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INTEGRATED PEST MANAGEMENT PLAN

CASA GRANDE RUINS NATIONAL MONUMENT
ARIZONA

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INTEGRATED PEST MANAGEMENT PLAN
CASA GRANDE NATIONAL MONUMENT

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FOUR YEAR PESTICIDE APPROVALS: 1997 TO 2001

Once the comprehensive IPM Plan for Casa Grande National Monument 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 (with piperonyl butoxide) aerosol space treatments for flying insects Benzyldiethyl methyl ammonium saccharide gustatory repellent for woodpeckers, rodents, or other animals that gnaw on structures/wires Boric acid baits (liquid and solid) for ants, roaches, silverfish, and other indoor pests Boric acid dusts for cracks and crevices Diatomaceous earth dusts Diatomaceous earth dusts with pyrethrins Fenoxycarb insect growth regulator for ants, fleas, roaches Hydramethylnon baits for ants, roaches, and crickets Methoprene insect growth regulator for fleas, ants Potassium salts of fatty acids (soaps) for insects on plants Pyrethrum (synergized with piperonyl butoxide) for mothproofing; contact sprays Resmethrin aerosols for space treatments, honey bees; outside applications Silica aerogel for dusting cracks and crevices and along pathways used by pests Silica gel with pyrenone for cracks and crevices Wasp freeze chemicals (without CFC's) for wasps
Bees, wasps, and hornets	Allethrin aerosol space treatments for flying insects Boric acid dusts in cracks and crevices Potassium salts of fatty acids (soaps) for bee colonies and swarms Pyrethrin for wasps Resmethrin spray or dust for outside space treatment of honey/bumble bee colonies Silica aerogel for dusting cracks, crevices, and burrows of pests Wasp freeze chemicals (without CFC's) for wasp nests
Birds (house finches, pigeons)	Benzyldiethyl methyl ammonium saccharide
Cockroaches	Allethrin aerosol (knock-down) Boric acid dust and liquid and solid baits D-phenothrin (flushing) Diatomaceous earth in cracks and crevices Fenoxycarb (IGR) bait Hydramethylnon bait Hydroprene (IGR) bait Pyrethrum and pyrethins aerosols (knock-down) Resmethrin aerosol for quick knock-down of populations Silica aerogel in sewers and cracks and crevices
Museum pests	Allethrin (with piperonyl butoxide) aerosol space treatments for flying insects Boric acid baits (liquid and solid) Boric acid dusts for cracks and crevices Diatomaceous earth as a dust Diatomaceous earth dusts with pyrethrins Fenoxycarb insect growth regulator Hydramethylnon baits Methoprene insect growth regulator Pyrethrin contact sprays Silica aerogel for dusting cracks and crevices and along pathways used by pests Silica gel with pyrenone for cracks and crevices

PEST	PESTICIDE AND USE
Rabbits	REPELLENTS: Ammonium soaps of higher fatty acids Benzyldiethyl methyl ammonium saccharide Capsaicin-based materials Coyote or fox urine Fermented eggs (BGR, Big Game Repellent)
Rattlesnake	Naphthalene and sulfur repellent around buildings
Rodents, burrowing (ground squirrels)	Carbon monoxide gas cartridges
Rodents (gnawing) and woodpeckers	Benzyldiethyl methyl ammonium saccharide gustatory repellent
Spiders	Contact pesticides are not very effective for spiders; see text Allethrin (with piperonyl butoxide) aerosol space treatments Boric acid dusts for cracks and crevices Diatomaceous earth as a dust or dust with pyrethrins Pyrethrum (synergized with piperonyl butoxide) contact sprays Resmethrin aerosol space treatments Silica aerogel or silica aerogel with pyrethrin for dusting cracks and crevices
Wood preservation	Borate wood preservatives and related products
Weeds, miscellaneous	2,4-D - for broadleaf weeds in grass Benefin - pre-emergent Glyphosate - non-selective herbicide Siduron - for annual grass in grass Triclopyr - for woody plants

INTEGRATED PEST MANAGEMENT PLAN
CASA GRANDE NATIONAL MONUMENT

I. INTRODUCTION

The Integrated Pest Management (IPM) Plan for Casa Grande National Monument (CAGR) is designed to assist the park manager in making sound pest management decisions and to serve as a basic resource for other CAGR 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 control 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 landscape grounds.
President Carter's 1979 Memorandum requiring all 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, Memoranda on the Department of Interior and the Federal Insecticide, Fungicide, and Rodenticide Act.

B. NPS Guidelines and Policies

NPS Management Policy (1988) which outlines the basic framework of the NPS IPM program:

Full implementation of IPM practices in NPS field areas has been a Service-wide 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.

The NPS Museum Handbook, Part I, Museum Collections (revised September, 1990) provides state-of-the-art guidance on museum pest management including identification of pests, establishing a museum IPM program, and actions to take should an infestation be discovered.

Presently, the IPM program has been reorganized and administration of the program has changed, particularly in regard to pesticide review and approval processes. Consequently, some portions of the Management Polices 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 memoranda.

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

C. Park Purpose

Casa Grande National Monument is located in south-central Arizona, about 50 miles south of Phoenix. The park was first authorized as a reservation on March 8, 1889 to preserve the massive four-story ruin built by Native Americans who farmed the Gila Valley about 600 years ago. Casa Grande was proclaimed a National Monument on June 22, 1892 and later redesignated by Presidential Proclamation on August 3, 1918.

The Integrated Pest Management program ensures public and official use of the park are compatible with the highest standards of resource protection and provides opportunities for public education in resource conservation ethics.

D. State Regulations Covering Pesticide Use

The State of Arizona requires Federal employees who apply Restricted-Use or state-limited-use pesticides in the park be certified as non-commercial pesticide applicators and to receive at least 6 hours of approved pest management continuing education each year in order to maintain certification. For a copy of state pesticide regulations or certification testing, contact the State of Arizona, Structural Pest Control Commission, 9545 East Doubletree Road, Scottsdale, AZ 85251, 602/255-3664.

It is illegal to use lethal traps (snap traps, snares, foot traps, body hold traps, etc.) to capture outdoor wildlife in Arizona; however, it is legal to capture rodents or other small animals considered to be pest species in lethal traps if the trapper is certified by the state as a pesticide applicator (pest control operator). It is not illegal to use lethal traps indoors to capture rodents. Where lethal traps are used, potential hazards to people, domestic animals, and non-target animals from the traps will be kept to a minimum by protecting the traps with covers (box or wire mesh covers).

III. OVERVIEW OF IPM PLAN

A. Description of the IPM Program

Integrated Pest Management coordinates all available biological, environmental and modern pest control 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 controls, decision-making processes, and risk reduction systems. Unlike any given single method of 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 pro-active IPM program. Some examples are:

- better preservation of cultural and natural resources and property.
- reduced manpower needs to control pests 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 pesticide 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

CAGR is located in a natural environment that supports an extremely wide array of vertebrate and invertebrate animals, some of which interfere with park management or personal objectives and become pests. Outdoors, pest animals find abundant natural harborage beneath rocks and among native plants. They obtain food from plants and their products, accidental food spillage, deliberate feeding by visitors and residents, and from garbage cans. Pests 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.

Control of 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 CAGR 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 IPM methods and information and includes use of the widest possible spectrum of mechanical, physical, cultural, and chemical controls. Basically, that information includes:

- an established and approved pest control plan defining 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 control measures; and

- available reference information.

The basic guideline for park IPM programs has been presented as a nine-step process which develops and makes available written information and protocols to help prevent pest damage while still protecting 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 with 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 non-chemical and chemical control measures,

- periodic evaluation of program efficacy, and,

- maintenance of records on treatments and results.

C. IPM Plan 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 some control must be taken).

- To provide rational, safe, effective IPM alternative methods for pest control within NPS procedural policy guidelines which describe controls 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 for written documentation of any control 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 if approved through proper NPS channels. 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 recommendations for non-chemical controls, listings of effective pesticides which under given sets of conditions will be approved by the Cluster IPM Coordinator.

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, when 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 control 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 control 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 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 4 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 CAGR IPM Coordinator:

- will gain proper identification for all pests that detrimentally affect park resources or pose health or safety concerns. When rodents or small organisms 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 of pest control.

- 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 control options for acceptability and/or feasibility before using chemical pesticides.

- will assure that any pesticide used in the park is approved by NPS approvals before use. The Coordinator will be responsible to inform pesticide applicators, whether in-house or contracted, about NPS policies and guidelines concerning pesticide use; monitor applicators for safe application; and assure applicators follow label precautions and guidelines for safe application.

- 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 control activities that might affect cultural resources.

- will make the information on any 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 or Acting Museum

Curator are important to the park IPM program. That person 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, or structural deficiencies or conditions that encourage pests. Inspections will record deficiencies or needed repairs on maps or floor plans. Additional "spot inspections" may be required 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 the findings on Museum Monitoring Reports.

- will semi-annually (preferably in early spring and late summer), and 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 soil, and re-visited to determine if rodents are actively using them.

- will increase monitoring efforts when inspections provide evidence of museum pest or rodent activity and, based on accepted Action Thresholds, contact the IPM Coordinator for pest control methods.

- 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 carrying out the park pest management program.

- 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 bird or 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 promptly report obvious pest damage or infestations, plumbing leaks, or other conditions supporting or encouraging pests.

- The Maintenance Division will punctually schedule repairs of all reported structural, utility, or vegetative deficiencies which support or encourage pest infestations. Where possible, proper grade will be established around buildings to allow 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 must be alert to conditions supporting pests, signs of pests, and pest damage. These employees 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. Park Rangers will constantly remind visitors to not feed animals and to place food refuse only in covered garbage receptacles.

6. Chief(s) of Resources Management (both Cultural and Natural): The Divisions of Cultural and/or Natural Resource Management will prepare Resource Management Project statements covering significant portions of 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 (if assigned): 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 or use. Health and safety hazards concerning pest infestations and pesticide use 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 the various health and safety matters surrounding pests and pest management.

- during safety inspections or monitoring of park resources, encourage employees to follow safety and health requirements.

- monitor for safe storage and application of Restricted-Use or state-limited-use pesticide compounds.

8. Chief of Interpretation: The Division of Interpretation will inspect for, monitor, and correct (if possible) any conditions of inadequate sanitation or the occurrence 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 activities. Employees in the Division will continually remind visitors to not feed wild animals and to only place food scraps and garbage in covered receptacles.

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

10. 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 will not be allowed to use pesticides (insecticides, rodenticides, herbicides, etc.) which have not been previously approved through the park IPM Coordinator.

IV. MAJOR PEST MANAGEMENT ISSUES

The pest issues at CAGR 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 CAGR was gathered as background for the current IPM Plan:

Burrowing rodents (mainly, round-tailed ground squirrels): Ground squirrels are regarded as one of the principal pest problems at CAGR because their burrows damage the archeological ruins.

Pigeons: Pigeons are considered to be a principal pest problem in the park. These and, to a smaller extent, other and smaller birds roost in the superstructure covering the major ruin and stain the walls, floors, and surrounding areas with their feces. Birds also make nests and roost in and enlarge already present holes in the adobe ruin which were caused by erosion. The activities of the birds increase the rate of structural deterioration.

Mice and woodrats: Native mice (Peromyscus spp.) and woodrats Neotoma spp.) are common in the park and become pests when they enter the Visitor Center, residences, offices, warehouses, and other structures to cause sanitation problems or possibly transmit diseases. A year or two ago, rodents damaged expensive transformers when the animals entered a shed and gnawed on electrical wiring.

Bees, wasps, hornets, and yellow jackets: Honey bees, wasps and yellow jackets are frequent problems around the garbage cans in front of the Visitor Center and sometimes around the residences an in visitor use areas. Once in a while a swarm of bees lands on the Great House walls. Stinging insect problems tend to worsen towards the end of summer when flowers in the area go to seed. The occurrence of stinging incidents, however, are very rare in the Monument and a documented Stinging Incident Log is not maintained.

Africanized honey bees (AHB) are known to occur in areas located some distance from the Monument, but are not known to occur in the Monument. Some staff members have concerns about possible future AHB problems.

Cockroaches: Cockroach infestations occur in some park residences.

Poisonous snakes: Although a goodly number of rattlesnakes are seen each year in the Monument, poisonous snakes are not considered to be a major problem. The occurrence of snake bites in the park is extremely rare.

Rabbits: Rabbits become pests around the Visitor Center where they damage decorative plants in the patio.

Termites: Old termite damage is seen in a number of historical and modern buildings.

Accidental pests: Scorpions, spiders, centipedes, and various other accidental pests that live outdoors sometimes enter the Visitor Center and residences. In one occurrence, a scorpion triggered a security system motion detector.

Vegetation: Miscellaneous plant and weed growth along road shoulders and in the ruin compound are continual problems. Previously, the park has used a drag on road shoulders but this was found to damage the blacktop and new methods of plant control must be developed. Weeds in visitor-use areas have commonly been removed by hoeing or chopping but this disturbs the surface of the ground and stimulates new plant colonization.

V. IPM METHODS

A. Pest Identification

An important first step in IPM is to accurately identify suspected pests. Identification makes it possible to obtain biological information on a pest species and its life history. All problem pests in CAGR 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 control 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 CAGR will be keyed to identifying the occurrence, abundance, and trends of pest populations and to note any climatical or other conditions (increased deterioration of structures or increased productivity of the habitat) which might forecast a suspected increase in the number of pest animals. In this way, inspections and monitoring serve as a forewarning of 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, "Inspection and Monitoring Guidelines and Sample Forms".

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 control 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 October or November) before native rodent pests begin to enter structures. Additional "spot inspections" may be required at other times of 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 controls, and serve as a guide for planning 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 inspections or monitoring, photo point records may be made of various or selected special problem areas that seem susceptible to pest damage. Over time, a comparison of the photo records will provide information on long-term changes.

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 so work can be prioritized.

2. Post-Treatment Monitoring and Evaluations

One of the most important parts of a successful pest control program is post-treatment monitoring. This provides for evaluations of the adequacy of treatment, cost-benefit ratios, and guidance for future programs. Where treatments are shown to be partially or wholly ineffective, post-treatment monitoring and evaluations will provide ideas for improvements that may lessen cost, make treatments easier or faster, or increase the permanency of controls. 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 which appear during management 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 eliminate all potential resources available to pests, good attention to sanitation will do much to restrict a site's "carrying capacity" and ultimately reduce pest numbers and make early detection easier.

1. Interior Sanitation

Because rodent and insect pests survive and can rapidly reproduce inside structures, good interior sanitation is mandatory for controls to be effective. Some pests can 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 and on shelving or pallets

to allow for cleaning.

- Proper refuse and garbage disposal practices are very important, do not allow garbage to remain in buildings overnight.

- Repair leaking plumbing. Insulate cold water pipes which collect condensation. Control sub-floor moisture sources with increased ventilation in the crawlspace.

- If possible, locate all pop, candy, or snack machines outside of the building so water condensation and crumbs will not be available to pests inside the building and to assure that pests are not imported into buildings with supplies. If machines must be located inside the building, establish good sanitation practices to keep the areas around them clean. 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 (or 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 and Exclusion

Rodents (and other pests) commonly move into structures from outside locations and then return outside again. Good exterior exclusion (closing entrance holes) will reduce or eliminate such movement. Seasonally, outdoor environments can support high numbers of animals (climatic conditions which produce harborage and food) and this results in crowding of pest populations which encourages pests to enter buildings. It is important to practice good sanitation and habitat reduction around buildings to lessen pest 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 next to buildings. Establish a 24 inch-wide, weed-free zone around building foundations to eliminate pest harborage. Do not let vegetation touch or overhang the building.

- Thin or remove dense vegetation in areas surrounding buildings. Some flowering shrubs (i.e., Spirea) attract adult Dermestid (carpet) beetles during spring, the time of the year when doors are more likely to be left open. Food odors and warmth attract beetles inside the structures where the insects they lay eggs.

- Monitor garbage and trash handling methods and keep trash cans and areas around cans clean. Keep tight fitting, secure lids on garbage containers.

- Improve grade around buildings. Fill or drain low-lying areas where puddles of water accumulate. Repair leaking air conditioners or other pipes and faucets.

- Improve drainage from roofs and down spouts by cleaning gutters and drains frequently.

- Do not place bird or pet feeders near buildings. Continually remove bird nests from building eaves or doorways to prevent attracting pests which may live in or be attracted to the 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 or yellow lamps which attract fewer insects.

- Frequently inspect building exteriors and interiors to find and close all possible pest entryways.

D. Action Thresholds

Action Thresholds are criteria used to justify the initiation of controls. The principal objective of an IPM program is to suppress or manage pest populations in such ways as to keep pest numbers below some 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 estimations or observations of:

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

Based on findings of inspections and monitoring and specific biological attributes of pests, Action Thresholds will be established (see descriptions of individual species) to determine the need for initiating specific pest management actions. 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 management actions in CAGR will be based on established Action Thresholds and will employ all feasible physical, mechanical, cultural, and biological control methods. Initial control of pests will be by exclusion, sanitation, habitat modification, and direct removal. NPS-approved, chemical pesticides will only be used as a last resort and when other controls do not achieve acceptable results.

Control alternatives are many; however, the success of controls relies heavily on persistence and diversification employed in applications. Never give up on trying to control pests and do not totally rely on any one, single control or preventive measure, not even one previously proving effective. Keep trying different controls until finding those that work. Pest control methods are always most effective when used in combination. Additional information on the management of specific pests at CAGR is found in the attached descriptions of individual pests.

F. Records

All pest management inspection, monitoring, and photo point data and records of exclusion and sanitation measures taken 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 measures.

The IPM Coordinator will complete, submit, and file all 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 and, because of their feeding and living habits, can spread diseases to humans. The potential for the spread of disease is one of the most important reasons which support pest management.

Because of recent Hantavirus ("Sin Nombre" virus or Hantavirus Pulmonary Syndrome <HPS>) outbreaks in Arizona, 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 when removing rodent feces/debris (see Appendix I, "Hantavirus Pulmonary Syndrome (HPS) Information"). 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. Prior to use, persons wearing respirators will conform with OSHA guidelines for a Respiratory Program, 29 CFR 1910.134.

Some of the 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, spore-borne valley fever, and hemorrhagic fever (Hantavirus). Additional descriptions of diseases are found in Appendix II, "Rodent and Insect Borne Diseases and Hazards".

Rodents (and other mammals) and birds carry parasites that can spread diseases to humans. In disease endemic areas, the State Health Department recommends 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. Dead animals or animals caught in traps should only be handled with gloves.

Bird, bat, and rodent nests in or on buildings, dead pest carcasses, and food stored inside structural voids by pests attract a variety of insect pests (i.e., stored product pests) which may 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 parasites) and will follow CDC recommendations for controlling rodents; 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 wildlife (especially ground squirrels and chipmunks). Although rabies is fairly common wildlife disease in the Southwest, rodents seldom carry it and rodent bites more often 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 mammals 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 can harm desirable plants. Therefore, it is mandatory that careful and continuous control is used when handling pesticidal chemicals 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 labels and in posted, non-flammable, temperature-protected, 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 hazardous substances they may be required to 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 park residences is crucial to protect 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: "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 available phone numbers for the Poison Center (1-800-732-6985) and Samaritan Regional Poison Center (Phoenix, 602/253-3334).

D. Other Safety Concerns Surround Pest Management Activities

After applying pesticides in areas subject to visitor use, post the treated areas with appropriate signing 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.

Workers using ladders and scaffolds should be warned about the dangers of encountering stinging honey bee, wasp, hornet, and yellow jacket colonies.

