stand of Tamarix (size of area unknown) annually transpires 7 or more acre-feet of water per acre per year, depending on water table depth and stages of plant growth. Dense thickets of Tamarix block drainages and increase the potentials for sedimentation and flooding.

Tamarix alters wildlife habitat; very few bird species use Tamarix thickets because Tamarix seeds contain very little protein and the plants provide poor understory conditions. If Tamarix invades an area, it may so drastically alter a habitat that native wildlife species can not survive.

It should be noted that the endangered Southwestern willow flycatcher (SWF) will sometimes nest in Tamarix. It is not a preferred site for nesting, but if willows are in short supply (often due to Tamarix invasion), it may be used.

Consequently, when considering Tamarix management, the park's Threatened and Endangered Species Coordinator should first confer with the USF&WS' Ecological Services Office staff located in Austin, Texas. The USF&WS staff may request that a survey be performed first, in order to assess what, if any, affect such actions might have on the SWF over the short term.

After a survey, it is possible that the USF&WS may request a Section 7 consultation, in order to comply with the Endangered Species Act. These can usually be accomplished at the "informal" level, by building mitigating measure into a project, should any be needed. An example of a mitigating measure would be incremental management of Tamarix, coupled with a simultaneous revegetation effort in the riparian corridor. This would ensure that SWF would have nesting sites at all times.

The simplest scenario involves management measures without pesticides, as no pesticide approval would be needed (however, the USF&WS should still be contacted). If a pesticidal treatment is proposed in a situation where the USF&WS wanted a consultation, the Section 7 consultation would have to be completed, with a "no effect" determination by the USF&WS, prior to undertaking the pesticide application.

In the unlikely event that a "may affect" or "will affect" termination is made by the USF&WS, then obtain the approval of the Washington Office IPM staff prior to application of the pesticide. The reason for the additional review in this case is that this IPM Plan has been reviewed and approved by the Park Cluster (SWSO) IPM

Coordinator, who does not have the authority to approve pesticide uses that can be expected to affect threatened or endangered plant or animal species.

Action thresholds

The Action Threshold for Tamarix will be individual plants (seedlings or mature plants) that grow in or near areas which could be ecologically or aesthetically damaged by the plant or serve as a source of additional invasions.

Inspection and monitoring

Inspecting and monitoring for Tamarix are similar activities. Carefully search for Tamarix plants in areas susceptible to invasion during late spring (April to June) while Tamarix is in bloom. This is the only practical time to find young Tamarix seedlings if they are mixed in with other vegetation. Prepare maps and diagrams showing relative ages and density of Tamarix stands.

Non-chemical management

Burning. Very hot burns may kill or greatly set Tamarix back, yet large variations are often seen in plant response. At least some of those differences relate to variations in individual plant morphology, physiological condition, and stage of development during fires.

Hot fires in Tamarix thickets on calm, mid-summer days, when fuel moisture is low and when plants are actively growing, may retard Tamarix resprouting the following year by as much as 60 percent. However, fires of similar intensity during the fall, when plants are entering dormancy, may only retard resprouting by 10 percent.

Multiple burnings (every other year or so) are more effective for Tamarix control than one-time burns because multiple burning seems to lower a plant's competitive ability by depleting the amount of nutrients stored in the roots.

Other differences in plant response to fire depend on the amount of heat produced. Usually, more intense fires have greater

effects on Tamarix. Low rates of plant mortality occur when fires are not severe enough to kill the basal stem buds which quickly resprout.

Flooding. Although prolonged flooding of areas for periods of 24 or more months (or for 2 to 3 successive growing seasons) may give up to 99 percent control, flooding also kills all other plants and animals and opens the area to rapid re-colonization by Tamarix.

At least 7 inches of water are needed to cover an area to prevent Tamarix from re-invading. Interruptions in inundations, if necessary, should be done during winter when Tamarix seeds are least likely to germinate.

Mechanical removal. Cutting plants, either individually or as an entire thicket, only provides about 54 percent control. For best results, plants should be cut between May and July since growth characteristics seem to be at their lowest strength during early summer (May to June) and at their greatest strength during late fall to winter.

Grub individual plants and cut them to within 2-inches of the soil line. Continually monitor plants during late winter (before flowering). In late spring, search for and destroy any new seedlings.

Revegetation. Replacing Tamarix with native species helps lessen or delay recolonization. Once good control is had over Tamarix in isolated desert spring areas, control is usually relatively permanent. Control of Tamarix on flood-prone river courses, however, is extremely difficult and most likely impossible.

After Tamarix is removed, some native plants that may be better adapted for revegetation purposes include: Fremont cottonwood (salinity tolerance of 2,000 to 4,000 ppm), black willow (salinity tolerance of 2,000 ppm or less), honey mesquite and blue paloverde (salinity tolerance of 2,000 to 10,000 ppm), and/or combined plantings of quailbush and inkweed (salinity tolerance of 2,000 to 10,000 ppm or more).

Biological controls. Two insects look very

promising for the biological control of Tamarix. One species is a mealybug; the second is a leaf beetle. As the time of this writing, the Agricultural Research Service (ARS) has developed an environmental impact statement (EIS) for the release of these two species. It is thought that the environmental compliance process will be completed during calendar year 1997. For the latest information on that subject, contact your park Cluster IPM Coordinator.

Chemical management

Although foliar application of herbicide may kill the top-growth of Tamarix plants, the plant usually recovers. Tamarix located on floodplains are difficult to kill with herbicides and may require 3 or more treatments. Herbicide treatments during fall and winter produce the best results because sap in the plant is moving downwards (for storage) and plants are approaching dormancy. Spring is the least desirable time to treat trees because the sap is flowing upwards.

Freshly cut Tamarix stumps must almost immediately be treated with herbicide or the processes of wound healing lessen potential absorption of chemicals. Two effective herbicides for Tamarix are: triclopyr (Garlon 3A, Garlon 4, Dowco 233) and glyphosate.

- Triclopyr is short-lived herbicide but a more toxic to mammals than picloram. Garlon-4 (one formulation of triclopyr) is said to be easier on the environment, safer to animal life, better for applications near water, and more effective on Tamarix than Garlon-3A; however, California may still be the only state registering Garlon-4 for cut-stump applications. Check for special local need registrations in other states.
- Successively treating Tamarix with either 2, 4, or 8 percent glyphosate solutions have been proven to be 95 percent effective.

Combinations of mechanical and chemical treatments are most often used in attempts to eradicate Tamarix but, as noted above, treatments do not always provide expected results.

Herbicide (2,4,-D) applications following hot, mid-summer burns have reduced Tamarix resprouting by 99 percent but similar treatments during the cooler, late-fall season were only shown to reduce resprouting by about 10 percent. The treatments in summer treatments may have been more effective because the plants did not have leaves, their root crown buds had sprouted, and the herbicide was readily translocated to the roots.

The science of chemical weed control is constantly changing. For up-to-date recommendations, contact your System Support Office IPM Coordinator or county extension agent.

Evaluating treatments

Treatment evaluations will be determined through subsequent examination, monitoring, and analysis of areas previously supporting Tamarix growth.

Evaluations of treatments will be used to supply essential information to adjust Action Threshold values, develop more effective management strategies, and demonstrate any apparent needs for new control methods or chemicals.

Chemical alternatives

Glyphosate
Triclopyr

Sources of advice, technical information, and supplies

National Park Service Videotapes

"Integrated Pest Management," 15 minutes.

"Pesticide Applicator Safety," 17 minutes.

See Appendix listings for equipment and chemical supplies.

Personal references

Clyde Hurst, 900 West 740 South, Richfield, Utah 84701; Utah State County Extension Agent, 801/896-4609.

Literature

Hyrum B. Johnson, USDA, Agriculture Research Service, PO Box 6112, Temple, TX; 817/774-1201.

Mietek Kolipinski, Western Regional Office, NPS, San Francisco, CA 94102; 415/556-8373.

Bill Neill, 4900 Gleenvue, Anaheim, CA 92807, 714/528-7201. Serves as a volunteer for Tamarix removal in California.

Other references

Kunzmann, Michael R.; Roy Johnson; and Peter S. Bennett. 1987, revised 1990. Tamarisk Control in Southwestern United States: Proceedings of Tamarisk Conference, Univ. of Arizona, Tucson, Sept. 2-3, 1987. Special Report No. 9, Cooperative National Park Resources Studies Unit.

Simmons, Sewell E.. 1985. Parklands Pest Management. California Dept. of Food and Agric., Sacramento California.

University of California. Agricultural Sciences Leaflet # 2402 for detailed information on planning a prescribed burn.

U.S. Dept. of Interior, National Park Service. 1984, 1994. Integrated Pest Management Information Manual, First and Second Editions.

Wasser, Clinton H. 1982. Ecology and Culture of Selected Species Useful in Revegetating Disturbed Lands in the West. Publ. FWS/ OBS-82/56. Western Energy and Land Use, Office of Biol. Serv., US Fish and Wildlife Ser., Washington DC.

Whitson, Tom D.; Larry C. Burrill; Steven A. Dewey; David W. Cudney; B.E. Nelson; Richard D. Lee; and Robert Parker. 1996. Weeds of the West (5th edition). Western Society of Weed Science and Western United States Land Grant Universities, Cooperative Extension Services.

THISTLES

Description, distribution, identification

Thistles belong to the plant families Asteraceae and Chenopodiaceae which contain a large number of species that are widely distributed throughout the United States. The exotic thistles regarded as significant plant pests in the park include:

ASTERACEAE

Canada thistle (Cirsium arvense)

Yellow starthistle (Centaurea solstitialis)

CHENOPODIACEAE

Russian thistle (Salsola iberica)

Canada thistles are colony-forming, perennial, deep-rooted plants with narrow, spiny leaves. Plants may become 4 feet tall. It is commonly found in northern regions but widely occurs throughout North America.

Canada thistle emerges in the spring as a rosette with spiny-tipped and wavy leaves. It shows its strongest growth during cool weather (fall and spring). Canada thistle produces unisexual, purple (may be white) flowers during July and August. This deep rooted, perennial plant reproduces by seed, rhizomes, and root fragments.

Canada thistle is listed as a noxious weed in the Federal Seed Act.

Russian thistle is a bushy, branched annual plant that may be 3 feet tall. It has red or purple striped stems. Russian thistle is distributed over most of the Central and Western portions of the United States. It is well adapted to and found on dryland areas supporting agriculture but also invades disturbed rangelands and wastelands.

Russian thistle reproduces by seed which are spread when the mature plant breaks off from its stem and is blown about by the wind. Seedlings rapidly germinate and become established following only

minimal amounts of precipitation.

Yellow starthistle is an annual plant that may grow 3 feet tall on various types of soil. It is found in cities, cultivated fields, waste lands, along roadsides, and vacant lots in many parts of this country.

A similar and related plant (Malta starthistle, Centaurea solstitialis) has smaller seed heads and smaller spines.

Yellow starthistle has an extended flowering and maturation period from June to September when yellow flowers are produced. The plant reproduces by seed which rapidly mature during late summer. Seeds remain viable in the soil for about 3 years.

Occurrence in the park

Such exotic thistle species like tumbleweed (Salsola spp.) and others are widespread in their occurrence on park range lands.

Potential damage and health concerns

Starthistle is a tough, exotic, invading species which becomes dominant in some habitats and crowds out native species.

Dead thistle plants cause fire hazards and are spiny and become nuisances. Some botanists believe that many thistle species release toxins into the soil (allelopathic) that prevent the germination of other plant species.

Thistles and other tap-rooted plants provide food for and tend to increase pocket gopher activity.

Russian thistle is the primary host of some pest leafhoppers.

Action thresholds

Because of their high reproductive potential, the observation of even individual exotic thistles will be the Action Threshold justifying control.

Inspection and monitoring

Inspections and monitoring are performed by walking or slowly driving along roads in areas suspected of being infested with thistles. For many species, this is best done during the early blooming period (when plants can best be recognized). Plot the locations, numbers, and growth stages of plants on maps.

Identify any new weeds found in the area to assure they may not cause future management problems. Any plants found that are recognized as noxious weeds by the state or county and which do not otherwise commonly occur in the area should be reported to the county extension agent or weed control supervisor.

Non-chemical management

Bradley method. The Bradley method for eliminating exotic weeds uses the above mechanical methods but in a persistent, long-term manner. It warns to not clear weeds out of large areas; this only leaves open, bare areas which encourage weeds re-colonization. Bradley suggests removing weeds from only relatively small areas (no larger than you can effectively cover) about once a month during the growing season. Mechanically remove weeds occurring singly or in groups of 4 or 5 plants and allow native vegetation to re-establish before expanding the size of control areas. Areas of solid weed infestation should not be worked until native vegetation has been established right up to the weed line; then, work weed patches only along the edges by forming small clearings of less than 6 feet in diameter.

Disking. Disking is the best control for vigorous, dense stands of annual thistles found growing in competitive stands of perennial grass. Although repeated disking may kill thistles, the plants maintain high soil seed bank reserves and treatments must be continued for 3 to 5 years until all seeds have sprouted and been killed.

Fire. Controlled use of ground fire is not generally an effective control for thistles in large fields because fuels are usually not fine enough nor tall enough to carry fire when thistles are most susceptible. When thistles are dry enough to burn, the seeds have already shattered and are in the soil.

The agricultural torch is effective for killing small groups of thistle plants where it would not otherwise be efficient to hand-pull them and when there is no fire danger. Thistles succumb to flaming after a number of treatments spread over a season or two. Portable agricultural torches are available equipped with small propane tanks such as used on recreation vehicles.

Hand pulling. Hand pulling of thistles during early spring and summer accomplishes the same end result as mowing; however, the entire root of Canada thistle must be removed to prevent re-sprouting. Continually pull up observed plants during the blooming period and before seed-set.

Mowing. Persistent mowing or cutting of most weeds before they flower ultimately controls even the most persistent of plants.

Canada thistle, left alone, continues to increase in numbers and ultimately replaces annual grasses. Cutting the plant below ground level and other methods of cultivation which breaks up rhizomes tend to increase the spread of Canada thistle. The best controls are long-term, multi-directional programs which include direct (herbicide) and indirect (grazing, fire, and re-seeding) efforts which encourage re-establishment of native vegetation. To re-establish perennial grasses in thistle infested pastures, thistle control must first be accomplished. Then, create shaded, moist micro-habitats which are more favorable to grass than thistles (or other broadleaf weeds). Finally re-seed grasses or other native vegetation.

Russian thistle is very difficult to control

because it is so easily spread by wind. Complete eradication is nearly impossible.

When young, individual plants or small groups of plants can be controlled by hand pulling, hoeing, disking, etc. during early spring. Temporary fences can be erected during fall to keep dry plants from blowing into susceptible areas. Don't move or scatter dry plants when found in piles in fence corners during fall, rather burn them on site.

Starthistle can be temporarily controlled by mowing but cutting encourages new stems to sprout below the cut. It is best to set the mower blade high for the first cutting and then lower the blade for the second cutting. This inhibits sprouting following the second mowing because the stems are too woody to produce new sprouts. Potential biological controls for starthistle, tested a few years ago, included various rust fungi (Melampsora euphorbiae, Puccinia carduorum, and P. jaceae).

Chemical management

Canada and Russian thistle. There are no effective pre-emergent herbicides for Canadian thistle but glyphosate and 2,4-D, are good for post-emergent control. Glyphosate is effective during any time of the year for both species when applied to actively growing plants. Both thistles are controlled with 2,4-D applied during the fall; two applications may be necessary. The most effective time to treat Russian thistle with herbicide is while the seedlings are still small.

Starthistle. One of the better herbicides for starthistle is 2,4-D which should be applied at a rate of 1 pound Active Ingredient per acre throughout an entire growing season while plants are in the rosette stage. When applied during later growth stages, 2,4-D is not effective.

The science of chemical weed control is constantly changing. For up to date

recom-mendations, contact your Systems Support Office IPM Coordinator or county extension agent.

New product: AgrEvo Environmental Health. Finale Weed and Grass Killer (glufosinate-ammonium, may be an alternative herbicide).

Evaluating treatments

Continued monitoring and inspection during the blooming period will show if plants have been effectively controlled.

Evaluations of treatments will be used to supply essential information to adjust Action Threshold values, develop more effective management strategies, and demonstrate any apparent needs for new control methods or chemicals.

Chemical alternatives

Glyphosate
2,4-D (In Texas, 2,4-D is a state limited use herbicide. The applicator must be certified to use it.)

Sources of advice, technical information, and supplies

National Park Service Videotapes

"Integrated Pest Management," 15 minutes.

"Pesticide Applicator Safety," 17 minutes.

See Appendix listings for equipment and chemical supplies.

Literature

Bradley, Joan. 1971. Bush Regeneration: The Practical Way to Eliminate Exotic Plants from Natural Reserves. The Mosman Parklands and Ashton Park Association, Mosman (Sydney), New South Wales.

Olkowski, William Daar, S., and H. Olkowski. 1991. Common-Sense Pest Control. Taunton Press, Newtown, CT.

Simmons, Sewell E.. 1985. Parklands Pest Management. California Dept. of Food and Agric., Sacramento California.

University of California. Agricultural Sciences Leaflet # 2402 for detailed information on planning a prescribed burn.

U.S. Dept. of Interior, National Park Service. 1984. Integrated Pest Management Information Manual, First Edition.

Ware, George W. 1988. Complete Guide to Pest Control - With and Without Chemicals. Thomson Publications, P.O. Box 9335, Fresno CA 93791.

Wasser, Clinton H. 1982. Ecology and Culture of Selected Species Useful in Revegetating Disturbed Lands in the West. Publ. FWS/OBS-82/56. Western Energy and Land Use, Office of Biol. Serv., US Fish and Wildlife Ser., Washington DC.

Whitson, Tom D.; Larry C. Burrill; Steven A. Dewey; David W. Cudney; B.E. Nelson; Richard D. Lee; and Robert Parker. 1996. Weeds of the West (5th edition). Western Society of Weed Science and Western United States Land Grant Universities, Cooperative Extension Services.

APPENDIX I

HANTAVIRUS PULMONARY SYNDROME (HPS) INFORMATION

HANTAVIRUS PULMONARY SYNDROME (HPS)

TECHNICAL REFERENCES:

MMWR (publication of the U.S. Dept of Health): Vol. 42, No. RR-11; July 30, 1993

Federal Centers for Disease Control and Prevention (CDC), Gary Maupin . . . 404/639-1075

CDC Sin Nombre Virus (HPS) Information Hotline 800/532-9929

CDC-Viral Diseases 404/639-1115

AZ Dept. of Health, Vector Control: Craig Levy, Manager 602/230-5918

Dept. of Fed. Occup. Health (DFOH); Dr. Scott 415/556-2975

NOMENCLATURE:

A variety of names has been used to describe the disease, Hantavirus Pulmonary Syndrome (HPS). It was first recognized and identified in May, 1993, in the Four Corners Area of Arizona, Utah, Colorado, and New Mexico. Some of the main names used, beyond HPS, have been the Navajo Mystery Disease, Muerto Canyon Hantavirus, with the latest accepted names being Sin Nombre Virus or HPS.

