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Natural Resource Stewardship and Science

Rodent Exclusion Manual

Mechanical Rodent Proofing Techniques; A Training Manual for National Park Service Employees

Natural Resource Report NPS/NRSS/EQD/NRR—2014/863

ON THIS PAGE
Deer Mouse (*Peromyscus maniculatus*)
Photograph by: NPS Photo.

ON THE COVER
Visitor Cabins at Yellowstone National Park
Gardner, Wyoming
Photograph by: NPS Photo.

Rodent Exclusion Manual

Mechanical Rodent Proofing Techniques; A Training Manual for National Park Service Employees

Natural Resource Report NPS/NRSS/EQD/NRR—2014/863

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Executive Summary

The National Park Service continues its commitment to preventing rodent-associated risks to people and park resources through education, prevention, and management. This document updates the *Mechanical Rodent Proofing Techniques: a Training Manual for National Park Service Employees*, released in 2005, to reflect new information and technology on rodent exclusion. Managing rodents in and near park structures and developed landscapes is critical as rodents present risk of disease transmission, food contamination, and damage, to park resources we are responsible for protecting. Successful rodent control is an attainable goal which requires an integrated approach and the commitment and cooperation among involved persons including planners, building occupants, pest management professionals, maintenance staff, and site managers. Although this document focuses on mechanical exclusion of rodents, additional parameters are involved in a rodent management program. These include providing educational information on rodent awareness to staff and visitors, training staff on rodent management, incorporating specifications to exclude rodents through planning and design, and conducting regular building inspections to detect and address rodent activity in a prompt and cost effective manner. In addition, conveying the importance of good sanitation practices and effective rodent snap trapping and on-going monitoring programs cannot be overstated. These measures are neither complicated nor excessively difficult. This document provides information for park staff and others involved in rodent exclusion and management.

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The original 1997 Rodent Exclusion Manual *Mechanical Rodent Proofing Techniques: a Training Manual for National Park Service Employee* was prepared by Gerry Hoddenbach-Rodent proofing Consultant and retired Integrated Pest Management Coordinator- Southwest Region, National Park Service. The document was revised in 2005 by Jerry Johnson, Chief, National Park Service Public Health Program, and Carol DiSalvo, National Park Service Integrated Pest Management Program, Assistant Servicewide Coordinator, with consultation from: Gregory Gurri Glass, Ph.D., School of Hygiene and Public Health, Johns Hopkins University: James Mills, Ph.D., Center for Infectious Diseases, Centers for Disease Control, DHHS: James Childs, Ph.D. Center for Infectious Diseases, Centers for Disease Control, DHHS.

Introduction and Purpose

This document provides technical guidance to all park employees, concessioners, contractors, permittees, licensees, and visitors, who use or are involved in the management of structures and developed landscapes on all lands managed or regulated by the National Park Service. The exclusion and control of rodents in buildings and developed landscapes is important because of the potential human health risks associated with rodents and the potential damage they can cause to physical structures, objects, and developed landscapes.

The most important consideration when building and renovating structures or designing developed landscapes is to build in rodent prevention strategies to *keep them from entering in the first place* and to design developed landscapes that are not conducive to rodent harborage and food sources. This concept demands collaboration among all involved persons, namely these three groups:

- Building and site occupants or users (employees, visitors, contractors etc);
- Pest management technical experts (integrated pest managers, maintenance staff, other);
- Site manager and/or decision-makers who are ultimately responsible and manage the budget.

The importance of open and ongoing communication between these three groups cannot be overstated. Good sanitation practices, effective snap trapping, and monitoring programs are essential for effective management. These measures are neither complicated nor excessively difficult; however, rodent control is usually unsuccessful when these critical steps are not fully undertaken. This manual is designed as a reference guide to making rodent control around structures and developed landscapes an attainable goal.

Mechanical Rodent Exclusion

Rodents have been a problem to humans since the Neanderthals occupied caves in the Stone Age[1i]. Even today, many people believe that rodent infestations are "inevitable" and there is nothing one can do. However, rodents can carry diseases with significant impacts on human health, such as hantavirus, plague, and tick-borne relapsing fever. Rodents can also damage structures and historic resources. Excluding rodents from park structures reduces potential health risks to people and potential damage to park resources. Before implementing physical exclusion efforts you are advised to review potential health risks and personal protective measures when working in rodent infested structures. If you are preparing to exclude rodents from historic structures, first contact your cultural resource representative to determine what exclusion strategies are acceptable by your State Historic Preservation Office.

[1] Bradshaw, J.l.,1997. Human evolution, a neuropsychological perspective. Accessed: September 6, 2014.

The successful control of rodents in structures and developed landscapes requires the following integrated pest management (IPM) principles implemented in accordance with NPS policies regarding (http://www1.nrintra.nps.gov/brmd/ipm/policy.cfm):

Basic knowledge of rodent biology: A fundamental understanding of the habits and reproductive abilities of the species of rodents in your local area is helpful in knowing where to look for signs of animals, and in selecting of the most appropriate control measures for the specific site.

Knowledge of National Park Service policy: Native rodents are protected under National Park Service policy (Management Policies 2006, Section 4). However, policy allows the management of native species under specific conditions to protect people and resources. This policy promotes the use of rodent exclusion methods under IPM—that is, keeping them outside in their natural habitats. (*Note: Management strategies will differ inside and outside, and are prescribed on a site specific and case-by-case basis.)*

Know Your Resource! Rodent management is site specific; hence, it is very important to know your resources, management objective, and site use. Knowing the basic construction of your structures from the foundation to the roof is extremely important. Understanding the design of your HVAC, electrical, and plumbing systems will enable you to determine likely rodent access points and pathways. How is your site used by employees, contractors, and the public? This information will enable you to address human use and behavior- a key component for successful rodent management.

Regular and Thorough Inspection: Regular and thorough inspection of the exterior and interior of each structure is necessary for protecting people and resources from potential risks associated with rodents. Inspections help to identify signs of rodent activity and structural defects that allow rodent entry into buildings, and also detect human behavior that may attract rodents. Inspections also provide information about the species of rodents present, key shelter areas, locations where animals obtain food and water, and to identify building conditions that favor rodent access and infestations. These findings will determine your priority actions for excluding animals from structures, and preparing recommendations to change conditions that support pest rodent populations.

Effective exclusion: Rodent control in structures is based on one simple rule as noted by Gerry Hoddenbach (retired), Southwest Regional IPM Coordinator of the National Park Service: *"If you keep them out, they can't get in." Rodents must be prevented from entering a building (or room*). Identifying and closing all potential access points, in an efficient manner, is one of the most important measures against infestation. Exclusion in conjunction with snap trapping and periodic inspection must be an on-going task, and should be incorporated into the routine building maintenance schedule. Coordinate between pest management specialists and designers at the planning and/or renovation stage to build rodents out of the project design from the start.

Good sanitation practices that eliminate potential food, water, and shelter for rodents: Good sanitation practices can prevent and/or remove resources required by rodents for survival, and will limit the number of animals that can be supported in any given area. However, even the best of sanitation measures will not prevent infestations where exclusion is inadequate. Conveying good sanitation practices to all occupants is a key component of successful rodent management.

Education: Education of employees, visitors, and contractors are a critical component in rodent management. They provide the "eyes and ears" to detect and report signs of rodent activity. Provide all occupants with basic education on how to recognize rodent signs and protocols for securing/removing their food, water and trash to prevent rodent access. All occupants (staff, visitors, contractors, etc.,) should be instructed to keep food or snacks in rodent proof containers, to immediately clean up food residue, and to remove trash from the building into rodent proof trashcans or dumpsters at the end of the day.

Monitoring: Monitoring documents change. Frequent and regular monitoring of each site will help determine if previous control efforts were effective, identify any newly-created rodent entry points, changes in harborage conditions, and changes in sanitation. Document all monitoring efforts on a site specific monitoring form. Include location, date, and individual conducting the monitoring, as well as any comments regarding improvements and needed management actions. Monitoring will show the level of rodent activity, at that point in time, and inform you of priority areas to focus exclusion efforts.

Cooperation and individual responsibility: Build consensus! Successful rodent management includes a team effort among the: site manager (the decision-maker, person controlling the funds, and ultimately responsible for the site); the people who occupy the site (staff, visitors, etc.,); and technical advisors (pest management experts, maintenance workers, other experts).

To ensure that each team member is aware of rodent-control activities, their own specific concerns and responsibilities as well as their counterparts' responsibilities, these three entities should convene to determine their specific tasks and responsibilities, with completion dates, and establish agreed upon actions in writing through a rodent management plan for their site. The plan should be signed by the Superintendent, Chief of Maintenance, Park IPM Coordinator, Public Health representative, and Safety Officer so that if immediate action is needed staff will be authorized quickly to address any issue to prevent further risk to human health or resources.

Common failures in controlling rodent infestations in structures are usually the result of one or more of the following oversights:

- Failing to have "buy in" or the consensus and cooperation of all site occupants, technical advisors, and site management staff.
- Failing to locate or effectively eliminate cracks or openings used by animals to enter buildings or rooms;

- Underestimating the severity of a rodent infestation -either the number of animals present or the size of the infested area;
- Using too few snap traps or improperly placing snap traps;
- Failing to secure garbage and other food and water sources;
- Placing reliance on poison bait (rodenticides) as a sole means of control.

Reasons for Controlling Rodents

The key reasons for controlling rodent populations in and around structures occupied by humans are risk to human health and damage to the resources.

Health Risks

By far the most important reason to control rodents is potential health risks from human contact with rodents or rodent-contaminated items. The Centers for Disease Control states that worldwide, rodents can transmit over 35 diseases to humans. Commensal rodents, those species which live in close association with people, can contaminate human foodstuff, eating utensils, bedding, etc., with their urine, feces, hair, and parasites. This activity has been responsible for the transmission of diseases to people.

Exotic rodents (meaning they are non-native to the United States) arrived in this country during the 17th -18th centuries from European and Asian ships. Exotic commensal rodents, which include house mouse (Mus musculus), Norway rats (Rattus norvegicus) and roof rats (Rattus rattus), can spread plague, hantaviruses, typhus, rat-bite fever, trichinosis, salmonella, and other infectious diseases.

Native rats and mice (rodents naturally occurring in this country) can carry plague, hantavirus, tularemia, leptospirosis, tick-borne relapsing fever, Rocky Mountain spotted fever, Q-fever, and other infectious diseases.

Rodent food caches, nests, and rodent carcasses (i.e., poisoned animals or animals dying from natural causes) can cause additional risks to people and resources. Rodent food, nests, or carcasses may carry or attract parasites, flies, carpet beetles, and other pests which can cause serious secondary pest damage to park resources and potentially act as vectors of human disease. Extensive subsurface burrowing can present physical hazards to people walking on the surface creating areas of unstable soil collapse and tripping hazards.

Damage to Resources

Many kinds of physical damage can be expected when rodents infest the interiors of buildings, other man-made structures, or developed landscapes. The animals often build nests and store large amounts of food (e.g., acorns, nuts, seeds, etc.) behind walls or in attics, and such storage can cause structural damage as well as attract other pests. Rodents often burrow into and re-arrange wall and attic insulation, and because of their habit of gnawing on objects, may damage upholstered furniture, museum collections, paper, leather goods, clothing, electrical lines and equipment (including computers). Snakes and other predators may also enter structures seeking rodents as a food source. Each year, many structural fires in this country are thought to result from electrical wiring damaged by rodents. Rodents frequently enter and make nests in parked machinery and vehicles, damaging electrical wiring and hoses.

Rodent activity at or near the foundations of buildings can increase the rate of structural failure. Rodent burrowing loosens soils and can lead to erosion around the foundation, create openings for increased water flow and penetration, and new access routes for other animals. The mere presence of

rodent burrows attracts predatory animals that enlarge the burrows, resulting in additional structural damage. Rodent-associated damage to buildings increases the potential for deterioration from weathering, moisture, and other sources. Rodents also damage historic landscapes and ornamental plants.

Commensal Rodents: Biology and Habits

Animals in the Rodentia Family are one of the most numerous, successful, and adaptable of all mammals. There are over 3,000 different kinds of rodents in the world, ranging in size from the 1/2 ounce, silky pocket mouse (*Peromyscus amplus*), a native to the U.S. Sonoran desert, to the largest rodent, a 100 pounds capybara (*Hydrochoerus hydrochaeris*), of South America. Rodents of one kind or another occur in every kind of environment, from desert to tundra.

> ***Note that only a few species of rodents are commensal rodents which present risks to humans and our resources. These pest species contaminate more human food than they eat.***

Rodents differ from other kinds of animals by virtue of their front incisor teeth, which are specialized for gnawing. Rodent incisor teeth grow continuously throughout the animal's life. Because of this, these animals must gnaw frequently to keep the tips of their incisor teeth worn down.

Rodents have a keen sense of smell, and produce many natural odors. Once rodents enter a hole, room, or building, their odors remain in the area and may attract other rodents. Rodents mark territory and pathways with oils on their skin as well as with urine markings. Their vision is poor; hence they rely on their keen olfactory, taste, touch, and hearing senses. They are nocturnal for the most part, foraging at night, navigating mainly in the dark while relying on long sensitive whiskers (vibrissae) and guard hairs on their body which guides them in the dark and allow the rodent determine the width and height of openings and pathways. They can also memorize these routes allowing for quick escape. Rodents present a serious problem in /around human food as they mark their territory by dribbling urine and hence contaminate more food then they eat. Water is necessary for all rodents. Rats must have a readily available water source; mice, however, can obtain sufficient water from their food.

Rodents present in this country may be either native or exotic. Since many rodent species look similar but may have quite different habits and living requirements, it is very important to accurately identify the species of rodent that are causing problems so that you will be efficient in placement of snap traps and other management tactics.

Native rodents include: white-footed mouse (*Peromyscus leucopus*), deer mice (*Peromyscus maniculatus*), pygmy (*Baiomys taylori*), pocket (*Chaetodipus baileyi*), grass-hopper (*Onychomys torridus*), harvest (*Reithrodontomys megalotis*), and jumping mice (*Zapus hudsonius preblei*); dusky-footed woodrat (*Neotoma fuscipes*), cotton rat (*Sigmodon hispidus*), kangaroo rat (*Dipodomys merriami*), and rice rats (*Oryzomys palustris*); voles; porcupines; pocket gophers; lemmings; nutrias; squirrels (ground, tree, and flying squirrels); chipmunks; marmots; prairie dogs; muskrats; and beavers.

Exotic rodents include the house mice (Mus musculus), Norway rats (Rattus norveigicus), and black rats (Rattus rattus). Exotic rodents are easily identified by their scaled, nearly hairless tails, giving them the name "naked-tail" rodents.

Mice and rats are the most common structural pests in buildings. A basic description of their biology follows.

Mice

Mice, because of their size and reproduction potential, are the most common indoor rodent pests in buildings. In the eastern United States, exotic house mice are the animals most often found inside buildings, but native mice which includes the white-footed mice (*Peromyscus leucopus*) and deer mice (*Peromyscus maniculatus*) are the most common indoor rodent pests in the western United States.

In general, rodents produce large numbers of young. This is necessary for the survival of rodent populations due to a high mortality rate. House mice, for example, can reproduce year-round indoors. During one year and under ideal conditions a single pair of house mice is capable of producing over 3,000 offspring. Mice can reproduce as early as 30 days of age, and a female can become pregnant with a second litter even while the first litter is still nursing. Native deer mice, better adapted to outdoor life, do not reproduce year-round (unless living in a warm building), and produce fewer young. Under ideal conditions, a pair of deer mice is theoretically capable of producing a population of approximately 800 mice during their 4-month-long breeding season—more if they are living in a heated structure. Mice are an important food source for many other animals. Natural predation by owls and foxes, together with competition between mice for space and food, results in the mortality of 80% to 90% of all young mice soon after birth. When ample food, water, and shelter are available, and when predation is absent (e.g., conditions found indoors), mouse populations can explode. Indeed, mice will occupy as many spaces in a building as possible until a limitation in the resources available to them restricts the numbers of animals that can survive.

Although mice tend to prefer grass seed and cereal grains, they will eat almost any foods consumed by humans and domestic pets. A mouse's daily food requirements are small—only about 1/10 ounce (½ teaspoon) of food and 1/5 ounce of water per day for survival—and much of their water requirements can come from the food they eat. Mice are sometimes difficult to poison with rodenticide, because they will only nibble on small bits of food from many locations. Unless they consume an adequate amount of poison bait, they may not get a lethal dose. Eating small amounts of poison bait may cause only mild discomfort and make the bait repulsive to them. Some animals have definite food preferences and will not eat bait at all.

Mice are most active after sunset, but will be seen during the day when there is extreme competition for spaces or food such as in severe infestations. Activity habits are different for native and exotic mice. Native white-footed mice occupy a home range area of about 1/3 acre to 4 acres, and they may travel 200 or more feet from the nest to a food source. They do not hibernate, but they are less active during winter. Exotic house mice have much smaller ranges, seldom travel more than 30 feet from their nest site to a food source, and are active throughout the winter months. Mice are very curious as compared to rats, and will investigate new objects, such as traps.

Mice are exceptionally agile, flexible animals and can jump 12 or more inches straight up from one flat surface to another. They can jump to even higher levels against a flat vertical surface such as a

wall using it as a springboard. They can jump down to the floor from an elevation of 8 or more feet without being injured. They can climb any slightly rough, vertical surface, such as wood, plaster, brick, metal pipes, wire mesh, and cables. In addition, mice have excellent balance and can easily run along horizontal electrical wires, ropes, and cables from one part of a building to another.