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

Employees handling live poisonous snakes and other possibly dangerous animals will be trained, only use the proper equipment, and will keep the public at a safe distance. Poisonous snakes and animals will be transported and released in safe manners.

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

VII. EMPLOYEE TRAINING

It is recommended that Park IPM Coordinator receive 40-hours of initial IPM training and be certified by the state as a non-commercial, Arizona, pesticide applicator. Training is critical to 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 large vertebrates. 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 Arizona requires federal employees to be certified as a pest control applicator when applying pesticides on federal land or when trapping animals (i.e., rodents) in kill-type traps in outdoor locations. If there are any questions about the state registry status on a pesticide or on training or regulations concerning pesticide applicator certification procedures, call the State of Arizona, Structural Pest Control Commission, 9545 East Doubletree Road, Scottsdale AZ 85251, 602/255-3664 for information.

VIII. FREQUENCY OF PLAN UPDATES

This IPM Plan for CAGR 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 CAGR and will make budget and manpower available to support annual monitoring, exclusion, and control needs.

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

The intent of the IPM Plan for CAGR 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 (except personally-owned insect repellents that are applied to the body) used in CAGR (by staff, residents, contractors, special-use permittees, agricultural lessees, or non-NPS personnel) 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 can result in environmental contamination, pose serious health hazards to personnel, or cause rapid development of pesticide resistant pest species. Preventive applications will be considered to be an "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 and 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,
- to preserve, maintain, or restore the historical integrity of cultural resources.

Exotic plant and animal species already present in the park will be manipulated or 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 some future time. 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. 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. To review the park's currently approved Pesticide Use Proposals, please see the Appendix added to that report by the Park IPM Coordinator. That Appendix is updated annually to reflect the park's current program.

PREVIOUSLY USED AND POTENTIALLY NEEDED PESTICIDES

PESTICIDES PREVIOUSLY USED OR REQUESTED

CHEMICAL	TRADE NAME	USE
Boric acid	BoraCare	termites, fungus, and carpenter ants
Glyphosate	Roundup	for weeds

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	animal repellent
Bacillus thuringiensis	Dipel, Thuricide	webworm
Benzyldiethyl 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
Copper-8-quinolinolate	various	wood preservative: fungus on wood
Dalapon	Dowpon	herbicide; annual or perennial grass in broadleafs
Diatomaceous earth with or without pyrethrins	Diatect, 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
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

CHEMICAL	EXAMPLE TRADE NAME **	USE
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
Naphthalene (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
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 or without pyrethrum	Tri-Die (PT-230), Silikil, Drione, Dri-Die	cracks, crevices; insect pathways; flea control
Thiram	Arasan	gustatory animal repellent
Trichloromonofluoromethane with d-trans-allethrin and phenothrin	Wasp-Freeze	wasp, hornet, yellow jacket nests
Triclopyr	Garlon-3A	woody weeds; salt cedar, Chinese elm
Ziram		animal repellent; fungicide
** SPACE ALLOWS LISTINGS OF ONLY A VERY FEW OF THE MANY COMMON BRAND NAMES		

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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.

XIII. AUTHOR OF PLAN

Gerard A. Hoddenbach, G & L Consultants (May, 1997), P.O. Box 750128, Torrey UT 84775, 801/425-3095, 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.

PESTS

INDEX TO PESTS

weed pests are included in this Plan for Casa Grande National Monument under

PESTS (CENTEPEDES AND SCORPIONS)

BEES, WASPS, HORNETS, AND YELLOW JACKETS

COCKROACHES

HOUSE FINCH

MICE AND WOODRATS

PIGEONS

RABBITS

RATTLESNAKES

ROUND-TAIL GROUND SQUIRRELS

SPIDERS

TERMITES

WEEDS

WEEDS, INTRODUCTION (GENERAL WEEDS)

ACCIDENTAL PESTS

Description

Many common household and work place 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, 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 (such as 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 and centipedes and are described in this section. Ants, bees, wasps, bats, mice, and other pests 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: attraction to structures, available entry points, and 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 (Appendix).

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. Check traps on each visit and identify all captures. Record the number, location, species, life stage, and time interval over which pests were caught in a journal. Recording such data on floor plan drawings will point out the areas of greatest pest activity and provide base-line information for post-treatment monitoring.

One innovative 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 (i.e., a small coin). This tends to increase capture rates for crawling insects preferring small, dark cracks.

Action thresholds

Action Thresholds for accidental pests are very 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, a variety of residual pesticides (which include resmethrin) are labeled for band application around building foundation walls,

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 or DDVP), for use in pest control. Vapona is only effective when used in enclosed areas (see label). However, when the active ingredient combines with air (hydrolyses) it produces acidic fumes which can present the potential for human health hazards and serious damage to objects.

DDVP is currently in special review at E.P.A. because 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 (i.e., 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 (with piperonyl butoxide) aerosol space treatments for flying insects.
Benzyldiethyl methyl ammonium saccharide gustatory repellent for woodpeckers, rodents, or animals that gnaw on structures/wires.
Boric acid baits (liquid and solid) for ants, roaches, silverfish, and other indoor pests.
Boric acid dusts for cracks and crevices.
Diatomaceous earth dusts.
Diatomaceous earth dusts with pyrethrins.
Fenoxycarb insect growth regulator for ants, fleas, roaches.
Hydramethylnon baits for ants, roaches, and crickets.
Methoprene insect growth regulator for fleas, ants.
Potassium salts of fatty acids (soaps) for insects on plants.
Pyrethrum (synergized with piperonyl butoxide) for mothproofing; contact sprays.
Resmethrin aerosols for space treatments, honey bees; outside applications.
Silica aerogel for dusting cracks and crevices and along pathways used by pests.
Silica gel with pyrethrin for cracks and crevices.
Wasp freeze chemicals (without CFC) for wasps.

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.

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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 species of centipedes 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

Centipedes of various species are native in the park area and can be expected to be found in residences, offices, and especially in structures which open to the outside environment (ruins, outbuildings, etc.).

Centipedes, along with a number of other outdoor pests, are considered "accidental pests", and most species seldom, if ever, take up permanent residence inside residences.

Biology

Centipedes are primarily carnivorous. They normally live outdoors in protected situations where they nest 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, etc. One species, the garden centipede (Synphylid), 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 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 other 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. Centipedes, like scorpions, sometimes enter a structure through drains where they are found trying to escape from bathtubs or sinks.

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 help to control centipedes inside structures. Remove centipedes seen inside a structure with a vacuum.

Outdoor sanitation is important to reduce the possibility of 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

- adequately ventilate 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 so lights are less attractive to insect prey. Install lighting on poles 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/or dust applications of resmethrin or boric acid are labeled for use in wall voids, cracks and crevices, along baseboards, and in other harborage.

Outside, a variety of residual pesticides (which

include resmethrin) are 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 as a last resort in worst-case scenarios.

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

Boric acid baits (liquid and solid) for ants, roaches, silverfish, and other indoor pests.
Boric acid dusts for cracks and crevices.
Diatomaceous earth dusts.
Diatomaceous earth dusts with pyrethrins.
Fenoxycarb insect growth regulator for ants, fleas, roaches.
Hydramethylnon baits for ants, roaches, and crickets.
Insect growth regulators for prey such as ants, roaches, grasshoppers, etc.
Methoprene insect growth regulator for fleas, ants.
Resmethrin aerosols for space treatments; outside applications.
Silica aerogel for dusting cracks and crevices and pathways used by pests.
Silica gel with 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.

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

See Appendix listings for equipment and chemical supplies.

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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

Scorpions are native arthropods and are found in or around park residences, offices, and other structures, especially those open to the exterior environment (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 potentially 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 bed coverings 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 (fluon) 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 and can help 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 captured 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 under them.

- 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 other 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 up 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 work well to reduce indoor 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 of these chemicals are labeled 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 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

Boric acid baits (liquid and solid) for ants, roaches, silverfish, and other indoor pests.
Boric acid dusts for cracks and crevices.
Diatomaceous earth dusts.
Diatomaceous earth dusts with pyrethrins.
Fenoxycarb insect growth regulator for ants, fleas, roaches.
Hydramethylnon baits for ants, roaches, and crickets.
Insect growth regulators for ants, roaches, grasshoppers, etc. which scorpions prey on.
Methoprene insect growth regulator for fleas, ants.
Resmethrin aerosols for space treatments, honey bees; outside applications.
Silica aerogel for dusting cracks and crevices and along pathways used by pests.
Silica gel with 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.

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

See Appendix listings for equipment and chemical supplies.

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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 in the park. They are attracted to flowering plants, heavy vegetation, disturbed soil, mud puddles caused by poor grade around structures, garbage cans, water leaks, etc.

Paper wasps and yellow jackets can be found anywhere in the park but become noxious pests when they establish nests around residences, offices, in water control boxes in the ground, and under buildings.

The Africanized honey bee does not yet occur in CAGR but is found in locations relatively close to the park.

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 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 with 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 (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. "Hands-on" experience in AHB control could be obtained if some CAGR staff were to be cooperatively assigned to Organ Pipe Cactus National Monument during AHB removal operations.

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 detergent in 16 parts 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 anyway. 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:

- 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 as a poison for destroying 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 (with piperonyl butoxide) aerosol space treatments for flying insects.
Boric acid dusts for cracks and crevices.
Potassium salts of fatty acids (soaps) for bee colonies, insects on plants.
Resmethrin aerosols and dusts for space treatments, honey bees and bumble bees; outside applications.
Silica aerogel for dusting cracks and crevices and along pathways used by pests.
Silica gel with pyrenone for cracks and crevices.
Wasp freeze chemicals (without CFC's) for wasps.

Sources of advice, technical information, and supplies

National Park Service Videotapes

"Integrated Pest Management," 15 minutes.

"Pesticide Applicator Safety," 17 minutes.

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

See Appendix listings for equipment and chemical supplies.

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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. Entomology, Texas A&M Univ., College Station TX 77843.

Texas. Bexar County Extension Agent, Andy Vestal.

Texas, State of; Department of Health
Touhey, Dr. John E., Chief, Bureau of Environmental and Occupational Health for San Antonio Metropolitan Health District, San Antonio TX.

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.

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SAMPLE STINGING RECORD 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?

8. Other pertinent information:

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 water puddles which support honey bees?

MONITORING

1. Counts of yellowjackets/bees/wasps that visit garbage cans during 10 minutes (identify can on an attached map):

2. Presence of active stinging insect nests in the area (identify on a map):

EMPLOYEE COMMENTS AND RECOMMENDATIONS: _____

_____

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 sometimes become pest problems in the park residences and a number of other NPS buildings.

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. Because of their size, American roaches are able to carry large pieces of food away to protected places where they eat it. Foods not eaten by American roaches sometimes attract other insect pests.

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 organisms; 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 reason 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 Thresholds, 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 (IGR) pesticides are available either as dusts, baits, or disposable packets. Some newer packets continuously release very small amounts of the material into the air.

D-phenothrin is sometimes used during inspections in a very small amount as a "flushing" compound. When applied into a crack or small hole, it forces roaches to quickly abandon their hiding places, verifying the presence of the insects.

Resmethrin-based aerosol sprays are effective for a quick knock-down of large cockroach 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 such as silica aerogel or boric acid dusts 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 pyrethins
Resmethrin
Silica aerogel and silica gel

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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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 a 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.

HOUSE FINCH

Description, distribution, identification:

House finches Carpodacus mexicanus) are small (5 to 6-inch long), social, sparrow-sized birds that sometimes forage in very large flocks and over extremely large areas of ground. Most males have a shiny red crown, breast, and rump but females are plain and generally patchy brown and white.

Occurrence in the park

House finches occur throughout the park and roost in the Great House ruin.

Biology

Habits

House finches in the West usually do not forage very far from their roosts, normally only within a 10 mile radius. Many birds may spend their lives within only a few miles of the location where they hatched.

Adult birds, which are usually widely scattered during the nesting period, begin to join together into flocks during mid-summer. Flocking behavior increases with the progression of summer and by December, most flocks have usually moved into areas having sufficient resources to support them.

Foods and feeding

House finches are generalists. They feed on grass and weed seeds during winter, leaf and flower buds in the spring, and insects during summer.

Reproduction

Female house finches will build nests in nearly any sheltered spot, including eaves and building ledges. During summer, a female house finch may produce from 3 to 7 eggs in each of 2 to 4 clutches. The eggs hatch in 13 days and young chicks leave the nest about 12 to 18 days later.

Potential damage and health concerns

The presence of large flocks of house finches usually signals an impending pest problem. House finch flocks in California can be made up of 1,000 or more individuals during summer and can become as large as 5,000 or more birds during winter. The size of such flocks makes them serious agricultural pests when they feed on grains, vegetable seeds, livestock feed, or fruits.

At CAGR, flocks of house finches are attracted to the Great House ruin where they roost at night. Roosting flocks produce a large amount of feces which stains ruin walls and floors.

Action thresholds

Any presence of roosting flocks of house finches (or other birds) in the Great House ruin will be the Action Threshold to initiate management actions.

Inspection and monitoring

Inspections and monitoring for house finches are similar activities and the same forms can be used for recording data.

Inspecting and monitoring for the presence, numbers, and behavior patterns of house finches can be done by counting (or estimating) the numbers of individuals, nests, and roosting areas within the ruin at any given time or by estimating the number of birds in flocks which arrive in the evening or depart in the morning. The source for video cameras and specially designed computer programs to photograph and count individual flying birds is available through the park Cluster IPM Coordinator.

Periodic inspection of the Great House will determine the extent of possible damages to walls and floors which result from bird feces, nesting activities, pecking on caliche, etc.

Non-chemical management

Legal. The house finch is a native and migratory bird and is protected by both Arizona law and the Federal Migratory Bird Act. Any management actions taken against individual birds or their nests require

depredation permits from administering agencies.

Exclusion

The best management alternative for keeping birds out of buildings and other partially enclosed spaces is by screening the open areas with 1/2 inch mesh, plastic netting.

Many different kinds of birds are prevented from roosting, perching, or nesting on building ledges by installing 60-degree slant boards, sharp pointed porcupine wire, tensioned lines (some electrically charged), or the application of sticky materials to building surfaces. House finches, however, are small enough to be able to make use of even very small roosting sites and the above methods are usually not fully satisfactory and would be aesthetically displeasing on archeological ruins.

Sanitation

If birds are known to commonly feed on the Monument grounds, control weeds before they bloom and early in the fall remove any dead ornamental plant parts which bear seed heads. Clean up spilled grain and other possible sources of food for birds. Remove bird feeders.

Habitat modification

Remove brush piles, stacks of pipe, piles of boxes, or other debris from the grounds to reduce the availability of nesting or resting areas for birds.

Population reduction

Modifications can be made to Australian crow traps which make them usable for capturing house finches. Those traps have been proven effective in capturing large numbers of finches in some areas. Proper trap location, however, is critical to trapping success.

Shooting house finches can reduce the numbers of birds present but is a time consuming activity, rather costly, and usually only a rather small percentage of birds can be removed from large flocks.

Repellents.

Common frightening devices (gas cannons, flags, dangling foil, and scarecrows) have not been found to be effective in deterring house finches.

More elaborate repellent devices might be conceived in attempts to prevent birds from roosting in the Great House. One such device might be a set of electrically-powered, moving arms, mounted at interior roof level and operated from an automatic timer which starts motion just before finches arrive to roost. This device would revolve while moving up and down and could be equipped with lights and sounds. Another device might be rising and falling helium-filled balloons accompanied with lights reflect light and cast moving shadows.

Chemical management

Repellents

Avitrol Mixed Grain is a toxic chemical causing flock-alarming reactions in birds that eat enough of the material. Toxic perches are also sometimes used in bird control. Both of these chemical alternatives are Restricted Use pesticides and require special approvals.

Toxicants

There are no toxicants registered for use against house finches.

Evaluating treatments

Periodic monitoring will provide information on the effectiveness of 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

None

Sources of advice, technical information, and supplies

National Park Service IPM videotapes

"Integrated Pest Management," 15 minutes.

See Appendix listings for equipment and chemical supplies.

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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. boylei). 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 the United States and the different species are 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 a specific habitat types. The woodrats most common in and around the park include the whitethroated woodrat Neotoma albigula, southern plains woodrat (Neotoma micropus), and Mexican woodrat (Neotoma 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 become nuisances and health-related pests when they enter residences, warehouses, offices, or other structures. Rodents sometimes gnaw on and damage electrical wiring in vehicles and (probably) in buildings.

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 cactus. 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

"Mice" is meant here to include the full array of smaller native rodents which can become pests and includes animals in the genera Perognathus, Peromyscus, Rheithrodontomys, and Onychomys and Mus, exotic house mice.

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 any significant damages 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 press) 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. And, parking vehicles in rodent-proof garages is the most effective way to prevent damage to wiring and hoses.

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 off-set 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.

Benzyldiethyl methyl ammonium saccharide is a gustatory repellent and can be applied to weather stripping, wires, etc. to prevent gnawing damage by mice. Often, this chemical must be applied rather frequently (once every week or two) to be most effective.

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

Benzyldiethyl 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 D^3) 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. This rodenticide has a Caution label and is relatively toxic but is reported to not show secondary poisoning characteritics in other mammals.

Whenever rodenticides are used, it is imperative that poisons only be placed in **sealed and child-resistant bait boxes** to protect non-target animals and humans. Bait boxes are commercially 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.

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*** **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.

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.

- 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. On the other hand, 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.

- 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 un-set 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 under-estimating 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 that are 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 lathe 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 then 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 contains 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 like brick, tile, and cinder and 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.

PIGEONS

Description, distribution, identification:

Wild pigeons (Columba livia) are typically, medium to large sized, gray colored birds having short, red-colored legs, rounded head, pointed wings and a fairly long, fanned tail. They usually have a white rump, two black bars on secondary wing feathers, a dark terminal tail band, and frequently have a purple head. Due to inter-breeding, however, some wild pigeons are gray, white, tan, black or of mixed colors. Females are always more dull in color than males.

When flying, pigeons glide with their wings raised at an angle and, when walking, bob their head. They are rather sedentary birds and spend a good part of each day preening and sunning. They make guttural cooing sounds.

Pigeons are not native birds and were introduced into this country as a new source of food from Eurasia during the mid-1600's. Now, pigeons commonly occur throughout North America, especially in urban environments, where they find abundant food and water and nesting sites.

Occurrence in the park

Pigeons occur throughout the area surrounding the park but flocks tend to roost and nest in the Great House ruin.

Biology

Colonies

Pigeons flocks in some areas of the country can be as large as several hundred birds, about half of which are females. Each flock seems to have an individual personality: some are extremely cautious, others very bold, still others very shy and will flare at anything that frightens them.

Habits

Pigeons have very constant and habitual behavior patterns. They routinely feed, nest, and roost in same places every day; however, their daily movements may be extensive with some flocks feeding and watering at sites up to 3 miles distant from nest sites.

Pigeons often pick darker-colored, warmer roofs as loafing areas and tend to favor perches with a southern exposure.

Pigeons have acute vision. They can hear in a range from 200 to 700 cps, much lower than humans. Sonic repellent devices have not proven to be effective in repelling pigeons. The birds quickly learn to recognize individuals who feed (or, disturb) them and they quickly learn how to navigate in restricted surroundings.

Foods and feeding

Pigeons primarily feed on grains and foods intentionally or unintentionally provided them by people. The birds will also feed on garbage, livestock manure, insects and a variety of other items should preferred foods become scarce.