DISEASE RESERVOIRS:

The principal reservoir for HPS has been found to be native deer mice (Peromyscus maniculatus). A 1992 study in the Four Corners area showed 30 percent of the deer mice to be positive of HPS. A second study in the same area, 1994-1995, found 11 percent of the deer mice to be positive. A study which covered 9 counties in Arizona, 1993-1994, showed 25 percent of the deer mice were positive.

Serologic evidence of Sin Nombre Hantavirus (HPS) found in various studies includes:

COMMON NAME	GENUS	PERCENT POSITIVE
Pinon mouse	<u>Peromyscus</u>	8 to 16% positive
Brush mouse	<u>Peromyscus</u>	8 to 18% positive
White footed mouse	<u>Peromyscus</u>	36 to 50% positive
(LA)	<u>Peromyscus</u>	7 to 13% positive
Cactus mouse	<u>Reithrodontomys</u>	19% positive
Western harvest	<u>Perognathus</u>	1% positive
mouse	<u>Neotoma</u>	0.6 to 1.5% positive
Desert pocket mouse		
Woodrats		

One CDC study, 1994-95, in the Four Corners area, determined the distribution and prevalence of Hantavirus in wild rodents. Over 3,000 mammals (55 species) were trapped in over 38,000 trap nights and Hantavirus positive rodents were found in 77 percent of the rodents from 9 ecological communities (3% of grasslands and 23% of pinion-Juniper areas). Overall, 11 percent of 609 deer mice from all community types were positive.

The Arizona study, 1993-94, captured 1,117 rodents of 34 species statewide from 19 locations in 9 Counties. It showed 92 rodents (8%) from 8 species to be positive for Hantavirus antibodies. Western harvest mice tested positive for a different strain of Hantavirus.

MICE IN THE GENUS PEROMYSCUS ARE THE PRIMARY RESERVOIRS ... AND THE GREATEST RISK TO HUMANS.

As of November, 19, 1996, 154 human cases of Hantavirus had been reported in 26 states with 74 cases (48%) resulting in death. Arizona and New Mexico were states leading in the number of cases (22 and 29, respectively) and followed by California (14 cases), Idaho (10 cases), Washington (10 cases), Utah and Colorado (8 cases each), and Texas (4 cases). Mortality rates in Arizona (about 29 percent) have been slightly lower than the national average.

GENERAL INFORMATION

COMMON NAME	GENUS	PERCENT POSITIVE
House mouse	<u>Mus</u>	2% positive
Western chipmunk	<u>Eutamias</u>	Unknown
CO chipmunk	<u>Eutamias</u>	16% positive
Cliff chipmunk (AZ)	<u>Eutamias</u>	3% positive
Rock squirrels	<u>Citellus</u>	1% positive
Cotton rat	<u>Sigmodon</u>	One occurrence

• Originally, all of the Arizona cases occurred in the northern part of the state and Hantavirus seemed restricted to elevations above 5,000 ft.; however, in 1995, new cases began to appear in Tucson, Phoenix, and Gila Bend. Studies in 1994 showed positive rodents from 7 out of 11 state habitats but infection rates seemed higher in Great Basin Desert Scrub, Montane Conifer/Pine Woodland, Spruce-Fir Alpine, Chaparral, and Pinyon-Juniper in habitats ranging from 4,000 to 10,000 ft. Lower elevation areas (Desert Grassland, Chihuahuan Desert) showed lower percentages of infection possibly because of seasonal fluctuations in infection rates. Higher rodent rates were generally found during winter and spring in southern AZ). The Arizona Department of Health recommends all residents take precautions because there is still not good information on the geographic limits of the disease and stresses that the potential for contracting Hantavirus occur year long.

INFORMATION ON HANTAVIRUS (HPS)

• Currently, there are no preventives nor cures for the disease. After becoming ill, the only treatment is to place victims on a respirator, drain fluids from the lungs, and provide general supportive care. A vaccine being tested by

the U.S. Army was thought to have been ready for trials in late 1994 but has not appeared. There are, nevertheless, presumptive laboratory antibody tests for Hantavirus which show results in a few days. Previously unexplained deaths can also be tested through an examinations of preserved tissues.

- There are area-specific strains of Hantavirus which allow officials to tell within a given area where a specific variant of the disease was contracted. This seems to indicate the disease is very old in the U.S. In fact, Zuni Indian legends describe increased human death rates occurring after seasons of unusually large pinion nut harvests (i.e., years of above normal precipitation and large numbers of rodents). Different strains occur in other states where the disease may be called by a different name.

- There seem to be geographic "hot spots" for the disease. For instance, one area northeast of Flagstaff AZ was considered a "hot spot" when 40% of all rodents tested were positive but a very similar habitat near Williams AZ showed only low disease frequency.

- Hantavirus does not cause illness in the infected rodent hosts; rodents shed the virus in saliva, urine, and feces for all their lifetime.

- Disease transmission can occur from rodent bites and/or dried and contaminated materials directly introduced into the lungs (inhaled on aerosol dusts), broken skin, eye, or - possibly - ingested on contaminated food/water.

- Recently, the NPS Public Health Officer sent a memo to field area public health officers reporting a number of persons in El Bolson, Bariloche, and Esquel in southern Argentina seem to have contracted Hantavirus in 1997 from other persons also sick with the disease. Person-to-person transmission of Hantavirus has not yet been documented in the United States.

- Cats and dogs are not known to be reservoirs of Hantavirus but often bring infected dead rodents into contact with humans. And, dog and cat pet foods, water dishes, and fecal matter provide attractive food and water sources for rodents.

- Hantavirus cases have been associated with persons:

- planting or harvesting field crops
- occupying previously vacant cabins/dwellings
- cleaning barns/other outbuildings
- disturbing rodent-infested areas when hiking/camping
- inhabiting dwellings with indoor rodent populations
- living in/visiting areas where rodent populations are numerous.
- with skin/open wound contact with surfaces contaminated by rodent feces/urine
- having eye contact with contaminated sawdust/wood particles during wood cutting with power equipment
- having contact with other persons also sick with Hantavirus

- Some specialists believe human resistance to Hantavirus is quite varied and some persons may not be susceptible. However, CDC recommends all persons follow special risk reduction precautions.

SYMPTOMS:

In its severe form, symptoms include **fever, headache, muscle aches, difficulties in breathing - like onset of the flu - and followed by bleeding, kidney failure, low blood oxygen, and shock which progress to lung disease and death in 50% of the confirmed cases in the U.S.** The most unusual things about the disease is its occurrence in otherwise healthy, young persons and that it can be lethal within 12 to 24 hours; however, normal incubation is about 1 to 5 weeks.

TREATMENTS:

The California Dept. of Health and CDC are making an intravenous ribavirin treatments available for treatment of persons suspected with Hantavirus. However, it isn't known how effective ribavirin is and, if beneficial at all, it must be administered in very large doses and quite early in the progression of the disease.

Human antibody tests can be conducted but many people who have had close association with rodents for years usually show negative results.

STANDARD AND RECOMMENDED DISINFECTANTS:

- **One part standard hypochlorite solution (5.25% commercial bleach; i.e., Clorox) mixed in 9 parts water.**

- General purpose household disinfectants (i.e., Lysol) mixed per label directions. Note: Lysol solutions may be nauseous to some persons.

- Although straight 70% ethyl alcohol (and probably isopropyl) is an effective germicide, it is not so labeled by EPA and cannot legally be recommended for use as a germicide.

- Detergents are not sufficiently germicidal without addition of bleach or disinfectant and are not labeled by EPA as germicides.

PRECAUTIONS:

- Controlling rodents without also controlling fleas may increase human risks for plague.

- **Avoid contact with either dead or live rodents and with rodent feces, dried urine, nest materials, etc.**

CONTROL OF THE DISEASE:

Complete eradication of all reservoir hosts (rodents) is neither feasible nor desirable. The best approach for disease control and prevention is inspection and monitoring which **REDUCES RISKS** with:

- good rodent-proofing which keeps rodents out of buildings

- good environmental hygiene/sanitation keeps rodents from colonizing homes or work places and **REDUCES HUMAN EXPOSURE** to dry rodent excreta or debris

- controlling rodent populations inside buildings with effective snap-trapping programs.

SPECIFIC DIRECTIONS FOR POSSIBLE DISEASE CONTACT

VI. GENERAL HOUSEHOLD PRECAUTIONS FOR RESIDENTS IN AFFECTED AREAS:

Eliminate rodents, reduce available food sources and nesting sites in the home:

- ✓ Follow recommendations to eliminate rodents in the home (monitor for rodent presence; when detected, exclude, trap, treat home with flea control chemicals)
- ✓ Protect food and garbage from rodents
- ✓ Practice good household sanitation (dishes/cooking utensils, garbage)
- ✓ Continuously use spring loaded traps in the home; and, as an adjunct, possibly use rodenticides in secure bait boxes.
- ✓ Reduce outside rodent harborage (trash/litter cleanup, raise objects/garbage cans onto stands/pallets, move woodpile and remove vegetation within 100+ feet of house)
- ✓ Trap and/or poison exterior rodents within 100 feet of the house
- ✓ Reduce exterior rodent food sources (pet foods, garbage, vegetation)
- ✓ Well ventilate closed buildings containing rodent debris for 1/2 hour or more before going inside.
- ✓ Treat the inside of structures with flea control chemicals

CLEAN UP PRECAUTIONS:

- Wear unlined rubber/plastic gloves when cleaning up rodent debris or removing rodents from traps.
- Spray and thoroughly soak dead rodents, rodent nests, droppings, food, or other items contaminated by rodents with a disinfectant solution and allow it to soak into the materials for 10 to 15 minutes. This also reduces dust during cleaning up. Clean up debris with paper towels/rags and place towels and debris into a plastic bag; tie the bag and place it into a second sealed plastic bag; seal the second bag; and dispose of the bag in a landfill or other approved garbage collection site. After all the items have been removed from floors, mop floors with a solution of water, detergent, and disinfectant. A second mopping is optional.
- Before removing rodents from traps, spray the trap and rodent with disinfectant solution and allow to soak in 10-15 minutes; place carcass and trap in a plastic bag and soak with disinfectant; place bag into a second bag and seal; dispose of as above or bury 2-3 feet deep or burn; set out new traps. Contact your local or state health department for additional information on disposal methods.
- Do not vacuum/sweep dry surfaces before mopping. Although some vacuum bags may filter out particles down to 5 microns in size, most vacuum bags usually allow passage of dust particles up to 10 microns in size. In both cases, these are much larger particles than pass through a CDC recommended HEPA filter (filter out

particles to 0.3 micron in size).

- Mop floors with a mixture of detergent and disinfectant; spray dirt floors with disinfectant. Carpets and upholstered furniture can be disinfected with household disinfectants or commercial-grade steam cleaning or shampooing equipment. Some disinfectants (including household bleach) will damage carpets and other fabrics; check the disinfectant label for usage precautions and/or do a test patch on a small carpet area in a hidden area (as a closet corner).
- Disinfect counter tops, cabinets, and drawers where evidence of rodents are seen with detergent, water and disinfectant.
- Launder contaminated bedding in hot water and detergent; use rubber gloves to handle dirty laundry then wash and disinfect gloves; machine-dry laundry on high settings or hang in the sun to dry. The virus quickly dies in sunlight.
- Disinfect traps no longer in use in disinfectant.
- Before removing gloves, wash hands in disinfectant and soap and water

II. SPECIAL PRECAUTIONS IN AREAS OF CONFIRMED HANTAVIRUS INFECTION OR HEAVY RODENT INFESTATION:

(May also apply to vacant dwellings harboring rodents and to dwellings/structures which have been occupied by persons with a confirmed Hantavirus infection.)

- Contact State/Local/Federal public health agencies for guidance.
- Public health agencies should thoroughly familiarize workers performing cleanup about transmission of Hantavirus and train workers to safely perform required duties.
- Get a baseline serum sample from all persons conducting structural cleanups in areas with heavy rodent infestation; store tissue samples at minus 20 degrees C.
- Workers doing clean up should wear coveralls, rubber boots or disposable shoe covers, gloves, goggles, respiratory protection (half-mask with high efficiency particulate air filter (HEPA filter). Note: facial hair may interfere with proper fit. A HEPA filter removes contaminated dust particles of 0.3 microns size from the air but does not filter unattached viruses; a respirator is not a guaranteed protection.

One source for HEPA respirators: Cabot Safety Corp., Safety Division of American Optical - AO #95050 paint/pesticide/ asbestos respirator; replacement cartridge #95055; call 1/800/444-4774 for technical information.

- Decontaminate personal protective equipment when removed at the end of the work day. Launder non-disposable cover-alls on site or soak clothes in liquid disinfectant solutions until laundering can be done.
- Double-bag all potentially infective waste (including respirator filters) and properly dispose of, bury, or burn. If bags of waste are to be transported, label them as "INFECTIOUS"

- Seek medical analysis for any febrile/respiratory illnesses occurring within 45 days of the last possible exposure to rodents or rodent debris.

- Wood cutters are a high risk group if, when cutting trees/logs with a chain saw, rodent nest materials splash back into their faces. Arizona Department of Health suggests workers wear goggles, gloves, respirators, and coveralls. And, remove coveralls at the end of the day, wash in hot water, and hang in the sun to dry. Fire fighters may also be at high risk when digging into rodent burrows on fire lines; precautions are the same.

III. PRECAUTIONS FOR CAMPERS AND HIKERS:

Persons engaged in outdoor activities as camping/hiking should take precautions to reduce all likelihood of exposure to infectious materials.

- Avoid contact with rodents/burrows/dens.
- Do not use infested cabins until they have been aired-out, cleaned, and disinfected
- Do not pitch tents/sleeping bags near rodent feces/burrows or near garbage dumps/woodpiles.
- If possible, do not sleep on bare ground; use a cot with sleeping surface at least 12 inches above ground. Use tents with floors.
- Keep all human/pet food in rodent proof containers
- Promptly bury/burn all garbage/trash or discard into covered trash containers.
- Use only bottled or sterilized (filtered, boiled, chlorinated, iodinated) water for drinking, cooking, washing dishes, tooth brushing, etc.
- Notify appropriate land or county health managers if dead or sick animals are found.

IV. PRECAUTIONS FOR WORKERS REGULARLY EXPOSED TO RODENTS IN AFFECTED AREAS - i.e., mammalogists, pest control workers, etc.

Persons in these professions are probably at higher risk than the general public because of frequency of exposure.

- Obtain a baseline blood serum sample at the time of employment and store samples at minus 20 degrees C.
- Provide workers information on disease symptoms and detailed guidance on prevention methods. Refer workers to medical assistance if they become ill within 45 days of the last potential exposure and inform physicians of possible Hantavirus risks. Physicians should immediately contact public health agencies and forward a blood sample and any available baseline serum to CDC through the state health department for antibody testing.
- Workers should wear HEPA air filters and gloves when removing rodents from traps or handling infected rodents or contaminated surfaces. Wash gloves in disinfectant before removing.
- Disinfect traps contaminated by rodents in a

disinfectant solution for 10 to 15 minutes. CDC recommends the use of Lysol or dimethyl dibenzyl ammonium chloride. After disinfecting, use a double rinse to wash the disinfectant from the trap. Properly dispose of dead rodents.

- Before dissecting rodents, contact the Special Pathogens Branch, Division of Viral & Rickettsial Diseases, National Center for Infectious Diseases, Centers for Disease Control (CDC) and Prevention (404/639-1115) for detailed safety precautions.

V. PRECAUTIONS FOR OTHER WORKERS HAVING POTENTIAL OR INCIDENTAL RODENT CONTACT: THOSE ENTERING CRAWLSPACES/OTHER POSSIBLY RODENT INFESTED SITES = telephone installers, maintenance workers, plumbers, electricians, certain construction workers

Insufficient information is available on protection; when requested, CDC will make recommendations on a case by case basis after a specific environment has been assessed and state and local health departments consulted.

APPENDIX II

RODENT AND INSECT BORNE DISEASES AND HAZARDS

RODENT, BIRD, AND INSECT-BORNE DISEASES AND OTHER HAZARDS

I. Potential rodent-borne diseases

Sylvatic plague

Sylvatic plague (in wild animals) is primarily a rodent disease, caused by the bacillus Yersinia pestis, and transmitted from rodent to rodent by fleas. The systemic form of plague (commonly known as bubonic plague) is transmitted to humans and other animals by the bite of an infected flea. A pneumonic form (based in the lungs) of plague can be transmitted to man by some animals carriers (i.e., house cats) by inhaling bacteria-laden, air-borne droplets from an infected host (without intervention of a flea) and can be directly transmissible between humans. Rodent-spread plague, found world-wide, is a significant threat wherever commensal rodent species contact wild animal reservoirs and man.

Murine typhus

Murine typhus is an entirely different disease than epidemic (or, louse-borne) typhus which does not involve rats or fleas. Murine typhus is a rickettsial infection (Rickettsia mooseri) present in domestic rodents and transmitted from animal to animal by lice, fleas, or mites. The itch of a parasite bite causes the animal to scratch and feces left by the parasite may infect the bite and transmit typhus. Murine typhus fever is a rather mild disease in man.

Rickettsial pox

Rickettsial pox is a mild rickettsial infection caused by Rickettsia akari and carried by house mice and transmitted to man through bites of house mites, (Allodermonyssus sanguineus or Dermanyssus sanguineus), which usually live on walls and floors of structures infested with mice. This is usually a mild and non-fatal disease in man.

Leptospirosis.

Leptospirosis is a disease caused by the spirochete, Leptospira icterohaemorrhagiae which lives in kidneys of rodents and is shed along with their urine. Humans can contact the spirochete in soil or water containing infected urine or by handling sick or infected animals or animal tissues.

Salmonellosis.

Salmonellosis (infectious food poisoning) is most commonly caused by Salmonella typhimurium or S. enteritidis. These disease organisms are spread to man when coming into contact with infected rodent urine or feces. Mice are more

important transmitters than other rodents. The infection most often occurs when contaminated foods are ingested or when foods are prepared on surfaces contaminated by mice.

Lymphocytic choriomeningitis.

The house mouse is the primary reservoir for this serious viral disease which may be transmitted to man (mainly children and pregnant women) in food or on dusts contaminated with fecal materials of infected mice and gerbils. The blood, urine, feces, nasal secretions, and internal organs of infected rodents carry high concentrations of the virus. The disease is not lethal to mice which may carry and excrete the disease organism for all their lives. Geographic areas of infection may persist for years.