The fur on mice makes them look larger than they actually are. Their slender body and lack of a collar bone allows them to squeeze through openings of ¼ inch in diameter (6mm), about the same diameter as a #2 wooden pencil. If a mouse can squeeze its head through an opening the rest of the body can fit through.

Outdoors, native mice are most numerous during late summer. Competition between individuals for food sources and nest sites increases with the onset of cold weather. This is when rodents begin to seek access into buildings as they are attracted to the warmth, shelter, food, and water offered in human occupied structures. Mice will continue to nest and reproduce indoors all winter with available food and water. Mice will also move into structures that are not human-occupied; such occurrences are found when people open up cabins or other buildings that have not been used through the winter. In these situations, the structure needs to be properly ventilated due to the potential presence of rodent borne diseases such as hantavirus. For additional information on hantavirus see http://www1.nrintra.nps.gov/brmd/ipm/rodent.cfm and http://www.cdc.gov/hantavirus/.

Rats

Exotic rats are the species most often found in human occupied structures, including the Norway rat, *(Rattus norvegicus)*, and the roof or black rat, (*Rattus rattus)*. These agile rodents, native to Africa, Europe, Asia, or Australia, were inadvertently introduced into North America on the ships of early voyagers. Once established, they spread throughout the country on ships, trains, in freight, and cargo. Both the Norway and roof rats adapted easily to the human environment (e.g., granaries, fields, sewers, attics, basements) and are commonly known as "urban rats". These exotic rats, and the house mouse, often live most of their lives inside human occupied buildings.

The Norway rat is believed to be introduced into the United States around 1775 and is currently found throughout the contiguous 48 states wherever humans live. Roof rats are not as adaptable as the Norway rat and prefer semitropical to tropical climates, hence they are not found in the interior of the country. Their range includes the lower East Coast, up through the Gulf States into Arkansas, and along the Pacific Coast and in the Hawaiian Islands. [2]

Other rodents such as the native Eastern grey tree squirrel (*Sciurus carolinensi)* and on occasion chipmunks may nest inside structures. The grey tree squirrel may gnaw and gain access into attics, use insulation as nesting material, and may chew on electrical wires, or enter the human living

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[2] Internet Center for Wildlife Damage Management. Accessed September 3, 2014 http://icwdm.org/handbook/rodents/

space[3]. Chipmunks and wood rats may nest inside buildings, attics, crawl spaces, and chimneys during the winter, these species usually feed outside and seldom enter occupied portions of a building. In the Western United States native "pack rats" (*Neomotoma sp)* as the name implies, have a tendency to pack away small objects such as jewelry, cooking and eating utensils, can tabs, and other items which can be found in nests they construct inside structures, wall voids, vehicles, upholstered furniture, and mattresses. They also create food "middens" which are piles of seed and other food. Pack rats gnawing can damage wooden items, electrical wires, and mechanical or other building components. [4]

Exotic female rats become reproductively mature when they are about 3 months old, and can produce an average upwards to 40 young per year. Native rat-size rodents are less productive than mice, but females can usually raise three to four surviving young each year. Rats will eat most any type of food but prefer grass seed /cereal grains, nuts, fruit, fish and other meat but will also feed on carrion. It is important to know the biology of the species you are managing to be successful. For example, roof rats will eat nuts, berries, snails, slugs, fruit, citrus, and avocado; Norway rats eat, grains, meats, fish nuts, some fruits. They require about 1 ounce (2 tablespoons) of food per day for survival. As is the case with mice, a water supply is not as critical for rats because most water comes from food. Rats require 1/2 to 1 ounce (15 to 30 ml) of water daily when feeding on dry foods but need less when moist foods are available.

Rats are very agile, and can leap 3 feet straight up or 4 feet horizontally. They can also climb up the outside of a 3-inch-diameter pipe, walk on wires between buildings, swim ½ mile in open water, tread water for days, swim up currents in sewer lines and through toilet traps, and survive a fall of more than 50 feet. Other native rodents (e.g., tree squirrels, wood rats, chipmunks, and some ground squirrels) are also very agile. Although rats are much larger than mice, they can squeeze through holes only ½ inch in diameter (12.69 mm), smaller than the size of a quarter.

Rats have powerful teeth and can gnaw through concrete block, aluminum siding, adobe brick, wallboard, plaster, wood, and various other durable materials. Usually, there must be an exposed edge to gnaw; smooth surfaces limit their ability to initiate holes.

Exotic rats usually range within about 100 to 150 feet of their nest. They may sometimes nest indoors and forage outside for food or nest outside and forage indoors. Depending on food and habitat availability, native rats, such as the wood rat *(Neotoma sp.)* have relatively large forage areas up to 1,500 feet and can move long distances from an indoor nest site to a food source. The actual range of individual rodents depends on a number of factors including site topography, food preference, competition, and availability.

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[3] Maryland Department of Natural Resources Natural Heritage Service
http://dnr.maryland.gov/wildlife/Plants_Wildlife/squirrels.asp

[4] Internet Center for Wildlife Damage Management. Accessed September 3, 2014
http://icwdm.org/handbook/rodents/

Inspection and Monitoring

In 1994 the National Park Service partnered with the Center for Disease Control to study rodent infestations in a number of buildings in three National Park Service areas. The interiors and exteriors of the buildings were inspected for rodent activity, conditions favoring rodent activity, and structural defects allowing rodent access. In this study, individual animals were captured outside of a building and then later re-captured inside the building. After the identified sources of rodent access into buildings were repaired during a one-time intervention, overall rodent infestations decreased by more than 90% when compared to similar structures not repaired. In most repaired structures, no rodent activity was detected. This study clearly demonstrates that the identification of structural defects, followed by relatively simple mechanical repairs, can significantly reduce or eliminate rodent problems in most buildings. Follow-up exclusions could completely eliminate rodents from all buildings.[5]

> ***SAFETY NOTE:*** *For personal safety reasons and because of the presence of hantavirus as well as other rodent related disease documented nationwide[6], anyone performing rodent inspections monitoring duties, exclusions, and/or who might come in contact with dead or live rodents or rodent debris, should follow the U.S. Center for Disease Control (CDC) guidelines in Appendix E and the National Park Service guidance on rodent management prior to performing tasks involving rodent monitoring or management. (The CDC's main rodent site is: http://www.cdc.gov/rodents/ and the NPS site for employees is: http://www1.nrintra.nps.gov/brmd/ipm/rodent.cfm). Park staff is also reminded that a Job Hazard Analysis is required when a task has the potential for harm. Contact your Safety Officer and visit Directors Order #50 B: Occupational Safety and Health Program- http://www.nps.gov/policy/DOrders/50B.htm.*

Inspections detect and document rodent activity, access points, and conditions that foster rodents. They provide recommendations and help set priorities. Inspections can be conducted by trained staff using this and other resources or by a contracted pest management inspector. (S*ee Appendix D: Contract Specifications for Inspection*)

Inspection versus Monitoring

Effective rodent proofing requires knowledge of rodent behavior; care in identifying and eliminating sources of rodent access, the education and cooperation of the people using the site, and the commitment of site managers and staff. Periodic follow-up through scheduled monitoring is needed to ensure that all sources of rodent access are eliminated and that no new access points are created

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[5] Glass GE, Johnson JS, Hodenbach GA, Disalvo CLJ, Peters CJ, Childs JE, Mills JN. Experimental evaluation of rodent exclusion methods to reduce hantavirus transmission to humans in rural housing. American Journal of Tropical Medicine and Hygiene. 1997;56:359–364. [PubMed]

[6] Mills JN, et al. A Survey of hantavirus antibody in small-mammals populations in selected united states national parks. American Journal of Tropical Medicine and Hygiene; 58(4),1998, pp.525-532.

through the repair or replacement of utility lines, and plumbing fixtures, and so forth. Rodent proofing involves periodic inspection and on-going monitoring.

The terms "inspection" and "monitoring," commonly used in the pest control industry, are sometimes confusing, because they describe what seem to be similar activities, but actually have different meanings.

Inspection is an initial and comprehensive site visit with a written (or otherwise documented) evaluation (a "snapshot" or evaluation of one point in time), in which the inspector, trained in rodent detection, meets with the site manager and key staff to examine the site, the structure, and human use patterns. The inspector looks for and documents the presence/absence of rodent activity, and rodent signs, conditions favoring rodents, potential rodent access into buildings, and provides the site manager with a report with specific recommendations to mitigate rodent activity. The education of occupants is also necessary.

Monitoring detects change. A systematic, repeatable, monitoring program allows you to observe and check the progress or quality of your rodent management efforts on a schedule using established protocols over a period of time. Monitoring involves a set of repeatable procedures that are implemented on a periodic schedule. These procedures include visual inspection, documentation of observations, and evaluating the effectiveness of rodent management efforts such as exclusion strategies, noting changing conditions over time, human behavior, sanitation effort, re-infestation, management of food and water, and noting any new sources of rodent access discovered since the last monitoring date, etc.

Procedures for Conducting Inspections

Plan ahead when preparing to conduct an inspection. Schedule your visit when the key contacts involved in rodent management are available. Review the building blueprints if possible and general site layout to plan your inspections and anticipate needed tools. If you plan to enter a closed or poorly ventilated, rodent-infested space, or your work may involve stirring up dust in a room with evidence of rodents, you will need to wear a fit-tested respirator. Consult a safety or public health officer for assistance **prior** to entering. (*See Appendix E: Hanta Risk Reduction: Worker Protection, for a summary of recent CDC recommendations on workers' protection)*

Inspection Equipment

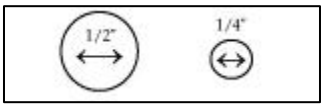
> ***Reminder:*** *When evidence of rodent activity is probable or found, it is extremely important that proper personal protection and disinfection protocols are determined and followed. Prior to entering areas with evidence of rodent activity review and implement the guidelines on safely cleaning and disinfecting areas with rodent infestations found in Appendix E: Hanta Risk Reduction: Worker Protection.*

Inspection equipment may include use of a disinfectant, disposable gloves, and use of a respirator, a clipboard, pencil or pen, flashlight/head lamp, and inspection forms and/or maps for recording inspection findings. A bright flashlight should be used during inspections, even during daylight hours. The light helps to concentrate your focus and better illuminates rodent signs, structural

deficiencies, and likely rodent harborage sites. Other useful equipment include: hand and extendable inspection mirror; tape measure; digital and/or video camera; pocket-size tape recorder to verbally document findings; Phillips and flat-head screwdrivers; step ladder; compass (to determine direction if needed); colored sticky labels and water-proof marker (to mark areas needing repair if digital camera is not available); and a hard hat and knee pads if sub-floor or attic areas will be entered.

The Internet Center for Animal Damage and Management provide the procedures and tools noted below when conducting a rodent inspection for potential rodent entry points:

- Rats can gain entry through holes larger than 1/2 inch (1.3 cm); mice can use holes larger than 1/4 inch (0.6 cm).



- Look for rub marks, droppings, tracks, gnawing, or other rodent signs. Special attention should be paid to areas discussed under Common Rodent Entry Points (below). Keep in mind the physical abilities and behavior of the of the particular rodents, especially their tendency to seek shelter behind, under, or in appliances, sinks cabinets, drawers, stored goods, wall voids, false ceilings, and other undisturbed areas;
- To conduct a thorough survey, inspectors will need an inspection form and paper for noting and illustrating items needing attention; a good flashlight; a mirror (to see under and behind objects); and screwdrivers and other small hand tools to remove interior and exterior vent grills, appliance base plates, and service doors to attics, crawl spaces, and utility cabinets;
- A tape measure is usually necessary when preparing a plan and estimating materials needed for repair. A small dustpan, broom, and some lime, talcum powder, are useful in preparing an area for a follow-up observation of fresh tracks;
- A camera can be of great value, especially when trying to design a project after leaving the site, or when seeking assistance from someone unfamiliar with the site;
- A simple item to use when measuring gaps under doors or around pipes, screens, or vents is a common wooden pencil or ball-point pen (usually 3/16 to 3/8 inch [0.5 to 1.0 cm] in diameter) — large enough for mouse entry.[7]

What to look for during the inspection

During the Inspection look for:

- Rodent signs and activity
- Changes in the numbers of animals present, or renewed rodent activity
- Locations of greatest rodent activity

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[7] Internet Center for Wildlife Damage Management, http://icwdm.org/handbook/rodents/RodentExclusion.asp. Accessed: September 6, 2015.

- Changes in the amount of food or shelter available for rodents
- Changes in the rates of structural damage or deterioration
- The relative effectiveness of control efforts

Preparing the Inspection report

Information derived from inspections is very useful in follow-up control programs. The written inspection report should document the following:

- Date and name of site and structure
- Name of inspector and site manager
- Note the site use and site management objective
- Type of rodent (species) and its biology
- Signs of rodent activity, such as gnawing, rub marks, and piles of cockroach wings (mice will eat cockroach bodies, leaving the cockroach wings and legs in a pile)
- Severity of the rodent infestation
- Locations of rodent entry points
- Possible supporting reasons for the infestation (i.e., available food, shelter, water, human use patterns)
- Presence and location of major rodent activity and harborage areas
- Sanitation efforts
- Observations and recommendations

Inspection and monitoring will help you in directing management efforts towards priority areas. Recommended actions may include installing rodent proof trash cans, trimming vegetation to remove rodent cover and habitat near structures, eliminating available water sources (repairing leaky faucets), installing rodent-proof trash cans, etc. Monitoring is discussed further in the section following rodent-control methods. (*See Appendix C: Example of a Written Inspection Report*)

Building Exteriors

Exterior inspections of buildings should ideally be conducted at least twice a year: once during spring, to evaluate winter damage or presence of rodent activity and a second time during fall, before rodents try to move into buildings. Inspections should document any new structural defects or building repairs/accidents, which may provide new points of entry for rodents. Ideally, the same inspector performs both inspections.

The first step in making an inspection of a building is to prepare a rough drawing of the building exterior. Show all major features where pests might find entry (Figure 1). This may include, but is not limited to, access points for electrical and plumbing service lines, doors and windows, crawl space and basement openings, window wells, porches and decks, dormer corners, and chimneys. Also indicate on the drawing the direction of north with an arrow, the point on the building where you begin the inspection, and a curved arrow to show the direction you moved around the building during the inspection.

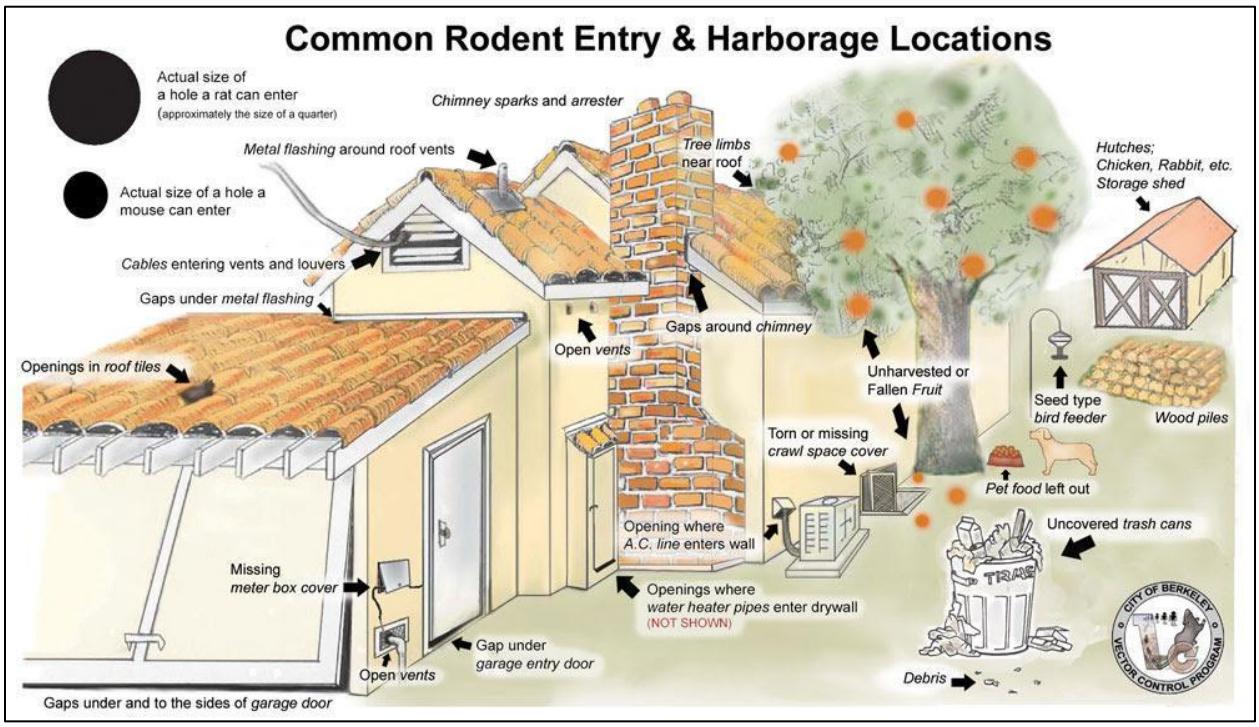

Figure 1: This figure shows potential areas to evaluate during a rodent exclusion inspection, including conditions that promote rodent harborage. Figure credit: courtesy of the City of Berkeley, CA.