Peak feeding periods for pigeons are during early morning and late afternoons. In a morning feeding, an adult bird will typically eat about 25 kernels of corn (or, about a pound of food per week). Although birds can go several days without eating anything at all, they must have water every day and they will regularly frequent the same water holes every day. Pigeons seem to have a need for lime in their diet and have been known to peck mortar out from between bricks in walls and eat it.

Pigeons prefer to feed in open areas where there is good visibility all around them, they tend to breed at loafing sites, and flocks habitually use the same roosting ledges.

Reproduction

Pigeons are monogamous and females first breed when 6 months old. From 8 to 10 days after mating, females produce 1 to 2 eggs in a clutch that hatch in about 18 days.

The mother bird feeds the squabs "pigeon milk" every day for the first week. Male pigeons also care for the young and guard the nest. When squabs are 10-days old, the adults begin bringing to the young grains and other forms of foods normally eaten by adult birds. The squabs become fully grown in less than a month and are ready to leave the nest when about 4 to 6 weeks old.

Female pigeons will lay additional eggs before the first young are fledged and can produce as many as 10 to 20 young per year when sufficient food is available.

Although pigeons typically breed between May and June and then again between August and November, some birds may breed all year. Average natural mortality in pigeons is reported to be about 30 percent per year in adults and 50 percent per year in young. Although some female pigeons have been known to live as long as 15 years in urban areas, most wild birds only survive 3 to 4 years.

Predators

Raptors are the main predators on pigeons.

Potential damage and health concerns

Pigeons are considered to be the most serious avian pest associated with human dwellings. The birds roost and nest on the Great House and peck out and enlarge existing holes in the building. Their droppings deface and probably accelerate deterioration of the adobe building and cleaning pigeon feces from the building increase maintenance costs. In 1993, up to five gallons of bird debris (including feces, feathers, and dead young) per week accumulated on and had to be removed from floors of interior ruin rooms. That material posed various potential health hazards and attracted other pests.

Pigeon nesting activities result in birds enlarging already existing holes in adobe walls and depositing nesting materials, feces, feathers, and dead young onto the structure. These organic materials deface building exteriors and attract insect pests. Large concentrations of pigeon droppings kill vegetation and produce objectionable odors.

The knowledge that pigeons will peck mortar out from between bricks in masonry walls and eat it causes concern that pigeons might be also be attracted to alkaline chemicals found in caliche and cause structural damage to the ruin.

In general, the public enjoys seeing and feeding pigeons and seldom recognizes the potential health hazards posed by the birds. Many health workers call pigeons "flying rats" because of their potentials for spreading diseases. Pigeon droppings can carry and transmit to man many serious diseases, including: pigeon ornithosis, encephalitis, newcastle disease, toxoplasmosis, salmonella food poisoning, and other diseases. Dusty pigeon manure may harbor airborne spores of histoplasmosis and organisms which cause a variety of fungal diseases. The dusts in old buildings harboring pigeon roosts, when stirred up, are known sources of infection.

Pigeons carry a number of parasites which include mites, fleas, ticks, and bugs, many of which readily bite man. Common arthropods found in pigeon and bird nests include bed bugs, mites, chiggers, earwigs, little house flies, and over 50 mosquito species. Other arthropods commonly found in bird nests include fabric and stored product pests such as: carpet beetles, cadelle beetles, clothing moths, drugstore beetles, furniture beetles, larder beetles, spider beetles, and yellow meal worms.

Action thresholds

Swann et. al. (1994) believed house finches, because of the greater number of birds present, were responsible for depositing relatively more feces in the Great House than were pigeons. Yet, pigeons are larger birds than finches and pigeons nest and spend considerably more time in the ruins than do finches. Ten pigeons could probably produce as much debris as 30 or more finches and 26 or more pigeons have been counted in the ruin at one time.

The relative amount of nuisance, annoyance, and damage caused by pigeon nesting, roosting, debris, feces, etc. will be used to develop an Action Threshold level for management. Until that additional information is available, the occurrence of only 1 pigeon that spends appreciable time in the ruin will warrant management actions to protect the ruin and to prevent the attraction of additional birds.

Inspection and monitoring

Inspections and monitoring for pigeons are similar activities. Record the presence of pigeons, pigeon damage, and other evidence of pests. Inspections and monitoring for pigeons should be keyed to obtaining 3 pieces of vital

information:

- existence, time, extent, and severity of infestation.

- location of harborage and food available to pests and pest activity and travel areas.

- the safest and most appropriate control strategies as based on site limitations

Inspecting and monitoring for the presence, numbers, and behavior patterns of pigeons is can be done by counting individuals, nests, and roosting areas. In order to gain as much information as possible on where and when pigeon management actions would be most effective, pigeon monitoring should obtain behavioral information on pigeons both on and off the Monument. This information should include such things as: time and relative numbers of birds present, where pigeons feed and take water, loafing areas, travel routes, diurnal and seasonal activity patterns, times for mating, fledging of young, etc.

Periodic inspection and monitoring and testing of the walls in the Great House will determine if any damage has been caused from bird feces, nesting activities, pecking on caliche, etc.

Non-chemical management

The 2 basic options for non-chemical pigeon management are exclusion and direct removal (by trapping or shooting).

Exclusion

Pigeon problems on many buildings are solved by reducing the number of available roosting sites. This may be done by installing on roof surfaces and edges such devices as: 60-degree slant boards, sharp "porcupine" wire, or sticky repellents. Or by installing 1/2-inch mesh wire or plastic netting around objects and holes used by the birds. Or, by stretching tensioned wire (which may be electrified) along roosting sites.

Some of these alternatives would be very expensive and possibly damage or aesthetically detract from the ruin and are, therefore, not considered to be feasible at CAGR.

Although materials, labor, and initial costs would be significant and, perhaps, even become aesthetically displeasing, screening the ruin with plastic netting would be one viable and, over the long-term, economical alternative for totally excluding the birds.

Sanitation

Good sanitation will remove available food and water resources from pigeons that frequent the Monument. Where possible, it would be beneficial to work with and help administrators of local communities and private landowners to help understand the needs to protect and clean up refuse, spilled grain, and exclude pigeons from buildings. This would also greatly help to reduce pigeon problems at CAGR.

Reproductive

Destroying pigeon nests every two weeks keeps squabs from entering the population and subsequently returning to the ruins as a nesting/roosting site. The San Diego Zoo and various municipalities have effectively used chemical reproductive sterilants to reduce the reproductive potential of pigeon flocks.

Any method which reduces reproduction in pigeons must be constantly used or peripheral populations will continually colonize an area.

Population reduction

<u>Trapping</u>

Capturing pigeons by using decoy pigeons placed in live-capture, bob-traps which are baited with grain is one common method for removing birds from roofs. This is a useful technique when only small populations are present or when local public opinion favors pigeons or resists direct control measures. However, live-trapping is a rather expensive and labor intensive undertaking.

When live traps are used, the traps should be placed in open, flat areas with 70 or more feet of clear space around the traps so the birds will feel safe in approaching the trap. Flocks that are bolder in their behavior can be trapped in more restricted environments.

Pre-conditioning the pigeons is vital to be able to get all the birds in a flock into the trap as soon

as possible after they arrive. Pre-bait sites with the traps wired open for 5 or more days, the longer the better. It is important to get as many birds as possible into the trap because once the bolder birds enter the trap and find they can not leave, their alarm calls will frighten shy birds away. If shy birds can not be quickly trapped, considerable time will be required to capture them, usually one at a time.

Pigeons are very much creatures of habit and do things on schedule unless something occurs to cause them to change. Capturing pigeons with bait is usually only effective at their usual feeding sites. At roost sites, birds are only present when sleeping or raising young and they have usually already eaten and are usually conditioned to feeding somewhere else. Trapping is also difficult at loafing sites because the birds only rest at those locations after feeding. Pigeons can sometimes be conditioned to feed at loafing sites but it takes considerable time.

Bait traps with cracked corn (most effective) or whole kernel corn.

Individual pigeons can be captured on rat-sized glue boards placed on ledges or horizontally nailed to the top end of tall sticks. Cracked or whole kernel corn is a good bait. A mild solvent or cooking oil can be used to remove any captured, non-target birds.

Individual pigeons can also be captured on Coniber body-gripping traps placed atop tall poles or on ledges. Body-gripping traps are lethal to birds and great care would have to be exercised and traps constantly tended to keep from killing non-target birds.

Shooting

Shooting pigeons is an effective means of control during early spring before the young fledge. The loss of adults reduces the reproductive potential of the flock and keeps population numbers low for at least for that season. It is important for the shooter to be able to place accurate shots and to remain hidden from view of the birds to prevent pigeons becoming "gun shy." Common weapons used in pigeon control include high-powered, pneumatic air rifles, low-velocity .22 caliber cartridges (using CB, BB, or dust shot ammunition), and 410 gauge shotguns. Rifles should be equipped with telescopic sights. Crossbows, pneumatic air pistols, bows and arrows, and mouth-powered blowguns have also been used.

Repellents and deterrents

One basic principal in bird management programs is to never allow birds to become established. Scarecrows and raptor-shaped kites which move in the wind (or are electrically powered) can be hung from roof edges and can effectively repel birds for a time. Falcon and accipiter models more effectively repel pigeons than do owl or buteo hawk models.

Noise making devices (propane cannons, distress or alarm calls, etc.), lights, reflecting tape, dead bird models, etc. are also sometimes used as deterrents but birds usually become conditioned to such distractions.

A few pigeons commonly remain on ruin walls throughout the day while other pigeons and flocks of house finches arrive in the evening to roost on the steel girders supporting the roof of the building. Flocking birds become habituated to specific roosting sites because of protection offered from weather, predators, and disturbances. Once the habit for using a specific site is broken is broken in a flock, the site must be discovered by new flocks.

Electrically-powered, moving mechanical arms, mounted at roof level, and operated by a timer that starts moving the arms at dusk (and, if necessary, added lights and sounds) might help to disrupt the comfort enjoyed by birds at the site. Similarly, rising and falling helium-filled balloons and lights which cast moving shadows would be another and scare tactic.

Changing human behavior patterns

Emphasizing the health concerns and economic and historical/cultural values of the ruins might be an effective means for soliciting cooperation from city/county governments, local residents, and health departments to exclude birds from other buildings and restrict available food, water, and harborage in the area. Area-wide pigeon control programs are always much more effective than attempting site-specific controls.

BIOLOGICAL CONTROLS

Although it might seem that an increase in predator (raptor) populations would help reduce the number of pigeons present in the ruin or from areas around the park, predators seldom control prey populations. Because of existing unnatural conditions and visitor and employee use in and around the Great House, native predators will probably never become established in sufficient numbers to control rodent or pigeon populations. However, NPS should continually protect the habitat of native predators which could prey on pest populations.

Chemical management

A number of toxicants are labeled and available for pigeon control, among which are amino-4-pyridine, diazacholesterol dihydrochloride, endrin, 3-chloro-p-toluidine hydrochloride, strychnine, and fenthion. Some of these chemicals are used in toxic perches and baits which can be very effective in pigeon control because pigeons habitually use the same perches, pigeons are primarily grain feeders, and pigeons will readily accept bait all year. Toxic controls are most effective during inclimate winter weather. However, the use of toxicants can pose great hazards to non-target animals, both on and off the Monument.

If all other methods of pigeon control are not adequate, the park Cluster IPM Coordinator should be consulted to determine the feasibility for using toxicants and, if so, will design a pigeon feeding roost or shed near the Great House.

Evaluating treatments

Periodic monitoring of pigeon populations and damage will provide information on the effectiveness of treatments.

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

Chemical alternatives

None unless approved by park Cluster IPM Coordinator.

Sources of advice, technical information, and supplies

National Parks Service IPM videotapes

"Integrated Pest Management," 15 minutes.

See Appendix listings for equipment and chemical supplies.

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RABBITS

Description, distribution, identification:

The rabbits and hares expected to be present at CAGR are the eastern cottontail (Sylvilagus floridanus), desert cottontail (Sylvilagus auduboni), and blacktail jackrabbit (Lepus californicus).

Both of the above cottontail rabbits range widely over southern Arizona. They are similar in appearance and about 12 to 17 inches long, with 2 to 3 inch ears, brownish or pale gray in color, and have a fluffy, cottony-white tail. The desert cottontail, however, is slightly smaller and lighter in color than the eastern cottontail.

The blacktail jackrabbit ranges throughout Arizona and is a much larger animal (about 17 to 21 inches long) with 6 to 7 inch ears. Jackrabbits are common inhabitants of prairies and sparsely vegetated deserts.

Occurrence in the park

Cottontail and jackrabbits are commonly seen in the Monument and are considered to be natural elements of the environment. However, these animals become pests when they graze on and damage ornamental plants around the Visitor Center and residences.

Biology

Habits

Cottontails are mostly solitary animals and are active from late afternoon throughout the night. They spend the daytime partially concealed in burrows or brush. Female rabbits use a home range that can be from 1 to 9 acres in size but males have home ranges nearly twice that large.

Blacktail jackrabbits are also generally solitary animals and are active from late afternoon through the night. During the day, they hide at the bases of bushes or clumps of grass. When both food and shelter are in close proximity, jackrabbits do not move far in a 24 hour period. However, when food and shelter areas are distant from one another, jackrabbits may range for up to 2 miles per day; during dry seasons, there are reports of jackrabbits ranging as far as 5 miles for food.

Neither cottontail rabbits or jackrabbits hibernate during winter.

Foods and feeding

Cottontail rabbits and jackrabbits both feed on green vegetation during the summer and bark and twigs in the winter. Blacktail jackrabbits, however, are larger and may require from 1/2 to 1 pound of green vegetation per day.

Reproduction

Cottontails are very prolific (females can mate within hours of giving birth) and form a prey base for many predators. However, the annual reproductive potential for both rabbits and hares is greatly controlled by environmental conditions and the availability of food.

The eastern cottontail produces 4 to 7 young per litter and from 3 to 4 litters per year. The young rabbits are usually born from March through May. Desert cottontails, likely because of their adaptations to warmer climates, can produce 2 to 6 young per litter throughout the year.

Jackrabbits usually bear 2 to 4 young per litter and from 1 to 4 litters per year.

Predators

Coyotes, foxes, hawks, owls, and snakes are the principal predators on cottontail and jackrabbits.

Potential damage and health concerns

Both cottontails and jackrabbits can be responsible for considerable damage to gardens, shrubs, and small trees. Some estimates indicate that 8 to 12 jackrabbits can consume as much vegetation as would a sheep.

Cottontails and jackrabbits frequently damage ornamental cactus and other plants in the Visitor Center patio; this often requires replacement of

the plants.

Rabbits and hares can be vectors for tularemia and sylvatic plague. Contact with rabbits and their parasites has been responsible for many human cases of tularemia east of Rocky Mountains and for several cases of sylvatic plague west of Rockies. Always wear gloves when handling live or dead rabbits.

Action thresholds

It is not desirable to have rabbits and hares in close proximity to the Visitor Center where they damage ornamental plants and, possibly, could be vectors for diseases. Rabbits and hares often return night after night to the same location to feed. The Action Threshold justifying management of rabbits and hares is the occurrence of only one plant severely damaged by the animals.

Inspection and monitoring

Inspecting and monitoring for rabbits and hares are similar activities and can use the same forms.

Look for and record rabbit trails worn between feeding and resting sites. Signs which identify the trails are scarred or freshly nipped prickly-pear cactus, light tufts of fur on thorns, tracks, nesting depressions, and pellet-like feces which the desert cottontail often deposits on logs and stumps (used as lookout points by rabbits after dark). Flour or talc tracking stations can be placed around plants suspected of being damaged by rabbits and hares. Night time observations made with a red filter on a spotlight can be used to watch rabbits while they feed.

Record the number and location of ornamental plants which have been freshly damaged by rabbits or hares. Look for damage to prickly-pear cactus pads and fruits and watch for woody pieces of other plants which have been cleanly cut off at an angle from the main stem.

Non-chemical management

Exclusion

Fencing. Fencing rabbits is a effective and feasible way to provide year-round protection to high-value resources. Jackrabbits can be excluded from areas (or individual plants) with fencing made from at least 20 gauge, woven wire or poultry netting. The mesh should be less than 1-1/2 inches in size and the fence should be from 30 to 36 inches tall with at least the last 6 inches of the fence buried below ground level.

Electric fencing is effective for rabbits and hares but is probably not feasible in NPS areas. Where used, electric fences should be made up of 6 strands spaced 3 inches apart and which alternate hot and ground wires.

Woven wire cylinders from 12 to 18 inches wide and made from 1 inch mesh poultry netting are effective to protect trees. The wire cylinders should be anchored with lath into the ground and braced away from trees to keep animals from pressing the wire against the trunk. Pre-made aluminum and nylon mesh tree protectors are also commercially available.

Jackrabbits are adapted to open areas where they can see predators approaching from a long distance away. There is some information which indicates jackrabbits, similar to prairie dogs, will only feed in areas where the vegetation (or artificially placed barriers) is less than 2 feet tall. However, cottontail rabbit populations increase when vegetation is tall enough to protect them from being seen by predators.

Although guard dogs, chained near crops, are sometimes used in agricultural areas, this alternative does not lend itself to NPS areas.

Population reduction

Legal. Blacktail jackrabbits are not considered as game animals in most states and are not protected by game laws. Many states, however, consider cottontails to be game animals and require permits for control of the animals.

All direct controls on rabbits and hares should be initiated as early in the season as possible and before populations become enlarged by the addition of young.

Box-type, live-traps are not effective for rabbits and hares because they will not enter an

enclosure. Body-gripping (Conibear) and foothold traps, however, are effective when placed in rabbit runways and trails. Conibear and foothold traps may be dangerous and cause injury to non-target wildlife, pets, and humans.

Where legal and safe, rabbits and hares can be shot with small caliber weapons (.22 CB or BB rounds) in areas requiring protection and this suppresses or eliminates damage. Shooting is most effective at night when using a spotlight but state game regulations should be checked to see that spot light shooting is allowed.

Chemical management

Repellents

Various distasteful chemical repellents (gustatory and olfactory repellents) are available for rabbits and hares but some must be tested for possible adverse effects to plants. Some effective repellents contain such things as ammonium soaps, benzyldiethyl methyl ammonium saccharide, capsaicin (chile), dried blood, naphthalene, tobacco dust, and thiram or ziram (fungicides).

Repellents should be applied either during the winter dormant season or summer growing season. At least one of these repellents (i.e., benzyldiethyl methyl ammonium saccharide) can make an entire plant bitter and should not be used on plants which will be used for food or fruits. Read and follow label directions for all materials.

Toxicants

Various toxicants are labeled for hares (but probably not for rabbits). Consult with local Cooperative Extension or USDA-APHIS-Animal Damage Control personnel to learn if anticoagulant baits can be legally used. The use of toxicants, however, always poses potential hazard to non-target wildlife, humans, and domestic pets. Any use of toxicants requires special NPS approval through SOARSO and/or the park Cluster IPM Coordinator.

There are no fumigants registered for jackrabbits or cottontails.

Evaluating treatments

Periodic monitoring of ornamental plants, night time observations with a spot light, and the presence or absence of trails or other signs of rabbits or hares will provide information on the effectiveness of treatments.

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

Chemical alternatives

Ammonium soaps
Benzyldiethyl methyl ammonium saccharide,
Capsaicin (chile)
Naphthalene
Tobacco dust
Thiram (fungicide)
Ziram (fungicide)

Sources of advice, technical information, and supplies

National Park Service IPM videotapes

"Integrated Pest Management," 15 minutes.

See Appendix listings for equipment and chemical supplies.

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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. Rattlesnakes are called pit vipers because they possess 2 heat-sensitive "pits" on the face which they use to locate warm-blooded prey.