Hemorrhagic fever (Korean hemorrhagic fever) and Hantavirus ("Sin Nombre" virus).

Hemorrhagic fever, of various Hantavirus origins, is found world-wide in many rats and field rodents, depending on location. Similar to choriomeningitis, infected mice shed the viruses in their urine, feces, and saliva and human infection seems to occur by direct contact with rodent debris or by inhaling air-borne dust particles contaminated by infected rodent excreta. Human Hantavirus mortality rates can be as high as 60 percent. Various centers of Hantavirus have been identified in this country, one of the last being for "Sin Nombre" virus in 1993 in the Four Corners states of Arizona, Utah, Colorado, and New Mexico. Since 1993, a number of additional human cases of Sin Nombre virus have appeared in 26 states.

II. Potential pigeon and bird-borne diseases

A. HEALTH HAZARDS

Many people become ill every year in the United States from diseases carried by pigeons, starlings, and English sparrows. Even healthy birds can pass on diseases to humans and domestic animals. Pigeons and bird roost sites are known sources of infection when dust is stirred up during cleaning or demolition. When pigeons roosts or nests are located near intakes for ventilation or air conditioner vents, disease organisms may be picked up and blown around inside buildings. A few of the diseases that may be transmitted to man by birds include:

- Ornithosis (psittacosis in parrot-like birds) is much publicized and, similar to viral pneumonia, is transmitted to man through infected feces or

respiratory droplets. Surveys show 30 to 75 percent of the birds in pigeon flocks may be infected without visible effects.

- Histoplasmosis (Histoplasma capsulatum) is a sometimes fatal respiratory disease contracted from a fungus that grows in dried bird droppings; it causes respiratory disease, ulcers, and anemia. About 5,000 persons/year in US are hospitalized for histoplasmosis infections and about 800 die.

- Cryptococcus (Cryptococcus neoformans) is a fungus that has been traced to pigeon, starling, and bat manure. Cryptococcus is a yeast found in the intestinal tract of pigeons which grows on feces and becomes airborne as feces dry. Illness often begins as pulmonary disease and later affecting central nervous system; causing a form of terminal meningitis.

- Salmonellosis and toxoplasmosis. Salmonella typhimurium (salmonellosis) causes food poisoning and disease organisms are found in substantial numbers of pigeon, starling, and sparrow flocks. Both Salmonella and the protozoan, Toxoplasma gondi (toxoplasmosis), are found in birds and can be transmitted to man by way of dusts coming into structures through ventilators and air conditioners. The dusts contaminate food and food preparation surfaces in homes and restaurants.

- Encephalitis is found in many bird species, including pigeons. These are a group of central nervous system diseases transmitted to man from birds by way of mosquitoes.

- Other diseases carried by birds and transmitted to man but of lesser importance include: Newcastle's disease, aspergillosis, thrush (Aspergillus fumigatus, Candida albicans), pseudo-tuberculosis (Pasteurella pseudo-tuberculosis), avian tuberculosis (Mycobacterium tuberculosis var. avian), pigeon coccidiosis (Eimeria labbeana), swine erysipelas (Erysipelothrix rhusopathiae) trichomoniasis (Trichomonas gallina and Hemoproteus columbae).

B. STRUCTURAL DEFACEMENTS

Bird feces cause defacement and deterioration to buildings, sidewalks, structures, and masonry. Feces when mixed with rainwater form a corrosive acid that can severely damage steel, other structural fabrics, and even automobile finishes.

III. Potential insect-borne diseases

Various kinds of invertebrate pests occur in the park, some of which pose human health hazards:

Ants. Although ants can carry pathogenic bacteria and may spread diarrhea and salmonella, they are not normally important transmitters of many diseases. Harvester ants commonly sting persons who may stand near the mounds and some persons show allergic reactions to stings.

Bees and wasps. The Africanized honey bee is not as selective for nest sites as the European honey bee and may nest in holes, voids, culverts, abandoned rodent burrows, and even under rocks and flower pots. Colonies of paper wasps, hornets, yellow jackets, and other stinging hymenopterous insects are common pests around areas of human activity. Many people are highly allergic to bee and wasp venom and, often, people running to escape stinging insects are injured in tripping falls.

Centipedes and scorpions. Centipedes and scorpions often enter buildings through cracks under doors and in walls and both of these arthropods will bite or sting. Residents often show paranoid fears when large, desert centipedes are found inside buildings.

Cockroaches. Cockroaches become contaminated with pathogenic bacteria found in the moist, environments where they live (i.e., fecal Streptococci, Staphylococcus, Clostridium, Salmonella, and Proteus and organisms causing bacillary dysentery, typhoid fever, cholera, polio, amebic dysentery, urinary tract infections, and infectious hepatitis. The insects then stain foods, dishes, and utensils with their excrement, regurgitations, and fluids from scent glands. Some studies indicate cockroaches could transfer disease agents into the environment where they live and to human foods, but the role of the cockroach as a vector for pathogens remains controversial. Cockroaches were compellingly implicated in one study as a causative agent for the spread of infectious hepatitis in a housing complex, but, it seems, the insects have never been clearly proven to be directly responsible for transmitting other diseases to humans. For more discussion, see Koehler et. al., 1990, item XII. REFERENCES in the IPM Plan.

Persons, particularly young persons, continually inhaling aerosol particles produced by cockroaches (dusts from egg cases, feces, and body parts) have been known to develop sometimes serious allergies and asthma-like symptoms.

Conenose bugs. Conenose bugs feed on blood and sometimes bite persons sleeping in bed. The conenose has been known to carry equine encephalitis virus and Chagas' Disease is carried by other bugs closely related to conenoses.

Dermestid (carpet) beetles. Dermestid (carpet) beetles are not normally important disease carriers, but persons ingesting or inhaling the hairs from larval carpet beetles can show allergic reactions (urticaria, conjunctivitis, nausea, respiratory tract irritations). The feeding habits of beetles (on dead organisms) may allow beetles to be incidental vectors for other diseases.

Fleas. Fleas leaving rodents and other mammals may carry plague, murine and endemic typhus, tularemia, tapeworms, brucellosis, and various other diseases. Persons continually inhaling house dusts contaminated with flea body parts may show allergic reactions.

Flies. Flies are well known disease carriers and, because of their biology and feeding habits, can potentially vector such human diseases as typhoid and paratyphoid fevers, cholera, dysentery, and parasitic worms.

Mites and ticks. Mites and ticks are important disease carriers, among which are relapsing tick fever, scabies, Rocky Mountain spotted fever, Colorado tick fever, typhus and scrub typhus, various human allergies, Lyme disease, tularemia, and tick paralysis.

Spiders. Only a few of the relatively common spiders are poisonous; however, many people show an excessive and paranoid fear of all spiders which has resulted in personal accidents. Contact with the body hair of spiders can result in various human allergies.

Other hazards

Many insects, including ants and cockroaches, will damage paper and other organic goods and are attracted to electrical circuits. They often enter the circuits and cause failures in pumps, motors, relays, security and fire alarms, and other equipment and the result of their activities could cause damage, injury, or health hazards.

APPENDIX III

INSPECTION AND MONITORING GUIDELINES AND SAMPLE FORMS

INSPECTING AND MONITORING GUIDELINES

More than anything else, integrated pest management (IPM) methods depend on "inspection and monitoring". These activities identify the conditions (including exclusion and sanitation) and/or activities that explain the occurrence and trends of pest populations and provide direction for control.

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

- **"inspecting"** refers to the initial discovery of pests or conditions supporting them, and
- **"monitoring"** refers to watching or measuring changing conditions over time to quantify whether pest populations or conditions supporting pest occurrence are static, decreasing/improving or increasing/worsening. The need for continual monitoring and prompt discovery of pests, especially insects and rodents, is urgent because populations can rapidly increase over just a short period of time and, when numerous, require significantly more effort, time, and expense to control.

Even though inspecting and monitoring may have different purposes, both activities deal with similar things. This Appendix makes an effort to generally outline the kinds of things to look for and to document on pest inspection and/or monitoring forms.

I. GENERAL GUIDELINES

To be effective, pest control should never begin with pesticides but rather with inspections to find the sources, kinds, and extent of infestations. There are always good reasons for every infestation and these must be discovered.

Inspections (and monitoring) for pests and pest damage should concentrate on obtaining information on:

- Existence, extent, and severity of pest infestations
- Locations of pest harborage, food, water, and activity areas
- Reproductive, life history, and behavioral information on pests
- Finding the safest and most appropriate control strategies, as based on site limitations

II. RODENT INSPECTIONS / OUT-OF-DOORS

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

Key rodent signs or deficiencies that should be noted during outdoor rodent inspections are many. Look for fresh burrowing activity, the presence of runways, damaged plants, etc. Document any poor condition of structural foundations, vents, subfloor crawlspaces and doors, door sweeps, porches, and windows allowing rodents access into buildings. Look for rodent activity where garbage disposal and transportation practices are poor. 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 1/4 inch mesh hardware cloth or similar exclusion device. Note any standing water, leaking pipes/hydrants, or poor grade conditions around buildings. Look for "vegetation ladders" allowing rodents 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 rodents in outside locations involves:

- Regular, documented, analysis of rodent activity and sign by means of visual observations, trapping, and burrow surveys.
- Maintaining weather records (i.e., water content in winter snowfall, precipitation, etc.) as early-warnings for climatic conditions favoring unusual plant growth that controls 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 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.

III. RODENT INSPECTIONS / INDOORS

Effective management of rodents inside structures is based on one very critical rule: **rodents must be prevented from entering structures**. A very recent Center for Disease study (Glass, et. al., in press) found rodents in rural cabins and mobile homes commonly move from outside habitats into structures to then back outside again. Interior infestations were reduced by more than 90 percent by increasing the standards of construction methods and maintenance. Rodent inspections and monitoring must first be keyed on finding those points of entry.

Rodent populations. Good information on the kind, distribution, and approximate size of a rodent population inside a building is necessary before initiating rodent control programs. Rodent control will only be effective where inspections uncover and correct structural deficiencies supporting rodent infestations: open points of access or movement between rooms, careless sanitation and garbage management practices, and inappropriate storage conditions. Pre-control inspection and monitoring data is used to as a base-line against which post-treatment results are compared to record the effectiveness of control efforts.

Exterior inspection. Both exterior and interior inspections are best performed by beginning at an identifiable point on the exterior of the building and methodically progressing around it to find evidence of pests or open points of pest access.

Interior inspection. Similar to exterior inspections, begin in an identifiable point on the interior and methodically progress along each wall and through all rooms to completely search out all possible points of rodent entry or elements supporting their presence. A sample data sheet for recording inspection data appears in the Appendix of this IPM Plan and should be used to list such inspection findings. Also, refer to methods used for indoor insect inspections noted below.

Rodent sign. The presence of rodents produces a variety of signs and these can be used for making subjective determinations on the size or occurrence of populations. Signs are often found throughout a building in/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. Various of the common signs of rodents to look for during inspections include:

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

- **Sounds:** Sounds of rodents gnawing, scratching, squeaking, or running in walls and across ceilings.

- **Droppings:** Rodent feces occur in proportion to the number and type of rodents present and how long they frequent a given place. Periodically vacuuming rodent debris in an area will give information on relative pest use during an elapsed time interval. Prior to vacuuming, disinfect the area for hantavirus, then use a high efficiency particulate (HEPA) vacuum to provide additional protection to the cleanup crew.

- **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, the key to using UV light is the ability to recognize stain patterns. 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.

- **Feeding stations:** Many rodents pick up food and carry it to what they consider is a safe place to eat it, usually in a protected corner. A greater abundance of feces and urine deposits will be seen in these areas. Also often seen are remnants of foods (candy wrappers, nut shells, etc.) they have carried there and these suggest food sources that should be inspected. Feeding stations are good places to trap rodents.

- **Smudge marks:** Dirt and oil on a rodent's fur leave smudge marks where they rub against pipes, beams, and openings. Once these areas are cleaned, the next monitoring session will show if rodents are still using them.

- **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, corn starch, flour, or talc) can be used on floors inside of buildings to verify the presence, activity routes, and relative abundance of rodents. Tracking patches are up to 150 percent more effective for rodent monitoring than snap traps.

- **Bait Consumption:** Before an inspection, carefully measured quantities of non-toxic baits (oatmeal mixed with peanut butter) can be placed in areas of suspected rodent activity. Measurements made during the inspection give an estimate of the amount of food eaten. These data, however, can easily misrepresent the size of a rodent population because rodents have the tendency to move more food than they eat and store it in hidden food caches.

- **Odor:** Musky rodent odors can be detected in well-established and large infestations, 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 enlargements to 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 a structure 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 strong interest in a wall or floor area when rodents are present, this is especially true when rodent invasion is recent.

IV. USE OF TRAPS FOR MONITORING RODENTS

When monitoring for rodents inside buildings, be sure a sufficient number of monitoring traps are placed along all rodent travel routes and in all probable areas of harborage. Two traps should be placed at each trapping station and stations located every 10 to 20 lineal feet along walls. Place traps adjacent to one another with the triggers pointing in opposite directions or towards 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.

Kind traps

Indoors, snap, sticky, and multiple-capture traps are used to monitor for mice and rat-sized snap traps or sticky traps are used for larger rodents.

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 (see Sources in the Appendix) and may catch rodents that can not be caught in snap traps. Rodents, seeking shelter or food, enter traps but are unable to leave. Often, cannibalism of one rodent by another may be evidenced. Some multiple capture traps can hold up to 30 mice without being emptied.

Multiple capture traps are best used in runways where rodent activity is high or in locations difficult to monitor with snap traps. Rodents that die from exposure or hunger in multiple-capture traps may cause odors and attract insects.

Sticky traps: Sticky traps are flat boards or trays coated with glue. Rodents become stuck on them and can not escape. Some models are more effective for mice than larger rodents and other traps are specifically designed for rats.

Sticky traps must be frequently inspected and replaced after capture of a rodent and before the animal begins to decay. Frequently, live animals are found on traps and can present a biting hazard to the person collecting the trap.

Use and placement of sticky traps are similar for snap trapping. Baited or un-baited sticky traps are placed in runways and other areas of rodent activity. Sticky traps often catch rodents that cannot be caught in other kinds of traps.

V. INSECT INSPECTIONS INSIDE BUILDINGS

Once insects invade a structure, control requires considerable time and can be very difficult and expensive because small, residual populations can survive under even the most sanitary of conditions. Given opportunity, latent, residual populations may suddenly explode into major problems.

Because the rooms in most buildings share adjoining attics, crawlspaces, pipes, and other connections, serious insect problems in a structure usually demands application of an intensive control program throughout the entire building. Only one untreated room can supply insect pests to all other rooms.

Inspections that find the sources of insect infestation and focus corrections on good exclusion, increased sanitation, and thorough building cleaning will generally control most insect problems.

Prompt discovery: It is important to discover insect infestations as early as possible because of the adaptability of these organisms and their high capacity for reproduction.

Exterior inspection: It seems better to begin with an inspection of the building exterior to be able to discover the presence of problem insects and the ways they get into the building. This requires an thorough examination of all potential pest harborage (clutter, cracks, crevices, etc) and possible food sources (animal and human food, fabrics, insects in the soil and around plants, organic artifacts, etc.) while at the same time looking for the evidence of insects, the various and (usually) many structural deficiencies allowing insects to enter, and careless sanitation or storage practices. Specific to ants and other crawling insects, look for "vegetation ladders" (plants overhanging or leaning over buildings). Once found, deficiencies should be prioritized for repairs. Until a building is made tight, pest management efforts will never be effective.

Interior inspection: Following the exterior inspection, inspect the building's interior. This requires the same thorough examination for all potential food sources, possible harborage sites, evidence of insects, and structural deficiencies or cultural practices plausibly supporting pests or allowing them access.

Because there are so many different kinds of insect pests (many very small in size) with different biology and requirements, inspections must be very thorough and the inspector must be exceptionally familiar with the expected species and their preferred habitat. Because of the apparent size difference between rodents and insect pests, inspecting for insects demands an examination of smaller and more hidden areas (i.e., cracks and crevices, voids, etc.). A premier-grade flashlight should be used in all pest inspections to help be able to see adults, larvae, shed larval skins or feces, and to evaluate harborage conditions.

Signs of an insect pest infestation can include a great number of things: shed skins; feeding debris or frass; exit holes; feeding holes; hair falling from fur/pelts; mats of fibers; silken tubes/cases; moth or beetle pupae; flying adult or crawling larval insects; evidence of live or dead insects on window ledges; damaged organic objects (i.e., fabrics, hide, fur, horn, silk, etc.); infested or damaged food or food packaging; insects captured in pheromone, sticky, or light traps or in ceiling light fixtures; being able to flush insects out of hiding with chemicals; and debris found in vacuum bags.

Procedures: Some of the applicable methods for an inspection include:

Traps. Place sticky, light, electrocutor, or pheromone traps in areas where they will attract and capture flying or crawling insects and check the traps on each visit (follow manufacturer's recommendations for placement). Pheromone traps are an excellent means for early detection of infestations since they capture certain insect pests that are specifically attracted to given chemical odors. Pheromone traps, however, should not be considered "control traps". Sticky, light, and electrocutor traps are not selective for species caught and most are not used for control purposes either. All 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 control measures.

Identify all captured insects and keep records of the numbers, locations, and time interval over which they were caught.

One innovative method for using insect sticky traps for some difficult-to-catch insects is to place them sticky side down on 1/16 inch spacers (such as small coins) which keep them separated from the floor. Traps set in this manner capture crawling insects seeking refuge in small cracks.

Finding harborage. Use a flashlight to visually inspect small cracks, crevices, and all other possible insect harborage. Cracks and voids can also be inspected with a flushing agent (2 percent pyrethrum, requiring NPS approval) which forces insects out of hiding. Information gained from inspections is used to key in on the presence or foci of insect activity.

Commonly overlooked sources of insect harborage may be under drawers, in cabinets and furniture; in attics or store rooms where rodents or other animals store food crumbs, pet food and bird seed containers; inaccessible wall voids where dead animal carcasses may be located; and near the motors of electrical equipment (including computers).

Locating moisture. Carefully inspect damp crawlspaces, plumbing lines, and drain traps which may contain slime, lint, or other potential insect food materials and which attract fungus-feeding beetles, flies, mites and other pests. Before controls can be effective, all sources of possible moisture sources for insect pests must be located and corrected.