Buildings can vary significantly in their style and construction materials, so it may be important to tailor inspection forms to suit the building construction type you are evaluating. A model inspection form (for both interior and exterior inspections) will help in developing forms specific to your needs. (*See Appendix B: Rodent Inspection Form*)

Slowly and systematically examine the entire building exterior from the ground to the roof while looking for defects that could allow for rodent entry, (You must think like a rodent). When you find

defects, note their locations on the drawing, and describe them as possible rodent entry points. The aim of an exterior inspection is to obtain as much information as possible on rodent access points, and on existing conditions in or near the building that might support rodent activity. Deficiencies seen on the exterior of buildings will provide clues as to what will be found inside.

Finally, a completed work order form for repairs should be provided to site maintenance staff for implementation.

The following descriptions offer general guidance as to some of the major deficiencies to look for. Sections of the manual that follow will discuss recommendations for repairs, and specific materials to use for repairs.

General Building Exterior

Carefully check the siding, eaves, soffits, cornices, gables, porches, chimney or furnace clean-out ports, loading platforms, utility line entry points, and all other external areas for cracks or holes that are ¼ inch or larger in size (Figures 3, 4). Check around porches and decks adjoining the building, dormer corners, and chimneys, for any holes, cracks, or gaps that could allow rodent entry. Corner joints and cracks in log buildings require detailed inspection. Check to see that exhaust flaps on clothes-dryer vents close easily and are not blocked open by lint (Figure 5). Use a rodent proof material, such as hardware cloth (Figure 2) to exclude rodents. Hardware cloth is a flexible, light weight wire mesh made of galvanized stainless steel. It is both rust and corrosion resistant and available in different gauges (diameter of the wire mesh) and different mesh or grid sizes (number of openings per square inch) for various needs. For mice exclusion use the ¼ “, 16-19 gauge hardware cloth; rats can be excluded using the ½” hardware cloth, however, it is recommended to install the ¼” for both animals to prevent potential mice entry.

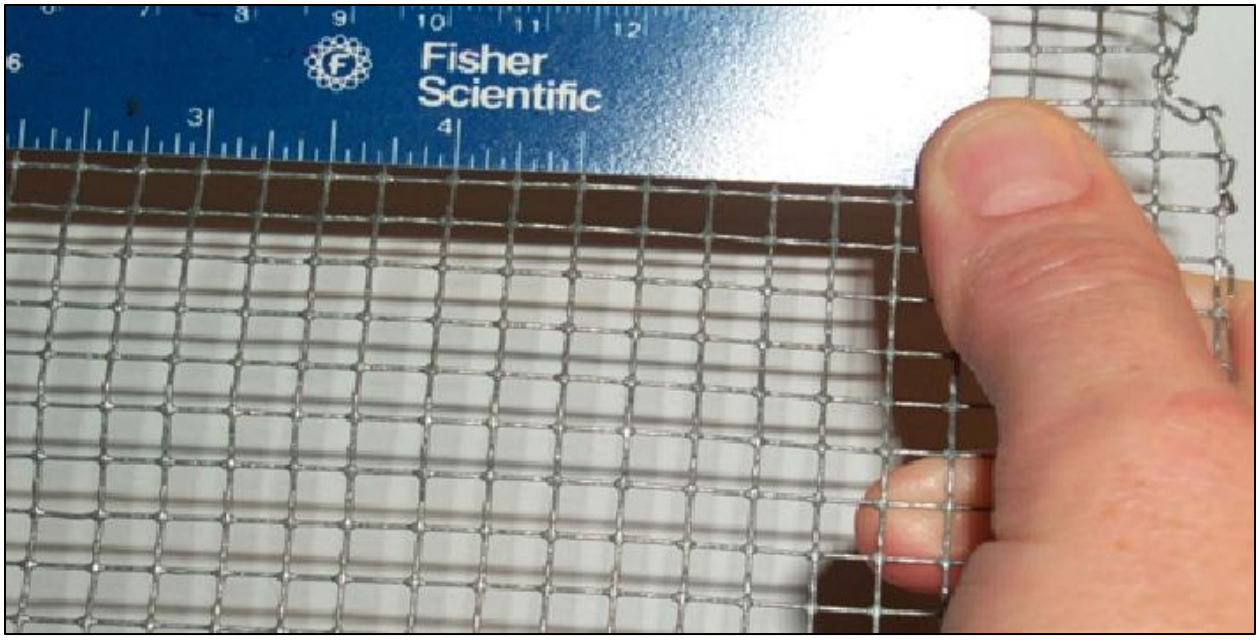

Figure 2: Hardware cloth is a standard tool for rodent exclusion. It is available in many different gauges (thickness of the wire).Use 16-19 gauge for rodent exclusion. The higher the number the thinner the diameter of the wire. Figure credit: NPS Figure.

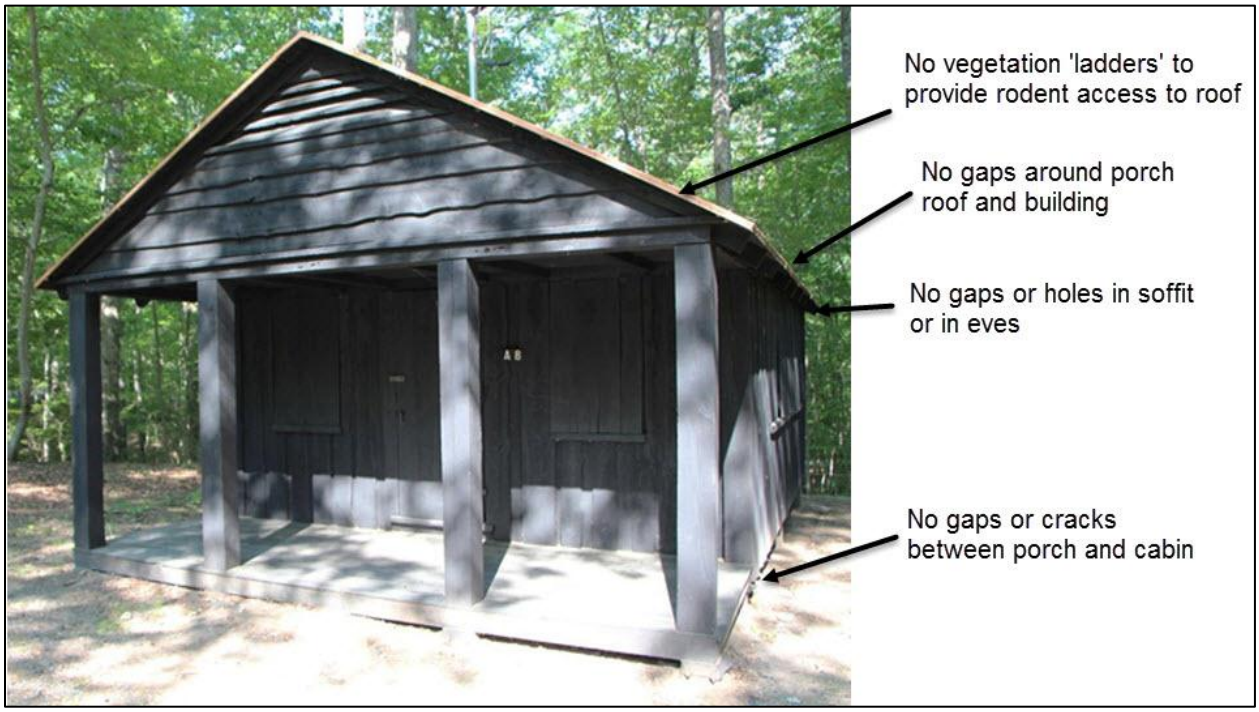

Figure 3: Examples of exterior inspection points on this cabin include: gaps around porch roof and building, gaps or holes in soffit or in eaves, vegetation ladders that provide rodent access to the roof, and gaps or cracks between the porch and cabin. Figure credit: NPS Figure.

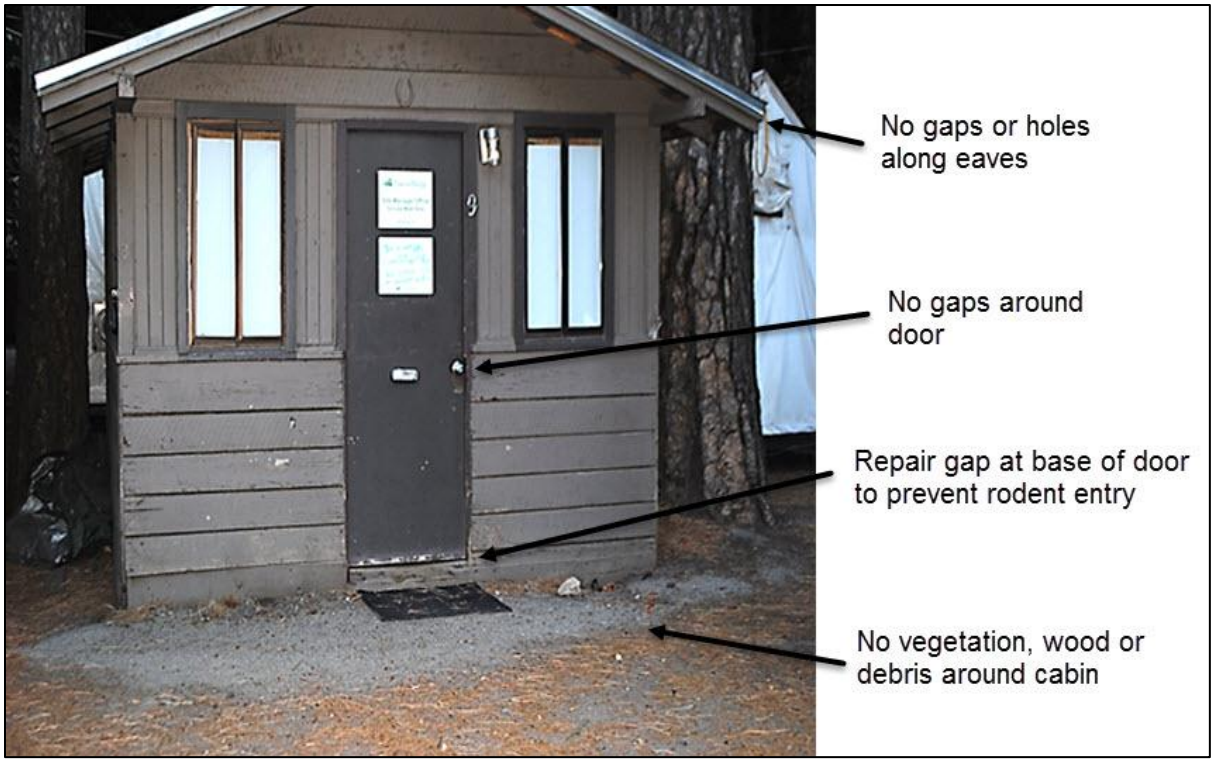

Figure 4: Additional points to evaluate on a cabin include gaps around eaves or door and the presence of vegetation, wood, or other debris around the foundation of the cabin. Figure credit: Bruce Badzik.

Figure 5: The lower exhaust flap on this dryer vent is missing and provides rodents access to the building interior. A new rodent proof flap needs to be installed with ¼ inch hardware cloth to exclude rodents. The vent must also be periodically cleaned to prevent lint build up. Figure credit: NPS Figure.

When in doubt as to whether or not holes are large enough to warrant follow-up, mark them anyway. Small holes can become larger with time, or allow an area for rodents to gnaw and increase the hole size. Record the locations and severity of all defects found on the structural drawing.

Report any obvious harborage around the exterior of the building such as piles or stacks of lumber, firewood, rocks, trash, debris, vegetation, or tree stumps found within 50 feet of the building (Figure 4). Make note of any shrubs with thick bottom leaves and stems that could provide shelter for rodents. Take note of tall vegetation growing next to the building; the wider the vegetation-free area around buildings, the better. Ideally an 18-inch vegetation-free zone around the outside of the building will discourage rodent activity. Watch for 'vegetation ladders' (i.e., shrubs or trees touching or overhanging a building) that allow rodents access to the tops of buildings.

Identify standing water near buildings, leaking pipes or hydrants, and inadequate water run-off (grade) from buildings.

Foundations

Foundations are particularly vulnerable to rodent entry (Figure 6). Identify cracks and holes in or under foundations, at the base of crawl-space or basement doors, openings around window wells, and so forth. Stone foundations or landscaping can provide crevices between large rocks that are ideal for rodent harborage. Observe signs of rodent activity next to buildings, as demonstrated by fresh burrowing, burrows that lead under foundations, rodent runways along walls, plants damaged by rodents, rodent tracks and droppings, rodent feeding stations, gnawing damage on structures, rodent rub marks, and rodent harborage (e.g., debris or tall vegetation).

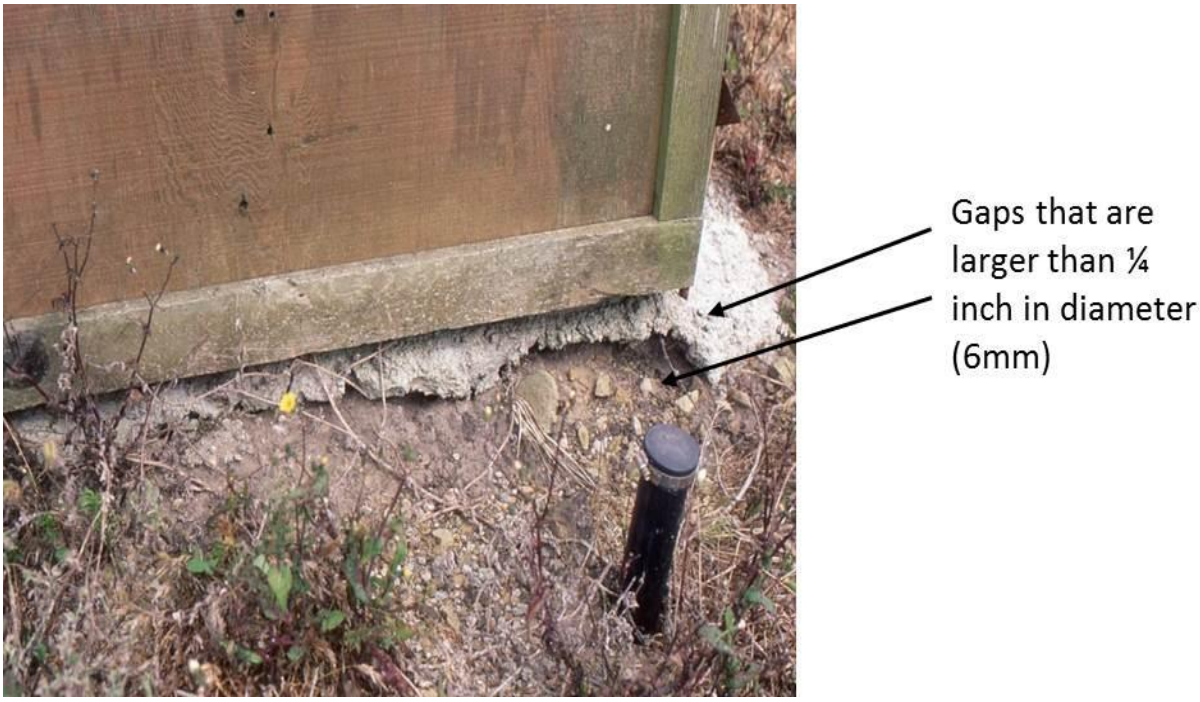

Figure 6: This foundation has a gap between the foundation and building providing potential rodent access into the building. Figure credit: NPS Figure.

Basement or crawlspace vents are critical for proper ventilation; however, they can provide easy access for rodents. Rodent proof these potential entry points as shown (Figure 7).

Figure 7: This crawl space vent is properly screened with ¼" hardware cloth (visible behind the metal bars). Figure credit: NPS Figure.

Doors and Windows

Doorways are one of the most common places rodents enter buildings. Rodents are drawn to outside doors, especially those with lights that attract night-flying insects and bats. Use yellow light bulbs which are less attractive to insects. Check doors and screen doors for functioning self-closing springs, tight fitting door sweeps, and metal screening that prevents gaps ¼ of an inch or larger.

Carefully examine exterior door frames, thresholds, and windows for cracks and gaps ¼ of an inch or larger (Figure 8).