Occurrence in the park

Various kinds of rattlesnakes occur in 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 thigmothermic (gain body temperature through contact with a warm substratum) 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 supports an extremely large number of rattlesnake species; however, the number of reported deaths from rattlesnake bites in Arizona has not exceeded two deaths per year since 1929. Still, the total number of rattlesnake bites per year in Arizona and in other Southwestern states has continued to increase over 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 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 with 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.

Snakes can be captured by trained staff with commercially-manufactured and professional, long-handled snake capturing tongs, available from pest control equipment suppliers (see listings for Animal Management, Critter Control, Wildlife Management Supplies, and other suppliers). To transport poisonous snakes, place them in a tight, solidly constructed container fitted with an interior screen and a tight, locking lid. 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. Appropriately mark containers with warnings so boxes will not be inadvertently opened.

Trained employees will have the option of destroying poisonous reptiles if they can not 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 harborage for snakes by closely mowing lawns and fields.

Good sanitation and effective rodent control around structures makes them less attractive to snakes.

Behavior modification. Signing in some parks which provides diagrams of snakes and courteously ask 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 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 it may not be as 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 monitoring and inspection show snakes are no longer present 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.

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.

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GROUND

on, identification:

irrels (Spermophilus odents and usually evation. Their wide andy, Lower Sonoran Life-zones of southern Arizona, Nevada, southeastern California, and into northern Mexico. This rodent is typically associated with creosotebush, mesquite, triangle-leaf bursage, and paloverde and is most common in low, flat areas devoid of vegetation.

Round tail ground squirrels are 5 to 6 inch long burrowing rodents with small ears and a sparsely haired, curved tail which is about an inch shorter than the body. They are uniformly pinkish to cinnamon colored with a grayish-cast on the upper parts. Different from the antelope ground squirrel, round-tails do not have stripes or spots on the sides of their body.

Occurrence in the park

Round-tail ground squirrels occur throughout CAGR Monument and become undesirable pests when they locate their colonies near archeological ruins, picnic grounds, or park structures.

Biology

Colonies/burrows

Where soil conditions allow, individual round-tail ground squirrels dig their own multi-entrance burrow which may be a foot or more deep and 4 to 5 feet long; however, they will also readily take over abandoned burrows.

Round-tail ground squirrel burrows are generally located in open areas where quick escape is possible should a predator approach. Although, round-tail ground squirrels tend to be gregarious and semi-colonial, they do not share burrows. Some burrows and burrow systems, however, may can be used by successive generations of ground squirrels for many years.

Habits.

Round-tail ground squirrels are diurnal animals with activity patterns that are dependent on temperature and weather conditions. They are most active during summer from about 8 am to noon and then again from late afternoon until sundown.

An individual ground squirrel may forage for a considerable distance (200 yards, Swann et. al, 1993) but territorial behavior is usually only seen when animals are near to their burrows.

In some geographic areas, round-tailed squirrels begin to hibernate in September and October but the animals never become completely dormant. Although most of a population may remain below ground from October to January, a few animals can usually be seen above ground every month of the year during warm days. Some reports indicate that male ground squirrels begin to re-emerge from burrows in January, about a month before the emergence of females.

Foods and feeding

Round-tailed squirrels are primarily vegetarians during most of the year and eat leaves, flowers, bark and pods of mesquite and fruits of creosotebush and chinchweed. However, when available, squirrels will also eat insects, carrion, and, probably, garbage.

Round-tail ground squirrels often climb into bushes and low trees in search of seeds and green vegetation but they do not store food as do many other rodents. Their water requirements are generally met by their habit of eating succulent foods.

Reproduction

Swann et. al. (1994) found that round-tail breeding occurs from February through March and litters of 1 to 12 young (average about 6.5) are born after a month-long gestation in March and April. The young squirrels spend their first month in the burrow, are weaned when about five weeks old, emerge from burrows in late April to May, and disperse to find a suitable home range in late June. This data is important because it

establishes the time of emergence for young and sets a time-frame when population controls could be most effective (before the young emerge). Additional studies of ground squirrels at CAGR would provide other information to help guide management efforts.

Although there is no clear evidence for two litters of young per year, round-tailed ground squirrel populations have a capacity to rather quickly increase in number. Litter size varies greatly between females and adult females outnumber males by a factor of 2.7 to 1. During years when conditions are optimum for ground squirrels, populations at CAGR could easily increase in size to 150 percent or more than what would be expected in years when conditions are more dry.

Young squirrels become sexually mature in slightly less than a year. About 33 percent survival is expected for young ground squirrels from one spring to the next and less than 1 percent of the adult animals survive beyond 4-years.

Predators

The wide array of predators on squirrels includes coyotes, foxes, badgers, raptors, thrashers, coachwhip snakes, rattlesnakes, gopher snakes, Gila monsters, and bobcats.

Potential damage and health concerns

The round-tailed ground squirrel colonies located near the Great house are responsible for the most obvious damage. The animals dig burrows under and hollow out the interiors of cement-capped walls where the full-extent of their damage cannot be observed. Ground squirrel burrows damage historic and modern irrigation ditches as well as road and sidewalk shoulders. They damage ornamental plantings by eating the seeds and emergent seedlings. Ground squirrel burrowing prematurely exposes and intermixes buried archeological artifacts, increases rates of wind and water erosion, and attracts predators which greatly enlarge rodent burrows trying to catch prey.

Ground squirrels, like many other rodents, may harbor a number of parasites (especially fleas) and can transmit various diseases to humans such as Hantavirus, plague, and salmonellosis.

Action thresholds

Round-tail ground squirrels can rapidly increase in number and controls are justified with the presence of structural damage or possible health concerns for park staff/visitors from rodent-borne diseases.

The Action Threshold for round-tail ground squirrels around archeological structures and other areas to be protected will be:

- Finding the burrow(s) of 1 or more squirrels within 50 feet of a structure (or other area to be protected) at any time of the year. The Recommended Actions will be to remove the rodent(s) and close the burrow before other animals appear at the site.

- Seeing more than 3 ground squirrels active around archeological structures at any one time during early spring (before rodent reproduction is completed); or, finding burrows into/under 5 percent or more of the buildings, walls, walkways, etc.; or, capturing 3 or more ground squirrels per 100 trap days in baited traps placed near structures or in areas to be protected. It is always be easier and quicker to remove a relatively few adults present during spring than to have to remove dozens of young animals later in the year.

Inspection and monitoring

Because of the recent appearance of Hantavirus in the Southwest, all persons doing rodent 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 activities are similar for ground squirrels and the same forms can be used to record data. Reports should document and "flag" needed repairs on maps and list any evident factors which support pests.

Inspections

Inspect and monitor areas around archeological ruins and other locations to determine the relative amount and kind of damage caused by ground squirrels. Also look for any conditions (natural or artificial) which supply harborage, food, or water to support rodent populations.

Monitor local, seasonal weather conditions so as to be able to recognize, as early as possible, when conditions of abundant winter or spring precipitation will likely support increased plant growth and greater rodent numbers.

Continually monitor rodent population densities and the numbers of active rodent burrows. Maintain census data on the number of animals in specific areas both prior to and following controls. Keep all abandoned burrows closed, even those made even by other species.

To be able to best plan for the most effective control times or other management activities, keep records on rodent activity in regard to season and time of day and document events in the annual reproductive behavior of ground squirrel populations.

Record the numbers, kinds, and locations of dead animals which may be an early-warning indication of the presence of disease in the ground squirrel population. Inform the state Department of Health or CDC about dead animals to learn of their interests in examining the animals or sites.

Non-chemical management

Legal. Round-tail ground squirrels are native, non-game mammals; although some states protect all native species, it is usually permissible to control ground squirrels when necessary. If in doubt, contact state wildlife agencies.

No single, 100 percent effective, long-term method of control is available for burrowing rodents in archeological sites. Animals will continually move in from surrounding areas. Based on the expected rate of ground squirrel reproduction, successful control will probably mean eliminating 85 percent or more of all adult animals present in specific areas during early spring and before young of the year emerge from burrows.

Methods of rodent control which can significantly reduce damage to ruins can be had with aggressive programs which include the following basic elements.

- **Habitat modification and sanitation**

Where possible, modify the habitat so as to reduce or eliminate harborage, water, and food. Continuously remove weeds and other non-desirable plant growth from areas around ground squirrel colonies. This reduces available food for the animals and causes them to forage further away where they are exposed to increased predation.

Use rodent-proof garbage cans and frequently collect garbage. Inform visitors to not feed rodents and to be careful with food scraps.

Promptly repair leaking water hydrants or pipes to reduce or eliminate all possible sources of free water.

- **Exclusion**

Promptly cover (or otherwise seal) all holes, pathways, or accesses into ruin walls or other buildings with 1/4-inch mesh hardware cloth.

- **Predation**

Because of visitation and other human activities within the ruin, native predators will probably never become established in any great number. However, the park should continue to protect the occurrence of native predators, which are an important part of the natural ecosystem.

Although predation on rodents in the ruin by native carnivores (those that do not attempt to dig animals out of the ground) should be encouraged, the value of predation in balancing rodent populations is never simple.

Many people may simply assume that rodent populations will be controlled if enough predators are present; yet, various studies show this is not true. Predation usually operates in only incidental manners, rather

than as a major control. Only in rare conditions has predation been proven to be a significant source of rodent mortality. And, over time, predators have even been known to support a higher number of rodents than could exist without predation.

Predators tend to feed on specific prey but only when that prey is easily available. When rodent numbers become too low, most predators either switch to a different prey or move out of the area. In general, predators only harvest surplus individuals from a population which does not greatly reduce population size. Because more food and habitat becomes available to rodents surviving predation, larger litters may be produced and/or survival of the young enhanced. When predators have been removed from an area, there usually has been only a temporary increase in the numbers of a given prey species before other natural regulatory factors take over.

- **Behavioral controls**

Behavioral devices that only scare animals (i.e. noise, scare crows, hawk-shaped kites, flags, predator models, etc.) are not proven effective for very long and usually can not be justified on the basis of expense, labor, and aesthetics. Dogs (or other animals) trained to chase and catch rodents might be another, but impractical, solution at CAGR.

- **Reproductive controls**

There are no chemical reproductive sterilants registered yet for rodent control but research is being done to develop those chemicals.

Population reduction

Where damage exceeds Action Thresholds, the preferred methods of population reduction for ground squirrels in problem areas will be by rat-sized, snap and/or Conibear traps which are protected to prevent injury to non-target animals; by box-type live-traps; and by shooting.

Ground squirrels are rather easy to trap; however, trapping can be more difficult during early spring when animals are feeding on green vegetation.

Set traps near or over burrow entrances and bait them with cereals, nuts, raisins, or other foods attractive to the squirrels. Continue trapping at burrows until all animals are thought to have been removed. When traps no longer catch animals, place wadded paper, leaves, etc. in burrows and revisit the sites for a few days to verify that animals are no longer using the burrows. When all animals have been removed, apply predator urine to the inside of a burrow, close the burrow with soil/rocks, smooth the surface of the ground, and apply more predator urine on top of the ground around the site. When animals can be prevented from using a burrow for some undetermined length of time, the odors of an active burrow dissipate and new animals are not so likely to be attracted to the site. Continually monitor the area for a few weeks to be sure new animals have not re-opened old burrows. If burrows are reopened, trap the animals again and seal the burrow entrance as before but finish by covering the hole with a 3-foot square piece of 1/2-inch mesh hardware cloth wire and cover it with soil.

If ground squirrels captured in live traps are to be released, visibly mark the animals before release and release them at least 3 miles from point of capture. Prior arrangements should be made with the Game and Fish Department, U.S. Forest Service, and/or other land owners/ managers for acceptable release sites. Destroy any marked animals that return to the park.

Shooting squirrels with a small caliber rifle or air gun is an effective, direct control measure where permitted, safe, and the numbers of animals to be removed is not excessive. However, squirrels quickly become gun shy when shooting is usually only effective if animals can be lured to bait stations.

Concentrate all rodent management efforts only on active burrows and continually trap ground squirrels until their impact on resources is acceptable.

Repellents

There are no good repellents for ground squirrels; however, some reports indicate that animals have been repelled (for at least short periods of time) with commercial coyote or fox urine, available from trapping supply outlets.

Ultimate non-chemical controls. Sometimes, all the various and innovative control methods available to control pests around valuable resources may not be sufficiently effective or can not be used because:

- habitat alteration may not be feasible or sufficiently long-lasting,
- biological controls may only have limited effectiveness,
- poisons are not permissible,
- direct reduction (i.e. trapping or shooting) is not allowed or desirable,
- repellents only have short action and are not reliable,

In such cases, mechanical exclusion (i.e., fencing, netting, or establishment of definite physical barriers) may be the only effective alternative for long-term control over free-ranging rodents. To justify the expense, the costs of fences should be pro-rated over their expected life.

Effectively excluding many kinds of squirrels with fencing can be difficult because of their climbing and burrowing abilities. However, not all kinds of ground squirrels are inclined to climb fences. Various types of solid and wire mesh fence designs should be tested to find if any are effective for round-tailed ground squirrels.

Chemical management

Although rodenticides might seem to be an easy way to control rodents, chemical controls pose significant disadvantages:

- Rodents may not eat available baits, not eat enough of the bait for it to be effective, or develop genetic resistance to the poison.
- Secondary effects of using poisons may injure non-target species (including humans and pets).
- Without additional mechanical/physical controls, toxicants only temporarily reduce the size of a target population; when the population rebounds following the treatment, it often attains greater size than it was before controls because of enhanced reproductive potential and available harborage.

Permethrin dust has good residual and is used to kill plague-bearing fleas in rodent burrows.

Where physical or mechanical methods of pest control are proven through monitoring and evaluation to not be effective and needs for control remain (significant damage, threat to human health, etc.), NPS approval will be sought for appropriate poisons to use in outdoor locations or unoccupied buildings. One of these poisons might be cholecalciferol, which is registered under a Special Local Needs permit (at least in New Mexico) for ground squirrels.

Fumigants

The only fumigants registered for ground squirrels and various other small, burrowing animals are aluminum phosphide and carbon monoxide gas cartridges.

To be effective, only fumigate active rodent burrows when the animals are not hibernating. Many rodents when preparing for hibernation, plug up the interiors of their burrows with soil and this protects the animals from the outside influences.

In outdoor locations, fumigants pose similar, though less pervasive, environmental hazards as poison baits.

- Poisonous gasses may seep into voids and rooms of still-buried buildings.
- Fumigants kill other (and sometimes beneficial), non-target wildlife which may be present in rodent burrows (burrowing owls, snakes, lizards, weasels, shrews, etc).
- The use of fumigants can pose a significant health and safety hazard to applicators.
- Fumigants are not 100 percent effective; some animals seal up burrows behind them when they detect gasses or strange odors. Or, burrow systems may be too

complex or long to allow for effective use of a fumigant. For instance, APHIS recently requested EPA to remove pocket gophers from the label of commercial gas cartridges for these reasons.

Evaluating treatments

Over time, monitoring the number of ground squirrels in specific areas and during favorable weather conditions will show current relative population size and indicate the effectiveness of previously used controls.

Evaluations of treatments will be used to provide information for adjusting Action Thresholds, developing more effective management strategies, and demonstrating apparent needs for new control methods or chemicals.

Chemical alternatives

Carbon monoxide gas cartridges
Permethrin dust (fleas in burrows)

Sources of advice, technical information, and supplies

National Park Service IPM videotapes

"Integrated Pest Management," 15 minutes.

See Appendix listings for equipment and chemical supplies.

Arizona Department of Health (identification of ectoparasites; information on the frequency of plague and other diseases in specific areas of the state).

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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, commonly found in the Southwest, are black widow Latrodectus) and brown recluse spiders Loxosceles).

Black widow spider. Five species of Lactrodectus 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 (such as 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 windows, however, are quite timid and usually make no effort to bite, even when provoked. Most black widow bites come about when the spider is accidently 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 suffering 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 sacks (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 (with piperonyl butoxide) aerosol space treatments
Boric acid dusts for cracks and crevices
Diatomaceous earth as a dust or dust with pyrethrins
Pyrethrum (synergized with piperonyl butoxide) contact sprays
Resmethrin aerosol space treatments
Silica aerogel or silica aerogel with pyrethrin for dusting 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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TERMITES

Description, distribution, identification

Termites include a large number of different insects in the genera Reticulitermes, Heterotermes, Incisitermes, Marginitermes, and Paraneotermes. These are native, social insects and serve important ecological roles in the natural decomposition of cellulose.

Usually, the first observed indication of termites in a structure is during the time insects swarm in the spring; this is when termites are most often mistaken for "flying ants". Termites differ from ants by having a broad waist, beaded and straight antennae, and wings of very similar size and shape. Ants have a pinched waist, elbowed antennae, and their forewings are larger than the rear wings. There are many native species of termites. but only two major pest species are noted here.

Eastern subterranean termites (Reticulitermes flavipes). These termites are widely distributed over North, Central, and South America. Adult insects capable of reproduction (alates) are black, about 1/3 inch long, and have wings. Worker termites are smaller (3/16 inch long), wingless, and white with a yellow-brown head. Soldiers are also white, wingless, and have enlarged heads and jaws (mandibles).

Western drywood termites (Incisitermes minor). Drywood termites normally only occur in the warmer climates of Florida, Texas, California, Hawaii, and Arizona, but they may be transported into other areas inside of infested furniture, lumber, and other wooden articles. Reproductive drywood termites are larger (1/2 to 9/16 inch long), lighter in color than subterranean termites, and have a reddish-brown head and thorax. Workers are creamy-white color with yellow-brown heads, and about 1/3 to 1/2 inch long. Soldiers are similar in size and color to workers but have large, rectangular, reddish-brown heads and massive jaws.

Occurrence in the park

The evidence of old termite activity is found in some of the archeological wooden structures in the Great House ruin.

Biology

Subterranean termite are the most widespread and destructive native termites in this country. They usually nest underground but always within easy reach of wood as a food source. A mature queen can produce 5,000 to 10,000 eggs a year and may have a life span of up to 30 years. Termites require relatively high humidity in their living and feeding areas, adequate shelter and temperature, and a plentiful food source. The colony will not flourish if any of these are not present. Even when all necessary factors exist, it may take many years before termites cause significant structural damage.

After establishing a nest, workers continually move between the nest and a food source (cellulose, wood) through earthen tunnels which protect the termites from ants and weather. Under most conditions, subterranean termites must have contact with the soil to survive but colonies may be found obtaining moisture from other sources (leaking pipes, puddles on a roof). Colonies less than 2 to 4 years old do not generally produce alates. Swarms ordinarily occur during a sunny day following a light rain.

Subterranean termites can be very destructive to wood which contains 20 percent or more moisture. They can survive in sandy loam soil with from 3 to 30 percent moisture levels (saturation point) and in sand with 1 to 20 percent (saturated sand) moisture levels. Humid, enclosed conditions allow termites to be more active and construct longer shelter tubes than drier environments. Where moisture is available, termites may form secondary nests above ground.

Drywood termites live in moderately dry wood and do not require moisture or contact with the earth. Colonies are much smaller than subterranean varieties and damage is usually confined to much smaller areas. Drywood termites do not construct mud tubes. Usually, the first indication of the presence of drywood termites is finding masses of sand-like, six-sided

fecal pellets, about 1/25 inch long, and located beneath the site of an infestation. The pellets are ejected from galleries through round "kick holes" or windows. The presence of these insects is also shown when reproductives emerge from wood on warm, sunny days in the fall. Drywood termite damage is seldom significant unless it occurs in valuable objects or an infestation has progressed unnoticed for several years.