Inspect areas around water coolers and fountains, dehumidifiers and humidifiers, pipes, and aquaria for spilled or condensed water. Also check boiler rooms, floors, and ceilings for water leaks; ask custodians where they have seen water leaks or had insect problems. Use a moisture meter to inspect walls and floors for moisture content and to identify leaking pipes or find areas that may attract or support insects, mold, or fungus. It is best to remove potted plants from offices, museums, and curatorial areas. If plants must remain, assure they are not over-watered. Look for insects in the soil, along the edges of pots, and under plates holding potted plants. Insects are often found under rugs close to water coolers as well as in motor and condenser housings. Inspect areas where water bottles are stored; some bottles may leak or be brought into the building in wooden crates which import pests or provide moisture or harborage to insects. Verify that condensation does not form, run off, or puddle under windows in cold weather. Check for residual moisture or puddles of moisture near boots and overshoes during winter and for water puddles left near entryways and in closets. Verify label and stamp moisteners and postal meters do not provide moisture to insects. Fish tanks and other open water sources should be covered tightly and not be located where they will attract insects. Check to see that rest rooms, sinks, drinking fountains, and coffee rooms do not provide condensed moisture on cold water lines.

Available food. Be sure employees do not store candy, sugar, fresh fruit, snacks, etc. in office desks and cabinet drawers. There should be no human foods used at all in curatorial areas and museums; if there is, educate the appropriate personnel so that the practice stops. Do not store empty aluminum cans indoors before they are moved to recycling stations.

Advocate regulations preventing visitors from bringing foods into museums. Check to see that interior floors are thoroughly vacuumed every day and that custodians notify supervisors where pests, evidence of pests, or food scraps are found. Keep garbage cans tightly covered; remove garbage from the building every night; frequently wash garbage cans.

Storage conditions. Be sure all items prone to insect infestation or which could give pests harborage are stored on shelves or platforms and 6 or more inches off the floor (this is an accepted standard for museum storage). This eliminates pest harborage beneath 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 monitoring traps.

Handling incoming goods. Inquire about inspection practices for items brought into buildings, museums, or curatorial areas (i.e., supplies, equipment, boxes, wooden pallets, specimens for acquisition, etc.). All incoming goods should be carefully checked for possible pests and, if infested, rejected or quarantined and then sterilized (deep-freeze, heat, fumigated, or by other means). Be sure directions state to place infested items in a polyethylene bag and tightly seal the bag. Label the bag and keep it well separated from collections or supplies until it can be determined that materials are pest-free.

Infested museum items. Any items in museum collections found to show signs of active pest infestations should be immediately removed from display or storage and isolated and treated. Following removal, the items and area surrounding the infestation should be inspected and treated by appropriate means.

Occasional insect invaders. It is important to emphasize that finding outdoor insect pests inside a building (accidental pests) demonstrates exclusion is inadequate and should trigger efforts to find and prevent their entrance.

Stinging insects. Monitor the number, relative size and aggressiveness, and location of stinging insect colonies near, in, or on structures (honey bees, paper wasps, yellow jackets, etc.). Especially watch to see that honey bee colonies do not develop sudden or unusual aggressive behavior, suggesting "Africanized" traits.

Other. Other information indicating the presence or abundance of pests in a building is usually easily obtained by questioning the staff, from random and un-announced inspections, or night-time inspections.

VI. BIRD AND BAT INSPECTIONS / EXTERIOR

Birds and bats enter buildings for nesting/roosting or when outside

conditions become too harsh. Keeping birds and bats from being attracted to/using buildings can be very difficult but is necessary to prevent accumulations of bird-associated debris and feces and to keep their ectoparasites from entering buildings.

Carefully inspect the eaves, roofs, gables, and other structural building elements for the presence of birds, bird nests, and bird and bat roosting sites. Verify that chimneys have bat-proof caps and roof vents are screened with woven hardware cloth (1/4 inch mesh) to keep birds from using them as entry ways into the building or as nesting sites. Look for small (1/4 inch diameter) holes around soffits, eaves, and attics to prevent birds, bats, or other animals out of attics or spaces between walls. Be sure that exterior garbage cans are in good condition, kept clean, and that disposal practices are appropriate. Be sure that visitors or employees are not feeding the birds, water sources are not available to animals, and grounds around buildings are free from debris or stacks of items. Plastic bird netting is an effective measure to exclude birds from alcoves, porches, and attics.

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

VII. LARGE MAMMALS / EXTERIOR

The presence of larger vertebrate animals (i.e., skunks, raccoons, rabbits, porcupines, ringtail cats, foxes, feral dogs and cats, etc.) encourages various other common pest problems and possible damage. Inspecting 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, remove them by trapping and then securely close 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.

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

Carefully inspect structural exteriors for all possible openings and to see that chimneys are screened.

CHECK LIST FOR MONITORING

TYPE OF APPROACH	ACTION SUMMARY
INSPECTIONS AND MONITORING	
INSPECTIONS	● Carefully inspect all park buildings at least twice a year; see attached Inspection Sheet. ● Correctly identify pest animals to Genus and, if possible, species.
MONITORING	● Monitor outdoor rodent activity twice a month from February through April, once a month from May through September, and twice a month from October until rodents hibernate. Document active rodent burrows, numbers of animals seen, damage done by predators, conditions of vegetative cover, etc. ● VISITOR CENTER: Monitor the Visitor Center continuously with sticky and snap traps. Visually monitor the Visitor Center once a month throughout the year. ● Monitor other buildings to assure rodents do not have access to wastes. ● Monitor rainfall and/or water content in winter snow and other climatic factors tending to increase rodent populations. ● Record the numbers, times, and locations where dead animals are found; inform the state Department of Health of findings. ● Continually monitor for the presence of other animals and insects: snakes, stinging insects, predators, carpenter bees, termites, etc. ● Compare monitoring results with established Action Thresholds and take proper actions. ● Once or twice a year, make photo point records of selected areas susceptible to pest damage. ● Monitor for rodents with numbered traps placed around areas of high activity; check traps daily and record catch data on forms and on diagram maps. ● Periodically review trap catch data from records to see where most pest problems occur and determine if pest problems are being reduced by current actions.
CULTURAL /MECHANICAL / PHYSICAL CONTROLS	
FOOD AND WATER AVAILABLE TO ANIMALS	● Be sure all garbage cans are rodent proof and equipped with a tight fitting lid. ● Remove all garbage from the Visitor Center and, if possible, grounds every night. ● Regularly steam clean the interiors and exteriors of garbage cans. ● Regularly monitor all plumbing for leaks and ground depressions that may accumulate water and promptly repair or fill. ● Do not store empty aluminum cans, garbage, or other rodent attracting items where rodents can gain access to it; provide secure utility buildings for storage. ● Do not place bird or pet feeders where they attract rodents.
EXCLUSION	● Seal all holes, cracks, and gaps in walls and foundations of buildings that support pest access or harborage. If necessary, place wire guards around building foundations or into existing rodent holes and seal with caulking.
RODENT HARBORAGE	● Seal or eliminate all cracks, holes, and crevices in walls, foundations, and in/under rocks, etc. to reduce possible harborage sites. ● Promptly trap animals and seal all burrows closed with soil; apply repellents as needed. ● Stack lumber and other necessary materials on racks 12 to 18 inches off the ground and with no vegetation beneath them; place other exterior storage on high pallets or otherwise off the ground. ● Eliminate or reduce piles of soil and rubble from the grounds. ● Promptly control all rodent burrowing along walls and foundations to prevent animals from becoming established
LIGHTING	● Minimize exterior lighting or use high-pressure sodium lamps to prevent attracting insects which can become food for rodents.
POPULATION CONTROLS	● On the basis of monitoring data, compare numbers of rodents of various species present during early spring with Action Threshold values and, if justified, reduce the number of adults by appropriate means before they reproduce. ● As justified by Action Threshold values, trap gophers during early spring and late fall and securely close their burrows. ● Promptly remove stinging insect nests (including harvester ants) that are within or close to visitor use areas.

TYPE OF APPROACH	ACTION SUMMARY
VEGETATION AND GROUNDS	● Keep all vegetation clipped very short around walls and foundations; trim all shrubs and trees back away from walls and foundations. ● If possible, trim out thick bases of shrubs that provide rodent harborage. ● Remove exotic tap-rooted plants and other weeds that attract gophers. ● If at all possible when removing vegetation, do not disturb the surface of the ground so as to avoid a disturbed area where new seed will become established ● Use stone rather than organic mulches around ornamental vegetation. ● Check for and correct any leaking pipes or other water accumulations. ● Prohibit all animal feeding on the grounds.
ENVIRONMENTAL	● If possible, remove any unnecessary structures that provide shade or other protection to rodents
OPERATIONAL	
GUIDELINES	● Establish written guidelines for pest control activities. ● Make information on IPM and pest control easily accessible to staff. ● Schedule monthly or bi-monthly meetings between IPM Coordinator, Chief of Maintenance and others where pest problems exist to discuss IPM concerns. ● Maintain good inspection and monitoring logs including information on where and when pests were captured. Evaluate records at least yearly. ● Assure sufficient funds and manpower are available for the IPM program.
TOXICANTS	● Obtain NPS approval and recommendations before using any toxicants (insecticides, rodenticides, herbicides, etc.)
POSITIONS	● Fully describe IPM duties of the IPM Coordinator in the Position Description. ● Prescribe a given percentage of time for the IPM Coordinator to fulfill IPM duties.
TRAINING	● Assure all persons working with dead or live rodents or other animals are trained in those activities and fully aware of potential health and safety hazards and wear proper protective equipment. ● Assure the IPM Coordinator has adequate training and management support.

INSPECTION AND MONITORING FORM

DATE: _____

INSPECTED BY: _____

GROUNDS AND EXTERIORS

This list is a reminder of things to look for during inspection/monitoring; however, do not neglect to watch for other things supporting pests.

1. **TRASH CANS:** Location(s)? Plastic can liners? Regularly emptied? Cans regularly washed/cleaned? Can bottoms under plastic liners clean? Can bottoms with holes? General can conditions? Lid conditions? General sanitation around cans? Food-waste only in special cans? Schedule for emptying?
2. **TRASH DUMPSTERS:** Dumpster locations at distance from building? Clean? Regularly emptied? Regularly steam cleaned? Lid conditions? Secure against rodent entry?
3. **FOOD:** Evidence of animals being fed by people? Other sources of animal food seen?
4. **EXCLUSION:** Buildings tightly sealed? Vehicles parked in rodent-proof garages? Fences/walls tight? Wires into building pests could travel on? Attics/crawlspaces screened? Foundations protected by concrete or wire curtain wall? Chimneys/vents screened? Door sweeps tight? Window/door frames in good condition?
5. **WATER:** All pipes/downspouts/gutters in good condition, not leaking? Standing water near/around facilities? Evidence of animals using water sources? Erosion problems? Grade against buildings? Peeling paint? Roof edges in good condition?
6. **HARBORAGE:** Cracks and crevices in walls? Flaking mortar from adobe? Rodent harborage under nearby rocks/storage? Debris on ground supporting/attracting animals? Weed-free area around buildings?
7. **LIGHTS:** Type and location? Evidence of live/dead insects around lights? Rodent evidence?
8. **VEGETATION:** Plants that attract rodents? Foundations and wall bases with weed-free zone? Vegetation touching/overhanging building? Wall bases clear and trimmed close to ground? Tap-rooted plants present to attract gophers? Hazard trees?
9. **SANITATION:** General cleanliness? Rubble or stored items near or adjacent to buildings? "Bone yard" neatly arranged, storage up off ground? How are building materials stored? Presence of pests?
10. **ANIMALS:** Open burrows and locations? Gopher burrows in visitor use areas? Active animals seen? Young animals? Dead animals? Raptors? Predators? Ant nests? Wasp/stinging insects? Evidences of pest infestations? Factors contributing to continued pest presence? History of animals present and types?
11. **GENERAL BUILDING CONDITION:** Type of construction material? Shade available for rodents?
12. **PHOTO RECORDS:** Pictures made?

NOTES

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2.	_____

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9.	_____

10.	_____

11.	_____

12.	_____

XXXX NATIONAL PARK - Location of trapping site: _____
INSPECTED BY:
WEATHER:
GENERAL ANIMAL EVIDENCE (Gnawing, tracks, feces, damages, etc.)
HOLES or BURROWS FOUND: ☐ YES; ☐ NO. SEVERITY OF DAMAGE AND ACTIONS TAKEN (Mark locations on map on reverse)
EVALUATIONS: Locations (map grids):
WOOD DESTROYING PEST INFORMATION: Results of soundings or moisture test of wood:
PESTS SEEN, ACTIVITIES, LOCATIONS:
TRAPS SET _____; # SPRUNG WITHOUT CATCH _____; # CAUGHT _____; CATCH SUCCESS RATE: _____%

TRAP LOCATIONS, SUCCESS, BAIT, SPECIES (Use grid locations from map)																	
GRID LOCATION																	
SPRUNG/ CATCH																	
BAIT																	
SPECIES																	
PHOTO RECORDS MADE: ☐ YES; ☐ NO; SITE NUMBERS/DESCRIPTIONS: _____ (Continue on reverse, if necessary)																	

STANDARD ABBREVIATIONS:

ABBREVIATIONS	BAITS	SPECIES
B = BURROW D = DAMAGE R = RUNWAY S = SCAT T = TRACKS Sp = SPRUNG Cp = CAPTURE Pp = PHOTO POINT	G = GRAIN CO = COTTON PB = PEANUT BUTTER	RS = ROCK SQUIRREL M = MOUSE B = BADGER RT = RINGTAIL

EXAMPLE SCHEDULE FOR EXTERIOR ACTIVITIES
(must be modified to fit specific areas)

EARLY SPRING	FEB-MAR	● First annual general building inspection; schedule repairs. ● Compare current and last years' inspection/monitoring data ● Assess burrowing squirrel populations; reduce by 50 to 75%, if necessary; close burrows. ● Spring control of harvester ant colonies in visitor use areas ● Monitor effectiveness of rodent controls ● Spring trapping control of gophers, if necessary ● Make photo point records ● Record plant and animal phenological observations
LATE SPRING and SUMMER	APR-MAY (young ground squirrels come up) and JUN-AUG	● Remove wasp and stinging insect nests while small; watch for carpenter bee activity ● Control harvester ant colonies in visitor use areas ● Monitor mouse activity near buildings; begin trapping if necessary ● Monitor previously closed ground squirrel burrows; re-trap if necessary ● Monitor ground squirrel numbers ● Monitor damage to buildings/grounds and weed growth; schedule repairs ● Monitor for proper sanitation around garbage ● Record plant and animal phenological observations ● Evaluate monitoring records
FALL	SEP-OCT	● Second annual general inspection of buildings; schedule repairs ● Monitor ground squirrel numbers before hibernation ● Monitor damage to buildings and weed growth around walls; schedule removal ● Make photo point records ● Monitor for proper sanitation around garbage ● Trap gophers, if necessary ● Record plant and animal phenological records
WINTER	NOV-JAN (ground squirrels go into hibernation)	● Fall-winter trapping control of gophers, if necessary ● Fall control of harvester ant colonies in visitor use areas ● Record plant and animal phenological observations ● Evaluate inspection and monitoring records in preparation for coming year activities

STRUCTURAL / INTERIORS

This list is a reminder of things to look for during inspection and monitoring; however, do not neglect to watch for other things supporting pests.

1. **WINDOWS:** Tightly sealed, glass complete, screens in good repair? Opened regularly? Pests between folds of curtains or drapes? Frames intact?

3. FACILITY AREAS:

MECHANICAL ROOM: Free from debris or water? Cracks or crevices in walls? Openings directly to outside? Vent traces sealed? Suspended ceilings? Pests in dust collectors and central vacuum systems? Door sweeps too high?

ELECTRICAL ROOMS: Conduits and lines open or sealed? Holes, cracks, or crevices in walls? Openings directly to outside? Suspended ceilings? Pests inside seldom-used equipment? Door sweeps too high?

CUSTODIAL CLOSETS: Cleanliness? Personal item storage? Food stored/consumed here? Walls, floors, sink areas with cracks, crevices, holes? Excessive long term storage of paper or supplies? Suspended ceilings? Mops off floor?

BOILER/STEAM ROOMS: Standing water? Holes in walls, floors, or ceilings? Pest evidence? What? Suspended ceilings? Door sweeps too high? Grates on drain?

4. **WATER SOURCES:** Standing water? All cracks, crevices, holes sealed? Pipe traces sealed?

5. MUSEUM COLLECTION STORAGE: How often inspected? Cracks, crevices, holes in walls, floors, ceiling? Temperature and humidity monitored/controlled? Control on material moving in/out of storage? Inspect seldom used storage areas, out-buildings, old books. Continual pest monitoring? How? Who? Doors/windows seal tightly? Storage on floor? Air conditioner sealed? Procedures for pest identification, isolation, preservation, record keeping? Suspended ceilings?

6. **GIFT AND ACQUISITION AREA:** Procedures for de-infesting new acquisitions/gifts? Regular inspection for pest infested materials? Isolation from primary collections storage? Route materials take to enter area? Specific unpacking area away from primary collections area? Suspended ceilings? Storage conditions?

7. **INTER-LIBRARY LOANS:** Procedures for examining incoming materials? Identify pests/damage? Isolation of suspected books? Food, beverage, etc. present? Suspended ceilings?

8. CONSERVATION LABORATORIES AND PRESERVATION

OFFICES: Separated from collection storage and other areas?
Treatment area present? Insect identification collection?
Maintained pest free and in pest-free drawers/containers?
Suspended ceilings?

1. _____

2. _____

3. _____

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APPENDIX IV

EXAMPLES OF PLANT AND ANIMAL PHENOLOGICAL OBSERVATIONS

Over time, observations of plant and animal phenological events can be very helpful. They can indicate when to expect pest problems and when to schedule management actions. The following are some examples of how such data might be recorded and used.