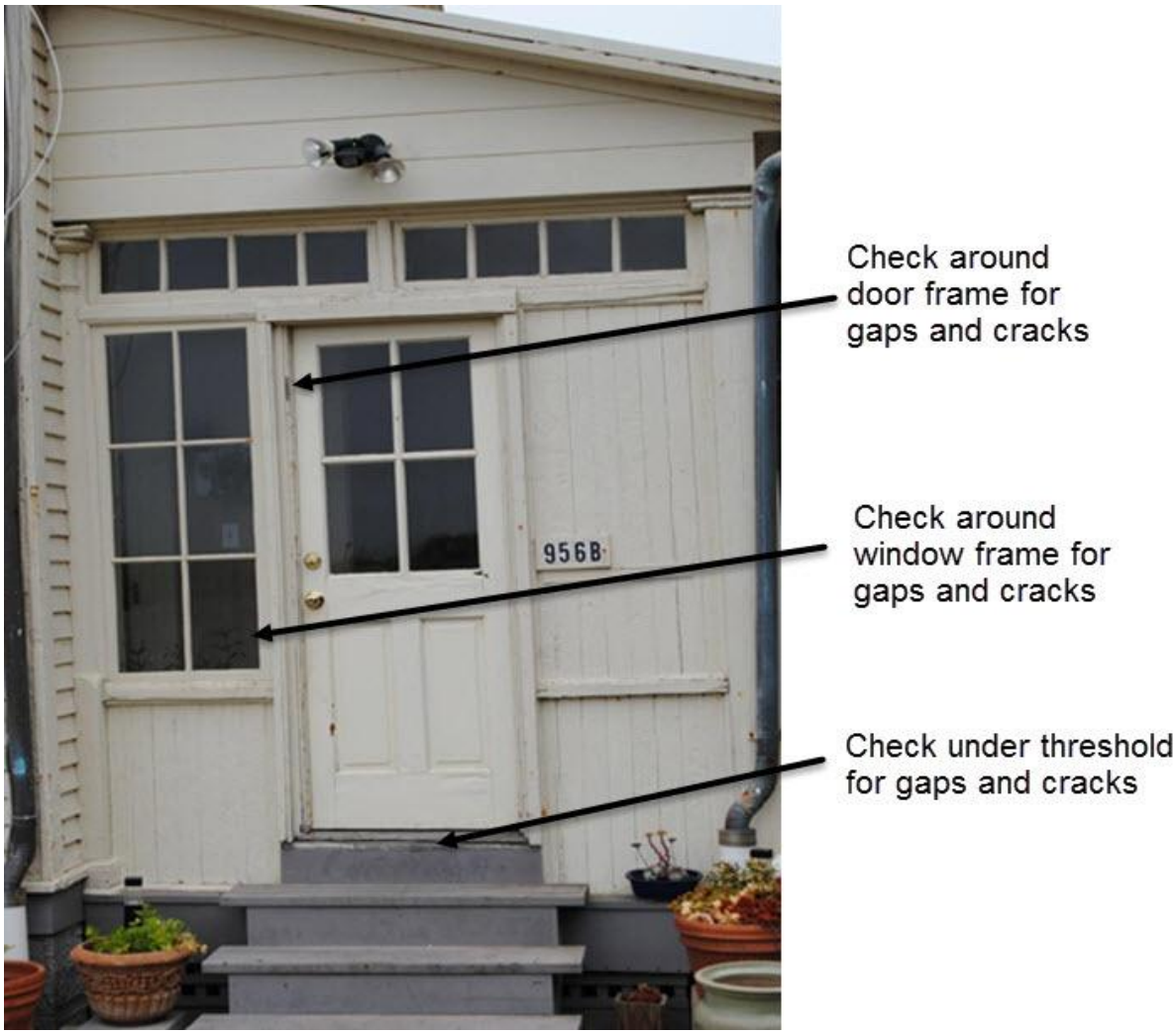

Figure 8: Check doors, windows, and door thresholds as these are common points of rodent ingress. Figure credit: NPS Figure.

Observe closed doors from the inside of the building during daylight hours to easily detect and evaluate the size of any gaps admitting light. Record these findings and submit a work order to install door sweeps or new threshold saddles to exclude rodents.

Service Lines and Breaker Boxes

Gaps and holes around electrical, plumbing, and gas lines entering the building are ideal rodent entry points. Check to ensure that there are no holes or gaps larger than ¼ of an inch around all electrical lines and pipes that pass through walls, foundations and roofs. Ensure that electrical breaker box doors fit tightly (Figures 9 and 10).

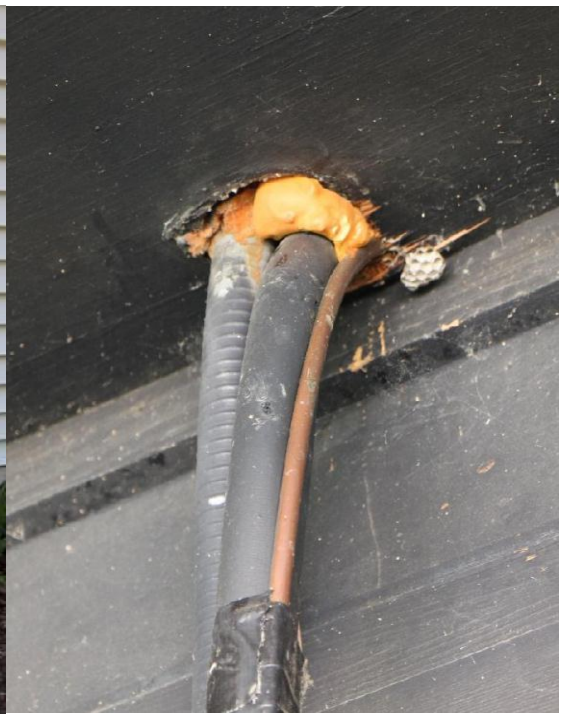

Figure 9 (left): Utility lines can leave gaps in the exterior of a building where they enter. Check for gaps or holes ¼" or larger around electrical, plumbing and gas lines entering the cabin, paying close attention to entry points that may be hidden behind service panels such as the ones shown in this picture. Seal up these openings to prevent rodent access. Figure credit: NPS Figure.

Figure 10 (right): The installation of utility lines entering the underside of this eave left a gap where rodents can enter the building. The gap has been partially filled with expanding foam, but an adequate opening still remains for rodent entry. Insert Stuf-it copper mesh into the opening, then trim and paint over the foam. Another option is to neatly cover the opening with ¼" hardware cloth. Figure credit: NPS Figure.

Roofs, Chimneys, and Vents

Use a ladder to examine soffits, gables, and other roof structures (Figure 11). Check to see if chimney and vent flashings form a tight seal between the chimney pipe and the roof of the building. Flashings made from aluminum or steel sheeting can create gaps if dented and asphalt material similar to shingles can crack and degrade with time. Fireplace chimneys should be capped when not in use or covered with a commercial rodent-proof chimney cover. Verify that all vent pipes are screened with ¼-inch-mesh, hardware cloth or appropriate exclusion device. Look for gaps around heating and air-conditioning units and vents. Be sure the open ends of corrugated metal and Spanish tile roofing are sealed. Check the general condition of the roof for defects and possible water leaks or depressed areas that might hold water. Note any cables or electrical lines leading to the roof and any overhanging vegetation, as the point where the electrical line enters the wall junction can provide rodent access (Figure 12).

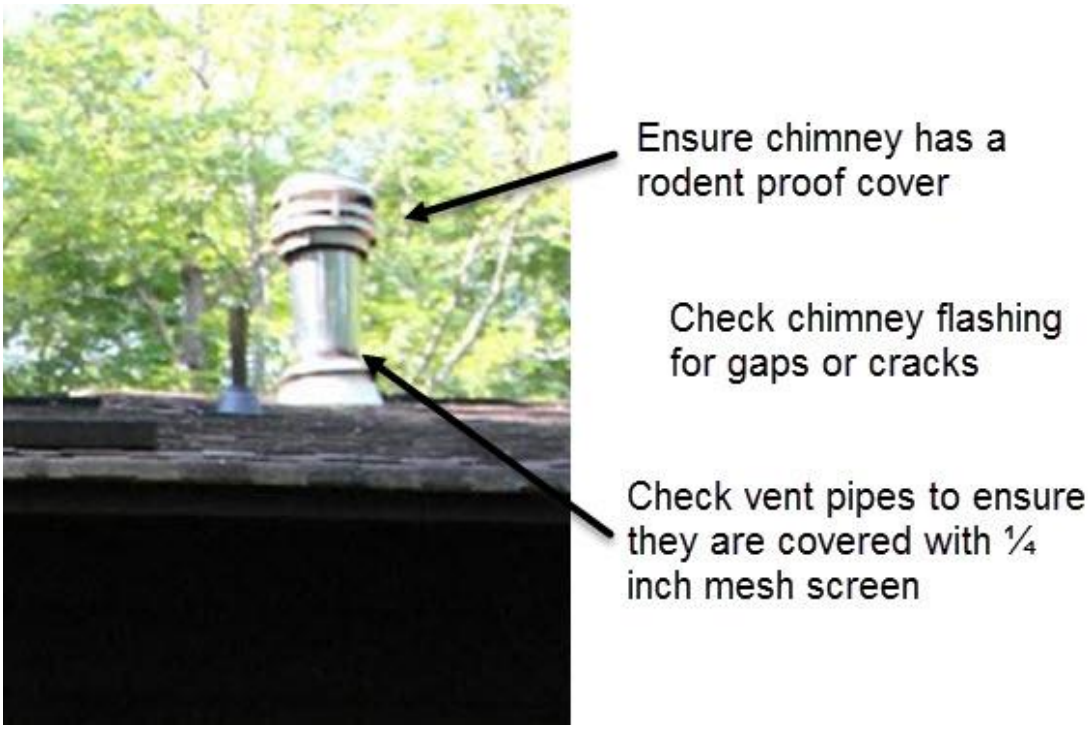

Figure 11: This properly installed chimney and vent pipe has a rodent proof cover. Evaluate the chimney and vent pipes on the roof to ensure that they are covered and flashing is tightly sealed to the roof. Also evaluate the roof for holes, gaps, or low points where water might pool and provide a water source to rodents. Figure credit: NPS Figure.

Figure 12: Electrical cables covered with ¼" hardware cloth at the cable/roof junction to exclude rodents at the cable entry point. Figure credit: NPS Figure.

Attics and Crawl Spaces

Identifying suspected rodent entry points from the exterior of an attic or crawl space can be difficult (Figure 7). The best method for inspecting these areas is to enter them during daylight hours. Turn

off all interior lights to observe any possible entry points which may be visible at locations where light enters from the outside. If holes in the roof are observed, insert a plastic straw or other thin item through the hole and return to the top of the roof to mark the locations. Seal the openings with the appropriate material for the structure.

Garbage-Proper Sanitation

Rodents are attracted to odors from garbage. Rodent proofed disposal storage units are mandatory and the area should be kept clean and clear of remnant garbage. Examine garbage containers for tight closure. Examine the surrounding areas for obvious rodent activity and proper sanitation. Poor sanitation (e.g., garbage on the ground, improperly washed concrete pads), garbage cans or dumpsters located too close to buildings, and loose-fitting garbage-can or dumpster lids attract rodents and other animals. Poor sanitation practices that support rodents should be noted in the inspection report and brought to the attention of building residents or managers immediately. Trash cans should be cleaned out weekly with soapy water to remove food residue or scum. This will greatly reduce rodents, flies, and other pest species.

Mobile Home and Stationary Trailer

The inspection of mobile homes, RV's, or house trailers (whether used for offices or residences) does not differ greatly from that of other buildings (Figure 13). Check every location where there is a pipe or utility line entering the structure for signs of rodent activity. Be proactive and prevent potential rodent access by fitting the underside with ¼" hardware cloth.

Figure 13: External points to evaluate on a mobile trailer: check that all exterior vents are screened, ensure no gaps exist around windows, no debris or vegetation exists within 18 inches of the base of the trailer, utility access door and trailer tongue are sealed, and the trailer skirt is absent or properly sealed and buried in the ground. Figure credit: NPS Figure.

Stationary Trailer Exteriors

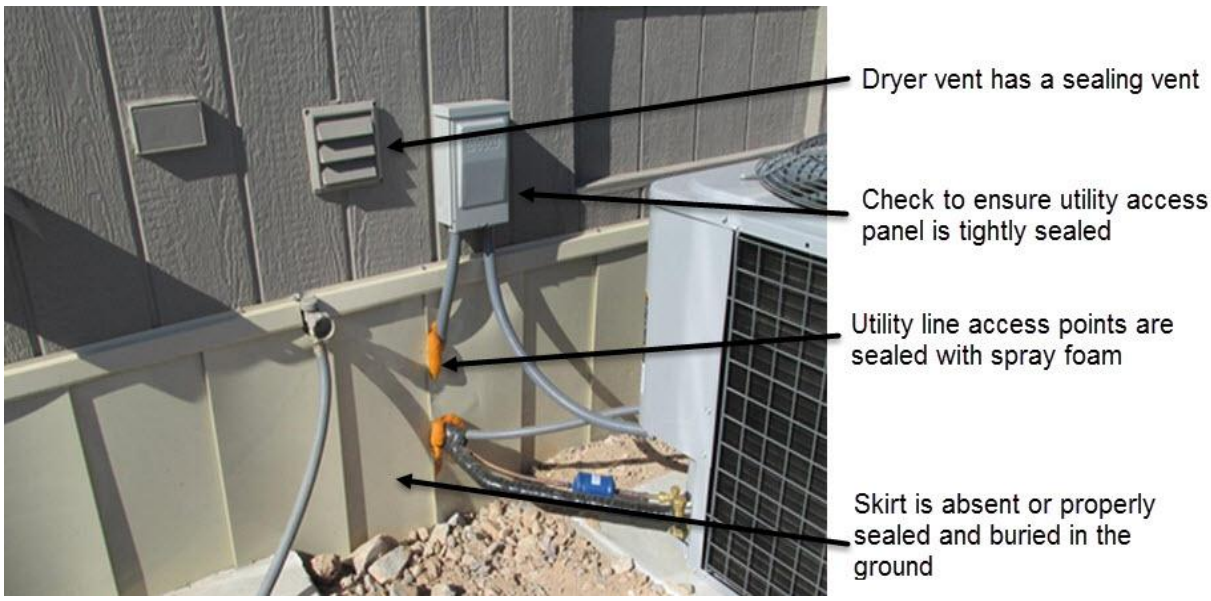

Figure 14: Examples of external points to evaluate on a trailer: the utility access panel is tightly sealed; utility line access points into the skirting are sealed with spray foam; the dryer vent has a functional sealing vent; the trailer skirting is buried underground to prevent rodent burrowing; no gaps or cracks exist between the skirting and the trailer base; and there is no debris or vegetation within 18 inches of the trailer skirt or base. Trim and paint over the foam to prevent UV damage. Figure credit: NPS Figure.

Trailers are more difficult to rodent-proof than permanent structures because of design, construction materials used, and subsequent repairs that may have damaged the integrity of the floors (commonly seen in the crawl space). New trailers should be inspected upon delivery, paying particular attention to the utility line access points and the type of materials covering the underside of the trailer. Most trailers have electrical lines on the sides of the trailer and the waste drain on the underside of the trailer. The undersides of the trailers are often only covered with fabric, which rodents can quickly chew through. To rodent proof the underside of a trailer, install ¼ inch hardware cloth on the underside of the trailer using a screw gun to secure the hardware cloth to the structure.

The exterior inspection must identify methods to keep animals from entering the structure. In addition to the items noted above, be particularly watchful for the following:

- The foundational skirting of the trailer must not have any sags, gaps, holes, or cracks, which could admit rodents into the crawl space beneath the trailer. If the trailer does not have a concrete or similar rodent-proof foundation, the bottom of the skirting around the trailer must be protected with a curtain-wire barrier (see Exclusion section) to prevent the animals from digging beneath it. Skirting should be bent into an outward facing ‘L’ shape with the bottom portion of the L buried at least six inches underground. In certain situations it is better to remove the skirting to prevent a sheltered rodent habitat.

- Holes are commonly found around the trailer tongue (hitch) when it has not been removed. Inspect the tongue area carefully for holes that rodents could use to access crawl space or walls. Seal the opening with copper wool or expanding foam.
- Electrical, water, gas, and sometimes sewer lines enter a trailer through or under the skirting. Check carefully around all service lines for gaps and holes and seal any ¼ inch or larger openings (Figure 14).
- Hot water heater closets on most trailers open to the outside and have pipes and wires that penetrate into the crawl space, and can serve as access points for rodents. Carefully examine hot water heater cabinet doors for warping or damage and thoroughly examine cabinet interiors for holes or gaps that could allow animals to enter the trailer. It is not uncommon to find considerable wood rot in hot water heater cabinets. This area must be examined periodically to check for decayed wood; repair as soon as possible to prevent rodent access.
- Check all exterior doors for tight fit, and check all windows for intact glass and screens. Metal exterior doors often become bent during use and do not close properly. Trailer residents sometimes remove window glass or make holes in screens for electrical extensions. These holes must be sealed with the appropriate caulking compound. Also check for weather-stripping around the edge of doors, and, if it is worn, cracked or otherwise not functioning properly, replace it immediately.
- Check all roof-mounted air conditioners, swamp coolers, and other appliances to determine if flashings are tight and units are adequately screened with ¼ inch hardware cloth. Check to see that roof ventilation vents are screened and that they close tightly and are not partly open because of an electrical extension line or water line leading to the outside.

Building Interiors

An interior building inspection is normally performed after inspecting the building exterior. Interior inspections require the same careful, methodical examination, documentation, and use of personal protective equipment to safely detect rodent access and entry points, food, water, and harborage conditions, signs of rodent infestation, and sanitation practices (or habits) that might support rodent infestations. Building interiors should also be inspected at least twice a year. Conduct inspections in late summer /early fall just before cooler weather causes rodents to move indoors or in the spring for buildings that have been closed for the season. In addition, it is desirable to continuously monitor building interiors to detect the presence of rodents or any changed conditions that could attract rodents or allow entry.

Obtain or make a rough drawing of the building's interior floor plan (Figure 15). Begin at an identifiable point on the inside (usually the front door) and systematically progress along each wall and through all rooms, including garage, storage, and utility areas. Inspect all buildings in the same manner and order to ensure areas are not forgotten. Look for any possible rodent entry points and for conditions that might support their presence. Record defects found on the inspection report and/or building floor plan.