Adult female drywood termites bore directly into wood or they may enter wood through natural holes, gaps, or cracks and then plug the hole with fecal material. Colonies reproduce very slowly and alates are not usually seen for the first 4 to 5 years. First-year colonies may only contain about 200 individuals but even older colonies seldom contain more than 2,000 individuals. In northern areas where temperatures fall below freezing during winter, drywood termites can not maintain colonies in unheated structures.

Predators. Ants are the primary predators on both kinds of termites.

Potential damage and health concerns

Termite infestations can seriously damage wooden historical resources and wood damaged by termites allows for increased rates of water penetration and growth of molds or fungi which can attract other, secondary wood destroying pests. Where termite damage has progressed for many years, there is always a potential for a damaged structural member to fail.

Soils in at CAGR, however, are exceptionally dry and termite damage would not be expected except in years of prolonged and abnormally high moisture. Even then, the return of hot and dry conditions would force the insects to retreat below ground to a source of moisture, reducing damage. If the historical wood in CAGR structures were vulnerable to serious or prolonged termite attack (or attack by other serious wood destroying insects) in normal climatic conditions, all the wood in the buildings would have been completely destroyed many years ago.

Termite infestations do not normally pose health concerns; however, their presence (or the presence of their empty galleries) may attract ants and ant nests which can spread pathogenic bacteria.

Subterranean termites. Termites can seriously damage wood having contact with the soil if the presence of the insects has gone unnoticed for a considerable number of years. Although it is important to treat structures for termites as soon as possible, subterranean termite damage to wood exposed to the elements in Southwestern areas seems to proceed rather slowly because the insects are limited by weather. They enter wood during warm, wet seasons but their activity is greatly lessened and termites retreat below ground (or colonies die) during hot, dry summer conditions and during freezing winter weather. If, under normal climatic conditions, exposed historic structural elements were highly subject to serious and prolonged termite (or wood-destroying beetle) attack, those wooden elements would have been completely destroyed many years ago.

Subterranean termites may sometimes damage living trees, plant roots, potatoes, and root crops when weather becomes dry and when termites require additional moisture. However, when termites invade a living tree, the tree was probably very unhealthy and dying before the infestation developed.

Drywood termite. Drywood termites establish colonies in dry, sound wood with low moisture content and maintain those colonies for as long as the wood lasts. The interior of wood damaged by drywood termites has broad pockets or chambers which are connected by tunnels that cut across the grain.

Action thresholds

Discovery of an active colony or colonies shown to be damaging buildings or other resources is the Action Threshold justifying control or preventative termite control actions.

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.

Termite inspections are rather extensive and require a thorough and technical examination of all structural components. The object of the inspection is to find, among various other things: active termite infestations and termite tubes, poor grade and drainage, potential water loading points, settling and/or cracked foundations and floors, wood decay, abnormal wood moisture levels, insufficient ventilation, wood to soil contacts, leaking pipes, etc. Termite tubes are often broken and then later re-examined to verify the presence of an active colony. Park staff usually are not equipped to perform the full extent of these inspections which must ultimately determine whether termites are actually present and the degree of future damage to be expected.

Periodic and less technical structural inspections to uncover apparent moisture damage and other deficiencies should be done every year by park staff and promptly corrected to prevent termite infestations. Inspections by park staff should also determine if buildings or foundations are settling, shifting, or cracking; if there is apparent abnormal moisture (greater than 20 percent) or decay in or under structures (by using an accurate wood moisture meter); if grade is adequate around the structure; if shingles are intact, roofs tight, and downspouts functioning properly; if paint is blistering; if pipes, hydrants, and shower pans are leaking; whether wood contacts soil around or under structures; if attics and sub-floor vents are screened or properly closed; if apparent termite damage exists and how it has changed since the last inspection; etc.

A rather recent and interesting method for tracing the possible source of subterranean termite infestations uses a process called "isotope dilution". A small amount of radioactive isotope (Scandium #46 or Lanthanum #140) is added to a food material attractive to termites and, within days, the radioactive substance will have spread through the colony (termites eat their own excreta). Three days later, standard radiation detection equipment can trace galleries and underground pathways leading from the nest to feeding areas and also provide estimates for colony size. The process is said to pose little or no threat to humans, the isotopes have low levels of activity and decay quickly.

Termite detecting dogs, introduced in the mid-1980's, are sensitive to odors produced by termites in concentrations as low as 1 part per billion. The dogs can also hear termite activity. Success rates for termite sniffing dogs may be as reliable as 80 percent while mechanical odor detectors or human inspections only obtain about 50 percent reliability. TADD Services leases dogs and dog handlers.

A termite odor detector, Termitect II, was invented in 1981. This hand-held, gas chromatograph detects methane, carbon dioxide, and hydrogen gasses produced by termites. The machine can only detect large termite infestations and functions best on slab foundations. The manufacturer says it takes about an hour to inspect an average 2,000 square foot home. The machine is especially good when used in combination with other methods but cannot be used in an outside environment.

An acoustic detector is also available. This hand-held, listening device is attached by means of sticky polymer to wood believed to harbor termites. The device detects the insects by amplifying termite sounds by 1,000 times or more. External background noise reduces the reliability of the test.

Inspect and monitor structures to find any sites lending themselves to termite infestation or invasion (i.e., moist wood and wood to soil contacts) before termites are known to exist invade a structure. Or, monitor for annual changes in activity of termite colonies known to be present. Whatever the purpose, watch for any conditions which could support termites while also being alert to the presence of other

pests.

Non-chemical management

The following guidelines are progressive levels of action when finding active termite colonies in buildings.

- Capture and identify the pest so its life cycle can be used for making control decisions.

- Thoroughly inspect the structure, foundation, and crawlspace for excessive moisture, adequate ventilation, screened attic vents, wood to soil contacts, cracks, wood debris, and old or new termite damage. Excessive moisture can result from a large number of things: missing or faulty down-spouts, inadequately designed gravel drains under/around buildings, insufficient sub-floor ventilation, wood contact with the soil, etc. If drywood termites may be present, inspect all furniture, window moldings, and other decorative wood both inside and outside.

- Control (and prevention) of active subterranean termites may require a technical inspection and application of a chemical barrier around/under buildings by a professional pest control operator. However, various alternative controls do exist: reducing or eliminating moisture conditions, installing sand barriers, baiting termites with insect growth regulators, and applying borates to wood. Upon discovery of active termite infestations, contact an appropriate NPS IPM specialist for recommendations and pesticide approval.

- Control of widespread drywood termite infestations may also require some level of fumigation by professional fumigators; however, even though effective, fumigation does not protect the structure or objects fumigated from future attack. Isolated drywood termite colonies are sometimes treated with heat, cold (liquid nitrogen), removal or replacement of infested wood or pesticide injection. Contact NPS IPM specialists for recommendations and chemical approvals.

Numerous, innovative techniques have been developed for non-chemical termite control. Although some techniques may be wholly or partially successful, none can be vouched for as guaranteed methods of termite control. All techniques, however, no matter how successful they may seem, which do not modify the basic conditions supporting termites (i.e., by reducing moisture or installing adequate mechanical or chemical barriers) do little to prevent future termite invasion.

Liquid nitrogen is one new technique used to treat both subterranean and drywood termites in areas of restricted size. Before treating a site with liquid nitrogen, assure that water, gas, and electrical lines are turned off and will not be damaged. Termite removal by this method does not provide protection against future infestation.

Heat sterilization (raising wood temperatures to 120 degrees F. for 35 minutes) is cited as a better alternative than fumigation with methyl bromide. Similar to liquid nitrogen treatments, heat may affect various materials and the method gives no protection against future infestations.

Various other non-chemical preventive measures and controls also available for drywood termites include screening attic vents with 18 to 20 mesh, non-corroding screen or covering susceptible wood with several layers of paint.

Repellents. In some parts of the country, barriers of specific-sized sand are reported to be effective in preventing subterranean termite invasions into buildings. Equipment and expertise needed to blow sand under buildings in the proper manner which guarantees a barrier of the proper size may be draw backs to this technique.

Exclusion. Provide a minimum clearance of 8 inches between the soil and wooden sub-structures.

The installation of metal termite shields is sometimes considered to be a method to exclude termites but the shields serve a

greater use during inspections by making it easier to locate termite tubes.

Sanitation. Remove all cellulose-based debris lying on the ground from under and around structures.

Habitat modification. Repair leaking pipes and otherwise correct possible abnormal sources of moisture in the building. Improve ventilation under and inside buildings.

Chemical management

Subterranean termites. Pre-construction application of a termiticide is the preferred treatment method, where possible, and then followed with exterior perimeter treatments around the foundation. A termiticide can also be applied after construction by drilling through the slab. This method should only be used as the last option for termite control because of the potential for chemical vapors to penetrate cracks in the slab and enter living spaces. There is also the possibility of inadvertently drilling into utility lines during this operation; however, that risk can be reduced by using a ground fault interrupter.

To prevent the possibility of toxins moving into occupied portions of a building, termiticides will not be used in:

- Buildings containing sub-slab or intra-slab heating, ventilation or air conditioning (HVAC) ducts.
- Buildings containing plenum type, sub floor HVAC ducts.
- Buildings where HVAC ducts are exposed to the ground in crawl spaces not having a vapor barrier.
- Buildings with other HVAC where any part of the ducting is exposed to the ground.

Treat susceptible or exposed wood with borate-based pesticides to prevent termite invasion or kill existing colonies. Softwoods absorb borate solutions better than hardwoods. However, if only one side of a wooden member is treated, termites can still invade from the untreated side. Structural wood is more adequately treated prior to construction; however, borates will leach out if wood becomes wet. Use a water repellent to protect the treated wood if the wood is subject to becoming wet.

Various chemicals are used to treat termite galleries located in wood. Chlorpyrifos and borates are commonly used for such spot treatments. Fenvalerate surface spray and injection applications are reported to be effective. Aerosol formulations of chlorpyrifos can be injected directly into termite galleries or infested wood. However, these products and methods used usually only retard the growth of subterranean termite colonies which have their nest in the ground.

Both toxic and growth regulator baits (IGR) are new developments in termite control. Termites are encouraged to feed on a preferable food source and then the food bait is exchanged for one containing a pesticide (hydramethylnon or imdacloprid) or insect growth regulator (hexaflumuron). Contact Keith Delaplane, University of Georgia Cooperative Extension Service, Athens GA, for more information. The current trend in the NPS is to use hexaflumuron, which offers the advantages of eliminating entire termite colonies with a low toxicity material and also eliminating the need for a soil drench. Contact your park Cluster IPM Coordinator for details.

Drywood termite colonies are sometimes poisoned by drilling 1/8 inch holes from 2 to 4 inches apart and almost through infested wooden members before injecting the wood with silica aerogel, boric acid, or chlorpyrifos. The holes are then sealed with dowel plugs. It is possible to drill wall boards and furniture on the underside to protect their appearance; however, do not use chlorpyrifos to treat furniture.

Drywood termite colonies can be effectively killed with localized gas fumigation, heat, or freezing but these may be expensive methods and become very difficult when colonies are scattered throughout a building, attic, wood trim, over inside walls, etc. and the treatments provide no

residual control.

** Additional guidelines on termite control are contained in the first edition of the NPS Integrated Pest Management Information Manual.

Evaluating treatments

Post-treatment monitoring is a very important element in a termite program to assure that the insects have actually been eradicated. Many commercial termite applications experience a call-back (noneffective treatment or re-infestation) rate of about 35 percent. Such a high rate emphasizes the value and need for continual post-treatment monitoring.

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 management methods.

Chemical alternatives

Allethrin (with piperonyl butoxide) aerosol space treatments for flying insects
Borate wood treatments for termites and carpenter ants
Boric acid dusts for cracks and crevices
Chlorpyrifos for pre-treatment and trenching
Diatomaceous earth dust
Diatomaceous earth dust with pyrethrins
Hexaflumuron insect growth regulator
Silica aerogel dusts inside termite galleries and along pathways used by pests
Silica gel with pyrethrin for cracks and crevices

Sources of advice, technical information, and supplies

See Appendix listings for equipment and chemical supplies.

Videos

"Structural Inspections -- A way of Managing Wood Inhabiting Insects," NPS training videotape; 23 minutes.

"Subterranean Termite Biology," NPS training videotape; 11 minutes.

"Wood Destroying Insect Training Video", Wood Destroying Insect (WDI) Program, c/o GRCS Inc., 1004 Van Buren St., Herndon VA 22070; 800/357-0404.

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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.

Occurrence and potential damage

No individual weed plants were identified by the park; however, miscellaneous plant and weed growth occurs along road shoulders and in ruin compounds and these remain as continual problems.

A number of weeds (undesirable plants) occur in the park. Although many weed species are exotic, both exotic and native weeds can become problems when they invade facilities (i.e., roadways), provide harborage or food for animal pests, infringe on desired native vegetation,

damage natural or cultural resources, or otherwise create unsightly appearances.

Weeds in visitor-use areas have usually been removed in the past by hoeing or chopping but this has been found to disturb soil surfaces and actually encourage additional plant growth.

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 which may cause safety hazards, provides fuels that support wildland fires, displaces native vegetation, and harbors rodent or pest populations which can support diseases or cause other problems.

Some weeds produce enormous numbers of seeds that can remain viable in the soil for decades before conditions encourage germination. The mere presence of weeds continually contributes to transport of seeds by wind, water, animals, people, equipment and vehicles, etc. into other areas of the park.

Action thresholds

Although the policy of the NPS is to eliminate exotic plants, this may not be economically (or, logistically) feasible for some wide-spread or difficult to control weed problems. Concentrated efforts to control weeds must usually be directed to high-profile plants causing obvious problems.

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 ther 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, a protective collar around non-target plants, or controlled spray.

Annual grassy weeds. Pre-emergent herbicides (such as benefin) 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). Post-emergent chemical control (as glyphosate, siduron, dalapon) 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 (applicator must be certified)
Benefin - pre-emergent
Glyphosate - non-selective 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).

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

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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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POTENTIAL VEGETATION CONTROLS

PLANT CHARACTERISTICS						POSSIBLE CONTROL ALTERNATIVES	
NAME/TAXON	EXOTIC/ NATIVE	REPRODUCTION	TYPE	ROOT	BLOOM	MECHANICAL	HERBICIDE
Bermuda grass Cynodon dactylon	E	Stems, rhizomes, seed	Warm season perennial	Fibrous		Prevent establishment, do not allow bare spots to form in turf Increase shade, if possible Use plastic mulch Hand pull; mow; disk Remove Bermudagrass rhizomes	Glyphosate Siduron
Cheatgrass Bromus tectorum	E	Seed	Summer or winter annual	Fibrous	Spring	Disking Burning	Glyphosate
Cholla cactus Opuntia and various spp.	N	Seeds, cuttings	Perennial	Fibrous	Early spring to summer	Cutting, pulling Burning Disking	2,4-D Glyphosate
Crabgrass Digitaria spp.	E	Seed, stems	Annual	Fibrous		High mowing retards	Pre-emergent Glyphosate
Johnson grass Sorghum halepense	E	Rhizomes, seed	Perennial, allelopathic	Fibrous		Prevention Mowing 6 to 9 times Flaming Fungi	Glyphosate Pre-emergent
Mesquite Prosopis juliflora	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 Verbascum thapsus	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	Glyphosate 2,4-D Triclopyr

PLANT CHARACTERISTICS						POSSIBLE CONTROL ALTERNATIVES	
NAME/TAXON	EXOTIC/ NATIVE	REPRODUCTION	TYPE	ROOT	BLOOM	MECHANICAL	HERBICIDE
Punctureveine Trihulus terrestis	E	Seeds	Summer annual	Tap	Summer	Mulching Cut plants before flowering Do not allow bare spots	2,4-D Glyphosate Pre-emergent
Quackgrass Agropyron repens		Seed, rhizomes	Perennial, allelopathic	Fibrous but deep		No effective Repeated disking	Glyphosate
Right of Way weeds (various)	E & N	Seeds, stems, rhizome	Annual and perennial	Fibrous to deep	Various	Cutting, disking before flowering Flaming	Glyphosate Triclopyr 2,4-D Pre-emergent
Saltbush (Atriplex) Atriplex canescens	N	Seeds	Perennial	Deep	Spring to summer	Mowing slows growth	Glyphosate 2,4-D Triclopyr
Sandbur Cenchrus incertus	E	Seed, stems, roots	Warm season annual	Fibrous	Mid- to late summer	Mulching Cut young plants	Benefin Glyphosate Pre-emergent
Tamarisk Tamarix aphylla	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 Cirsium arvense	E	Seed, roots	Perennial	Deep tap	Late summer	Persistent mowing/cutting	Glyphosate 2,4-D
Thistle, Russian Salsola kali	E	Seed	Annual	Fibrous	Summer	Flaming, disking before flowers appear Exclusion (fences)	Glyphosate 2,4-D
Thistle, yellow star Centaurea solstitialis	E	Seed	Annual	Fibrous	June to September	Cut plants before flowering Pulling when numbers small Disking Flaming	Glyphosate 2,4-D
Rose (Rosa spp.)	N/E	Seeds, roots	Perennial	Branching	Late spring	Frequent mowing slow growth	Glyphosate 2,4-D Triclopyr

ANNOTATE ANY CONTROL ACTIONS TAKEN, WHEN TAKEN, AND SUCCESS RATES TO MAKE CHART MORE USEABLE IN THE FUTURE

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 (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 different names have been used to describe the disease, Hantavirus Pulmonary Syndrome (HPS) which 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, behond 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	Peromyscus	8 to 16% positive
Brush mouse	Peromyscus	8 to 18% positive
White footed mouse (LA)	Peromyscus	36 to 50% positive
Cactus mouse	Peromyscus	7 to 13% positive
Western harvest mouse	Reithrodontomys	19% positive
Desert pocket mouse	Perognathus	1% positive
Woodrats	Neotoma	0.6 to 1.5% positive

COMMON NAME	GENUS	PERCENT POSITIVE
House mouse	Mus	2% positive
Western chipmunk	Eutamias	Unknown
CO chipmunk	Eutamias	16% positive
Cliff chipmunk (AZ)	Eutamias	3% positive
Rock squirrels	Citellus	1% positive
Cotton rat	Sigmodon	One occurrence

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 March 17, 1997, 158 human cases of Hantavirus had been reported in 26 states with 76 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 (11 cases), Utah and Colorado (10 cases each), and Texas (7 cases). Mortality rates in Arizona (about 27 percent) have been slightly lower than the national average because of disease recognition and initiation of treatment.

GENERAL INFORMATION

- 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 appeared 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 rates in rodents were generally found during winter and spring in southern AZ). Studies in 1996 showed infection rates in rodents drastically reduced. The Arizona Department of Health recommends all residents continue to take precautions because there is still not enough information on the climatical or seasonal effects or geographic limits of the disease. The Department stresses that there can always be a potential for contracting Hantavirus from rodents.

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.

• Cats and dogs are not known to be reservoirs but often may bring infected dead rodents into contact with humans. And, dog and cat feces and pet foods and water dishes provide food sources attractive to 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.

• 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 germicidal, it is not so labeled by EPA and cannot legally be recommended for use as a germicidal.

• Detergents are not sufficiently germicidal without addition of bleach or disinfectant and are not labeled by EPA as germicidal.

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

I. 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; place new traps out. Contact you 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 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, 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 to 0.4 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, INSECT, AND OTHER DISEASES AND HAZARDS

I. Potential rodent-borne health hazards

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 sanguineous), 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 icterohaemorrhagieae 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 over 21 states.