EXAMPLES OF PLANT AND ANIMAL PHENOLOGICAL OBSERVATIONS
(to be verified with site-specific observations)

PHYLUM	EVENT	ITEM TO RECORD	DATES OBSERVED
PLANTS	LEAF OUT	• Cottonwood • Dandelions • Lilacs • Willows • Chinese elm trees • Various fruit trees • Rabbitbrush • Russian olive trees • Locoweed • Black locust trees	
	BLOOM		
	FRUIT SET		
	LEAF FALL		
ANIMALS	APPEARANCE IN SPRING	• Various species of ground squirrels • Various lizard species • Skunks • Deer • Swifts and swallows • Grosbeaks • Hummingbirds • Chukar • Bluebirds • Tent caterpillars	
	BREEDING		
	APPEARANCE OF YOUNG		
	HIBERNATION		
OTHER	MONTHLY DATA	• Average temperature • Average precipitation (inches of water) • Number of overcast days • Number of visitors in the park • First/last snowfall • Highest/lowest temperatures	

PHYLUM	EVENT	ITEM TO RECORD	DATES OBSERVED
ACTUAL, ABBREVIATED DATA FROM A SOUTHERN UTAH PARK AREA			
<u>COMPARATIVE</u> <u>EXAMPLES</u>	JANUARY	- January thaw and warmer weather often occurs during the last 2 weeks of January as day length increases - High daily temperatures average 59-F, and low average 15-F; common maximum snowfall averages less than 3 inches and melts quickly.	
	FEBRUARY	- Thin leaf alder blooms in mid-February, just as adult rock squirrels start to become active; red-shafted flickers are seen more often. - Warm days in mid-month bring out spiny lizards and butterflies begin to be seen. Visitor travel and camping use doubles that of the previous month.	
	MARCH	- Spring rapidly comes in March but temperatures remain similar to those of early November with chances for snow being good. Low temperatures average about 64-F, and nights about 55-F. - Sometimes a few early spruce blooms are seen along south facing cliffs and cottonwood catkins begin to emerge during the 1st week of the month but will not mature until next month. - Striped skunk activity increases and spiny and side-blotched lizards begin to show increased activity on warm days and <u>lizards</u> are beginning to lay their first clutch of eggs. Beaver are breeding. Chukar coveys begin to break up and breeding calls are often heard. - March travel about doubles that of February.	
	APRIL	- Average high temperature is about 68-F, and lows about 37-F. - Yellow clover begins to emerge early in month; asparagus spears are abundant by the 3rd week of the month. - Penelope shrikes are active at nest sites. During the 1st week of the month, tent caterpillars begin to be seen, hummingbirds return, and young mammals begin to become active, bumblebees begin to be seen, and a few snakes are found along roads. - Rock squirrel young emerge during the second week of the month, about the time tree lizards leave hibernation and as <u>lizards</u> are laying their second clutch of eggs. Chukar females are carrying shelled eggs. - April travel about doubles that of March.	

AN EXAMPLE AND PRESUMPTIVE PHENOLOGY OF BURROWING RODENTS

(to be verified with seasonal observations)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
ROCK SQUIRRELS (or other common animals in a given park)												
ADULTS			Males emerge	Females & yearlings emerge, breeding	Breeding	Breeding	Breeding ends		Males begin to hibernate	Females begin to hibernate		
YOUNG					Young born but remain in burrows		Young emerge and begin to disperse				Young hibernate	
OTHER KINDS OF GROUND SQUIRRELS (or other common animals in a given park)												
ADULTS			Adults emerge and breed						Adults hibernate			
YOUNG				Young emerge								

SHADED PORTIONS INDICATE POTENTIAL CONTROL TIMES

- CONTROL OF ADULTS (EARLY SPRING) REDUCES CURRENT YEAR'S DAMAGE, NUMBERS OF YOUNG PRODUCED; CRITICAL TIMES FOR REDUCTION ARE:
 - MARCH THROUGH MAY FOR ROCK SQUIRRELS
 - FEBRUARY THROUGH MARCH FOR GROUND SQUIRRELS
- CONTROL OF DISPERSING YOUNG REDUCES NEXT YEAR'S BREEDING CROP AND PREVENTS HOME RANGE ESTABLISHMENT; BEST TIMES ARE:
 - JULY THROUGH OCTOBER FOR ROCK SQUIRRELS
 - MAY THROUGH AUGUST FOR GROUND SQUIRRELS

APPENDIX V

COMMON PESTICIDES (NAMES AND FORMULAE)

COMMON PESTICIDES (NAMES AND FORMULAE)

Abamectin (see macrocyclic lactone glycoside)

Acephate (Orthene): 0, S-dimethyl acetylphosphorothioate; organic phosphate; contact/systemic poison; LD₅₀ 866-945 mg/kg; **Caution label**; some formulations are designated as Restricted Use; low vapor pressure; high water solubility; residual 6-9 days; 1/2-life in soil 11 days; 5-10% degrades into methamidiphos (more toxic); both rapidly excreted by mammals.

Afirm (see: macrocyclic lactone glycoside)

Allethrin (pyrethrin, bioallethrin, Pynamin, Pyrethrins, Sactrol, X-Clude, Pyrenone, Exciter, Kicker, Bio-allethrin, Esbiothrin): d-cis-and/or-trans-chrysan-themum monocarboxylic acids ester of di-2-allyl-4-hydroxy-3-methyl-3- cyclopen-ten-1-one); one of first synthetic pyrethroid (not a natural botanical but name shows similarity to natural pyrethrins in structure/mode of action); synthetic pyrethroid; contact/stomach/fumigant poisons; LD₅₀ 860 mg/kg; **Caution label**; ineffective in alkaline solutions, not compatible with lead, brass, copper, zinc, iron; non stable in sunlight. PT-565: can cause allergic reactions and skin/eye irritation.

Altosid (see methoprene)

Ambush (see permethrin)

Amdro (see hydramethylnon)

Amidinohydrazone (see: hydramethylnon)

Ammonium fluosilicate (see: silica aerogel)

Anti-freeze (see: ethylene glycol)

Avermectin-B1 (Affirm; see: macrocyclic lactone glycoside)

Bendiocarb (Ficam W, Ficam Plus, Ficam G, Turcam): 2,2-dimethyl-1, 3-benzodioxol-4-y1 methylcarbamate; carbamate; contact/stomach poison; LD₅₀ 46-150 mg/kg; some formulations are designated as Restricted Use; **Warning/Caution label**; rapid knockdown, good residual to 10 weeks; no odor. Becomes a dust as the carrier dries and dust gives good kill in bee/wasp nests. Not effective for German roaches (resistant).

Benlate (see benomyl).

Benomyl (Benlate): methyl 1-(butylcarbamoyl)-2-benzimidazole carbamate; benzimidazole; foliar fungicide; LD₅₀ > 10,000 mg/kg; toxic to fish. **benlate**)

Bioallethrin (see d-trans allethrin, allethrin)

Bioresmethrin (resmethrin, Scourge, Synthrin): (5-benzyl-3-furyl) methyl 2,2-dimethyl-3-(2-methyl-propenyl) cyclopropane carboxylate; synthetic pyrethroid; contact poison; LD₅₀ 7,070 mg/kg; **Caution label**; not stable in sunlight.

Biothrin (see: permethrin)

Borate (Tim-Bor, Bora-Care; see borax) borax derivatives

Borax (sodium tetraborate): inorganic; mild antiseptic/fungicide; LD₅₀ - 2660-5190 mg/kg; **Caution label**, not same as boron/boric acid, borax is much less toxic and not often used as an insecticide.

Boric acid: (Roach-Prufe, Roach-Kil, Perma-Dust) inorganic; contains boron; contact/stomach poison; LD₅₀ 2660; saturated solution is 2% boric acid; anti-fungal; persistent; small amounts of adjuvants (magnesium stearate, tricalcium phosphate) often added to prevent agglomerations, to improve flow, increase toxicity but also increase repellency.

Brodifacoum (Talon, Havoc, Klerat): 3-(3-(4'-bromo(1,1'-diphenyl)-4-yl)-1, 2,3,4-tetra-hydro-1-naphthalenyl)-4-hydroxy-2H-1-benzopyran-2-one; organocycloacoulantronicide; LD₅₀ 0.27 mg/kg; some formulations are designated as Restricted Use; **Caution label**; very toxic. Can cause nausea, vomiting, muscle pains.

Bromadiolone (Maki, Contrac, Bromone): 3-(3-(4'-bromo(1,1'-diphenyl)-4-yl)-3-hydroxy-1-phenylpropyl)-4-hydroxy-2H-1-benzopyran-2-one; organic anticoagulant rodenticide; LD₅₀ 1.125 mg/kg; **Caution label**, very toxic. Can cause bleeding, cardiac problems, neurologic symptoms.

Butacide/Butocide (see piperonyl butoxide)

Casoron (see dichlobenil)

Chlorobenzene: 1,1,1-trichloroethane; methylchloroform; a solvent, as ar. inert in pesticides, irritating to skin/lungs/eyes; may cause nervous depression, mucous membrane and upper respiratory tract irritation and contact dermatitis. Not a proven carcinogen but can cause mutations in living cells; National Cancer Institute says to treat with caution in workplace; EPA classifies as "potentially toxic." Used in pesticides and solvents.

Chlorophacinone (Rozol, Drat, Caid, Isotrac Tracking Powder, Liphadione, Microzul, Toptox): 2-(p- chlorophenyl)phenylacetyl)-1,3-indandione; anticoagulant rodenticide; LD₅₀ 20.5 mg/kg; Rozol has **Caution label**, some other formulations are designated as Restricted Use; very toxic, may be absorbed through skin.

Cholecalciferol (Quintox, Rampage, Vitamin D-3/Vitamin D-2): LD₅₀ 40-50 mg/kg; **Caution label**; rodenticide which creates a calcium imbalance in rodents and results in heart attack; no or minimal secondary poisoning dangers.

Clethodim (Select, Envoy): LD₅₀ (oral in rats) 1.4 mg./kg; **Warning label**; post-emergent herbicide; minimal risk to avian, aquatic, and mammalian species; no evidence of unacceptable

human health hazards. Clethodim is easily degraded by photolysis and aerobic microbial action; degradates are not persistent.

Combat (see: hydramethylnon)

Contrac (see: bromadiolone)

Cyfluthrin (Tempo, Baythroid, Optem): (cyano (4-fluoro-3-phenoxyphenyl) methyl 3-(2,2-dichloroethenyl)-2,2-dimethyl-cyclopropanecarboxylate; synthetic pyrethroid; contact/stomach poison; LD₅₀ 500-800 mg/kg; **Caution label**; fast acting.

Cypermethrin (Cynoff, Demon, Ammo, Arrivo, Barricade): (+/-) alpha-cyano-3-phenoxybenzyl (+/-) cis, trans 3-(2,2-dichlorovinyl)-2,2-dimethyl cyclopropane-carboxylate; synthetic pyrethroid; contact/stomach poison; LD₅₀ 247 mg/kg; **Warning label**; little more active than permethrin; fast knockdown, 4-week residual on livestock; for use in/on buildings.

d-Trans-allethrin (bioallethrin); LD₅₀ 425-860; **Caution label**

DDVP (see: dichlorvos/dichlorphos)

Deet (Off, Muskol, Cutters); LD₅₀ 1950-2000 mg/kg; **Caution label**

DEF - a synergist

Deltamethrin (Suspend) - synthetic pyrethroid

Demon (see: cypermethrin)

Diacide D-10: (pure 9 micron size diatomaceous earth). Used in grain.

D-20: (diatomaceous earth, sustained release pyrethrins, and piperonyl butoxide.

D-21: (pyrethrins and piperonyl butoxide)

D-32: (pyrethrins, piperonyl butoxide, pine oil). Use to help deodorize pets and dislodge ticks

Dianex (see: methoprene)

Dialect 2D: (see pyrethrin and/or diatomaceous earth); 0.2% pyrethrins, 1% PBO, 88% diatomaceous earth. Diatomaceous earth with pyrethrin has superior pesticidal actions over diatomaceous earth lacking additives.

Diatomaceous earth (Dialect, Diatomite). Pure diatomaceous earth can, in some instances can be a pesticide showing as much as 90 percent control; however, insect control may take a long time. To reduce the potential for contracting silicosis when using diatomaceous earth, only use amorphous (fresh water form without spicules) diatomaceous earth and wear a respirator.

Dichlorodifluoromethane: similar to tetrachloro-ethylene; non-flammable but toxic substances are formed under heat/flame; refrigerant, aerosol propellant.

Dichloromethane: industrial solvent, paint stripper; used in aerosol and pesticide products, in photographic film production; a carcinogen.

Dichlobenil (Casoron): 2,6-dichlorobenzonitrile; aromatic nitril preemergent herbicide; LD₅₀ 3160 mg/kg; residual all season, does not build up/move in soil; no contact activity; do not use on light, sandy soil.

Diflubenzuron (Dimilin); LD₅₀ 4640->10,000; **Caution label**; chitin inhibitor affecting all invertebrates

Diphacinone: (Ditrac); 2-diphenylacetyl-1,3-indandione; organic anticoagulant rodenticide; LD₅₀ 7 mg/kg; some formulations are designated as **Restricted use**; very toxic; long persistence. Can cause bleeding

d-Limonene (Demize); **Warning/Caution label**

Dri-Die 67: (see: silica aerogel)

Drifone: (see natural pyrethrum, piperonyl butoxide <PBO; butacide>, silica aerogel, petroleum distillate). Useful in sewers and structural voids. Toxic to fish.

Dursban (see: chlorpyrifos)

Ethylene glycol (anti-freeze): sweet taste, appeals to animals; less than 1 tablespoon per 5 lbs. body weight lethal to dog/cat, LD₅₀ in rat/guinea pig 6-8 g/kg, mice 14 ml/kg, humans 1.4 ml/kg or 100 ml.

Fenoxycarb (Logic, Ultraban, Regulator, Torus, Pictyl): ethyl [2-(p-phenoxyphenoxy)ethyl] carbamate; carbamate; LD₅₀ 16,800 mg/kg; IGR/contact/stomach poison; no immediate insect control; contains carbamate but is not cholinesterase inhibitor.

Fenvalerate (Pydrin, Pyrid, Tribute, Conquer, Ultraguard): cyano(3-phenoxyphenyl)methyl 4-chloro alpha (1-methylethyl)benzeneacetate; synthetic pyrethroid; contact/stomach poison; LD₅₀ 451 mg/kg; **Caution label**; some formulations are designated as **Restricted Use**; fast knockdown, good residual, not rapidly broken down by sunlight

Ficam (see: bendiocarb)

Formaldehyde: In disinfectants, fertilizer, embalming fluids, particle board; carcinogen, toxic if inhaled.

Garlon (see: triclopyr)

Gencor (see: hydroprene)

Glyphosate (Roundup, Kleenup, Rodeo): n-(phosphonomethyl) glycine (isopropylamine salt); herbicide; LD₅₀ 4900 mg/kg; breaks down in soil/dirty water; do not use/store in galvanized/unlined steel equipment, reacts to produce combustible gas; low toxicity.

Hydramethylnon (amindinohydrazone; Andro, Combat, Siega, Maxforce): tetrahydro-5, (3-(4-(trifluoromethyl)phenyl)-1-(2-(4-(trifluoromethyl)phenyl)-propen-ylidene) hydrazine; organic compound; slow acting stomach poison, very safe; LD₅₀ 1131 mg/kg; **Caution label**; no

specific antidote; do not store in high temperatures; 3-month shelf life after opening; ant control in 1-4 weeks.

Hydroprene (Gencor): ethyl (2E,4E)-3,7,11-trimethyl-2,4-dodecadienoate; synthetic organic juvenile hormone (IGR); LD₅₀ 5100 mg/kg; **Caution label**; cockroaches; makes adults unable to reproduce.

Ivermectin (see: abamectin)

Killmaster (see: chlorpyrifos)

Kleenup (see: glyphosate)

Lambda-Cyhalothrin (Demand, Commodore, Karate)

Linalool (see d-Limonene, Demize)

Logic (see: fenoxycarb)

Macrocytic lactone glycoside (Abamectin, Affirm, Avert, Ascend, Roach-Ender, avermectin-B-1): 5-O-dimethylavermectin A-1a(R=C2 H5)=B1a 5-O-dimethyl-25-de-1 methylpropyl-25-(1-methyl-ethyl) avermectin A1a(R=CH3)= B1b; natural product with macrocyclic lactone glycoside (product of fermentation, Avermectin MK-933 from soil microorganism Streptomyces avermitilis); LD₅₀ 10 mg/kg; slow acting, good persistence.

Magnesium stearate (see: Boric acid)

Makl (see: bromadiolone)

Maxforce (see: hydramethylnon)

Metaldyhyde (Deadline 40): snail bait

Methylchloroform: see Chlorobenzene

Methamidophos (see: acephate)

Methoprene (Altosid, Dianex, Diacon, Pharoid, Kabata, Precor): isopropyl (2E,4E)-11-methoxy-3,7,11-trimethyl-2,4-dodecadienoate; organic insect growth regulator (IGR); LD₅₀ 34,600 mg/kg; stable but non-persistent; residual control; only affects emerging adults.

Methylene chloride: commodity fumigant, industrial solvent for cellulose acetate; damages plastics; degreaser/cleaning fluid; anesthetic (by inhalation); propellant in aerosols; mixed with other insecticides; flammable but not explosive; LD₅₀ 1.6 ml/kg. Narcotic to humans in high concentrations; toxic to nervous system, causes cancer in laboratory animals; human cancer risk estimates from hair spray at exposure levels encountered by hair-care specialists/consumers range from 1 per 1000 to 1 per 10,000 and judged unacceptably high; . EPA is requiring more health/safety data be supplied or 200 registrant companies face potential for cancellation (1989). Technical Report, Jul. 1989, Vol.3 No.7:3 - "FDA bans methylene chloride in hair spray" because

of unacceptable cancer risks.

MGK Repellent 11 (see R-11)

MGK-264: [N-(2-ethylhexyl)-5-norbornene-2,3-dicarboxamide] or N-octyl bicyclopheptene dicarboxamide; synergist used in pyrethrin compounds; superior to most synergists for raising allethrin effectiveness on roaches; interrupts natural insect defense to insecticides. Used at 5% MGK-264 with 1% piperonyl butoxide technical and 0.3% piperonyl butoxide synergist under label "Vermonox" for flies.

Orthene (see: acephate):

Paraffin oil: same as mineral oil, may be kerosene in some countries (see Petroleum distillate).

Perchloroethylene (see: tetrachloroethylene)

Petroleum distillate: made from crude/mineral/white/summer/superior/dormant/ rock/coal oils; Stoddard solvent; kerosene. Low mammalian toxicity, LD₅₀ 28 grams/kg in rabbits. Defatting action on skin leads to irritation/infection; inhaling high concentration causes headache, drowsiness, coma; ingestion causes G.I. irritation with vomiting/diarrhea.

Pharoid (see: methoprene)

Phenothrin (Fenothrin, Sumithrin): 3-phenoxybenzyl-d,1-cis,trans 2,2-dimethyl-3-(2-methylpropenyl) cyclopropane carboxylate; synthetic pyrethroid; contact/ stomach poison; LD₅₀ 10,000 mg/kg; **Caution label**; fast knockdown, used in flushing compounds, short residual in sunlight; do not mix with alkaline compounds.

Pine oil: obtained from pine trees by steam distillation/solvent extraction; low mammalian toxicity, large doses may cause humans CNS depression; used as spray ingredient/manufacture of terpins/disinfectants/deodorants; some germicidal and possible insect repellent actions.