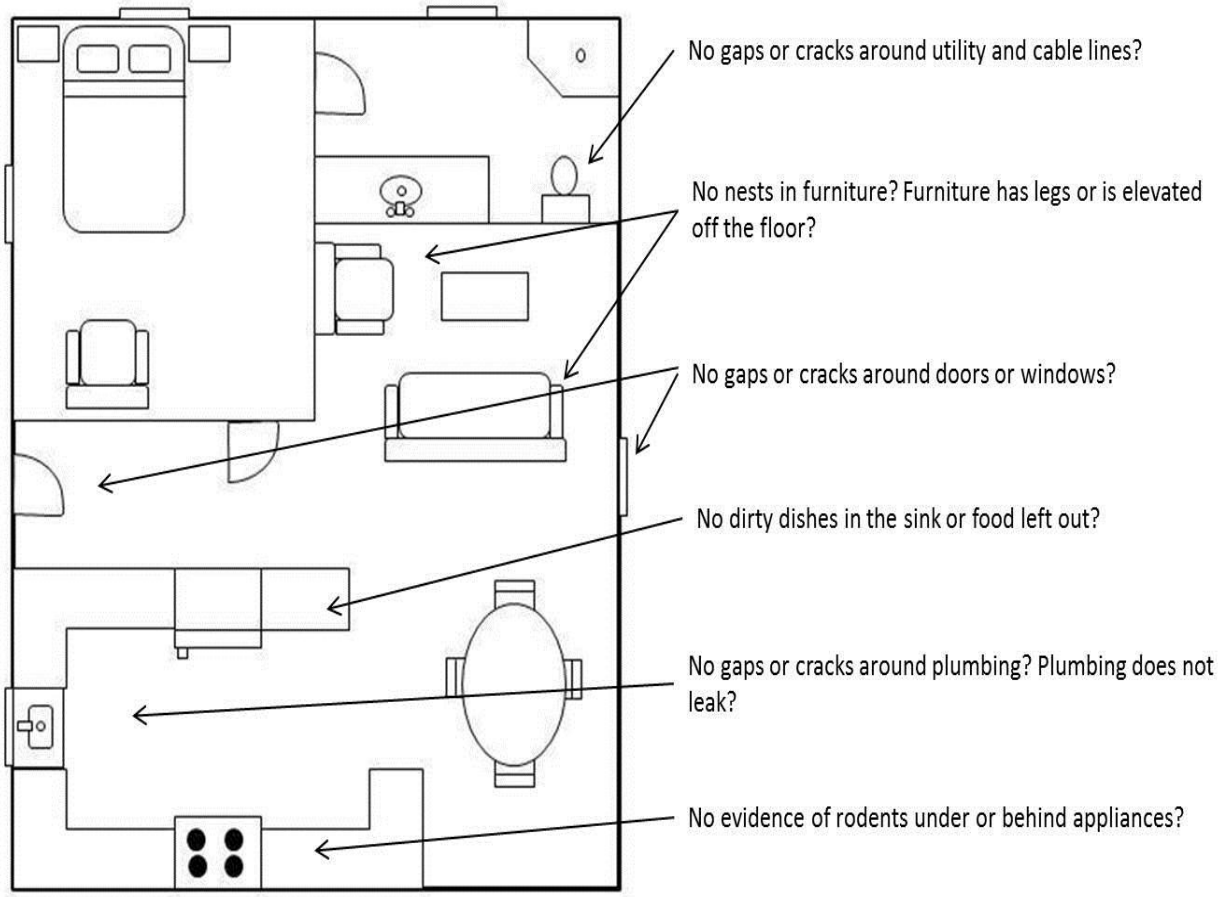

Figure 15: Review these key points to evaluate during an interior inspection for rodent exclusion.

Finding Rodent Entry Holes

Thorough interior inspections are essential, because rodents can enter rooms through any small hole, crack, or gap—just ¼ inch or slightly larger, which connects room interiors with the outside or with wall, floor, and ceiling voids or crawl space and attic areas. The most common entry places are under doors and through the "larger-than-required" holes in walls and floors (i.e., chases) provided for passage of electrical, water, gas, and sewer lines and vents and conduits (Figure 16).

Figure 16: Evaluate service entry points. Here plumbing entrance points are sealed using a commercial flange that is sealed to the wall tile using caulk. Figure credit: NPS Figure.

Carefully check all potential rodent entryways, thresholds, and pipe and electrical chases. Holes and gaps around stone or brick fireplaces are also common entry places for rodents. Other entryways that are more difficult to find may be hidden in dark corners of rooms and closets; behind or under built-in cupboards; and around hot-water heaters, furnaces (Figure 17), radiators, dish and clothing washers, and stoves. Seal all openings to exclude rodent access.

Figure 17: Evaluate utilities for potential entry points, which are commonly found behind the hot water heater or furnace. Also check for nesting material underneath or behind these appliances. Figure credit: Bruce Badzik.

Use a professional flashlight for inspections to examine all corners and closets for signs of rodent activity; remove items and thoroughly inspect behind and under the lower drawers of cupboards, refrigerators, stoves; and inspect around appliances.

Identifying Rodent Food and Water Sources

Identify any sources of food or water available to rodents. Examples may include, but are not limited to, the following:

- desks
- kitchens
- snack rooms
- soda and candy machines
- coffee stations
- candy and snacks in concessions area
- indoor recycling storage areas (e.g., aluminum cans)
- dead insects on sticky traps or on rodents in snap traps
- bars of soap in restrooms
- garbage left overnight in buildings
- broken packages or spilled foods in storage cabinets
- open drains, dripping air conditioning units, or leaking pipes
- pet food bowls and water

Always be on the lookout for “rodent feeding stations” when conducting rodent inspections. They may be partly visible sites where rodents feel it is safe to eat food they have collected from other locations. Usually, feeding stations are located in protected room corners; under or behind the bottom drawers of kitchen cupboards; under stoves, refrigerators, or sinks; and under or behind furniture. The stations are identified by a greater than normal amount of rodent feces and urine deposits in a certain spot or by the remnants of a variety of foods (e.g., candy wrappers, nut shells) and remnants of cockroach carcasses. The food remnants found in feeding stations can offer helpful clues as to whether or not there is a need to inspect other locations for rodent activity.

Identify and eliminate any sources of moisture available to rodents and other pests. Ask building occupants if they have observed or are aware of water leaks, document findings and submit request for repairs. Be on the lookout for moist areas, swollen wood, and cracked paint. If necessary, use a moisture meter to check walls and floors for suspicious excess moisture coming from leaking plumbing, improper grade or drainage, clogged drain traps, condensation on cold pipes or windows, humidifiers and de-humidifiers, fish tanks, and potted plants. The presence of excess moisture also supports mold, fungus, slime, lint, and insects (e.g., fungus-feeding beetles, flies, mites, and centipedes), as well as spiders and scorpions. All of these can be a source of food and water to rodents. Correcting moisture problems in a building is not only important for pest control but also for the longevity of the building.

Note on the inspection report any poor sanitation practices that promote rodent infestations, and bring these to the attention of building residents or managers.

Indicators of the Presence of Rodents

Indicators of the presence of rodents in a building include these signs (Figures 18 - 28):

- Rodent carcasses and odors
- Visual sightings of rodents
- Droppings and urine stains, and odors
- Sounds of gnawing or movement in walls, ceiling voids
- Presence or evidence of snakes or other rodent predators found indoors
- Piles of cockroach wings/legs
- Seeds/husks, nuts/shells
- Rub or grease marks
- Hair in openings
- Evidence of gnawing
- Shredded nesting material
- Presence of Dermestid beetles and blowflies indicates a carcass is nearby
- Rodent nests

Figure 18: Rodent feces (droppings) confirm rodent activity in this wall void. Figure credit: Carol DiSalvo.

Figure 19: Evidence of packrat gnawing activity. Figure credit: Charles Conner.

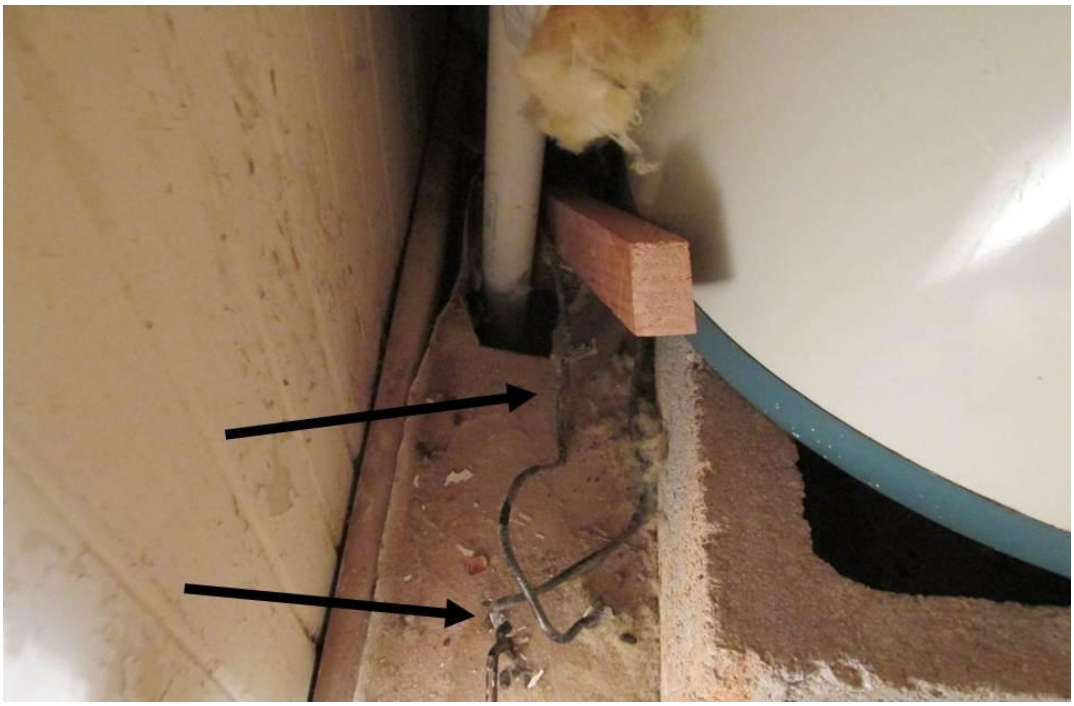

Figure 20: Wire damage from packrats. Figure credit: Charles Conner.

Figure 21: Grease marks from a Roof rat (Rattus rattus). Figure credit: NPS Figure.

Figure 22: Presence of snakes indoors may indicate a potential rodent infestation. This black rat snake (*Elaphe obsoleta)* removed from a drop ceiling during a rodent clean-out project. Figure Credit: Carol DiSalvo.

Figure 23: The larder beetle (*Dermetes maculatus*), feeds on rodent and other carrion. Finding these insects indoors indicates there may be a carcass in the structure. Figure credit: University of Milwaukee.

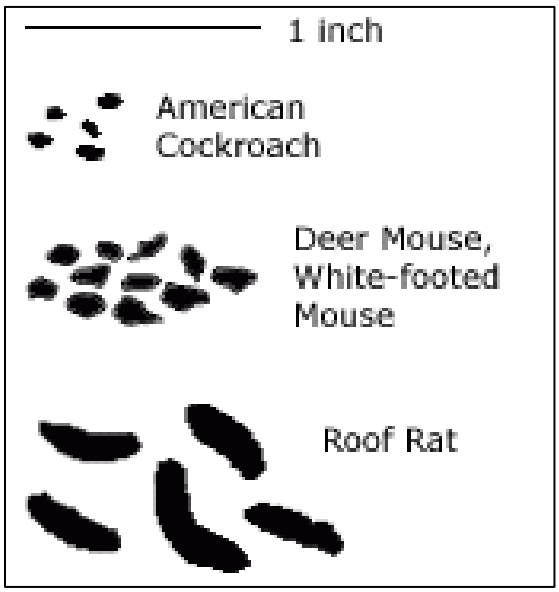

Figure 24: Comparison: American cockroach fecal pellets are similar to mice. Note that the American roach pellets are blunt on the ends whereas mice are pointed. The roof rat and Norway rat droppings are larger. Figure credit: earthobservatory.nasa.gov.

Figure 25: Mice will eat cockroaches however they will leave behind the spiny legs and stiff wings which are difficult to consume. Figure credit: NPS Figure.

Figure 26: Pack Rat (*Neotoma albigula*) entrance hole. Figure credit: Charles Conner.

Figure 27: Pack rat (*Neotoma albigula*) fecal pellets in a closet. Figure credit: Charles Conner.

Figure 28: This active rodent burrow is located at the foundation of the building. Note the entrance and runway is clear of vegetation and the rodent has created a “run”. Figure credit: NPS Figure.

One indicator of the presence of mice in closed rooms can be observed by a musky odor they leave behind. Request that building occupants immediately report to their supervisor or the park housing

officer, where they have seen mice or evidence of rodent activity such as feces, partially eaten nuts, candy wrappers, and/or shredded paper, nesting material, or where mice have gotten into their food items.

If evidence of an active rodent infestation is found in a room, it is very important to concentrate efforts on finding the entry points. Monitoring will determine where entry points are likely to be. Snap traps are effective in removing the rodents, reducing the risk of disease and damage, and will help you locate rodent access points. Place snap traps at each door threshold (when setting snap traps in interior rooms: use 4 per door, two on each side of the door threshold). Conduct an initial inspection documenting the location of where you have set snap traps; conduct required follow-up inspections a day after placing snap traps and record results. Rodent activity can also be monitored using non rodenticide tracking powder on the floor perimeter or on small boards around the room to identify rodent runways. The tracking powder is non-toxic and visually shows rodent tracks. Notice which direction the tracks are going in to determine the location of origin to help you focus on areas where the rodent is coming from. Closing interior doors between rooms at night will limit rodent activity and allow you to isolate points of entry.

How to Use Snap Traps

Use of snap-traps is an efficient method to immediately reduce risk and rodent activity. Find additional information on indoor rodent management at **http://www.cdc.gov/rodents/** and the **Rodent Management** page. (*See Appendix F: Proper Use and Placement of Snap Traps*)

Identifying Rodent Harborage

Rodents use many areas to hide and build nests. They prefer undisturbed clutter, dark corners, cavities or furniture, wood piles, inside cabinets, in and among boxes and other items stored on floors, under dressers and chests of drawers, behind and inside machinery (e.g., kitchen appliances, water coolers, etc.), around hot-water heaters and furnaces, and in employee lockers. Sometimes overlooked sources of rodent harborage and activity are found under the lower drawers in kitchen cupboards or stoves, in refrigerator drip pans and coils, inside upholstered furniture or furniture having hollow legs, in attic and storage room clutter, inside wall voids, electrical motors, and computer cases. Use a flashlight to look for rodent signs in these shelter areas. Turn down interior lights and shine a black light on surfaces to detect rodent urine trails, which will fluoresce under the black light.

Ensure that boxes and other items stored on floors are placed on shelves or pallets and are elevated 6 or more inches above the floor. Keep stored items 18” away from walls to deter rodents from nesting, facilitate inspections, and allow for snap trapping. Moving items off the floor and away from rodent activity eliminates attractive hiding places, allows floors to be cleaned and inspected, and provides locations for the placement of rodent traps.

House-Trailer Interiors

Figure 28: The underside of trailers should be rodent proofed prior to human occupation. Figure credit: NPS Figure.

Methods used in constructing house trailers may leave many access points for rodents that lead to open spaces (voids) behind walls, ceilings, and sub-floors, allowing entry to living spaces. An interior inspection of house trailers should be conducted on a regular basis. Particular attention should be paid to the following:

- New trailers: the underside of trailers is typically covered with an insulation fabric. To prevent rodent access install ¼" hardware cloth (16-22 gauge) on the underside to prevent rodent entry prior to human occupation.
- Carefully check all points where gas, water, electrical, and drain lines and vents penetrate floors, ceilings, or walls. Open gaps around pipes are often found under the kitchen sink (Figure 16). Check for loose pipe escutcheons that do not properly seal the chase around incoming water lines. If the hot-water heater is located inside the trailer, carefully check the interior of the cabinet for openings. Look inside the kitchen cupboard above the stove for gaps around the area where the stove vent penetrates the top of the trailer ceiling. If kitchen vents exhaust through the side of the trailer, ensure that either the louvers close properly or that the open end is screened.
- Thoroughly examine the interior of built-in furnace cabinets for gaps or holes. Look for rodent feces, grease marks, or other evidence inside floor-mounted heating registers. Rodents sometimes gnaw through plastic heating ducts in the crawl space and can then move up into rooms through heating registers. Heating conduits under trailers can also become unattached from the furnace and provide rodent access to heating ducts. Look for openings on ceilings and walls around air-

conditioning installations. Look for gaps around the area where the furnace vent penetrates the uppermost portion of the trailer ceiling; this may require the removal of a ceiling and/or wall panel.

- Check for gaps around washing machine pipes and hose bibs. Inspect the exhaust flaps on clothing dryers to ensure that louvers are not restricted by lint buildup. If the clothing dryer is vented to the crawl space, inspect the vent line for possible holes. If a washing machine and/or clothes dryer are not present, verify that pipes and vents are tightly sealed.
- Many of the main electrical circuit breaker boxes of trailers are mounted on a bedroom wall. Check to ensure that the box is properly installed and does not have open spaces around or inside of the box.
- Carefully inspect the interiors of upholstered furniture for possible nesting sites.

If evidence of rodents is found inside the trailer, document findings in detail and report to the staff responsible for repairs, involve the Park IPM Coordinator, Public Health and Safety Officer and send a copy of the report to the park Superintendent.

Prevention and Management of Rodent Infestation

Excluding Rodents

Exclusion is necessary to prevent and manage rodents in structures. Exclusion is done to correct structural defects in the building and prevent future access. Most exclusion can be accomplished with simple tools and construction materials. Occasionally building construction styles or mandates to maintain a given historical appearance may not allow building exteriors to be permanently altered. However, the National Historic Preservation Act allows for non-permanent measures to be taken to assist in rodent exclusion and management. If the building is a historical structure, contact cultural resource management staff to determine acceptable methods for rodent exclusion.