II. Potential pigeon and bird health hazards

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 health hazards

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 allergenic 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, environements 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 complext, 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 encephalititis 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 allergenic 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 AND SAMPLE FORMS

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 cleaning up rodent debris in an area will gives information on relative pest use during an elapsed time interval.

- **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, electrocuter, 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 electrocuter 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 upside down on but separated from the floor with 1/16 inch spacers (such as small coins). Traps set in this manner will capture crawling insects that seek 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, de-humidifiers 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: When screening chimneys and stove pipes, soot will build up on the screen will reduce draft and cause smoke-filled rooms or other safety hazards. Periodic scrubbing of screening with a 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.

DATE:_____ INSPECTED BY:_____

SAMPLE INSPECTION AND MONITORING FORM

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?

2. **DOORS:** In good repair, effectively seal off rooms/areas? Seals and sweeps tight (no light showing through)? Close properly?

3. **FACILITY AREAS:**

   PIPES: Routinely inspected? In good repair? Leaks? Pipe traces open or sealed?

   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?

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9. **GALLERIES/EXHIBITS/VISITOR CENTER:** Vacuumed regularly? Custodian reports pest signs? To whom? Materials moving into/out of galleries checked for pests? Food/drink allowed in galleries? Exhibit preparation/manufacturing areas clean? Holes in walls, ceilings, floor; cracks, or crevices? Pest presence? Continually monitored for pests? By whom? Monitoring documented? Doors and windows in/adjacent to galleries seal tightly? Suspended ceilings? Air/heating vents filtered? Door sweeps too high?

10. **GIFT AND SALES AREAS:** Ongoing monitoring for pests? Display cases with pest harborage under/around them? Infested materials immediately removed, isolated for identification and treatment? Food, drinks eaten here, properly stored, disposed of? Proximity of area to museum galleries? Administrative offices? Pipe, electrical line traces sealed? Suspended ceilings?

11. **STAFF LOUNGE AREA:** In same building as museum and museum storage? Refrigerator clean (including defrost drain pan)? Is only central area where food allowed? Sink/counters in good repair, clean? Pest presence? Microwave/stove/oven clean? Coffee pot/other appliances clean? Trash can has liner, lid? Emptied every night? Regularly washed? Empty pop cans stored in building? Floors regularly mopped, dusted, vacuumed? Personal lockers present? All pipe, electrical line traces sealed? Suspended ceilings? Door sweeps too high?

12. **WATER SOURCES:** In good repair? Floor drains screened? Water fountains with pipe traces sealed, pipes insulated to prevent condensation? Leaks? Sinks, lavatories in good repair, clean? Bottled water dispensers leak? Aquaria? Plants?

13. **STAFF AREAS, WORK STATIONS, AND OFFICES:** Food, water present; coffee/cold drinks allowed? Candy/snacks/foods in desks? Trash cans with liners, lids? Only food/paper or mixes of trash put into cans? Dried/live flowers/plants present? Pest evidence? Pipe, electrical line traces sealed? Proper storage of supplies, equipment, other materials? How long paper/envelopes stored? Doors, windows close tightly? Suspended ceilings? Pests behind/under desk drawers, cabinets, etc. Air and heating vents covered with filters? Door sweeps too high? Monitored for pests?

14. **ATTIC AND BASEMENTS:** Holes to outside? Pest evidence? Inspect under attic insulation. All pipe, wire traces sealed? Ducts, vents screened and sealed? Water leaks? Damaged wood? Moisture present? Doors, windows tightly seal? Proper storage? Suspended ceilings? Grates on drains?

15. **WALL VOIDS:** Inspect for insects, dead animals, or odors.

16. **CRACKS AND CREVICES:** Present? Inspected for accumulated hair or lint and pest harborage?

17. **OTHER:**

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INSPECTION AND MONITORING FORM

DATE:_____ **INSPECTED BY:** _____

STRUCTURAL / INTERIORS

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2. **DOORS:** In good repair, effectively seal off rooms/areas? Seals and sweeps tight (no light showing through)? Close properly?

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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 builings 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 dirt 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.

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.

EXAMPLE PLANT AND ANIMAL PHENOLOGICAL OBSERVATIONS

(to be verified with site-specific observations)

PHYLUM	EVENT	ITEM TO RECORD
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 ground squirrel species • Various lizard species • Skunks • Deer • Swifts and swallows • Grosbeaks • Hummingbirds • Chukar • Bluebirds • Tent caterpillars
	BREEDING	
	APPEARANCE OF YOUNG	
	HIBERNATION	

PHYLUM	EVENT	ITEM TO RECORD
OTHER	MONTHLY DATA	• Average temperature • Average precipitation (inches water) • Number overcast days • Number of park visitors • First/last snowfall • Highest/lowest temperatures

COMPARATIVE EXAMPLES	JANUARY	• January thaw and warmer weather often occurs during last 2 weeks of January when day length increases • High daily temperatures average 59-F and lows 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 begin to become more active and red-shafted flickers are seen more often; warm days in mid-month bring out spiny lizards just as butterflies begin to be seen. Visitor travel and camping use doubles that from previous month.

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 PESTICIDE COMPOUNDS

COMMON PESTICIDES (NAMES AND FORMULAE)

Abamectin (see macrocyclic lactone glycoside)

Acephate (Orthene): 0, S-dimethyl acetylphosphoramidothioate; organic phosphate; contact/systemic poison; LD_{50} 866-945 mg/kg; **Caution label**; some formulations are designatedas Restricted Use; low vapor pressure; high water soluability; residual 6-9 days; 1/2-life in soil 11 days; 5-10% degrades into methamidiphos (more toxic); both rapidly excreted by mammals..

Affirm (see: macrocyclic lactone glycoside)

Allethrin (pyrethrin, bioallethrin, Pynamin, Pyrethrains, Sectrol, X-Clude, Pyrenone, Exciter, Kicker, Bio-allethrin, Esbiothrin): d-cis-and/or-trans-chrysan-themum monocarboxylic acids ester of dl-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; LD_{50} 200-300 (680-1000 ??) mg/kg; **Caution label**; ineffective in alkaline solutions, not compatible with lead, brass, copper, zinc, iron; non stable in sunlight. PT-565: can cause allergenic 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; LD_{50} 46-150 mg/kg; some formualtions 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; LD_{50} >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; LD_{50} 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; LD_{50} - 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; LD_{50} 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, D-Con, Havoc, Klerat): 3-(3-(4'-bromo(1,1'-diphenyl)-4-yl)-1, 2,3,4-tetra-hydro-1-naphtha-lenyl)-4-hydroxy-2H-1-benzopyran-2-one; organic anticoagulant rodenticide; LD_{50} 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; LD_{50} 1.125 mg/kg; **Caution label,** very toxic. Can cause bleeding, cardiac problems, neurologic symptoms.

Butacide/Butocide (see piperonyl butoxide)

Carbaryl (Sevin): 1-napthyl methyl carbamate; carbamate; contact/stomach poison; LD_{50} 307-986 mg/kg; **Caution label;** 21 day residual on vegetation; toxicity rises with increased temperature; 1/2-life in aerobic soil 7 days; rapidly excreted by mammals

Casoron (see dichlobenil)

Chlorobenzene: 1,1,1-trichloroethane: **methylchloroform;** a solvent, as an 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; LD_{50} 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): LD_{50} 40-50 mg/kg; **Caution label;**

rodenticide acting to create calcium imbalance in rodents; no secondary poisonings.

Combat (see: hydramethylnon)

Contrac (see: bromadiolone)

Cyfluthrin (Tempo, Baythroidd, 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; LD_{50} 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); LD_{50} 425-860; **Caution label**

DDVP (see: dichlorvos/dichlorphos)

Deet (Off, Muskol, Cutters); LD_{50} 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)

Diatect 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 (Diatect, 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 spikules) diatomaceous earth and wear a respirator.

Dichlorodiflouromethane: 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; LD_{50} 3160 mg/kg; residual all season, does not build up/move in soil; no contact activity; do nt use on light, sandy soil.

Diflubenzuron (Dimilin); LD_{50} 4640->10,000; **Caution label;** chitin inhibitor affecting all invertebrates

Diphacinone: (Ditrac); 2-diphenylacetyl-1,3-indandione; organic anticoagulant rodenticide; LD_{50} 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)

Drione: (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, LD_{50} 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; LD_{50} 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; LD_{50} 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; LD_{50} 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; Amdro, Combat, Siege, Maxforce): tetrahydro-5, (3-(4-(trifluoromthyl)phenyl)-1-(2-(4-(trifluoromethyl)phenyl)-ethenyl)- propen-yilidene) hydrazone; organic compound; slow acting stomach poison, very safe; LD_{50} 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); LD_{50} 5100 mg/kg; **Caution label**; cockroaches; makes adults unable to reproduce.

Ivermectin (see: abamectin)

Killmaster (see: chlorpyrifos)

Kleenup, (see: glyphosate)

Lambda-Cyhalothrind (Demand, Commodore, Karate)

Linalool (see d-Limonene, Demize)

Logic (see: fenoxycarb)

Macrocyclic lactone glycoside (Abamectin, Affirm, Avert, Ascend, Roach-Ender; avermectin-B-1): 5-0-dimethylavermectin A-1a(R=C2 H5)=B1a 5-0-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); LD_{50} 10 mg/kg; slow acting, good persistance.

Magnesium stearate (see:Boric acid)

Maki (see: bromadiolone)

Maxforce (see: hydramethylnon)

Metaldyhyde (Deadline 40): snail bait

Methylchloroform: see Chlorobenzene

Methamidophos (see: acephate)

Methoprene (Altosid, Dianex, Diacon, Pharorid, Kabata, Precor): isopropyl (2E,4E)-11-meth-oxy-3, 7,11-trimethyl-2,4-dodecadienoate; organic insect growth regulator (IGR); LD_{50} 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); propellent in aerosols; mixed with other insecticides; flammable but not explosive; LD_{50} 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-norbonene-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 botoxide 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, LD_{50} 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.

Pharorid (see: methoprene)

Phenothrin (Fenothrin, Sumithrin); 3-phenoxybenzyl-d,1-cis,trans 2,2-dimethyl-3-(2-methyl-propenyl) cyclopropane carboxylate; synthetic pyrethroid; contact/ stomach poison; LD_{50} 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, Butacide/Butocide) alpha-[2-(2-n-butoxyethoxy)-ethoxy]-4,5-methyl-enedioxy-2-2propyltoluene; 3,4-methylenedioxy-6-propylbenzyl n-butyl diethyleneglycol ether; (butylcarbitol) (6-propyl-piperonyl) ether; organic synergist for pyrethrins/resmithrins/rotenone made from peppercorns; LD_{50} 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 indiacted 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 botoxide synergist under label **Vermonox** for flies.

Precor (see: methoprene)

Pyrenone: a mixture of pyrethrins and piperonyl butoxide (1:5 to 20:1 ratio).

Pyrethrin (see: allethrin, Synerol)

Pydrin (see: fenvalerate)

Pyrid (see: fenvalerate)

Quintox (see cholecalciferol)

R-11 (also MGK Repellent-11): (2,3,4,5-bis(2-butylene)tetrahydro-2-furaldehyde) insect repellent; LD_{50} 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; LD_{50} - 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: bioresmethrein)

Sevin (see: carbaryl)

Silica aerogel (Dri-Die, Tri-Die, Silikil, Drione): inorganic; contact poison, removes the protective cuticle from insects; LD_{50} 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, salufer): contains sodium, silicon, flouride as white/granular powder; LD_{50} orally in rats 125 mg./kg; used in china/porcelain enamels, manufacture of opal glass, insecticide, rodent poison, mothproofing of woolens, 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; LD_{50} 5 g/kg in rats; suggested inhalation threshold 100 ppm; aromatizing compound

Tetramethrin: (Neo-Pynamin): 3,4,5,6-tetrahydro-phthali-midomehyl-d-cis-trans-chrysanthemate; organic, sythetic pyrethrum derivitive; contact poison; LD_{50} 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; LD_{50} 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

Trichloromonoflouromethane: refrigerant, aerosol propellant, less toxic than CO_2; decomposes into harmful materials under heat/flame; destroys ozone layer; prepared from carbon tetrachloride and antimony triflouride, 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)

Vermonox (see: MGK-264)

Vitamin D-3/Vitamin D-2 (see: cholecalciferol)

Warfarin (Coumafene, d-Con, Dethmor, Duocide, Warfaricide): 3-alpha- acetonylbenzyl) 4-hydroxycoumarin; anticoagulant rodenticide; LD_{50} 3 mg/kg; **Caution label**; massive dose of vitamin K is antidote; most rodents are resistant now.

Warfarin+ (Prolin); anti-coagulant rodenticide; LD_{50} 1000; **Caution label;**

Wasp Freeze (PT-515) (OLD FORMULATION): trichloromonofluoremethane, dicholofifluoromethane, 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; LD_{50} 100 mg/kg.

2,4-D (aqua kleen/demise/weed-b-gone/weedar-64/weedone): 2,4-dichlorophenoxyacetic acid; phenoxy herbicide; suspected carcinogen.

1080 (see: sodium fluoroacetate)

CHEMICAL DESCRIPTIONS:

(Listed by chemical formula)

A

alpha-[2-(2-n-butoxyethoxy)-ethoxy]-4,5-methylenedioxy-2-2propyltoluene; 3,4-methylenedioxy-6-propylbenzyl n-butyl diethylene glycol ether; (butylcarbitol) (6-propylpiperonyl) ether: **Butacide/Butocide** (piperonyl butoxide):

C

cyano(3-phenoxyphenyl)methyl 4-chloro alpha (1-methylethyl)benzene acetate: **fenvalerate** (Pydrin, Pyrid):

cyano(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

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, Pharorid, Precor):

isopropylamine salt [n-(phosphonomethyl) glycine]: **Rodeo** (Roundup, glyphosate, Kleenup):

M

methyl 1-(butylcarbamoyl)-2-benzimidazole carbamate: **Benlate** (benomyl)

N

[N-(2-ethylhexyl)-5-norbonene-2,3-dicar-Soxamide]: **MGK-264**:

N-octyl bicyclopheptene 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 acetylphosphoramidothioate: **acephate** (Orthene).

S

Sodium hexafluorosilicate, sodium silicofluoride, salufer: **sodium fluosilicate**

T

tetrahydro-5,5-dimethyl-2(1H)-pyrimidinoine (3-(4-(trifluoromthyl) phenyl)-1-(2-(4-(trifluoromethyl)phenyl)-ethenyl)-propenyilidene) hydrazone: **Amdro** (amindinohydrazone, hydramethylnon, Combat, Maxforce):

+/-

(+/-) alpha-cyano-3-phenoxybenzyl (+/-) cis.trans 3-(2,2-dichloro-vinyl) -2,2-dimethyl cyclo-propane-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-y1 methylcarbamate: **bendiocarb** (Ficam, Turcam):

2,4-dichlorophenoxyacetic acid: **2,4-D** (aqua kleen/demise/weed-b-gone/weedar- 64/weedone):

2,6-dichlorobenzonitrile: **dichlobenil** (Casoron):

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, biothrin):

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-phthalimidomehyl-d-cis-trans-chrysanthemate: **tetramethrin**:

3,5,6-trichloro-2-pyridyl-oxyacetic acid: **triclopyr** (Garlon):

4

5

(5-benzyl-3-furyl) methyl 2,2-dimethyl-3-(2-methylpropenyl) cyclopropane-carboxylate: **Bioresmethrin** (resmethrin, Scourge, synthrin):

5-0-dimethylavermectin A1a(R=C2 H5)=B1a 5-0-dimethyl-25-de-1 methylpropyl-25-(1-methylethyl) avermectin A1a(R=CH3)=B1b: **abamectin** (Affirm, avermectin- B-1):

APPENDIX VI

VERTEBRATE TRAP SIZES AND BAITS

COMPARATIVE TRAP SIZES AND BAITS

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.t, 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 livetrap 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 repellers; v-top sparrow and starling live trap cages.

Bird-X, 730 W. Lake St., Chicago IL 60661; 312/648-2191. Plastic bird netting, Irri-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; 51/6/694-9000. Ro-Pel (benzyldiethyl 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 pheromnone 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 CarsonSt., 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 flamers.

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. Tyrne metal for excluding pests.

Forestry Suppliers, Inc. 205 West Rankin Street, PO Box 8397, Jackson, MS 39204-0397; 800/647-5368. Weed flamers; 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 deodoroizer.

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.

USDA-ARS Carl Hayden Bee Research Center, Tucson AZ; 2000 E. Allen Road; 602/629-6380. Identification of Africanized honey bees.

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, Micology Center, Div. Infectious Diseases and International Health, Duke Univ., Durham NC 27710; 919/684-3717. Tests for Histoplalsmosis 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.

Poison Control Center: 1-800-732-6985.

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. Grennlaw 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. Li'l 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.

Paraclipse, 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 andother traps for mammals, birds, and turtles; full line of animal damage control equipment.

Reed-Joseph International, Box 894, Greeville 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. Gentrol 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. Enrlich 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 an 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 Tourney 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).

APPENDIX VIII

DISPOSITION OF LIVE CAPTURED ANIMALS

DISPOSITION OF LIVE CAPTURED ANIMALS

Considerable discussion and strong sentiments often surround questions on the best way to control pest animals (i.e. mice, squirrels, rodents, skunks etc.). That is, whether to use lethal snap traps (or other direct control methods such as shooting) and how to dispose of live-captured animals: to transport them to a new site for release or to euthanize them in the trap. Below are a number of reasons supporting direct control or euthanization of trapped animals rather than live-capture and release.

▸ Recently, the Arizona Department of Health and U.S. Center for Disease Control (CDC) recommended the following reasons for killing rodents in snap traps rather than live-capturing them:

- to prevent possible spread of Hantavirus into unaffected rodent populations
- to attempt to limit the spread of rodent urine/saliva/feces around trap sites
- to prevent humans from contracting the disease from possible rodent bites
- to prevent human contact with disease contaminated aerosols during trap handling/release.

▸ Live captured animals may carry non-apparent (or new) diseases or parasites which, when animals are returned into the wild, potentially, allows for the spread of disease into previously uninfected wildlife populations.

▸ Man's introduction of captured animals into any given area where populations are naturally balanced disrupts existing wildlife systems and behavior and has been shown to cause detrimental change.

- Introductions of animals into areas already occupied by that same species almost always results in a high mortality for introduced individuals.

Animals, by nature, are very territorial; natural systems do not normally have "empty" sites (territories) providing room for man's imports. If such openings were available, they would almost immediately be filled through reproduction.

Natural survival rates for young animals - from birth to maturity - seldom exceeds 20 percent (more than 80 percent of all young die soon after birth) because of severe competition with already existing and established individuals. New animals can only an open territory by chasing established animals off all or part of a range or by finding a "hole" created by the death of a resident animal.

- Moving skunks, feral dogs/cats, squirrels, etc. into new areas forces resident animals of the same species to aimlessly wander in hopes of finding an open territory/home range. Introductions by man usually cause animals to become problems for other people - or - an introduced animal simply starves to death (or is killed by resident animals) because it cannot establish a feeding territory or den site.

▸ Trauma experienced through live capture, transport, and release often physically injures animals (many freeze to death or terminally dehydrate in live traps) or otherwise emotionally weakens them in ways contributing to or causing their ultimate demise when released.

▸ Live capture and release of animals is very time consuming and expensive. The expense, expected minimal survival of releases, and potentials for biological disruptions eliminates most justifications for live release.