Piperonyl butoxide (PBO, Butoxide/Butoxide) alpha-[2-(2-n-butoxyethoxy)-ethoxy]-4,5-methylenedioxy-2,2-propyltoluene; 3,4-methylenedioxy-6-propylbenzyl n-butyl diethyleneglycol ether; (butylcarbitol) (6-propyl-piperonyl) ether; organic synergist for pyrethrins/resmethrins/rotenone made from peppercorns; LD₅₀ in rats 6150->7500 mg/kg; **Caution label**; ingredient in insecticidal oil solutions, aerosols, dusts, wettable powders, slurries. Low toxicity but large doses may cause vomiting/diarrhea; one reference indicated possible liver microsomal affect. Slows down light degradation on pyrethrin; prevents insect recovery after knock down, damages insect nerve cells. Used at 5% MGK-264 with 1% piperonyl butoxide technical and 0.3% piperonyl butoxide synergist under label **Vermonox** for flies.

Precor (see: methoprene)

Pydrin (see: fenvalerate)

Pyrenone: a mixture of pyrethrins and piperonyl butoxide (1:5 to 20:1 ratio).

Pyrethrin (see: allethrin, Synerol)

Pyrid (see: fenvalerate)

Pyriproxyfen 2-[Methyl-2-(4-phenoxyphenoxy)ethoxy]pyridine; 4-phenoxyphenyl. Juvenile hormone mimic; also used as an insecticide and has ovicidal activity. Patented by Sumitomo Pharmaceuticals Co., Osaka, Japan.

Quintox (see: cholecalciferol)

R-11 (also MGK Repellent-11): (2,3,4,5-bis(2-butylene)tetrahydro-2-furaldehyde) insect repellent; LD₅₀ 2500 mg/kg orally in rats; **Caution label**. 1990: S.C. Johnson recalled all Deep Woods Off containing R-11, manufacturer (McLaughlin Gormley King, decided to cancel registration of R-11 in US/Canada because interim results of oral feeding animal study indicated oncogenicity and reproductive effects (ovarian atrophy).

R-874 (MGK 874); insect repellent; LD₅₀ - 8500; **Caution label**

Rampage (see: cholecalciferol)

Resmethrin (see: bioresmethrin, Cross fire, Synthrin, Vectrin, Chryson)

Rodeo (see: glyphosate)

Roundup (see: glyphosate)

Rozol (see: chlorophacinone)

Salufer (see: sodium fluosilicate)

Scourge (see: bioresmethrin)

Sevin (see: carbaryl)

Silica aerogel (Dri-Die, Tri-Die, Silikil, Drione): inorganic; contact poison, removes the protective cuticle from insects; LD₅₀ 3160 mg/kg; made from sodium silicate treated with sulfuric acid and then drying/grinding residual; often contains fluorine (ammonia fluosilicate) to give material insecticidal properties.

Sodium fluosilicate (sodium hexafluorosilicate, sodium silicofluoride, salsan): contains sodium, silicon, fluoride as white/granular powder; LD₅₀ orally in rats 125 mg/kg; used in china/porcelain enamels, manufacture of opal glass, insecticide, rodent poison, mothproofing of woollens, pediculicide.

Sodium hexafluorosilicate (see: sodium fluosilicate)

Sodium silicofluoride (see: sodium fluosilicate)

Sodium tetraborates (see: borax)

Spectracide (see: diazinon)

Sumithrin (see: phenothrin)

Synthrin (see: bioresmethrin)

Talon (see: brodifacoum)

Tetrachloroethylene (perchloroethylene): fumigant; LD₅₀ 5 g/kg in rats; suggested inhalation threshold 100 ppm; aromatizing compound

Tetramethrin (Neo-Pyramin): 3,4,5,6-tetrahydro-phthal-midomethyl-d-cis-trans-chrysanthemate; organic, synthetic pyrethrum derivative; contact poison; LD₅₀ 4640 mg/kg; **Caution label**; long storage ability; fast knockdown.

Tricalcium phosphate (see: boric acid)

Triclopyr (Garlon): 3,5,6-trichloro-2-pyridyl-oxyacetic acid; picolinic acid herbicide; LD₅₀ 713 mg/kg; degrades rapidly in soil; more effective on many species than 2,4,5-T; more toxic to mammals than tordon.

1,1,1-trichloroethane: solvent for cleaning precision instruments; used in pesticides, textiles; irritating to eyes/skin. A concern exists for this material in regard to cancer and NPS will no longer approve chemicals with this as an ingredient

Trichloromonofluoromethane: refrigerant, aerosol propellant, less toxic than CO₂; decomposes into harmful materials under heat/flame; destroys ozone layer; prepared from carbon tetrachloride and antimony trifluoride, non flammable.

Tri-Die (PT-230): (pyrethrins, silica aerogel, piperonyl butoxide, petroleum distillate). Non-flammable, crack and crevice and exclusion dust.

Turcam (see: bendiocarb)

Vapona/vaponite (see: dichlorvos/dichlorphos)

Vernonox (see: MGK-264)

Vitamin D-3/Vitamin D-2 (see: cholecalciferol)

Warfarin (Coumatene, d-Con, Dethmor, Duocide, Warfaricide): 3-alpha- acetonilybenzyl) 4-hydroxycoumarin; anticoagulant rodenticide; LD₅₀ 3 mg/kg; **Caution label**; massive dose of vitamin K is antidote; many rodents show resistance.

Warfarin+ (Prolin): anti-coagulant rodenticide; LD₅₀ 1000; **Caution label**;

Wasp Freeze (PT-515) (OLD FORMULATION): trichloromonofluoromethane, dichlorofluoromethane, petroleum distillate, methylene chloride, pine oil, rotenone, pyrethrins; **Caution label**; killing wasps, hornets, bees, yellow jackets at the nest.

Wasp Freeze (PT-515) (NEW FORMULATION): d-trans Allethrin, *3-Phenoxybenzyl-(1RS, 3SR)-

2,2-Dimethyl-3-(2-methylprop-1-enyl) cyclopropanecarboxylate. * = Phenothrin; **Caution label:** killing wasps, hornets, bees, yellow jackets at the nest.

Zinc phosphide (Gopha-rid, ZP Tracking Powder, ZP Bait):

Zolone: 0, 0-diethyl S-((6-chloro-2-oxobenzoxazolin-3-yl) methyl) phos-phorodithioate; organic phosphate; contact/stomach poison; LD₅₀ 100 mg/kg.

2,4-D (aqua Kleen/demise/weed-b-gone/weedar-64/weedone): 2,4-dichlorophenoxyacetic acid; phenoxy herbicide; suspected carcinogen.

CHEMICAL DESCRIPTIONS:

(Listed by chemical formula)

A

alpha-[2-(2-n-butoxyethoxy)-ethoxy]-4,5-methylenedioxy-2-2-propyltoluene; 3,4-methylenedioxy-6-propylbenzyl n-butyl diethylene glycol ether; (butylcarbitol) (6-propylpiperonyl) ether: **Butacide/Butocide** (piperonyl butoxide):

C

ciano(3-phenoxyphenyl)methyl 4-chloro alpha (1-methyl(ethyl)benzene acetate: **tenvalerate** (Pydrin, Pyrd):

ciano(4-fluoro-3-phenoxyphenyl) methyl 3-(2,2-dichloroethenyl)-2,2-dimethyl-cyclopropanecarboxylate: **cyfluthrin**:

D

d-trans Allethrin, *3-Phenoxybenzyl-(1RS, 3SR)-2,2-Dimethyl-3-(2-methylprop-1-enyl) cyclopropanecarboxylate. <* = Phenothrin>: **Wasp Freeze, PT-515**

E

(E)-(+)-2-[1-{{(3-chloro-2-(ethylthio)propyl}-3-hydroxy-2-cyclohexen-1-one: **clethodim**

ethyl [2-(p-phenoxyphenoxy)ethyl] carbamate: **fenoxycarb** (Logic):

ethyl (2E,4E)-3,7,11-trimethyl-2,4-dodecadienoate: **Gencor** (hydroprene):

I

isopropyl (2E,4E)-11-methoxy-3,7,11-trimethyl-2,4-dodecadienoate: **Altosid** (methoprene, Dianex, Pharotid, Precon):

isopropylamine salt [n-(phosphonomethyl) glycine]: **Rodeo** (Roundup, glyphosate, Kleenup):

M

methyl 1-(butylcarbamoyl)-2-benzimidazole carbamate: **Benlate** (benomyf)

N

[N-(2-ethylhexyl)-5-norbonene-2,3-dicar-Soxamide]: **MGK-264**:

N-octyl bicycloheptene dicarboxamide: **MGK-264**:

n-(phosphonomethyl) glycine (isopropylamine salt): **Rodeo** (Roundup, glyphosate, Kleenup):

O or o

0, 0-diethyl S-((6-chloro-2-oxobenzoxazolin-3-yl) methyl) phosphorodithioate: **Zolone**:

0, S-dimethyl acetylphosphoramidodithioate: **acephate** (Orthene).

S

Sodium hexafluorosilicate, sodium silicofluoride, salufer: **sodium fluosilicate**

T

tetrahydro-5,5-dimethyl-2-(1H)-pyrimidinone (3-(4-(trifluoromethyl) phenyl)-1-(2-(4-(trifluoromethyl)phenyl)-ethenyl)-propenylidene) hydrazone: **Amdro** (amindinohydrazone, hydramethylnon, Combat, Maxforce):

+/-

(+/-) alpha-cyano-3-phenoxybenzyl (+/-) cis,trans 3-(2,2-dichloro-vinyl) -2,2-dimethyl cyclopropane-carboxylate: **cypermethrin** (Demon):

1

1,1,1-trichloroethane: **methylchloroform**; solvent, inert in pesticides, irritating to skin/eyes, nervous depression, mucous membrane and upper respiratory tract irritation, contact dermatitis.

2

2-allyl-4-hydroxy-3-methyl-2-cyclopenten-1-one ester of 2,2-dimethyl-3-(2- methyl propenyl)-cyclopropane barboxylic acid: **allethrin** (pyrethrin, bioallethrin):

2-diphenylacetyl-1,3-indandione: **diphacinone**:

2-((p-chlorophenyl)phenylacetyl)-1,3-indandione: **chlorophacinone** (Rozol):

2,3,4,5-bis(2-butylene)tetrahydro-2-furaldehyde: **R-11** (insect repellent)

- 2, 2-dimethyl-1, 3-benzodioxol-4-yl methylcarbamate: **bendlocarb** (Ficam, Turcam):
- 2,4-dichlorophenoxyacetic acid: **2,4-D** (aqua kleen/demise/weed-b-gone/weedar- 64/weedone):
- 2,6-dichlorobenzonitrile: **dichlobenil** (Casoron):
- 2-[Methyl-2-(4-phenoxyphenoxy)ethoxy]pyridine: 4-phenoxyphenyl: **pyriproxyfen IGR**
- 3
- 3-alpha-acetonylbenzyl) 4-hydroxycoumarin: **warfarin**:
- 3-Phenoxybenzyl-(1RS, 3SR)-2,2-Dimethyl-3-(2-methylprop-1-enyl) cyclopropanecarboxylate: **phenothrin**
- 3-phenoxybenzyl-d,1-cis,trans 2,2-dimethyl-3-(2-methylpropenyl) cyclopropane carboxylate: **phenothrin** (sumithrin):
- (3-phenoxyphenyl)-methyl (+/-) cis-trans-3-(2,2-dichloroethenyl)-2,2) dimethylcyclopropane carboxylate: **Ambush** (permethrin, biotrin):
- 3-(3-(4'-bromo(1,1'-diphenyl)-4-yl)-1,2,3,4-tetrahydro-1-naphthalenyl)-4-hydroxy-2H-1-benzopyran-2-one: **Talon** (brodifacoum):
- 3-(3-(4'-bromo(1,1'-diphenyl)-4-yl)-3-hydroxy-1-phenylpropyl)-4-hydroxy-2H-1-benzopyran-2-one: **Contrac** (Maki, bromadiolone):
- 3,4,5,6-tetra hydro-phthalimidomethyl-d-cis-trans-chrysanthemate: **tetramethrin**:
- 3,5,6-trichloro-2-pyridyl-oxyacetic acid: **triclopyr** (Garlon):
- 4
- 4-phenoxyphenyl: **pyriproxyfen IGR**
- 5
- (5-benzyl-3-furyl) methyl 2,2-dimethyl-3-(2-methylpropenyl) cyclopropane-carboxylate: **Bioresmethrin** (resmethrin, Scourage, synthrin).
- 5-O-dimethylavermectin A1a(R=C2 H5)=B1a 5-O-dimethyl-25-de-1 methylpropyl-25-(1-methylethyl) avermectin A1a(R=CH3)=B1b: **abamectin** (Affim, avermectin- B-1).

APPENDIX VI
VERTEBRATE TRAP SIZES AND BAITS.

COMPARATIVE TRAP SIZES AND BAITES

ANIMAL / TRAP	SNAP	LEG-HOLD	HAVAHART	TOMAHAWK	CONIBEAR	BAITS
Badger	NR	#2, 3 4	NR	NR	#220-2	
Feral cat	NR	#1, 1-1/2, 2	#1045(3), #1050(3A), #1079; #1081	#106, 107	#110-2, #220-2	Canned fish, cat food, chicken bones, catnip
Chipmunk	Rat	#0 to 1-1/2	#1025; #1078	#102	#110-1 #110-2	Peanut butter
Coyote	NR	#3N	N.A.	#110A, 110B	#330-2	Gland and food lures; meat products
Deer	NR	Clover, drop net, fence net traps				Apples
Dog, large	NR	#3, 4, 4-1/2	N.A.	#110B, 110C	#330-2	Meats
Dog, small	NR	#2	#1081	#110A, 110B	#220-2	Meats
Fox	NR	#2, 3	#1081	#109	#220-2	Meats
Gopher	NR	Macabee; Victor #0610, #0611; California; Gopher-getter; pincer				None
Mice	Mouse	#0, 1	#0745; #1020; #1025;	#101	NR	Peanut butter, pumpkin/sunflower seeds, cotton
Mole	NR	Victor #0631; #0645				
Porcupine	NR	#1, 1-1/2, 2, 3	#1045 (3); #1050 (3A)	#108, 109	#110-2	Salt
Prairie dog	NR	#0, 1, 2	#1030 (2)	#103 to 109	#110-2	Grains, vegetables
Rabbit	NR	#1	#1030 (2); #1078	#103 to 107	#110-2	Fruits, lettuce
Raccoon	NR	#2, 3	#1045 (3); #1050 (3A); #1079; #1081	#207, 207.1, 608	#110-2	Gland and food lures
Rats (wood)	Rat	#1	#0745; #1025	#102	#110-2	Grains, peanut butter
Skunk	NR	#1, 1-1/2, 2	#1078	#105	#110-2	Canned fish/meat
Squirrel/ ground	Rat	#0, 1, 1-1/2	#0745; #1025; #1078; #1030 (2);	#103, 104	#110-2	Nuts, peanut butter
Squirrel/ tree	Rat	#0, 1, 2	#0745; #1025; #1030; #1078	#104; #0745	#110-2, 220-2	Nuts, peanut butter

NR = not recommended N.A. = not available

APPENDIX VII
SOURCES OF PEST CONTROL SUPPLIES

SOURCES OF PEST CONTROL SUPPLIES AND EQUIPMENT

The following list of pest control equipment and chemical suppliers is not meant to completely cover the entire field and is offered as an assistance in finding specific products. Space limitations do not permit including every possible vendor. Undoubtedly, the list omits some products or companies that did not come to our attention. Products or companies listed here are not endorsed or recommended by the United States Government or G&L Consultants. No discrimination is intended against products or companies not listed. Additional listings classified by subject are found in: Scott E. Hygnstrom, Robert M. Timm, and Gary E. Larson, 1994; Prevention and Control of Wildlife Damage, Coop. Exten. Div., Inst. Agric. and Nat. Res., University of Nebraska, Lincoln NE.

ALPHABETIZED LISTING

Advantage Products, P.O. Box 307, 2343 Commerce Blvd., Mound MN 55364; 800/257-3464. Dustick telescopic pesticide applicator, rodent bait stations.

AgrEvo Environmental Health, 95 Chestnut Ridge Road, Montvale NJ 07645; 201/307-9700. Herbicides; Finale.

Agricultural Warehouse, Box 237, Ennis TX 75210; 214/875-0090. Deodorizers.

Allen Special Products, 800/848-6805. Stuf-Fit, copper mesh for filling holes in structures.

Almac Plastics, 6311 Erdman Ave., Baltimore MD 21205; 301/485-9100. Bird and bat netting

American Cyanamid Co., 1 Cyanamid Plaza, Wayne NJ 07470. Seige (Amdro) fire ant and harvester ant bait cockroach gel bait.

Animal Care Equipment & Services, P.O. Box 3275, Crestline CA 92325; 800/338-2237. Animal handling gauntlets, capture nets and guns, animal handling equipment, traps.

Animal Damage Control (magazine), ADC, P.O. Box 224, Greenville PA 16125, 412/588-3492. References and information.

Animal Management Inc., 720 Eppley Rd., Mechanicsburg PA 17055-9786; 717/790-9346, 800/745-8173. Snake traps, deodorizers.

Animal Repellents Inc., Box 510, Orchard Hill GA 30266; 404/227-8222, 800/241-5064. Deer Ban and Rabbit Rid (thiram) repellents; Attack Repellent against bears and dogs.

AO Safety; distributor: Public Health Equipment & Supply, P.O. Box 10458, San Antonio TX 78210, 800/284-0106, 800/444-4774. Respirators, personal protective safety equipment.

Arbico, P.O. Box 4247 CRB, Tucson AZ 85738-1247; 800/827-BUGS. Beneficial and predatory insects, fly parasites, insect traps, animal repellents, outdoor fly control, pet products, literature, etc.

Atlantic Paste and Glue Co., 4-53rd St., Brooklyn NY 11232; 718/492-3648. Catchmaster insect and rodent sticky traps.

Austin, Bill. P.O. Box 284., Kaycee WY 82639. Line of coyote calls, instructs in coyote trapping methods.

Batrap, 4744 Enders Rd., Manlius NY 13104. Batrap livetraps for capturing bats, videos, educational materials.

Beneficial Bio-Systems, 1603 63rd Street, Emeryville, California 94608. Pteromalid Wasps, fly predators; Encarsia formosa, predatory mini-wasp against greenhouse whiteflies.

Beneficial Insectary, 245 Oak Run Road, Oak Run, Calif. 96069; 916/472-3751. Muscidifurax zaraptor, Nasonia vitripennis, Spalangia endius, S. cameroni.

Beneficial Insects, Inc., P.O. Box 40634, Memphis, Tenn. 38174-0634; 901/522-0285; 276-6879. Encarsia formosa, Spalangia endius, S. cameroni, Pyemotes tritici, Trichogramma pretiosum.