Exclusion is straightforward: (1) identify access points; (2) eliminate (or minimize) all holes, cracks, and gaps of ¼ inch in size or larger through which rodents can enter; and (3) remove food, water, or potential rodent shelter. Rodent exclusion efforts are practical and effective: in a 1994 study of rodent infestations in three National Park units, rodent exclusion was accomplished by maintenance crews with no specialized training in rodent management at an average cost of about $600 per structure using standard construction methods and materials. Descriptions of various rodent-proofing materials and sources are noted at the end of this chapter. The cost for exclusion varies depending on the building's size, construction, age, and significance.

> *Note: Exclusion is never permanent. Weather, building settling, construction, and site use may affect the integrity of the building envelope. Hence continuing, on-going inspection, exclusion, sanitation, and monitoring are required to keep buildings tight enough to prevent or control re-infestations and to deprive rodents of food and harborage.*

Building Exteriors

Most small holes and cracks in building siding can be filled with the appropriate type of caulk of a suitable color, or be painted after the caulking dries (Figure 29).

Figure 29: Methods to fills gaps can include caulk and ¼ inch hardware cloth fastened with a staple gun or screws. Figure credit: NPS Figure.

Larger holes may require filler (e.g., wire mesh or sheet metal) before caulking is applied. Expanding foam, sometimes used for difficult-to-seal cracks, may require follow-up trimming after drying is complete (Figure 30). The foam can break down in the presence of sunlight, and presents an unfinished appearance unless it is sealed with paint or caulking. Re-inspection is needed.

Figure 30: Expanding foam can be used to fill gaps. This foam must be trimmed and painted once dry to protect it from breaking down or becoming brittle in the sun's UV rays. Figure credit: NPS Figure.

Holes with large open spaces behind them (voids) that prevent the use of fillers (e.g., holes made through sidings by squirrels or woodpeckers) are usually covered with thin, galvanized sheet metal and then painted. When using sheet metal, ensure that all edges are securely attached to the structure.

Utility Lines

Most of the ¼ inch or less small gaps and holes around electrical lines, plumbing and drain pipes, conduits, gas lines, air conditioners and ducts, and TV lines that enter the building can be sealed with caulking compounds, hardware cloth, cement, or sheet metal.

Sheet metal is sometimes used to fabricate conical or flat rodent-proof guards around wires to prevent animals from climbing onto roof structures (Figure 31).

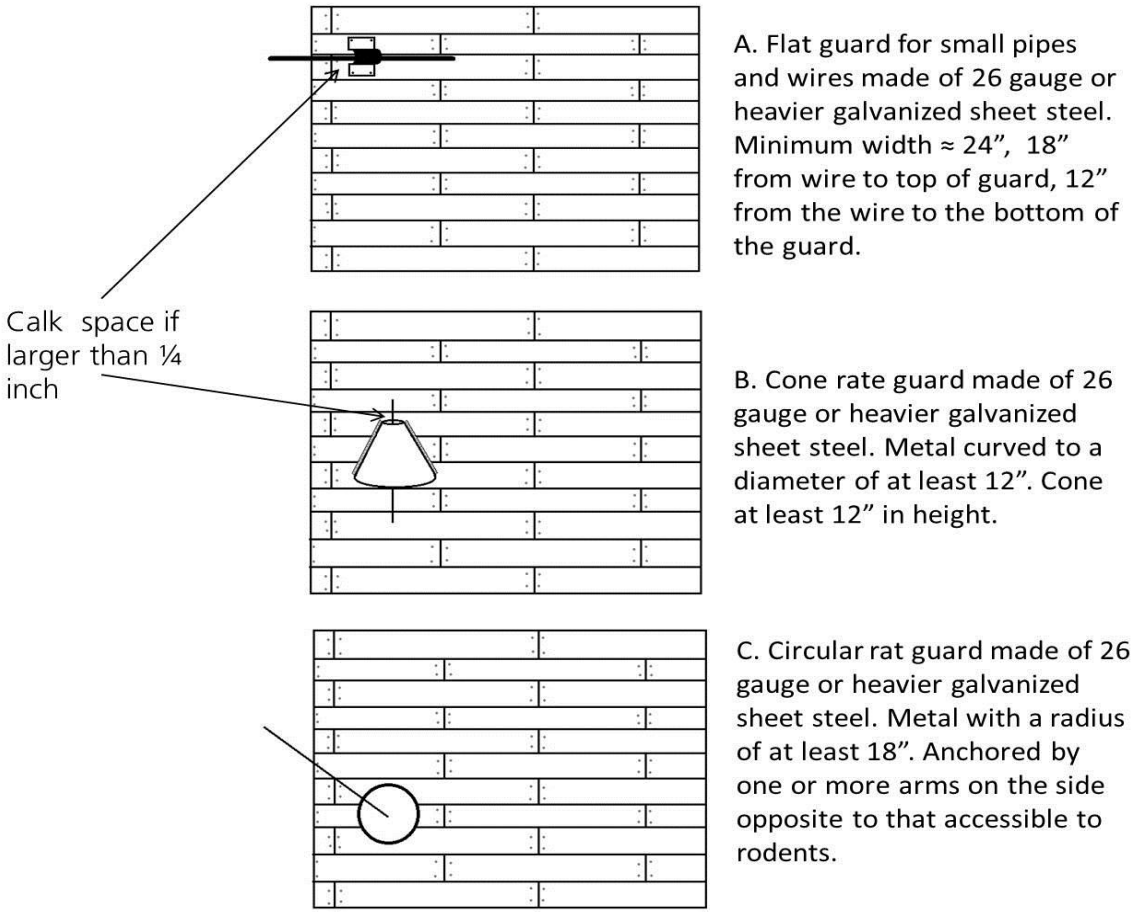

Figure 31: Examples of rodent guards constructed out of sheet metal. The heavy black line depicts wires entering or running along a building. The top graphic shows a flat guard for small pipes and wires. The guard is made of 26 gauge or heavier galvanized sheet steel. Minimum dimensions: 24 inches wide, 18 inches from wire to top of guard, and 12 inches from wire to bottom of guard. The center graphic is a rat guard made of 26 gauge or heavier galvanized sheet steel. Metal curved to a diameter of at least 12 inches. Cone is at least 12 inches in height. C. Circular rat guard made of 26 gauge or heavier galvanized sheet steel. The metal has a radius of at least 18 inches and is anchored by one or more arms on the side opposite to that accessible by rodents. Figure credit: Internet Center for Wildlife Damage Management, http://icwdm.org/handbook/rodents/RodentExclusion.asp.

Vents and Chimneys

Where permitted and safe, screen the open ends of plumbing, exhaust, heating, and air conditioning vents, and other pipes, with ¼-inch hardware cloth. Terminal ends for clothing-dryer vents are available that exhaust the air vertically rather than horizontally, and they appear to be more effective in excluding rodents than flapper-type vent ends. Install commercial, rodent-proof chimney guards over fireplace chimneys if hardware cloth could cause a fire hazard (Figure 11).

Clothes dryer vents require special treatment as improper screening hastens lint build-up and increases the likelihood of fires. Check building codes to see what dryer vent work is permitted, as it varies state to state, and make sure the dryer exhaust pipes meet Consumer Products Safety Commission standards. Properly seal any gaps between the pipes and the structure to prevent rodent entry. Consider installing a dryer vent cover that utilizes a floating ball that secures the vent when the dryer stops.

Note: Hardware cloth less than ½ by ½ inch significantly reduces airflow. In buildings where ventilation is already marginally adequate or inadequate, such further restrictions may be unacceptable. In some locations, small mesh screens can become clogged with dust or freeze over. In such situations, the use of ½ by ½ inch hardware cloth may be a reasonable compromise between ventilation requirements and rodent control.

Doors and Windows

Most small holes around door and window facings can be filled with caulk of an appropriate color, or painted after the caulk dries. Install metal kick plates, tight-fitting door sweeps, or metal thresholds on all exterior doors that allow no more than ¼-inch clearance between the door and floor.

Windows must close properly and have intact screens, preferably constructed of metal. Seal all cracks and gaps around windows and doorframes with caulk, or repair the facings. Use only metal window screening material rather than plastic when windows or screen doors are accessible to rodents. If needed, screen windows with woven/welded hardware cloth as an added measure.

Overhead doors

Close the gap at the top or sides of overhead or roll-up doors with a heavy-duty, rubberized material shaped to fit into the door frame and mounted on the top door jamb. Several commercial products exist designed specifically for this purpose. Seal gaps at the bottom of the door using tension brushes or strips or heavy duty compression seals. Although rodents can gnaw through bristles, rodents perceive a continuous line of well-maintained bristles as a uniformly closed surface, and usually continue to move along walls and doors searching for direct openings.

Foundations and Trailer Skirting

If rodent burrows extend under foundations or trailer skirting and there are no other obvious exit points, rodents and other animals must be removed by trapping or other means before exclusion devices can be installed. (S*ee Appendix F: Proper Use and Placement of Snap Traps*) Repair cracks in stone and cement foundations with concrete or mortar.

Discourage rodent burrowing around foundations by:

- Maintaining a clean, 18 to 24-inch inch vegetation-free area around building foundations, concrete slabs, and footings. This also eliminates a potential food source and attractive rodent harborage;
- Conducting regular, close mowing of vegetation;
- Laying one-inch diameter (2.5-cm) or larger, gravel in a band at least two feet (60 cm) wide and 1/2 foot (15 cm) deep adjacent to foundations;
- Installing a 14-inch, L-shaped "curtain wire barrier" of ¼-inch, heavy gauge, hardware cloth around the building foundation. Attach the vertical edge of the wire tightly to the building's side about five to six inches above ground level then bend (at a 90-degree angle) and extend the bottom edge of the outward horizontally about 5 to 6 inches from the building. The horizontal section of wire should be made tight by staking it to the ground at approximately every foot of length and then covered with 2 or more inches of soil and rocks.

Norway rats are more aggressive in their attempts to burrow under foundations, and may require the construction of a concrete curtain wall. This is a four-inch thick, L-shaped wall of concrete that abuts the foundation. It extends above ground six to eight inches and below ground for a minimum of two feet. The lower and horizontal portion of the curtain wall should extend at least one foot out from the building. Although this type of construction can be used for nearly any type of foundation, it is expensive to retrofit structures because a two foot deep ditch has to be dug around the building and concrete forms have to be constructed.

Attic and Crawl Space Vents

Install tight doors or commercially available, screened, self-closing vents over attic and crawl space openings, or screen them with ¼-inch-mesh hardware cloth (Figure 7).

Trailer Tongues

Generally, ¼-inch hardware cloth wire is the best material for closing irregular openings around trailer tongues. Chose an appropriate method to secure the hardware cloth to the trailer tongue, and attach the wire to both the tongue and trailer siding. Extreme cases may require the use of quick-setting construction cements or epoxy compounds.

Vegetation

To keep rodents from using vegetation as a pathway onto roofs, trim all trees and shrubs 18-24 inches away from buildings, and remove limbs that overhang or are in close proximity (six feet) to roof lines. Whenever possible, maintain an 18-inch -vegetation free zone around all structures. Filling the 18-inch zone with gravel creates an exposed area where rodents are visible to predators and discourage rodent activity in this area. This also helps keep the foundation dry and facilitates foundation inspections for termites. This method may require the approval of cultural resource management prior to implementation for historic structures.

Garbage and Trash Areas

Metal trash cans are preferred as rodents cannot chew through them. Be sure that all trashcan and dumpster lids fit tightly to prevent rodent access. Screen any large drain holes in the bottoms of the receptacles with ¼-inch-mesh hardware cloth (Figure 2) to prevent rodent access and install a drain plug to prevent rodent access and to retain liquid waste. Periodically rinse the cans with soapy water to remove food residue which attracts rodents, flies, other animals.

Automobiles and Machinery

Rodents can damage wiring and hoses in automobiles and other machinery. Spraying the wiring and hoses with rodent repellents is not effective. It is very difficult to exclude rodents from vehicles and machinery when they are parked outside; they can only be kept free from rodent damage by parking in enclosed, rodent-proof garages. The same general guidelines that were described previously for other buildings apply to the exclusion of rodents from garages and outbuildings.

- Keep vehicles and equipment free of food and or food residue.
- Check to see if spare tire wells have drain holes, and cover this hole with a rubber plug or rodent-proof material.
- A rodent-deterrent tape, coated with capsaicin, is available from Honda and other auto dealers.
- Rodent repellents such as Fresh Cab, Earthkind (www.e-kind.com), are available on the market and have shown to be effective in enclosed cabs but must be replaced frequently according to manufacturer guidelines.
- If possible, remove vegetation in parking areas to remove potential rodent habitat and protection. Do not park vehicles near firewood or construction supplies, tall vegetation, trash cans or other rodent food sources.
- Installing an 18-inch high fence of metal flashing that encircles stored vehicles and machinery may help exclude some rodents.
- For vehicles parked outside, keeping the hood up (not necessarily all the way) will discourage rodents from nesting in the engine compartment.

Building Interiors

All holes, gaps, and cracks in walls, floors, ceilings, and cupboard interiors, and around bathtubs or chimneys, etc., must be sealed to keep rodents from entering rooms.

Similarly, all open chases and gaps must be sealed around conduits, electrical wires, circuit-breaker boxes, water pipes, gas lines, drains, exhaust vents and ducts, air conditioners, and other elements that penetrate walls, floors, and ceilings.

Fit exterior doors with self-closing devices (springs, hydraulic door closers), and reduce the threshold gap to less than ¼ inch.

Unlike on building exteriors, the use of ¼” hardware cloth wire or sheet metal to cover cracks and holes on the building interiors may not provide the desired finished appearance, and caulking, plastering, and/or painting may be needed to provide an acceptable finish.

Screens for floor drains in custodial closets, laundry rooms, and lunchrooms with stainless-steel grates should be retrofitted to have openings less than ¼ inches in diameter. The smaller opening will require periodic inspection and cleaning to ensure the drain is functioning.

Interior doors may also be fitted with close-fitting door sweeps to make it possible to contain or isolate indoor rodent problems within specific rooms or areas. Install ¼ inch, hardware cloth over heating registers and cold-air return vents if rodents use these pathways.

Rodent-Proofing Materials

Materials selected for rodent-proofing must discourage and prevent rodents from penetrating them and be as easy to work with. Regardless of the materials used, no holes should be left open on the inside or outside of buildings that are more than ¼ inch in diameter. (*See Appendix G: Traps, Exclusion, and Building Materials, and Repellents)*

Solid-metal Materials

Sheet Metal: Galvanized sheet metal of 24-gauge or heavier is recommended for most general rodent-exclusion uses. Sheet metal can be shaped to cover a variety of openings and is suitable for many rodent-proofing purposes.

Kick Plate: A 24- or 26-gauge metal (galvanized steel or brass) kick plate installed at the bottom of a door will prevent rodents from gnawing on the door and creating entry points.

Rodent Guards for utility lines: Flat or tunnel-shaped rodent guards for single vertical utility lines leading into buildings can be made from sheet metal. Ensure that any gaps between the guard and utility line that are larger than ¼ inch are filled with caulk.

Multiple vertical utility lines require more elaborate guards. Protect horizontal lines leading into buildings with 18 inch- radius metal disk-guards set far enough away (at least 4 feet) from buildings to keep animals from jumping from the line to the roof.

Aluminum coil: Aluminum coil is soft and easily shaped, and excludes birds (except woodpeckers) and bats, but mice, rats, and squirrels can easily gnaw through aluminum. Galvanized sheet metal is more appropriate for rodent exclusion. If aluminum coil must be used, be sure to select the heaviest gauge possible.

Screening Materials

Expanded Metal: Galvanized (non-rusting) expanded metal, 28-gauge or heavier, resembles heavy-duty hardware cloth. Although it is bulky and somewhat difficult to work with as it is very stiff, it is very effective as it is highly resistant to most animals (Figure 32).

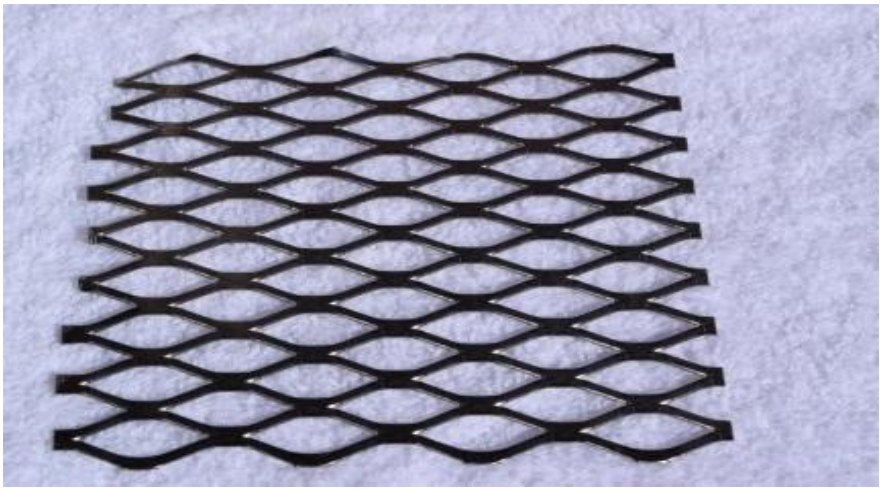

Figure 32: Expanded metal. Figure credit: Bruce Badzik.