▸ Usually, many fewer live/cage traps can be used than kill/snap traps because live traps are so much more expensive and difficult to transport. The smaller number of live traps used results in less efficient control efforts.

▸ A recent CDC study of the effectiveness of rodent exclusion methods verified that mice captured inside and then released of buildings often re-enter and are re-captured inside; and, later, re-captured again outside.

Animals have strong homing instincts and often return to point of capture. Some reports note that marked mice have returned from a release point a mile away, raccoons and squirrels from 10 to 20 miles, and grizzly and black bears from over 40 miles. In one case, a tourist who lost a house cat on one side of the United States was very surprised, after more than a year, to see the cat return home -- understandably, very gaunt and tired. Pest animals returning to point of capture defeat the efforts and expenses required to move them.

Therefore, although live-capture and release may seem a "humane" treatment of animals; it isn't and, indeed, may be the most <u>inhumane</u> thing that can be done to a captured animal.

- A brief note from personal experience:

Over a two year period at CARE, we live-captured over 200 mule deer, marked them with tags, and released them into the wild on nearby mountains. The deer were <u>severely</u> traumatized, both psychologically and physically, during capture and

extraction from nets. A number of human injuries occurred when freeing animals from the nets and while moving them to vehicles. Tags reclaimed later from a number of animals showed they had greatly wandered after release (trying to find a new home range) and often into extremely poor habitat that would not support deer. Very few animals lived more than a few months after release. Autopsy of recovered dead animals showed most were extremely emaciated and in bad physical condition at death (red bone marrow).

• Similarly, Bill Olkowski (Director, Bio-Integral Research Center; editor of the IPM Practitioner and Common Sense Pest Control Quarterly) recently said, in support of destruction of captured pest raccoons (Common Sense Pest Control Quarterly, Vol. VIII(4), Fall 1992):

"Sentiment often suggests that trapped wildlife such as raccoons should be transported to a wild and far away place and released to live happily ever after. But there may be more Disney than reality in that scenario. Apparently, raccoons do not possess a homing ability, and this fact suggests that relocated animals are unlikely to return. However, there appears to be several good reasons for not transporting and releasing wild vertebrates that have become nuisances around human dwellings and gardens.

First of all, people living in the area to which the raccoons are transported may not appreciate their garbage can or garden-raiding habits any more than you do. You are just moving the problem, not solving it. Secondarily, there is a good chance you may be moving infectious diseases around. For example, in the 1980's, raccoons transported from southern Florida to Virginia were suspected of being a major cause of raccoon rabies. (Jenkins and Winkler, 1987). This can happen because the animals may be incubating a disease without showing any symptoms during the period of capture and removal.

But, perhaps, the best reason of all is that it is unlikely that the raccoon will survive in the new environment. One study (Rosatte and MacInnes, 1989) concluded that 50 to 70 percent of all relocated raccoons died within the first three months of relocation. They posed the question, 'Would it be more humane to euthanize the problem animals at the time of initial capture, or subject them to disorientation (sic being out of home range), starvation, and mortality by dogs, automobiles, poison, and shooting?' We recommend you contact your local municipal or county animal control department for a quick, humane handling of your raccoon problems."

Although there may be a few cases where live-capture might be considered a desirable alternative (i.e., to prevent spread or release of ectoparasites from the point of capture, as for squirrels in air ducts), sacrifice of live-captured animals before release is still wisest and most humane."

The above opinions are supported by NPS-77 which allows for lethal control of native wildlife in NPS units:

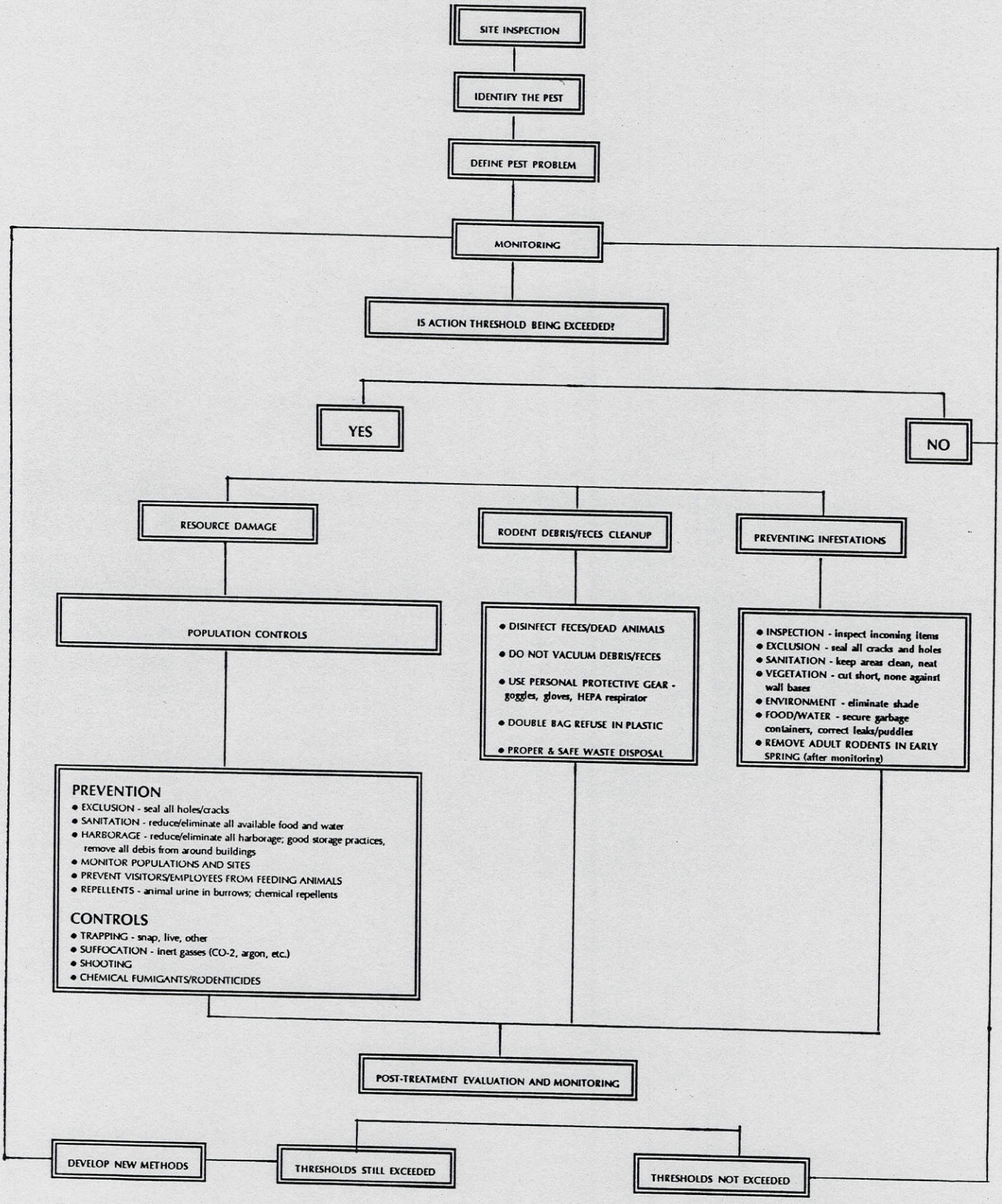
• native animal populations or individuals may be controlled: ... when they present a threat to safety and health ... when necessary to protect property or landscapes.

• native pests can be controlled: ... to prevent loss of a host or host-dependent species ... to prevent disease outbreaks from spreading ... to conserve threatened/endangered species ... to preserve or restore historical integrity of cultural resources ... to protect other native species ... to manage human health hazards or protect against threats to public safety ... when negatively influencing the purposes for which a development or special-use/cultural zone was established ... when known as a pest population and IPM procedures are followed in conducting a management program ... where there is an unnatural concentration of animals due to unnatural or human influences.

APPENDIX IX

PEST CONTROL ALTERNATIVES (FLOW SHEET / DECISION TREE)

PEST CONTROL ALTERNATIVES



IPM ACTION PLAN FOR THE CASA GRANDE GREAT HOUSE RUIN

I. INTRODUCTION

The comprehensive Casa Grande National Monument (CAGR) Integrated Pest Management (IPM) Plan is the primary reference supporting the park IPM program in CAGR. It contains information on the use of pesticides, descriptions of pest biology and alternatives for managing pests, and a number of helpful appendices. Two site-specific Action Plans are attached to the CAGR IPM Plan:

- The IPM Action Plan for the Casa Grande Great House Ruin

- The Museum IPM Action Plan for Southern Arizona Group (SOAR) Parks focuses on managing museum and invertebrate pests inside all SOAR visitor centers and curatorial areas.

Casa Grande National Monument was authorized in 1889, proclaimed in 1892 and redesignated by proclamation in 1918 to preserve massive four-story ruins constructed by Native Americans who farmed the area 600 years ago. The Monument is located about 50 miles south of Phoenix in habitat typical of the Sonoran Desert.

Bird and rodent damage to archeological ruins has been a management problem at CAGR for many years; however, during the summer of 1993, rodent damage was found to be greater than normal. That season had been preceded by three years of above average rainfall throughout Arizona which, state-wide, greatly favored increases in rodent populations. The increased number of rodent burrows around the Great House ruin in 1993 caused CAGR staff to be concerned about the amount of damage rodents were doing to the unconsolidated, cement-capped, caliche walls of the ruins. Rodents had completely hollowed out the interiors of some walls and rodent burrowing was exposing and intermixing previously buried archeological artifacts, increasing the rates of wind and water erosion, and attracting rodent predators. Rodent predators searching for prey were responsible for enlarging existing rodent burrows.

The increased number of rodents present in Southwest states in 1993 was also a health threat. Rodents were found to be directly responsible for 10 persons in Arizona contracting Hantavirus Pulmonary Syndrome (HPS) and 4 of those persons died from the disease. HPS is a potentially lethal viral disease which can effect humans who come into contact with infected rodents (dead or alive), rodent feces, their body fluids or nests, or dust contaminated by sick rodents.

The Southern Arizona Group Office (SOAR) contracted University of Arizona (UA) researchers (Swann et. al., 1993, 1994) to identify and provide natural history on birds and mammals causing damage to CAGR ruins and offer alternatives for control. The UA study identified the animals responsible for most of the damage as: round-tailed ground squirrels, pigeons, house finches, with secondary predators like kit foxes, badgers, and coyotes. Their report also noted the ruins have existed in their present condition and providing habitat for many small organisms for over 500 years. Therefore, short-term attempts to eliminate animals from the ruin would only have limited benefit before the animals would again recolonize the site.

The numbers of pigeons and other birds present and the amount of damage birds were inflicting on adobe walls of the Great House also seemed greater in 1993 than during previous years. One count in 1993 showed there were at least 26 pigeons in the ruin and pigeons and smaller birds were continually roosting and nesting on the deteriorating ruin walls. The numbers of birds roosting and nesting in the Great House were so great in 1993 that up to five gallons of bird debris (feces, feathers, and dead young) per week was falling onto interior ruin floors and had to be manually removed by park Maintenance. The bird debris was thought to be supporting potential health hazards as well as attracting other pests. There were additional concerns that bird feces, being highly acidic in nature, could react with the alkaline-based caliche walls and cause increased erosion. The birds were also enlarging existing holes and cracks in the walls to make nests and find shelter. When it was learned that pigeons sometimes eat the mortar between bricks in masonry walls for contained lime, concerns were voiced that pigeons might also be attracted to the alkaline minerals present in caliche and adobe.

II. PAST AND CURRENT TREATMENT METHODS

There have not been any long-term or consistent management actions taken against rodent or bird pests around the Great House ruin. For a period of time one summer, some years ago, a number of round-tailed ground squirrels were live-trapped around the Great House and animals were released into areas adjacent to the Monument. That trapping effort resulted in a short-term decrease in the number of ground squirrel burrows around the ruin. Similarly, intermittent efforts have been taken to shoot pigeons (with a pellet rifle) and those attempts were also effective for a short period of time.

III. PROGRAM SUPPORT

Pest management, to be most effective in outdoor ruins, must be a long-term, continuous, persistent action. Continuity and trained employees are important to the success of the CAGR IPM program. Training recommendations are described in CAGR comprehensive IPM Plan. At least 2 persons will be trained and assigned to IPM inspection and monitoring duties to guarantee program continuity in the event one of those employees leaves the park.

IV. INSPECTION AND MONITORING

All pest animals observed at CAGR will be identified to Genus and species, if possible. The relative frequencies of pest sightings, dates of sightings, potential and realized damage and/or health threat, and other pertinent biological information will be recorded. Where rodents or other small animals found in the area can not be properly identified, they will be captured, preserved, and sent to a university or other specialist for proper identification. Only photographs of larger animals need be sent to specialists.

All personnel involved in rodent trapping or inspections and who are brought into close contact with rodent debris will wear approved personal protective equipment and follow Arizona Department of Health or Federal Centers for Disease Control (CDC) guidelines (see Appendix I, "Hantavirus Pulmonary Syndrome (HPS) Information', in the comprehensive park IPM Plan.) At a minimum, personal protective equipment will include rubber gloves, hard hat, coveralls, and a dust mask capable of screening particles as small as 0.3 microns in size (i.e., HEPA filter). Prior to use, persons required to wear respirators will be tested for respirator fit, trained in the use of ladders, and informed about specific hazards surrounding their work.

Inspections and monitoring, general

The Great House and its grounds will be inspected at least twice a year (once during early spring and then again in fall) and will then be monitored once a month from March through December to detect the presence of rodents, active burrows, pigeons and other birds, and pest damage. Inspection and monitoring activities will focus on obtaining information on the presence, time, extent, severity, and conditions (food and harborage) supporting pest infestations that could lead to increased pest numbers; trails or areas most used by animals; observations of structural damage; and general area sanitation. Results of inspections and monitoring will be recorded on appropriate forms from which Work Orders will be prepared and referred to the Division of Maintenance. Additional inspections and monitoring may take place at other times of the year, as dictated by need. For additional information, see Appendix III, "Inspection and Monitoring Guidelines and Sample Forms", in the comprehensive park IPM Plan.

Continual monitoring inside the Great House will document the presence and/or relative numbers of active rodents (mice, woodrats, etc.) and record on a floor plan diagram any observations of nesting activity (by non-toxic tracking boards, covered snap traps, or other appropriate means), potentially available rodent harborage, quantity and size and age of rodent droppings, remains of foods eaten by animals, gnawing damage, and observed runways, tracks, grease marks, or urine stains, etc. Monthly comparisons of data obtained from monitoring will provide information on the presence of rodents and help with the planning of management actions. A log will be established listing specific cleaning activities and schedules for the Great House so it will be possible to estimate the relative age of any newly discovered pest evidence. Additional monitoring may take place at other times during the year, as dictated by need.

When monitoring shows evidence or signs of rodents or other pests that exceed the established Threshold

Levels, appropriate control actions will be taken.

The numbers, kinds, and locations of animals found dead from unexplained reasons will be identified during regular inspections and monitoring. Dead animals can be an important early-warning indicator for the presence of disease in natural populations. The Arizona Department of Health or CDC will be informed about the presence of dead animals to determine their interests for examining the animals or site.

Round-tail ground squirrels

Counts of active ground squirrel burrows and the numbers of animals present in and around the Great House ruin will be made twice a year: one during early spring (February or March) before rodent reproduction begins and again in late fall (November) before animals hibernate. Those counts will justify the need for control actions and provide data indicating annual changes in the numbers of animals present. Counts of animals will be made during mornings and evenings and repeated at different times during the season. Observations will include counts of individuals; active burrows; feeding stations; numbers and locations of burrows under structures; damage to rock walls, foundations, or buildings; etc. Those counts will justify the need for control actions and provide data showing annual changes in the numbers of animals present. Once or twice a year, photo point records will be made of specific ruin areas most susceptible to ground squirrel activity to provide insight into accumulative damages.

Methods for Estimating Rodent Density

BURROW COUNTS. Mark all burrows with flagging and record the locations on a site map. Close all burrows with soil and return in a day or two to record the numbers and locations of burrows re-opened by animals. Changes in population size can be estimated through sequential sampling efforts.

RECAPTURE ANALYSIS. Statistical comparisons may be made between the proportion of recaptured and marked animals in a given sample and the numbers of animals previously captured, marked, and released. However, a relatively high percentage (90+ percent) of a population has to be both marked and recaptured to reduce the expected sampling variance. One formula that can be used is:

$$\text{Estimated Number of Animals Present} = (M+1)(n+1) / (m+1)$$

M = animals marked and released in first sample
n = total animals captured in second sample
m = number of animals recaptured in second sample

The mathematical variance (reliability) for the Estimated Number of Animals Present is:

$$\text{Variance} = (M+1)(n+1)(M-n)(n-m) / (m+1)^2 (m+2)$$

Equal "trappability" cannot be measured. The assumption that all animals can be equally trapped will result in an underestimate of numbers and should always be regarded as a minimum estimate of population size.

Weather records (i.e. water content in winter snowfall, timing and amount of precipitation, etc.) and observations of plant and animal phenology will be monitored to serve as early-warning of seasonal climatical conditions which could support sudden seasonal increases or decreases in pest populations.

Pigeons and house finches.

The presence and estimated numbers of pigeons in the ruin will be obtained from periodic counts (daily, bi-weekly, or weekly) of the number of individuals, nests, and roosting areas present at specific times. When feasible, individual pigeons will be identified by color pattern, size, or other obvious characteristics. Records on individual birds will be used to estimate population size and to determine if the birds or flocks exhibit specific habitual behavioral patterns which could enhance management actions.

The ruin will be monitored two or three times a week for the presence of house finches and other small birds. Monitoring of birds that roost at night in the ruin will be done from an hour before sunset to 30 minutes after sunset, and from 30 minutes before sunrise to an hour after sunrise. The better times for monitoring for the presence of birds in the ruin will be periodically evaluated.

Observations will be made on the behavioral characteristics shown by birds (i.e., times and relative numbers of birds present at specific locations): where they feed and obtain water; common loafing or roosting areas and habitual travel routes; and diurnal and seasonal activity patterns resulting from nest building, mating, fledging of young, etc.). These observations will be made, whenever possible, for sites both in and out of the Monument to provide information on the behavior of flocks in the geographic areas surrounding the Monument.

The walls of the Great house will be periodically inspected and monitored to determine if bird feces, nesting activities, pecking, etc. are causing significant damage to the adobe.

Honey bees, paper wasps, and other stinging insects

The number, relative size and aggressiveness and location of paper wasp, yellow jacket, hornet, or honey bee colonies will be identified during monitoring and inspections. Honey bee colonies will be closely monitored for noticeable increases in size and for sudden aggressive behavior which could indicate "Africanized" traits.

Carpenter bees and termites

The presence of carpenter bee and termite activity will be identified during inspections and appropriate actions taken to prevent further nest development. Park staff and/or termite specialists will perform periodic building inspections every two years to determine if active termite colonies are present.

Termite prevention

The prevention of subterranean termite infestations in structures is usually done through good design and building practices which also helps prevent and control other pest problems. Archeological ruins present unique problems because they can not usually be modified in manners that correct the conditions attracting termites. Some of the more important preventative practices against termites that should be noted during inspections and monitoring include:

- At least a 6 inch clearance will be maintained between wooden structural members and ground surface, where possible. Record any locations where termite shelter tubes lead from the ground to exposed wood.

- Where possible, only pressure treated wood will be used in making building modifications. If pressure treated wood cannot be used, and allowed, wood will be treated with commercial borate wood preservation products.

- The grade around buildings will be sloped to cause water to drain away from foundations.