B & W Sales; 800/843-6334. Maxforce (Amdro) cockroach and ant baits, fly traps and monitoring systems.

Beacon Dogs, 1409 Bay Head Rd, Annapolis MD 21401, 301/7757-4999. Termite sniffing dogs.

Beeman Precision Arms, 5454 Argosy Drive, Hunting Beach CA 92642; 714/890-4800. Air rifles.

Beneficial Biosystems, 1603-P 63rd St., Emeryville, CA 94708; 415/655-3928. Light traps for extended outdoor use, fly management instruction booklet, commercial fly attractants.

Benjamin/Sheridan Co. c/o Crossman Corp., Rte 5 and 20, E. Bloomfield NY 14443; 716/657-6161. Air rifles.

Ben Meadows Co., PO Box 80549, Atlanta, Georgia 30366; 800/547-8813. Weed flamers.

Bird Busters, 1083 Thomas Jefferson St., N.W., Washington DC 20007; 202/338-6263. Tensioned wire bird repellent system, architectural bird nets.

Bird Gard, 201/666-8334. Electronic bird repellents; v-top sparrow and starling live trap cages.

Bird-X, 730 W. Lake St., Chicago IL 60661; 312/648-2191. Plastic bird netting, Irr-Tape reflective mylar.

Blizzard System, Tallon Pest Control, Long Beach CA; 800/300-COLD. Freezing/cold treatments for insect pests.

Blue Diamond Exterminating Mfg. Inc., 3518 W. Irving Park Road, Chicago, IL 60618; 312/539-1774, 800/237-5705. MRF 2000 (boric acid) Paste Formula for roaches; ant baits for sensitive locations.

Bonide Products Inc., 2 Wurz Ave., Yorkville NY 13495; 315/736-8231. Dogzit (methyl nonyl ketone), tobacco dust, thiram repellents.

Bramton Co., Dallas TX 214/438-0397. Outright Skunk Odor Eliminator (enzyme from Bacillus subtilis which chemically breaks down skunk odor).

Brody Enterprises, 9 Arlington Place, Fair Lawn, New Jersey 07410; 1-800/GLU-TRAP. Rodent snap/live traps, glue boards, fly ribbons; electro-pheromone trap; cockroach lures; fly pheromones.

Burlington Scientific Corp., 222 Sherwood Ave., Farmingdale NY 11735; 516/694-9000. Ro-Pel (benzyl diethyl methyl ammonium saccharide) general gustatory repellent.

C.B. Waterbury Co., Waterbury CT 06722; 800/845-3495. Drax boric acid roach and ant baits.

Cabot Safety Corp., Safety Div. of American Optical; 1/800/444-4774.

HEPA filters and respirators.

Chim-a-lator, 8824 Wentworth Ave. S., Minneapolis MN 55420; 612/884-7274. Animal-proof chimney covers.

Chim Cap Corp., 120 Schmitt Blvd, Farmingdale NY 11735. Animal proof chimney covers.

Clean & Fresh, 6619 13th Ave, Brooklyn NY 11219; 800/373-7487. Odor neutralizers, degreasers, and cleaning supplies.

Consep, Inc., 213 SW Columbia St., Bend OR 97702; 800/367-8727. Yellow jacket and wasp traps, fly traps, clothing moth pheromone traps, teflon (fluon) barrier paint, covered rodent traps.

Conwed Corp., 620 Taft, Northeast Minneapolis MN 55413; 612/378-6300, 800/426-6933. Plastic bird and bat netting.

Copperfield Chimney Supply, 800/247-3305. Chimney caps

Critter Control Inc., 640 Starkweather, Plymouth MI 48170, 313/453-6300. Rodent and animal traps and control supplies.

Crossman Corp., Rte 5 and 20, E. Bloomfield NY 14443; 716/677-6161. Air rifles.

Daisy Mfg. Co., P.O. Box 220, Rogers AR 72756, 501/636-1200. Air rifles.

DAP Inc., USG Corporation, PO Box 277, Dayton OH 45401. Asphalt and other kinds of caulking.

Direct Safety Co., P.O. Box 50050, Phoenix AZ 85076-0050 (7815 South 46th St., Phoenix AZ 85044); 800/528-7405. Respirators (UVEX), other safety equipment.

Don Gilbert Industries, 5611 Krueger Dr., Jonesboro, AR 72401-9102, 501/932-6070; 800/643-0400. Electronic fly traps.

DowElanco Chemical, 9002 Purdue Rd., Indianapolis IN 46268. Acoustic termite detector, Sentricon (hexaflumuron) insect growth regulator (IGR) for termites.

Dr. T's Nature Products Co., Box 682, US 19 N., Pelham GA 31779; 800/299-6288. Snake-A-Way sulfur-based snake repellent.

Dragon Corp., Box 7311, Roanoke VA 24019; 703/362-3657, 800/533-2488. Methyl nonyl ketone, Chaperone (naphthalene-base), tobacco dust repellents.

Earl May Seed and Nursery Co., 208 N. Elm, Shenandoah IA 51603; 712/246-1020. Rabbit Scat (ziram-base) rabbit repellent.

Eco-Bait, Donald D. Hicks, Box 321, Geraldine MT 59446; 406/737-4291.

Ecopic, 725 South Adams, Suite 270, Birmingham MI 48009; 810/647-0505. Bird and bat netting.

Elco Mfg. Co., 111 3rd St., Pittsburgh, PA 15215; 412/782-1850. Moisture meters, blacklights, decontaminants, bait stations/trays, disinfectants, glueboards, tracking powder stations, automatic/live traps, other products.

Epoleon Corp., 3858 Carson St., Suite 212, Torrance CA 90503; 213/316-4242. Deodorizers.

Etex Ltd. PO Box 33160, Las Vegas NV 89133; 800/543-5651; 702/382-3966. Electrogun for termite treatments.

Fireplace Technologies, 1715 Dixie Highway, Louisville KY 40210; 800/737-1067. Remote control chimney cap and damper system.

Flintrol, Inc., 950 Scott Blvd., PO Box 1770, Hutchinson, KS 67504-1770, 316/663-1414, 800/643-0000. Light traps.

Flame Engineering, Inc., PO Box 577, LaCrosse, KS 67548; 800/255-2469. Weed flammers.

Flintrol, Inc., 950 Scott Blvd., PO Box 1770, Hutchinson, KS 67504-1770, 316/663-1414, 800/643-0000. Electronic fly traps.

Flowtron, 2 Main St., Melrose, Massachusetts 02176, 617/321-2300. Light traps and fly control supplies.

FMC, Oldham's Chemicals Co., P.O. Box 18358, Memphis TN 38118, 800/888-5502. Pest control and lawn care supplies.

Follansbee Steel, PO Box 610, Follansbee WV 26037; 304/527-1260. Tyne metal for excluding pests.

Forestry Suppliers, Inc. 205 West Rankin Street, PO Box 8397, Jackson, MS 39204-0397; 800/647-5368. Weed flammers; live/multiple capture/snap traps; monitoring equipment, other products.

Fox Valley Marking Systems, Inc., 172 S. Northwest Hwy, Cary, IL 60013; 800/323-4770. Metal traps.

Fritsche, Dodge & Olcott Inc, 76 Ninth Ave., New York, NY 10011. Neutroleum alpha, odor eliminator.

Gardner Mfg., 1201 West Lake St., PO Box 147, Horicon, WI 53032, 414/485-4303. Decorative, ultra-violet light traps and other fly control supplies.

Gilbert Industries, 5611 Kruger Dr., Jonesboro AR 72401, 800/643-0400. Industrial and decorative wall sconce, ultra-violet light traps for flying insects.

G.G. Bean, Brunswick ME; 207/729-3708. Skunk Kleen, water based deodorizer.

Glendale Protective Technologies Inc., Woodbury NY. Respirators, filters, HEPA filters.

Guardian Trap Co, PO Box 1935, San Leandro CA 94577, 415/357-0900. Gopher traps.

Gurney's Seed and Nursery, 110 Capital St., Yankton SD 57079; 605/665-1930. Beneficial insect predators, fly wasp parasites, pesticides, bird nets, traps, gopher gassers, repellents, other products.

Gustafson Inc. Box 660065, Dallas TX 75266; 214/985-8877, 800/527-4781. Gustafson 42-S (thiram-base) deer repellent.

Havahart Traps, Woodstream Corp. Front and Locust Streets, Lititz, PA 17543, 717/626-2125. Live traps.

HY-C Co., 2107 North 14th St., St. Louis MO 63106; 314/241-1214. Animal-proof chimney covers.

INSECT IDENTIFICATION SOURCES: call/write to inquire about services or other sources of identification.

American Entomological Inst., 5950 Warren Rd., Ann Arbor, Michigan 48105. General insect identification.

Arizona Dept of Health Services, Disease Control, 3008 N. 3rd

Ave., Room 201, Phoenix AZ 85012. Pests of public health concern.

A & L Mid West Laboratories, Inc., 13611 B Street, Omaha, NE 68144; 402/334-7770. Complete chemical/analytical lab services.

Combined Scientific Supplies, P.O. Box 1446, Fort Davis, Texas 79734; 915/426-3851.

Consulting Diagnostic Service, 992 Santa Barbara Rd., Berkeley, CA 94707; 415/642-4950 (days), 415/524-9476 (evenings).

Duke University Medical Center, Microbiology Center, Div. Infectious Diseases and International Health, Duke Univ., Durham NC 27710; 919/684-3717. Tests for Histoplasmosis in guano/feces.

Fumigation Service and Supply, 10540 Jessup Blvd., PO Box 40641, Indianapolis IN 46280-1451; 317/846-5444.

New Mexico State University, Las Cruces, New Mexico, Department Entomology; Cooperative Extension Service; New Mexico Pest Survey and Detection Program.

Okumura Biological Institute, 6669 14th Street, Sacramento CA 95831; 916/421-8963. Stored products pests.

Pan-Ag Pan-Agricultural Laboratories Inc., 32380 Ave 10, Madera CA 93638; 209/675-0889. Agricultural pests.

Raltech Scientific Services, Inc., P.O. Box 7545, Madison, WI 53707; 608/241-4471.

Snelling, Dr. Roy R., Natural History Museum, Los Angeles County, 900 Exposition Blvd, Los Angeles CA 90007; 213/744-3365. Western United States ant specialist.

Texas Plant Disease Diagnostic Laboratory, Texas Agricultural Extension, LF Peterson Building, Room 101, College Station TX 77843-2132. Plant disease problems.

University of Arizona, Cooperative Extension, 2400 S. Milton, Flagstaff AZ 860001, 602/774-1868.

U.S. Dept of Agriculture, El Paso, Texas; Bob Eads, Area Insect Identifier.

US Dept of Agriculture, Forest Service, Forest Pest Management, PO Box 5500, 2500 Shreveport Hwy, Pineville, LA 71360; 318/473-7160. Diseased arboreal plant material.

US Dept of Agriculture, Forest Pest Management Laboratory, 2323 E. Grennaw Lane, Flagstaff AZ 86004-1890; 602/556-7400. Forest disease organisms.

Improvements, 4944 Commerce Parkway, Cleveland OH 44128; 800/642-2112. HEPA vacuum bags, door sweeps, weather stripping, epoxy kits.

Industrial Safety Co., 1390 Neubrecht Rd., Lima OH 45801; 800/53-7-9721. Respirators and replacement cartridges, safety supplies.

Insect-O-Cuter, 1531 Stone Ridge Dr., Stone Mountain, GA 30083-1489, 404/939-2835. Electronic light traps for flies.

Insects Limited, 10540 Jessup Blvd., PO Box 40641, Indianapolis, IN 46280-1451; 317/846-5444, 800/992-1991. Insect pheromones and pheromone trap kits (warehouse, flour, sawtoothed, grain, drugstore, and cigarette beetles; clothing moths; German cockroach); museum

pest monitoring kits; pheromones monitoring and software programs.

Isothermics, PO Box 18703, Anaheim CA 92817; 714/778-1396. Heat treatments for termite infestations.

IntAgra Inc., 8500 Pillsbury Ave. S., Minneapolis MN 55420;; 800/468-2472. Get-Away vertebrate repellent.

Internet Inc., 2730 Nevad Ave. North, Minneapolis, Minn. 55427; 612/541-9690. Bird and bat netting.

J. Norris Corp, 25 W. Merrick Rd, Freeport NY 11520. Dazie Disk skunk odor remover.

J.T. Eaton and Company, 1393 East Highland Rd., Twinsburg OH 44087; 800/321-3421. Rodent traps, sticky traps, rodenticides, bait boxes, diatomaceous earth.

Johnny Steward Wildlife Calls, P.O. Box 7594, Waco TX 76714; 800/537-0652. Electronic wildlife calls and tapes.

K Fence Systems, Rt. 1 Box 195, Zumbro Falls MN 55991; 507/753-2943.

Ketch-All Company, 4149 Santa Fe Rd, #2, San Luis Obispo CA 93401; 805/543-7223. Animal catch poles and restraining devices.

Kirk, Dennis, RD 1 Box 231-B, Franklin NY 13775; 800/342-2557. Raccoon calls used to lure animals to traps.

Kness Manufacturing, Hwy. 5 South, P.O. Box 70, Albia IO 52531-0070; 800/247-5062. Snap/multiple-capture rodent traps; supplies.

Kunafin Insectary, Quemado TX. Parasitic wasps for fly control.

Lab Safety Supply, P.O. Box 1368, Janesville, WI 54547-1368; 800/356-0783. HEPA filters, respirators, vacuum cleaners, disposable coveralls.

Miracle Marketing Manufacturing Corp., P.O. Box 520125, Salt Lake City UT 84152; 800/634-6102. Lil Hummer backpack vacuum system (HEPA filters to 0.3 microns), electronic equipment kits, germ filters.

Live Trap Manufacturing Co., P.O. Box 411, Pioche NV 89043; 702/962-5402. No Spray Skunk Live Trap, enclosed area allows skunks to hide and protects trapper.

Lowry Products and Services Inc., Box 531966, Grand Prairie TX 75053; 214/647-8727. Deodorizers.

M & M Fur Co., Box 15, Bridgewater SD 57319-0015; 605/729-2535. Animal lures and predator urine, traps, trapping supplies.

MaxForce Professional Insect Control, 800/843-6334. Dry and gel insect baits.

McClintock Metal Fabricators, Haul-All Equipment Systems, Woodland California 95695; 800/350-3588. Hid-A-Bag, tightly closing garbage cans for vertebrate pests.

McLaughlin Gormley King Co., Minneapolis MN 55427. MGK Big Game Repellent Concentrate (putrescent whole egg solids-base) deer repellent.

Meyer Brand Trapline Products, Box 153, Garrison, Iowa 52229; live traps.

Michel and Pelton Co., Emeryville CA 94608. Mapco Products Deer Repellent (cresol, potassium naphthanate, and polysulfides, pyridin).

Micro-Gen Equipment, 800/777-8570. Innovative fly and insect control systems.

Moldex-Metric Inc., Safety Products Div., 4671 Leahy St., Culver City CA 90232; 800/421-0668. Disposable fume, dust, mist, HEPA respirators; fit testing kits.

Morrison Manufacturing Co., PO Box 52, Highway #175, Morrison IA 50657, 800/648-CAGE, 319/345-6406. Safe-N-Sound Live Traps live traps.

Mustang Mfg. Co., Box 920947, Houston, TX 77292; 713/682-0811. Live traps.

National Animal Damage Association, NADCA, Rte. 1, Box 37, Shell Lake WI 54871. National association of wildlife damage management professionals.

National Animal Damage Control Association, 800/828-6474. Animal control, public health, and wildlife officials. Training.

Necessary Trading Co., 422 Salem Ave., New Castle, VA 24127, 703/864-5103. Soil care, plant care, equipment, pest management, animal care, information, organic pesticides, bird netting, Tanglefoot (sticky paste), traps, pheromones, predatory insects, other products.

Neutron Industries, Formula NI-712 Super Concentrated Organic Odor Eliminator; 800/421-8481.

Nilfisk of America, 300 Technology Drive, Malvern PA 19355, 213/647-4620. HEPA filter vacuum cleaners.

Nisus Corp, Cherokee Place, 101 Concord St. N.; Knoxville TN 37919; 615/637-1226, 800/264-0870. Bora-Care, borate wood treatment products, Niban-FG boric acid ant bait.

Nixalite of America Inc, 1025 16th Ave, East Moline IL 61224, 309/755-8771. "Porcupine wire" mechanical bird repeller.

On Target Animal Attractants, P.O. Box 5345, Glendale Hts. IL 60139, 708/858 4895. Lures and scents.

Pace International Ltd., Leffingwell Chemical Division, 111 S. Berry St., Box 1880, Brea CA 92621; 714/529-3973. Hinder (ammonium soaps of higher fatty acids); Repel (ammonia, rosin, and fatty acids) deer and rabbit repellents.

Paracclipse, Inc., 2271 29th Ave. East, P.O. Box 686, Columbus NE 68602; 402/563-3625. Decorative light traps for flying insects.

Pestgon Products. Snooper 2000 PCO Pest Detector rake-like device producing heat, vibration, and color; attracts fleas to a disposable sticky trap.

Pet Chemical, P.O. Box 18993, Memphis TN 38181. Demize (linalool), Flea and Tick Dip (d-limonene), pet products.

Phillips Petroleum Co., Bartlesville OK 74004. R-55 (tert-butyl selfenyldimethyldithiocarbamate) pocket gopher/burrowing animal repellent; for use in soil and on cables; phytotoxic.

Phoenix Agritech, P.O. Box 10, Truro, Nova Scotia, Canada B2N 5B6; 902/662-2444, 800/353-9468. Flexinet, netting, posts, chargers to exclude pests.

Professional Equipment, 130 Dale St., West Babylon NY 11704; 800/334-9291. Full line of test equipment, moisture meters.

Pocatello Supply Depot (PSD), USDA-APHIS Animal Damage Control; U.S. Fish and Wildlife Service, 238 E. Dillon St., Pocatello ID 83201;

208/236-6920. Gas cartridges for gopher, ground squirrel, coyote, and skunk control; neutroleum alpha and Ecosorb deodorants; Fatty Acid Scent (FAS) and Synthetic Monkey Pheromone animal lures; electronic animal guard frightening device; strychnine gopher baits.

P-W Manufacturing, 610 High Stree, Henryetta OK 74437; 918/652-4981. Death-Klutch DK-1 and DK-2 Gopher Getter gopher traps.

Racal Health and Safety, 7305 Exexutive Way, Frederick MD 21701-8368; 301/695-8200, 800/682-9500. Delta 3 HEPA Filter.