Perforated Metal: Galvanized (non-rusting) perforated metal (with openings of ¼ inch or smaller, 24-gauge or heavier), is also highly resistant to most animals, but it is also somewhat difficult to work with (Figure 33).

Figure 33: Perforated metal. Figure credit: Bruce Badzik.

Hardware Cloth: Hardware cloth is one of the easiest and most durable materials to use for screening foundation vents, open pipes, and other holes. It effectively excludes mice and most rats (Figure 34).

Use 16- to 19-gauge, welded-at-each-joint, ½-inch by ½-inch- mesh, galvanized-after-welding wire screen to exclude larger animals or aggressive rats. This is extremely strong material, and will last 10 to 20 years due to its heavy zinc coating. Use 201 to 239, or heavier gauge, galvanized, ¼-¼ inch or smaller mesh hardware cloth to keep smaller animals (e.g., mice) out.

It may be difficult to find the heavier gauge hardware cloth in hardware and home improvement stores. Contact the manufacture for addresses of local vendors or purchase directly from the manufacturer. Heavier gauge material is more expensive to purchase and install; however, the longer lifespan makes it more economical over time.

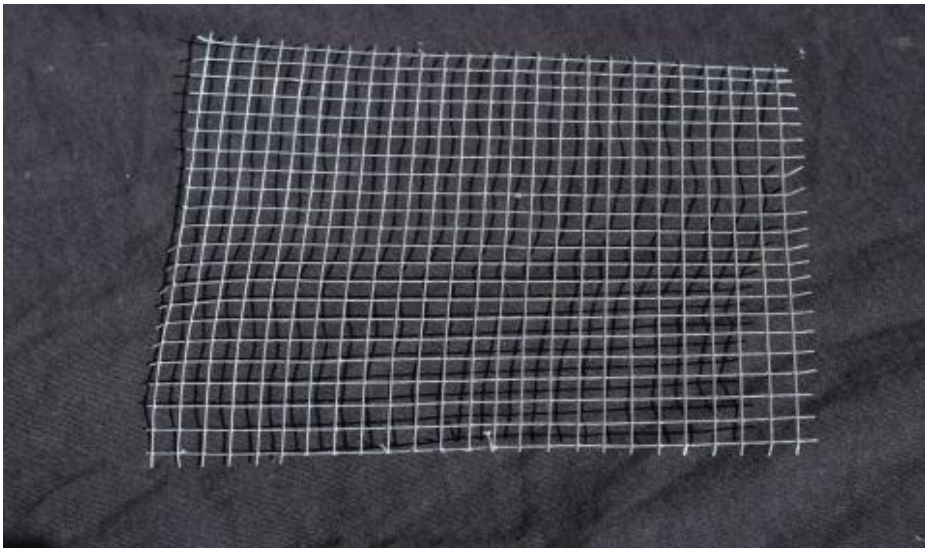

Figure 34: Hardware cloth. Figure credit: Bruce Badzik.

Stainless-steel Hardware Cloth: Cover floor drains with ¼ inch mesh, heavy 16- to 19-gauge stainless steel hardware cloth or a commercial cover with openings smaller than ¼ inch; do not leave any openings around the sides any larger than ¼ inch. Covering drains will increase clogging, so be sure to inform building maintenance staff when you install these screens.

Metal Window Screening: Although all windows should be screened and sealed, it is especially important to select rodent-proof material for the screen of windows near the ground. Low windows can be protected from rodents with 19-gauge, 1/4 inch mesh galvanized wire cloth. Use metal screening on all other windows.

Weather Stripping

Many different types of weather stripping are commercially available for sealing small spaces between movable parts like doors and windows. However, special types of weather- stripping can be obtained for unusual applications. Refer to manufacturer catalogs for specific products suitable for your needs. (*See Appendix F: Traps, Exclusion, and Building Materials, and Repellents*)

Compression Seals: Compression seals are used around pipe wall junctions to eliminate air flow. They are commonly made from felt, foam, or sponge materials and are not highly resistant to gnawing rodents. Compression seals are best used for non-uniform gaps, are inexpensive, and are easy to install; however, they are less durable than other kinds of weather stripping.

Interlocking Seals: Interlocking seals are made in two pieces and form a double seal on door jambs, door bottoms, and windows. They are relatively expensive, and they may require installation by a carpenter. They are not suitable for non-uniform gaps, but they are permanent, highly effective and unobtrusive, and they offer moderate resistance against rodents.

Door Sweeps

Although door sweeps require frequent repair, good door sweeps are one of the most important means for keeping rodents out of structures. To keep rodents from gnawing on door sweeps, install metal kick plates on the outside of doors, allowing less than ¼-inch clearance to the floor. Gustatory repellents (bad-tasting substances) are sometimes applied to rubber and vinyl door sweeps and seals to keep rodents from gnawing on them.

Compressible Threshold Seals: Compressible rubber or vinyl threshold seals fit on door bottoms or thresholds and are suitable for uneven gaps. These will require regular inspection and maintenance over time.

Common Door Sweeps: Common door sweeps include felt, vinyl, and stiff-bristle sweeps that are inserted in a metal holder and used to weather-seal door bottoms (Figure 35). They are suitable for slightly uneven gaps, are moderately priced, are easy to install, but they are highly visible. Sweeps with elongated mounting holes for screws allow readjustments as the sweep wears. Automatic door sweeps are also available; these drop to seal against the floor when the door closes, but they may require professional installation.

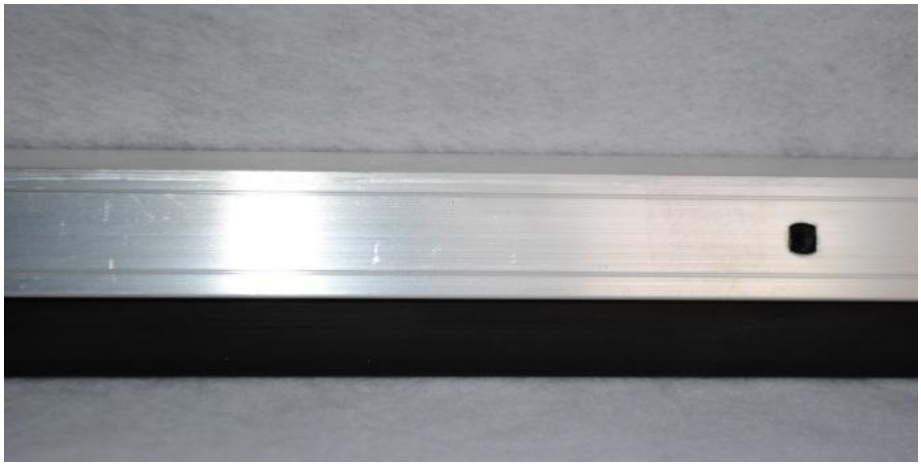

Figure 35: Common Door Sweep made from aluminum and a heavy-duty rubber material. Figure credit: Bruce Badzik.

Brush-Style Door Sweeps: Heavy-duty brush door sweeps offer excellent rodent proofing for a wide variety of door types (e.g., standard doors, roll-up doors, hangar doors, etc.). Although more expensive than other door sweeps, they are very cost effective (Figure 36).

Garage-door Strips: Weather stripping used on overhead garage doors is usually either a flat rubber strip or round rubber gaskets that compress under the weight of the door. Garage door sweeps are suitable for somewhat uneven gaps, are durable, are moderately priced, and are easy to install. Rodent damage to garage door sweeps and compression gaskets is usually confined to gasket corners but these areas can sometimes be protected with metal flashings. Brush kits specifically made for garage doors are also very effective at keeping rodents out.

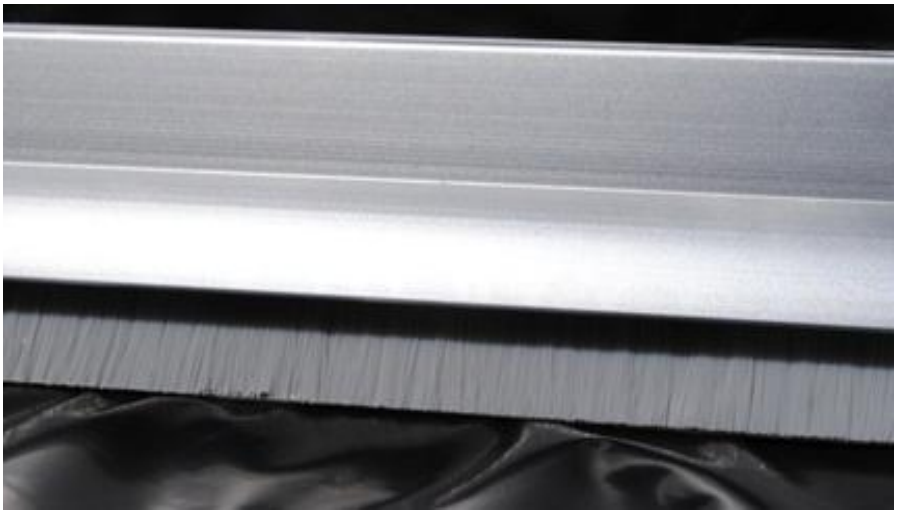

Figure 36: Brush style door sweep. Figure credit: Bruce Badzik.

Filler Materials

Lath Screen or Lath Metal: This is a galvanized, light-gauge metal mesh that is installed over wooden walls before the plaster finish is applied. This material is extremely malleable and can be wadded up and pushed into holes and is highly rodent-proof. Lath screen does not rust or bleed through caulk and can be easily compressed to completely fill odd-shaped openings. After forcing lath screen into holes, slightly expand its sharp edges with a screwdriver to better fill the cracks and force the metal into the edges of the hole.

Steel Wool: Only 00-sized steel wool can deter rodents and is an "easy to use" filler for small holes. However, steel wool is flammable, rusts, and rodents often work their way between the steel wool and edges of the opening. Always caulk over steel wool to seal it in place and to make it easier to determine if rodents have penetrated the seal.

Copper Mesh: Copper mesh material, such as the commercially-available Stuf-Fit®, is a compressible product that does not rust. As is the case with steel wool, it is best to caulk over openings filled with copper mesh as rodents can push the mesh aside to gain entry through an opening (Figures 37 and 38).

Copper Screen: Copper is a soft metal and can be penetrated by rodents over time. However, copper may be more durable than stainless steel in marine environments. Copper screening must be regularly inspected to ensure rodents have not penetrated.

Aluminum and Plastic Screen: Aluminum and plastic screens only serve as a temporary rodent deterrent as rodents can easily chew through them.

Figure 37: Stuf-Fit® copper mesh. Figure credit: Bruce Badzik.

Figure 38: Steps for installing copper mesh to exclude rodents: fecal pellets (droppings) were detected, area was cleaned with bleach, and snap traps were set. Stuf-Fit® copper mesh was installed to eliminate rodent access point. Figure credit: NPS Figure.

Caulking Compounds

The terms caulk and sealants refer to two different types of products:

- Caulks or caulking compounds are non-elastomeric, i.e., they do not return to their original size and shape after being stretched or compressed and should only be used for filling small joints (1/4 inch or less) where little or no movement is expected;
- Sealants are elastomeric materials used to seal joints where movement is expected;
- Sealers, a third type of material used in pest exclusion, (not to be confused with sealants) is used to seal pores and hairline cracks.

Oil and Oil Resin Caulking Compound: These inexpensive, easy-to-apply products are long-lasting (from one to four years), cure slowly and have superior smoothing qualities, even in cold weather. However, they may discolor, shrink, or adhere poorly to porous surfaces (e.g., brick) and require paint thinner for cleanup. An oil-based caulking compound is adequate for filling small holes and cracks that are not subject to stress (e.g., between wooden frames and siding).

Latex Caulking Compounds: This caulking can be either acrylic or vinyl. Acrylic latexes are good for non-moving joints, last longer, and have better weathering characteristics, but they are more expensive than vinyl latexes. Both products are easy to apply, cure quickly, do not stain or bleed, clean up with water, are durable (three to ten years), have good adhesion, and do not shrink greatly. However, latex caulking compounds may freeze before hardening if applied during cold weather.

Butyl Caulking Compounds: These are slow-curing products but very good for sealing gaps between metal and masonry and for joints up to ¾ inch wide and 3/8 inch deep. Butyl caulking compounds are slightly more durable than latex-based caulking compounds but are more difficult to apply. However, butyl-based caulking compounds are resistant to shrinking, possess excellent adhesion properties, and are good for use below ground level. This material is flammable when wet and requires paint thinner for clean-up.

Elastomeric Sealants

This group of materials includes silicones, polyurethanes, polysulfides, etc. They are best used for joints subject to movement (e.g., between masonry and wood, metal, or fiberglass siding). Silicones can be used in cracks larger than 1 inch wide and ½ inch deep and are quite durable (for up to 20 years). Elastomeric sealants cure rapidly, are waterproof, remain flexible in a wide range of temperatures, show excellent resistance to shrinking, and adhere well to most materials. However, only certain formulations can be painted and these sealants are more expensive than other caulking compounds and require solvents for clean-up.

Asphalt Sealants: Asphalt sealants are tough, outdoor caulking materials that mice have been observed gnawing but not penetrating. It remains flexible between expanding and contracting surfaces; resists oil, grease, salt, and heavy traffic; and sets up tack-free in about 30 minutes. The color selection is limited, and they require mineral spirits for clean-up and thinning. Vegetable oil may also be used for cleaning.

Roof Cement (in caulking tubes): This material is softer and thinner than canned roofing cement and is easier to apply. Products containing fiber material can fill larger gaps and are more durable.

***Roof Cement (in cans):* This material is waterproof, pasty, and expands and contracts with temperature fluctuations, sticks to nearly everything it touches (as long as the items are dry and not dusty) and is a good for cementing around chimney flashings. Roof cement lasts twice as long as mortar when applied to clean and dry surfaces and is relatively inexpensive when compared to other types of adhesives.**

Epoxy and Fiberglass Resins: These materials can be used for caulking and filling holes. They are available from auto and boat-repair supply sources. Many formulations harden quickly, are highly durable, weather-resistant, and rodent-proof.

Mortar and Cement Products

There are many new concrete patching products on the market, some dry in as short as 30 minutes and others come pre-mixed. Read the label before purchasing to ensure proper selection and usage. There are numerous quick-setting products such as Fix-All®, or Quick-Fix® which are for interior use, and Concrete Patch®, Rockite®, or Pour Stone® for interior or exterior use. The five previously mentioned products are specifically designed for repairs and have good adhesion, quick setting, non-shrinking properties which make them very well suited for exclusion work.

Traditional cement and concrete: These materials are good for large jobs (e.g., steps, sidewalks, tuck-pointed foundations, chimneys, barriers around slabs and sidewalks). The best cement mixes for rodent-proofing are one part cement to three parts sand or richer. For concrete, use one part cement to two to four parts sand, or richer. Reinforcement with hardware cloth is recommended for vertical or overhead horizontal surfaces to add strength and the necessary backing. Rats can claw and gnaw at concrete and Portland cement until it is fully cured, so the use of ½ inch hardware cloth in the top of the patch may be necessary if rodents are using the repair area as an entry point.

> *Note: Metal products placed within 1 inch of a concrete surface will oxidize and corrode and may discolor the concrete.*

Cement Mortar: Mortar, is a mixture of lime or cement with sand and water and used as a bedding and adhesive between adjacent pieces of stone, brick, or other material in masonry construction. Lime mortar, a common variety, consists usually of one volume of well-slaked lime to three or four volumes of sand, thoroughly mixed with sufficient water to make a uniform paste easily handled on a trowel. Lime mortar hardens by absorption of carbon dioxide from the air. Once universally used, lime mortar is now less important because it does not have the property of setting underwater and because of its comparatively low strength. It has largely been supplanted by cement mortar, commonly made of one volume of Portland cement to two or three volumes of sand, usually with a quantity of lime paste added to give a more workable mix. Cement mortar, besides having a high strength generally equal to that of brick itself, has the very great advantage of setting or hardening underwater.

Cement Patching Powder***:*** Cement patching powder has similar physical characteristics to cement but is used in smaller applications. It is available in small-sized containers, easy to mix, and most brands harden in less than four hours and provide good to moderate rodent exclusion (Figure 39).

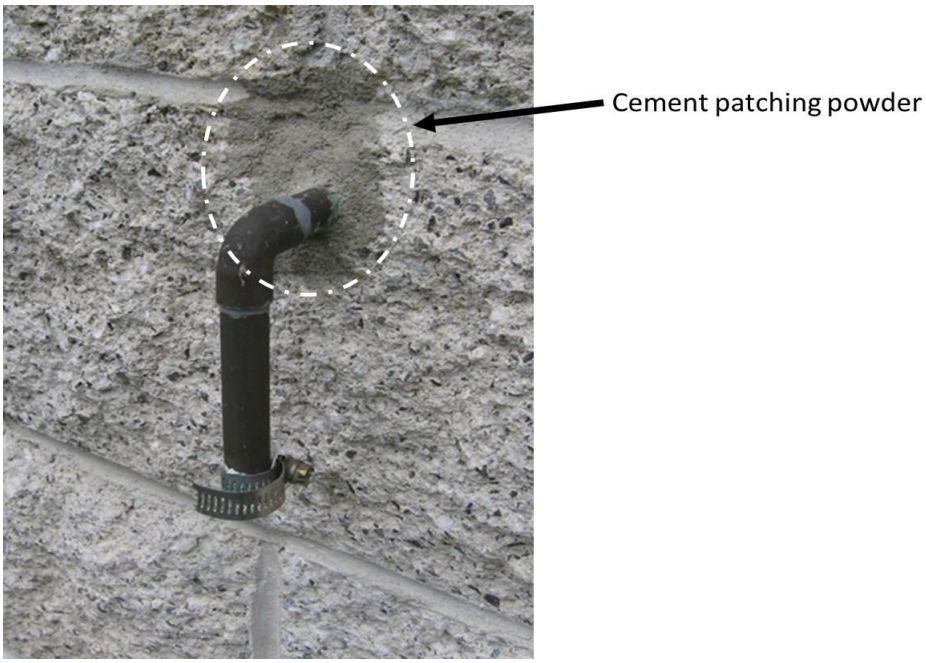

Figure 39: Cement is suitable for some pipe-wall exclusion. Figure credit: NPS Figure.