- Where possible, proper ventilation will be maintained under buildings to lower the humidity and promote more rapid drying of the soil. Vapor barriers covering about 70 percent of the ground surface in crawl spaces will be used where moisture conditions become excessive.

Larger mammals: ringtail cats, skunks, porcupines, foxes

Observations of the presence and signs of larger mammals (coyotes, foxes, and other predators and rabbits, gophers, etc.) will be made during regular monitoring. Records will be kept on burrowing, plant damage, or other activity by those animals which cause damage to the grounds or structures.

Other monitoring

Weather records (i.e. water content in winter snowfall, timing and amount of precipitation, etc.) and plant and animal phenological observations will be monitored to serve as early-warnings for seasonal climatical conditions which could support sudden seasonal increases or decreases in pest populations.

V. ACTION THRESHOLDS

When inspection and monitoring provides evidence of rodent or other pest activity which exceeds given Action Thresholds (comprehensive CAGR IPM Plan), pest management programs will be initiated. The Superintendent will review and may change or modify Action Threshold values or preferred control methods to best meet the needs of management objectives for the area.

VI. CONTROL ACTIONS

To best preserve the Great House and other archeological ruins at CAGR, consistent efforts must be taken to prevent pest damage. This can be done by changing environmental conditions in attempts to discourage pest populations from moving into the ruins from areas surrounding the ruins, continually removing animals from around the ruins to keep pest populations below Action Thresholds, and/or "hardening" certain areas within the ruins to exclude pests. These actions are best achieved with methods that specifically fit each site and pest biology.

CAGR will continually protect the habitat of native predators which might prey on pest populations. However, it is recognized that predators seldom, if ever, control the numbers of prey populations and the most effective and cost-efficient methods for preventing pest damage will be through direct management.

Round-tailed ground squirrels

Reducing available resources

Animals will be prevented from gaining food or water in areas surrounding the Great House and Visitor Center by good garbage collection practices, promptly correcting water leaks or other conditions favoring water accumulation on the ground, and enforcing regulations that keep visitors from feeding animals. Although ground squirrels do not normally feed on garbage, poor garbage storage and collection practices encourages other pests. Visitors will be informed to place food scraps in covered garbage receptacles.

Within context of cultural resource objectives, the grounds around the Great House will be maintained in a weed-free condition to eliminate pest harborage and keep plants and seeds from becoming food for ground squirrels and pigeons. Weeds and other superfluous plant growth will be removed from the compound with an agricultural torch (or chemical herbicide) in manners that do not disturb soil surfaces or encourage re-growth. If an herbicide is used for weed removal, the areas treated will be posted in an approved manner to prevent visitor-use until the herbicide is dry.

Reduce available harborage

Where possible, plant growth which provides pest harborage will be removed. Plants growing next to buildings and within the compound will be removed or thinned, the bases of ornamental shrubs will be opened up by pruning and thinning, rock or debris piles used by rodents for harborage or to escape predators will be removed, and abandoned animal burrows will promptly be filled.

Exclusion and habitat modification

Effectively excluding pests is a long-term, low-maintenance solution to many pest problems. Various methods of exclusion will be tested at CAGR before initiating more direct controls on ground squirrel populations.

Holes into or under ruin walls will be covered with 1/4-inch hardware cloth and the edges of the wire will be buried beneath the ground to discourage animals from digging under it. Concrete will be used whenever possible in making repairs. Open passageways through culverts are sometimes used by ground squirrels as travel lanes and to escape predation; where possible, these will be screened with 1/2-inch mesh hardware cloth. However, to prevent flooding, it may not be possible to screen those culverts that direct rain water run-off.

Tests will be made to see if short (12-inch high) sheet metal or plastic portable walls would be effective in excluding round-tail ground squirrels. If animals climb over test walls, the design will be improved by adding an over-hanging top to the fence and testing it again. Should tests prove favorable, segments of wall will be erected during summer to lessen the number of animals coming into the compound from adjacent, wild areas. Tests will also be made to determine if it would be feasible to fence ground squirrels out of the picnic area by installing 1/2-inch hardware cloth mesh along the bottom 2 feet of existing fence which surrounds the picnic area. The bottom of the hardware cloth wire should have an "L-shaped" bottom which faces away from the fence and buried slightly beneath ground. Should this test prove favorable, a hardware cloth bottom will be installed on the fence around the picnic area.

Repellents

Coyote and fox urine have been used, with limited success, in a number of national park areas as a short term measure to keep rodents from damaging new ornamental plantings. Although the repellency of predator urine is not long-lasting, its usefulness will be tested in CAGR.

Surveillance as an aid in control

Observational records will be kept on rodent feeding and other activities in the ruins to provide information helpful for possible management approaches. Records will also be kept on natural floral and faunal phenology and used to estimate expected seasonal pest activity and schedule management actions (i.e., when pests come out of hibernation, reproduce, differential food availability, when animals go into hibernation, etc.). Additional information is found in Appendix III, "Examples of Plant and Animal Phenology Observations," in the comprehensive park IPM Plan.

Direct control

Before any rodent reduction program is begun, the park will consult with the federal or state Public Health Service to evaluate any need for controlling rodent parasites.

When Action Thresholds are exceeded and where other methods of pest management are not proven to be sufficiently effective, pest populations in and around the Visitor Center and Casa Grande ruin will be reduced in manners approved by park management. The goal will be to remove all (at least 90 percent) of the breeding adult rodents from the Great House grounds early in the spring of each year (before the completion of reproduction). When necessary, additional population reductions will continue throughout the season.

Because of Hantavirus and other disease concerns, the Arizona Department of Health recommends the use of kill type traps rather than live-traps to capture rodents. Kill traps prevent possible spread of Hantavirus into unaffected rodent populations, limit the spread of rodent urine or saliva or feces around trap sites, prevent humans from possible rodent bites, and prevent human contact with disease organisms in contaminated aerosols during trap handling and release. It is illegal to use lethal traps (snap traps, snares, foot traps, body hold traps, etc.) in capturing outdoor wildlife in Arizona; however, it is legal to capture rodents or other small animals considered to be pest species in lethal traps if the trapper is certified by the state as a pesticide applicator (pest control operator). It is not illegal to use lethal traps indoors to capture rodents. Where lethal traps are used, potential hazards to people, domestic animals, and non-target animals from the traps will be kept to a minimum by protecting the traps with covers (box or wire mesh covers).

Rodent removal methods at CAGR will concentrate on using rat-sized, snap traps placed in or at the mouth of active rodent burrows. The economy of snap traps will allow for more burrows to be trapped over a given amount of time and will help prevent employees from coming into contact with live animals. Rodents will only be captured in snap traps before or after hours when visitors are present. However, if approved by the Superintendent, rodents may be captured in live, box-type traps during the day when visitors are present on the Monument. Rodents captured in live traps will be moved to a location away from public view and euthanized.

If animals captured in live traps are to be released (i.e., for scientific studies, etc.), arrangements will be made with Arizona Game and Fish, U.S. Forest Service, or other land owners to find acceptable release sites. Personnel will take all possible precautions against disease transmission or personal injury during cage handling, transport, marking, and release. Before release, animals will be marked by toe-clipping, ear-tagging, paint or by other suitable means. Burrowing rodents will be moved no less than 5 miles out of the park for release. Marked animals returning to the park will be destroyed.

Burrowing rodents will be removed from burrows in and around the ruins as soon after discovery as possible to prevent the holes being re-used by new animals. Animals will be removed from burrows by trapping, direct reduction, fumigation (with NPS approval), or other means. After animals are removed from holes, repellents will be applied into the open burrows, the burrows filled with soil, and additional repellent applied to soil surfaces around the burrow opening. If animals re-open burrows, animals will be trapped again and burrow entrances sealed as before and then covered with a 3 foot square piece of 1/2 inch mesh hardware cloth. If burrows continue to be re-opened, an area-wide reduction of burrowing rodents will be initiated.

Records will be kept on all management actions (dates, locations, methods of control, target species, bait used, numbers of traps used, trap success rate, species caught, etc.) on forms designed by the park IPM Coordinator (sample forms are include in Appendix III in the comprehensive park IPM Plan). These data will be used to evaluate the efficiency of control programs.

Where trapping is not shown to be effective or in areas where trapping rodents at their burrow entrances is not feasible (areas outside of the ruin compound), rodents will be removed in early spring with a high-quality pellet rifle. Shooting ground squirrels will require the written approval of the Superintendent.

When mechanical methods of control are not shown to be sufficiently effective or if a "quick knockdown" of rodent populations is necessary (i.e., disease), NPS approvals will be requested for using carbon monoxide or other gas cartridges to fumigate burrows. Carbon monoxide, sulphur dioxide, and other gas cartridges or poison bait will only be used in rodent burrows under the authority of the Superintendent and at times when visitors are not present on Monument grounds.

When other methods of control are not adequate and poison bait is considered to be necessary for controlling rodents in outdoor environments, requests will be made through the park Cluster IPM Coordinator to use appropriate rodenticides in outdoor areas.

Pigeons and house finches

Reduce available resources

Pigeons will be prevented from gaining access to food and water around the Great House and Visitor Center through the actions used to manage rodents.

Pigeon control, to be most effective, should become an area-wide project. Park staff will initiate coordination with nearby city administrators to discuss the potential health hazards posed by pigeons and to suggest ways the cities could protect county dumps and refuse piles from pigeons. The staff will also contact and cooperate with groups of local residents and offer advice on excluding pigeons from buildings and on the need to reduce spilled grain and other foods.

Exclusion and reducing available harborage

Where possible, open holes and cracks in adobe ruin walls will be filled with mud to reduce their attractiveness to pest birds.

Various means for excluding pigeons from buildings will be evaluated before taking more severe control measures on the birds. Most of the commercial devices used to exclude pigeons from walls and ledges or keep them from nesting on buildings are not considered feasible to use on NPS ruins. However, it might be possible in some sites, to install 1/2-inch mesh wire or plastic netting around objects (or across holes) or to stretch non-electrified, tensioned wires (or monofilament) on wall tops where pigeons normally roost.

Reproductive

Where possible, long sticks will be used by the staff to destroy pigeon nests every two weeks. This will reduce the number of surviving young which, if not destroyed, would return as adults and nest in the ruin. Nest destruction must be persistent as long as pigeon populations remain in surrounding cities.

Behavioral

Flocking birds become habituated to specific roosting sites which offer protection from weather, predators, and disturbances. Once the habits for using specific sites are broken in the birds, the sites will remain free of birds until new flocks rediscover the site. Bird flocks will not be allowed to become established in the ruins.

Various mechanical (sound and electromagnetic) devices are available to frighten rodents and birds from areas but test data has never shown such devices to be effective for any period of time. Visual and noise deterrents, even when effective, usually have limited value because pests soon become conditioned to them. However, to obtain base-line data necessary to justify the possible need for more intensive bird management methods, tests will be made on the effectiveness of a variety of deterrents: scarecrows (including raptor models) and raptor-shaped kites (falcon and accipiter models) that move in the wind (or are electrically powered); large predator "scare-eyes"; thin strips of reflecting mylar tape hung from roof edges. Should funding be available, other and more elaborate deterrents may also be tested. Two of these might be:

- large, horizontal fan blades mounted on the interior roof that start with an automatic timer at dusk. The arms would move up and down while revolving and, if necessary, could be equipped with lights and sounds.

- rising and falling helium-filled balloons and lights which cast moving shadows.

Repellents

Pheromone repellents are not considered to be effective on birds.

Direct control

When Action Thresholds are exceeded and where other methods of pest management are not proven to be sufficiently effective, pigeon populations in and around the Visitor Center and Casa Grande ruin will be reduced in manners approved by park management. The management goals will be:

- to annually remove all (at least 90 percent) of the breeding adult pigeons from the Great House early during early spring (before the initiation of reproduction). When necessary, additional population removals will continue throughout the season.

- to continually (at least monthly) remove any pigeon nests from the ruin walls that can be reached with a long pole

- to continually harass and use visual and noise deterrents as a means to drive house finches

and other smaller birds out of the ruin.

Direct pigeon control will be done with a high-quality, accurate pellet rifle equipped with a telescopic sight. Pigeon reductions will be performed for 1 to 2 hours a day (or, night) and 2 to 3 times a week (as required by pigeon population numbers). Controls will begin just after the sun comes up and last until visitors are permitted to enter the Monument grounds. Shooting may also take place at night with aid of a portable spotlight. Temporary blinds will be used when shooting pigeons during the day to least alarm birds. Written approval from the Superintendent will be required before pigeons are controlled by shooting.

When and where feasible, baited pigeon bob-traps or feeding platforms covered with a live-capture drop net will be tested as a possible means for capturing pigeons (especially in winter when food for birds is scarce). Wide mist nets attached to tall poles that extend above the top of the lower, outside walls of the Great House will be evaluated as a means to capture pigeons and other birds leaving or returning to roost sites. Pigeons captured alive in nets or traps will be euthanized or donated to a public institution. Consultations with state and federal wildlife conservation agencies will determine the disposition of house finches and other migratory birds.

Direct pigeon reductions such as shooting, trapping, or netting will only be done prior to or after visitors are present on the Monument.

When other methods of control are not adequate and avicides are considered to be necessary for controlling birds in outdoor environments, requests will be made through the park Cluster IPM Coordinator to use toxic baits in outdoor areas or unoccupied structures.

Rabbits

Commercial gustatory inhibitors will be tested for their effectiveness in preventing rabbit damage to ornamental plantings around the Visitor Center. Gustatory inhibitors, however, can not be used on plants to be eaten by humans or domestic animals. Where inhibitors are not effective in reducing rabbit damage to plants, rabbits will be removed with a high-powered pellet rifle or by other direct means.

Larger animals

Larger mammals (ringtails, skunks, foxes, coyotes, etc.) which cause damage to the grounds will be live-captured in cage-type traps; however, larger animals (by approval of the Superintendent) may also be controlled by direct means (body-gripping traps or shooting) where those methods are shown more expedient, and humane. Larger animals that are live-captured will be marked (with paint or other obvious means) and released at least 20 miles away from the park. Marked animals returning to the park will be euthanized when recaptured or donated to a public institution. The practice of releasing of captured animals into other locations is a controversial one and a number of reasons support destruction rather than release (see Appendix VIII, "Disposition of Live Captured Animals," in the comprehensive park IPM Plan for a discussion of this subject).

Personnel will take all precautions against disease transmission or injury when handling, trapping, or releasing larger animals.

Honey bees, paper wasps, and other stinging insects

Repellents

Sanitizing empty trashcans or outdoor food preparation surfaces with a diluted ammonia solution will repel wasps and bees for a short time.

Direct control

Colonies of stinging insects, judged aggressive or which endanger the public or employees or cause damage to structures, will be destroyed by physical or mechanical means (heat, vacuum, freezing,

etc.) or with chemicals approved through IPM channels.

Carpenter bees

Carpenter bees, when found making holes in wooden portions of buildings, will be killed (by swatting), if possible. Otherwise, holes will be marked and approvals will be requested for chemicals to kill the adults and developing larvae. Following treatments, carpenter bee holes will be plugged with a dowel, plastic wood, or other approved means and holes will be camouflaged with paint or mud to prevent attracting other female carpenter bees.

Weeds

Where mechanical methods of weed removal are not possible or undesirable, NPS approvals will be requested for glyphosate or other appropriate herbicides.

CHEMICAL CONTROLS

All available physical, mechanical, and cultural management options will be fully explored before deciding that pesticides are essential for managing pests at CAGR. Pesticides will only be used as a last resort when other pest control options are not feasible or have not achieved acceptable results. The use of all pesticides in CAGR will be approved through the park Cluster IPM Coordinator.

Pesticides selected for use will be the least toxic and most efficient for providing the longest contact time with pests, used when pests are in the most vulnerable stage of development, and used only at times posing the least possible hazards to humans, resources, or environment.

All employees who apply pesticides will receive appropriate training and be certified by the State of Arizona in one or more categories as a Pesticide Applicator or be directly supervised by an approved Certified Applicator.

Commercial chemical pest repellents and gustatory inhibitors are available and are sometimes used to deter rodents and other pests from specific areas for short periods of time. Animal repellents are based on a variety of ingredients: ammonium soaps (Hinder), benzyldiethyl methyl (Ro-Pel), bone tar oil (Magic Circle Deer Repellent), capsaicin (Hot Sauce Animal Repellent), naphthalene (Shoo, Chaperone), putrescent egg solids (MGK-BGR), and thiram (Magic Circle Rabbit Repellent, Gustafson 42-S, Chew-Not, Shoo, Chaperone, and Scram 42-S). However, the effectiveness of these materials usually only has short duration and their odor can sometimes be offensive. NPS approvals will be requested for testing the efficacy of various of these repellents in the ruins.

VII. POST-TREATMENT MONITORING AND EVALUATIONS

A very important part of a successful pest control program is post-treatment monitoring. It evaluates the adequacy of treatment, cost-benefit ratios, and guides future management actions. Park management will compare year to year and month to month trapping and monitoring records to determine the effectiveness of management actions. Post-treatment monitoring will be done following control treatments and, again, before winter (November; to prevent confusing data with natural winter mortality of pests). Information from post-treatment monitoring will be used to evaluate the overall effectiveness of treatments and provide guidance for subsequent management actions.

VIII. RESPONSIBILITIES AND ADMINISTRATION

IPM Coordinator

The park IPM Coordinator will be responsible for performing IPM activities outlined in this Action Plan and for providing training to employees assigned to pest management duties.

The park IPM Coordinator will prepare inspection and monitoring forms or maps which will document and "flag" needed repairs and deficiencies on area maps and/or structural floor plans. Completed inspection and monitoring forms will be filed in a permanent IPM file and copies of the reports will be referred to the Chief Ranger and Chief of Maintenance.

Superintendent

The Superintendent will request assistance from the Arizona 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 presence of plague, Hantavirus, and other infectious diseases.
- collecting and/or identifying parasitic arthropods (fleas, ticks, mites, etc.)
- information on the status or potential presence of rodent- or pest-borne diseases at CAGR.

The Superintendent will annually review this Action Plan for possible additions of new information or for changes in pest management procedures.

Superintendent and IPM Coordinator

The Superintendent and park IPM Coordinator will contact the city administrators in surrounding communities with the goal to reduce the number of wild pigeons in the general geographic area of the park. An emphasis will be placed on the historical and cultural values of the ruins and concern for public health in efforts to solicit cooperation from city/county governments, local residents, and health departments to better exclude pigeons and remove food, water, and harborage available to the birds.

Other

Records will be kept on relative frequencies of pest sightings, dates of sightings, potential and realized damage and/or health threat, and other pertinent biological information. IPM records will be kept in both central and IPM files and will include the timing, techniques, and kinds of pest management treatments made and evaluations of the relative effectiveness of treatments.

Evaluations of month-to-month and year-to-year trapping and monitoring efforts and evaluations of pre- and post-treatment pest census data will be used by park management to rate the overall effectiveness and economics of control actions.

IX. ANNUAL WORK PLAN OF ACTIVITIES BY MONTH

Seasonal work plan elements are incorporated with the above descriptions of individual species and in the comprehensive park IPM Plan.

X. FTE AND BUDGET

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

XI. REFERENCES

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NATIONAL PARK SERVICE IPM TRAINING VIDEOTAPES

"Integrated Pest Management," 24 minutes

"Integrated Pest Management; Commensal Rodents," 23 minutes

XII. AUTHOR OF THE ACTION PLAN

Gerard A. Hoddenbach, G & L Consultants (May, 1997), P.O. Box 750128, Torrey UT 84775, 801/425-3095, is the author of this Action Plan. Information used to develop the 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.