R.C.F. Developments Inc., 2509 Browncroft Blvd, Rochester NY 14625. Skunk-Off odor eliminator.

R.C. Steele Veterinarian Supplies, 1989 Transit Way, Box 910, Brockport NY 14420-0910. Happy Jack Flea Trap sticky trap with attached heat source.

R.E. Chapin Mfg Works Inc., 700 Ellicott St., Batavia NY 14021-0549; 800/444-3140. Hand dusters for application of pesticide dusts.

R-P Outdoors, 505 Polk St., P.O. Box 1170, Mansfield LA 71052; 800/762-2706. Cage and other traps for mammals, birds, and turtles; full line of animal damage control equipment.

Reed-Joseph International, Box 894, Greenville MS 38702; 800/647-5554. Scare-Away System bird and animal repeller devices.

Rob Erickson's On Target A.D.C., P.O. Box 5345, Glendale Hts, IL 60139; 708/858-4895. Animal lures, baits, handling equipment, animal damage control training videos.

Roussel Uclaf Corp., 95 Chestnut Ridge Road, Montvale NJ 07645; 201/307-9700. Finale non-selective herbicide.

Sandoz Agro, Inc., 1300 East Touhy Ave., Des Plaines IL 60018. Genrol Point Source aerosol cockroach growth regulator; pesticides.

Science Products Co. Inc., Chicago IL 60646. Science Rabbit and Deer Repellent (thiram) for deer, meadow mice, rabbits.

Sherman, H.B.; 3731 Peddie Drive, P.O. Box 20267, Tallahassee FL 32303, 904/575-8727. Sherman folding live traps.

Specialty Products, 977 Waterman Ave., East Providence RI 02914; 800/224-8486. Pest control systems for sensitive sites.

Survival Air Systems (SAS) Co., 3401 69th St., Long Beach CA 90805; 800/262-0200. Respirators, personal protective equipment.

State College Laboratories, Subsidiary of J.C. Enrich Chemical Co. Inc., Reading PA 19612. Magic Circle Rabbit Repellent (thiram) for rabbits, meadow mice, and deer; Magic Circle Deer Repellent (bone tar oil-base) for deer.

Sudbury Laboratory Inc., Box 34820, Phoenix AZ 85067; 602/285-1660. Chaperone Deer and Rabbit Repellent (thiram-base) rabbit, deer, meadow mice repellent.

Sutherlin Enterprises, 110 W. Nippino Trail, Nokomis FL 34275; 813/484-4568. Critter Ridder, attachments for turning a metal garbage can into a live trap that is attractive to pests.

Sutton Ag Enterprises, 746 Vertin Ave., Salinas CA 93901; 408/422-9693. Pyrotechnics, sonics, and visual devices to scare birds.

TADD Services, 1617 Old County Road Ste, 4, Belmont CA 94002; 415/595-5171. Termite sniffing dogs.

Target Specialty Products, Box 1117, Cerritos CA 90702-1117; 213/865-9541, 800/352-3870. Deodorants.

Termask, Biologic, PO Box 1777, Willow Hill, PA 17201; 717/349-2789. N-Viro, 610 Walnut Ave., Bohemia NY 11716; 516/567-2628. Nematode predators for termites.

Termi-barrier (Doug Carver), Live Oak Structural, Berkeley CA 510/524-7101. Sand barriers to prevent termite invasion.

Termitect II, PO Box 8301, Albuquerque NM 87198; 505/263-3703; 505/268-7739. Odor Detector to inspect for termites.

Termite Inspector, Mission Hills CA; 800/322-9661; 805/294-2600. Microwave treatments for termites

Tomahawk Live Trap Co., PO Box 323, Tomahawk, WI 54487; 715/453-3550. Live traps, animal control equipment.

Tramex, 1893 Coyote Cir., Golden CO 80403, 303/582-3538. Non-destructive moisture meter.

U.S. Borax, 26877 Tournay Rd., Valencia CA 91355, 800/984-6267, 231/251-5630. Timbor borate wood preservative.

UVEX Safety, LLC, 10 Thurber Blvd., Smithfield RI 02917; 401/232-1200, 800/343-3411. HEPA-Tech 3010 Filter.

Van Waters and Rogers, 2600 Campus Dr., Box 5932, San Mateo CA 94403, nation-wide number 800/888-4897; Phoenix office: 602/272-3272, Tucson office: 602/747-8717. Full line of chemicals, pest control equipment and supplies.

Whitmire Chemicals, 3568 Tree Court Ind. Blvd., St. Louis MO 63122; 800/325-3668. Aerosol pesticides, flushing agents, caulking.

Wilco Distributors, 1215 W. Laurel Ave., Box 291, Lompoc CA 93436; 805/735-2476. General pest control supplies.

Wildlife Control Technology Inc., 2501 N. Sunnyside Ave. #103, Fresno CA 93727; 209/294-0262, 800/235-0262. Fencing materials, Bat Kit with instructions; seminars in pest control, professional trade magazine.

Wildlife Management Supplies, Critter Control Inc., 640 Starkweather Rd., Plymouth MI 48170; 800/451-6544. Chimney covers, skunk deodorants.

Williams Trapping Supply, 4647 E. Station Rd., Roanoke IN 46783; 219/672-3721. Live traps, animal lures, trapping supplies.

Windear Manufacturing Co., 119 Parkway N., Lanesboro MN 55949; 800/726-5030. Lanesboro GT 100 Gopher Trap similar to standard rat trap.

Wire Fabricators, P.O. Box 115, Garrison MD 21117-9999; 410/363-1551. Rat Katcher multiple-capture live trap for rat-sized rodents.

Woodstream Corp., Lititz PA 17543, 717/626-2125. Victor Gopher Getter and Victor Gopher Trap; Havahart live traps; cockroach pheromone sticky traps.

ZA Macabee Gopher Trap Co, 110 Loma Alta Ave., Los Gatos CA 95030, 408/354-4158. Gopher traps.

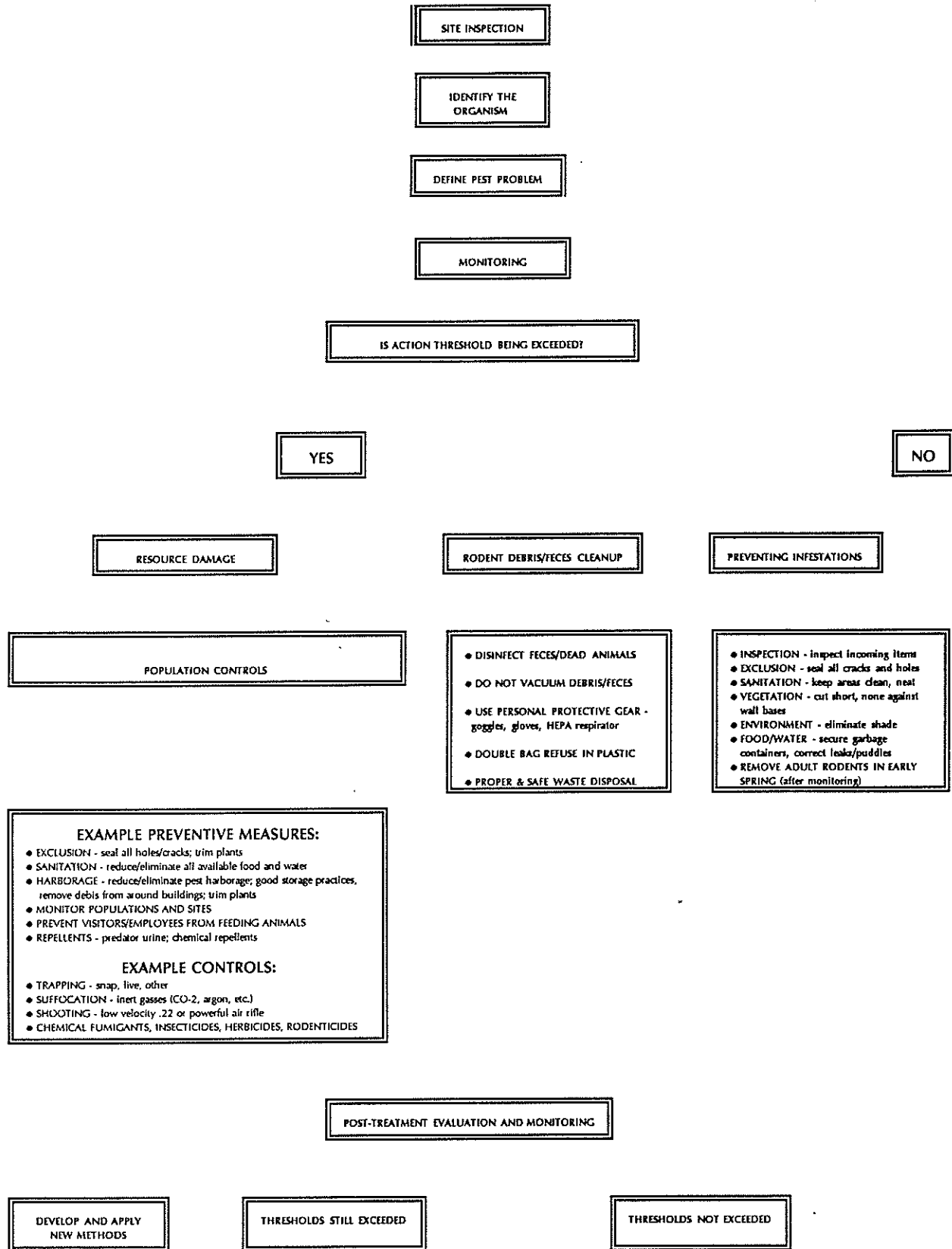
Zoecon Industries, Professional Pest Management Div., 12200 Denton Drive, Dallas, Texas 75234, 214/243-2321, 800/527-0512. Produces insect growth regulators (IGR's).

WASP-FREEZE
VOPAK 800 888-4897

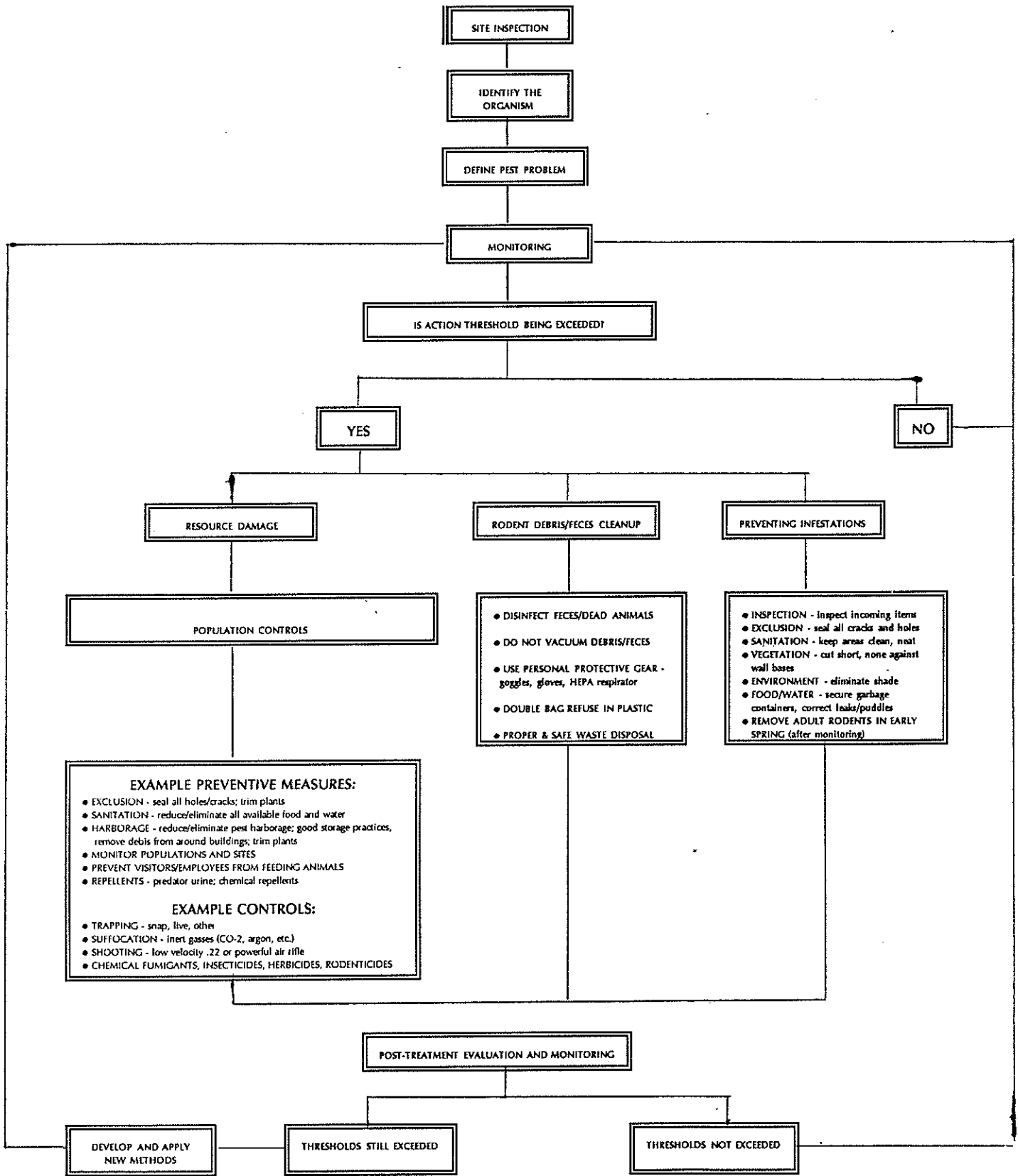
APPENDIX VIII

PEST CONTROL ALTERNATIVES (FLOW SHEET / DECISION TREE)

PEST CONTROL ALTERNATIVES



PEST CONTROL ALTERNATIVES



APPENDIX IX

FOUR YEAR PESTICIDE APPROVALS: 1998 THROUGH 2001

FOUR YEAR PESTICIDE APPROVALS: 1998 THROUGH 2001

Renewed
thru '05 (BS)

Once the comprehensive IPM Plan for BIBE is signed and approved by all parties, the park will receive NPS approval to use the following pesticide for a period of 4-years following the Plan approval date. After that date, the Plan must be reviewed and re-approved before these or additional pesticides can be used.

PEST	PESTICIDE AND USE
Accidental pests	Allethrin aerosol treatment for flying insects Boric acid bait (liquid and solid) for ants, roaches, silverfish, and other indoor pests Boric acid dust for cracks and crevices Diatomaceous earth with or without pyrethrin Fenoxycarb insect growth regulator for ants, fleas, roaches Hydramethylnon bait for ants, roaches, and crickets Methoprene insect growth regulator for fleas, ants Potassium salts of fatty acids (soaps) for insects on plants Pyrethrin contact spray Resmethrin aerosol for space treatment of honey bees; outside applications Silica aerogel with or without pyrethrin for cracks, crevices, and pest pathways
Ants	Allethrin aerosol for flying insects Borate wood treatment for carpenter ants Boric acid bait (liquid and solid) Boric acid dust for cracks and crevices Diatomaceous earth with or without pyrethrin Fenoxycarb insect growth regulator Hydramethylnon bait Methoprene insect growth regulator Potassium salts of fatty acids (soaps) for ants on plants Pyrethrin contact spray Resmethrin aerosol treatment Silica aerogel with or without pyrethrin
Bedbugs	Diatomaceous earth with or without pyrethrin Pyrethrin spray Silica aerogel with or without pyrethrin
Bees, wasps, and hornets	Allethrin aerosol for flying insects Pyrethrin spray for wasps Resmethrin spray for outside space treatment of honeybee and bumble bee nests Silica aerogel with or without pyrethrin for tunnels of carpenter bees and solitary bees Wasp freeze chemicals (without CFC's) for wasp nests
Cockroaches	Allethrin aerosol for initial knock-down Boric acid dust, liquid, and solid bait D-phenothrin (flushing) Diatomaceous earth with or without pyrethrin in cracks and crevices Fenoxycarb (IGR) bait Hydramethylnon bait Hydroprene (IGR) bait Pyrethrin aerosol (knock-down) Resmethrin aerosol for quick knock-down of populations Silica aerogel with or without pyrethrin for sewers and cracks and crevices
Deer	<u>REPELLENTS:</u> Ammonium soaps of higher fatty acids Benzyl-diethyl methyl ammonium saccharide Capsaicin-based products Fermented eggs (BGR, Big Game Repellent)

PEST	PESTICIDE AND USE
Fleas	Boric acid dust for cracks and crevices Carbaryl dust (consult with Cluster IPM Coordinator prior to use) Diatomaceous earth with or without pyrethrin Fenoxycarb insect growth regulator Flea powder with pyrethrin (commercial) for pets Flea soap with pyrethrin (commercial) for pets Linalool (d-limonene) Methoprene insect growth regulator Pyrethrin contact spray Resmethrin aerosol with or without pyrethrin for cracks and crevices Silica aerogel with or without pyrethrin for cracks and crevices
Javelina	There are no chemical toxicants or repellents labeled for javelina
Mice	Benzyldiethyl methyl ammonium saccharide gustatory repellent
Rattlesnake	Naphthalene and sulfur repellent around buildings
Ringtails	There are no toxicants or repellents labled for ringails See pesticides previously listed for flea control
Skunks	Carbon monoxide gas cartridges for skunks in holes (not to be used near occupied structures) Mustard oil and capsaicin gustatory repellent See pesticides previously listed for flea control
Spiders	Contact pesticides are not very effective for spiders; see text Allethrin aerosol Boric acid dust for cracks and crevices Diatomaceous earth with or without pyrethrin Pyrethrin contact spray Resmethrin aerosol Silica aerogel with or without pyrethrin for cracks and crevices
Ticks	Boric acid dust for cracks and crevices DEET repellent (up to 30 percent concentration) Diatomaceous earth with or without pyrethrin Permethrin repellent (for clothing) Pyrethrin spray Resmethrin aerosol Silica aerogel with or without pyrethrin for cracks and crevices
Vultures	There are no toxicants or repellents labeled for vultures
Weeds, miscellaneous	2,4-D - for broadleaf weeds in grass (state limited use herbicide; applicator must be certified) Clethodim - for grasses Glyphosate - non-selective herbicide Pendimethalin - pre-emergent herbicide Siduron - for annual grass in grass Triclopyr - for woody plants
Bermudagrass	Clethodim Glyphosate Siduron
Johnsongrass	Clethodim Glyphosate Pendimethalin
Mesquite	Glyphosate Triclopyr

PEST	PESTICIDE AND USE
Tamarix	Glyphosate Triclopyr
Thistles, Russian (tumbleweed)	Glyphosate 2,4-D (state limited use herbicide; applicator must be certified)