Wood

Wooden patches on holes can effectively repel smaller rodents if there are no gnawing edges (e.g., butts, joints, holes, other surface breaks). Use the smoothest and best grades of wood available.

Sanitation and Habitat Modification

Although it is clear that excluding rodents is the most important key to preventing rodent infestations, good interior sanitation is always important in managing rodents. Good sanitation practices have tremendous impact in limiting the sizes of or increases in rodent populations.

Guidelines to good sanitation practices include the following:

- Reduce and eliminate all possible food and water available to rodents and promptly repair all water leaks.
- Store all foodstuffs (e.g., dry pet food, grass seed/cereal grain, groceries) in glass, metal, or durable plastic rodent-proof containers.
- Keep all garbage cans tightly covered, remove garbage from buildings every night, and empty outdoor garbage containers at least twice a week.
- Promptly remove leftover food not eaten by pets or people.
- Remove or secure in rodent-proof containers foods stored in desks, cupboards, or filing-case drawers.
- Do not take food into rooms other than the kitchen or snack room.
- Keep stove tops clean, and clean frequently around and under stoves and lower stove drawers.
- Clean frequently under bottom drawers in built-in kitchen cabinets.
- Clean lint from refrigerator cooling coils, drip pans, and from under refrigerators.
- Ensure all site occupants understand that their cooperation managing their own food and trash is essential to prevent rodent activity. Each person is responsible for immediately cleaning up all crumbs, and cleaning dirty dishes, putting food away in secure containers, and cleaning cookware and dishes to prevent potential rodent food sources.
- Mice will nest in any undisturbed area. Move furniture when vacuuming to clean behind /under it and to inspect for rodent signs.
- Store items a minimum of six inches above the floor to reduce potential rodent habitat. Elevate furniture above the floor by placing on legs or blocks to facilitate inspections and cleaning beneath it.
- Remove all stacks of paper, plastic sacks, cardboard boxes, and other items rodents could use for shelter. All forms of clutter should be eliminated.
- Remove as much grass, weeds, clutter and debris as possible from around buildings. These materials provide food sources and harborage sites for rodents.
- Maintain an 18-inch wide, gravel or rubber mulch, vegetation-free zone around buildings. Wood mulch should not be used because it can retain moisture against the building perimeter and provides suitable habitat for ants, scorpions, and other perimeter invaders. Trim back plants 18-24 inches from structures and cut tree limbs back to six feet from structures. Trim tree limbs back

as well and remove vegetation growing on the structure as this provides pathways and habitat for rodents.

Importation of Rodents

Rodents can easily be transported into buildings from the outside. Animals are sometimes brought in with grocery sacks, boxes, patio furniture, firewood, and other items. Do not store firewood inside unless it will be used immediately. Firewood stored outside should be stored six inches or more off the ground and as far away from the structure as practical. Isolate and inspect all incoming items for live rodents or signs before bringing them inside.

Construction Sites

Store lumber, rubbish, equipment, construction materials, and other items on pallets raised at least 18 inches off the ground and located at least 30 feet from buildings, walls, and fences. It is better to place exterior lighting on poles out and away from structures and to direct the light back on to buildings from a distance. This prevents the attraction of night-flying insects, which can serve as a food source for rodents.

Preventing Rodent Damage in Unoccupied Buildings

Reduce rodent damage to furniture and household contents in unoccupied cabins and houses by removing or limiting food, harborage, and nesting sites. Remove bed linens and hang mattresses on taut lines between ceiling beams. Remove padded cushions from furniture and store cushions on edge, separated from one another and off the floor. Store all boxes and other materials on raised pallets or shelves. Place all stored food in rodent-proof containers or cabinets. If routine monitoring can be done, set (un-baited) snap traps and check periodically for rodent activity. Leaving traps unattended for long periods of time may result in rodent carcass serving as a food source or attractant for other pests such as Dermestid beetles or blow flies.

Evaluation

Once exclusion work is completed, the effectiveness of the intervention must be evaluated by post exclusion (ongoing / periodic) monitoring and evaluation. It is extremely important for maintenance, resource managers, park concessioners, and integrated pest management staff to all be involved in this process. Because rodent management involves and affects many different parties across disciplines, every park should have a mechanism for streamlined communication and documentation of rodent-related issues. This documentation system must integrate input from several different sources:

- Reporting Signs of Rodents (see The Indicators of the Presence of Rodents):
  - Visitor observations (these MUST be documented and addressed)
  - Employee observations
  - Other – Fire, Interpretation, Friends Groups, etc.
- Inspections: Inspections from the following program areas must be compiled into one location so the Park IPM Coordinator can evaluate. Inspections should involve occupants using the site and structures (input from employees, residents, visitors).
  - Integrated pest management Park IPM Coordinator Public health and safety staff
  - Risk Management staff
  - Housing staff
  - Concessions representative
  - Facilities Maintenance staff
  - Cultural Resources
  - Concessions
  - Ranger Activities
- Maintenance/Facility Management:
  - Maintenance requests can be submitted from both concessioner and park staff to the designated Park IPM Coordinator or Maintenance Chief with an alert to the Park IPM Coordinator so these can be prioritized, categorized, and flagged as rodent-related to allow tracking of completion
  - Once a request for rodent-related work is submitted, it is extremely important that a follow-up inspection occurs following any maintenance work

Visitors, employees, and concessions staff, are the eyes and ears in the park, having the most contact with buildings and facilities where rodent issues may occur. Therefore, it is crucial that any and all reports of rodent activity or signs are documented in a manner that facilitates concessioner and park maintenance to safely and immediately address these issues. This system of documentation must have protocols in place and be made available to wildlife/resource managers, facilities maintenance, and integrated pest management personnel to allow reporting, documentation, and surveillance. This

on-the-ground early detection and monitoring can help to identify problems and facilitate rapid response before they become too big to easily handle or before significant public health effects occur.

The system used for documenting rodent complaints would ideally link to a facilities management information system that allows automatic generation of work orders and alerts for maintenance and concessioner personnel. Otherwise, each report of rodent activity should be entered into the facilities management information system as a work order. Regardless of the system used, work orders need to be categorized or specifically noted as rodent-related or rodent-exclusion work. This will help integrated pest management, resource, facilities, concessions, risk management, and public health and safety staff monitor the needs and success of the program. Inspection reports from concessions, maintenance, public health and safety, and integrated pest management that are inserted or linked to the facilities management information system to hasten work order generation and maintenance actions.

Most importantly, every work order for rodent exclusion must be re-inspected after work is completed. Rodent exclusion is often an iterative process, where trial and error are required to ensure all access points are identified and exclusion efforts are sufficient to withstand rodents' efforts to re-enter the excluded structure.

Monitoring records will demonstrate the effectiveness of treatments. This information can be used to show the needs for developing more effective management strategies or control methods. This information should also be presented at regularly scheduled meetings with site occupants and the site manager to ensure their cooperation.

Use diagrams of exterior and interior floor plans to document exclusion work on a structure and monitor effectiveness, to identify locations where traps or non-toxic tracking stations have been placed. Assign specific individuals to conduct regular monitoring, and establish a fixed schedule for those activities. Maintain written records (on a monitoring form), to show rodent signs around the outside of structures, developing structural deficiencies or deterioration that could allow access. Signs clearly indicating the potential for rodents to move into structures are increases in numbers of rodents around a building (resulting from changes in weather, or from seasonal changes in the amount of food or shelter available to rodents) and newly developed structural deterioration.

Monitor for possible rodent activity inside buildings, by placing traps and non-toxic tracking stations in all areas of likely rodent harborage. (*See Appendix F: Proper Use and Placement of Snap Traps)* Regularly check traps and tracking stations, and individually record them on a floor-plan drawing, along with the numbers and types of rodents captured (or tracking stations showing rodent activity). Maintain records of the location of snapped traps that failed to catch rodents and of traps not snapped but had the bait removed as these incidents provide information on rodent activity and help you to focus your exclusion efforts.

Observe and record the presence and locations of any rodent sign (e.g., feces, food damage, feeding stations, gnawing damage, rodent holes), and question occupants about their observations of rodent activity.

Over time, the written monitoring record will provide very helpful information on the actual presence of rodents, on the relative increases and decreases in the number of animals present, and will also clearly point out those areas in the building where rodent activity is heaviest.

A Final Note

Native rodents in natural settings are wildlife and protected under National Park Service policy as they are an integral and ecologically important component of healthy ecosystems. Nonnative rodents however, present a threat to native ecosystems and must be removed when feasible through active management. In human occupied areas, structures and in developed landscapes, neither native nor exotic (nonnative) rodents can be tolerated due to the potential human health risks from rodent borne disease and to the potential damage rodents can cause to park resources. The information in this document provides guidance on managing rodents through exclusion in human occupied structures and developed landscapes.

The *Rodent Exclusion Manual*: *Mechanical Rodent Proofing Techniques: a training manual for National Park Service Employees* will continue to be updated as new information is available on rodent management.

September 2014

Appendix A: Selected References

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Appendix B: Rodent Inspection Form

Inspected by_____ Date_____ Bldg. No._____

EXTERIOR AREAS

Trash areas cleaned and well maintained to deny rodents food. Yes ___ No___

Wood stacked and stored directly next to the foundation providing rodent habitat.
Yes___ No___

Foundation areas free of clutter or trash that might attract rodents. Yes___ No___

Pet food and water present proving food source for rodents and wildlife. Yes___ No___

Gaps greater than ¼ inch at siding –foundation junction to allow rodent entry. Yes___ No___

Holes or crevices in foundation that are ¼ inch or larger that allow mouse entry.
Yes ___ No___

Soft or spongy areas of roof, rodent burrowing. Yes___ No___

Shingles damaged or missing, allowing rodent entry. Yes___ No___

Evidence of water pooling or inadequate drainage. Yes___ No___

Gutters leaking, unclogged, properly pitched. Yes___ No___

Rain cap/spark arrester on chimney and in good condition. Yes___ No__

Chimney missing bricks or mortar in poor condition. Yes___ No___

Flashing on chimney present, signs of deterioration, leaking. Yes___ No___

Evidence of rodents or other animal activity. Yes___ No___

Plumbing stack screened. Yes___ No___

Flashing present around stacks, signs of deterioration or leaking. Yes___ No___

Kitchen and bath vents screened. Yes___ No___

Attic vents if present, screened. Yes___ No___

Tree limbs at least 6 feet away from roof areas. Yes___ No___

Other plants providing access to the roofs (i.e. ivy, tall shrubs, vines) Yes___ No___

Shrubs are not overgrown or provide habitat for rodents. Yes___ No___

Moisture damage behind or under gutters. Yes___ No___

Soffit screens present and screened. Yes___ No___

Other ventilation openings (bathroom, kitchen) present and screened. Yes___ No___

Presence of gaps ¼ inch or larger between siding and frieze boards and/or fascia boards.
Yes___ No___

Presence of "smudge or grease marks" (rodents accessing attic through gaps). Yes___ No___

Dryer, bathroom, or kitchen vents caulked and screened. Yes___ No___

Openings for air conditioner and gas utility pipes and hose sealed. Yes___ No___

Electrical, cable TV, telephone openings in the siding sealed. Yes___ No___

Threshold seal present and in good condition. No gap ¼ inch or larger. Yes ___ No ___

Garage door, no light visible from inside looking out. Yes ___ No ___

Rodent proofing brushes or weather stripping installed at door to floor/trim Yes___ No ___

Gaps present at molding-siding junction and need sealing. Yes __ No ___

Gaps at siding-foundation junction allowing rodent entry. Yes __ No ___

Cracks in foundation. Yes __ No__

Foundation vents screened and in good condition. Yes ___ No___

Vents not blocked by landscaping. Yes __ No ___

Vines climbing on structure. Yes __ No ___

Shrubs are overgrown and/ or create "caverns" attractive to rats. Yes__ No ___

Evidence of animals nesting/ hiding under decks, porches or outbuildings. Yes ___ No ___

INTERIOR AREAS

Attic vents screened and in good repair. Yes __ No ___

Attic well organized with access to all perimeters walls and corners. Yes __ No___

Rooms, closets, and other areas uncluttered and allow for a rodent inspection. Yes ___ No ___

Plumbing, and electrical openings in walls and floors with gaps ¼ inch or larger Yes ___ No ___

Cracks and crevices in walls, between cabinets and walls. Yes ___ No ___

Cracks in concrete slab ¼ inch or larger allowing rodent entry Yes___ No ___

Garage, basement, and crawl space well organized with access to all perimeter walls,
Yes ___ No ___

Windows and/or vents tight fitting, no gaps. Yes ___ No ___

Floor drains with tight fitting covers and screened. Yes ___ No ___

Exterior doors weather stripped, good condition no gaps over ¼ inch. Yes___ No ___

Pet food, bird seed, and/or human foods in rodent-proof containers.
Yes ___ No ___

Diagram of findings, use numbers from corresponding questions on other site to identify problems

Notes:

Required follow-up tasks and date each work order was submitted:

Appendix C: Example of a Written Inspection Report

Site: Housing Complex A **Inspector:** Bill Raticus

Structure name & Asset #: Employee Housing Building #008 **Date:** 4/05/2014

Rodent Inspection and Recommendations of Trailers

Notes: This trailer is approximately 8 years old and used for seasonal housing of temporary employees. Due to obvious rodent activity in both trailers #1 and #2, I recommend implementing a snap-trapping program immediately as well as exclusion measures noted below. If these actions cannot be implemented the residents should be relocated until the trailers can be rodent proofed and cleaned in accordance with current rodent management guidelines.

The general sanitation and trash management needs overall improvement indoors and exterior trash cans need to be replaced with new receptacles with rodent proof cans with tight fitting lids. I recommend providing information on rodent detection and management to the residents as their cooperation is required to remove food and clutter/potential rodent habitat

Trailer # 1

I was finally able to inspect the interior of this trailer and speak with the resident before I left the park. The resident and his roommate have only been in the trailer since early October and said they have had considerable problems with mice and have lost food items to rodents. I observed mouse feces in the trailer and larger, rat-size fecal pellets were found near the kitchen corner next to the furnace cabinet. Although sanitation in this trailer left a lot to be desired, there are several changes the residents can make to lessen rodent problems inside the trailer until major repairs are completed.

DEFICIENCIES

EXTERIOR

- A large portion of the trailer skirt is missing from this trailer. The bottom covering of this trailer is relatively intact and seems to only be broken on the south east corner and where pipes penetrate the floor. It may be possible to repair the bottom covering and screen pipe penetrations rather than installing a completely new skirt. If the decision is to install a new skirt, install 'L' wires, hardware cloth at the base of the skirt all around the trailer.
- Repair windows that do not close and remove wadded up plastic bags that are currently filling these openings.
- Remove all vegetation at the rear of the trailer out to 3 feet from the trailer.
- Install supporting wooden framework for the hot water heater cabinet and a cabinet door. Carefully inspect the existing cabinet and replace rotten floor, open pipe, and electrical line chases and wall separating the cabinet from the kitchen sink.

INTERIOR

- Remove copper mesh pushed into crack (West side) of the living room floor and repair and reseal the floor.
- Close the opening around the clothing washer bib and caulk pipe chases at floor level.
- Re-caulk/seal the bathtub; various cracks are nearly large enough to allow mice to enter.
- Caulk the pipe chases under the bathroom sink at the toilet.
- No rodent activity was seen inside the furnace inspection door at this time however, I recommend sealing the bottom and upper louvers with hardware cloth.
- Caulk the pipe chase for the copper water inlet line located in the cupboard to the right of the kitchen stove.
- Replace the wall under the kitchen sink which separates the kitchen from the hot water heater cabinet; seal all pipe and chases.

TRAILER # 2

I was not able to speak with the resident of this trailer but a resident from nearby Trailer # 3 told me that the individual living in # 2 has had considerable rodent problems which they have not been able to control and, lately, found large, 'rat-like' animal feces in the kitchen. I planned to speak with the resident of trailer # 2 to provide a few pointers on both sanitation and rodent control or at least leave a note; however, our inspection of the trailer showed that major repairs are the priority here and need to be implemented ASAP to exclude rodents.

DEFICIENCIES

EXTERIOR

- Install a furring strip under the drip flashing.
- Install an 'L' wire, hardware cloth barrier at base of skirting.
- Caulk up the small holes around the trailer tongue.
- Caulk the gas line inlet chase.
- Repair loose trailer skirting panel on west side.
- Install new floor in hot water heater cabinet and seal all holes and pipe/electrical chases in interior walls and ceiling.

INTERIOR

- Insert compressed metal wire (lathe metal or copper mesh) in and then caulk over the open rodent hole in the bottom of the door facing.
- The kitchen stove contains rodent nests; remove and clean stove. We found rat-sized feces under the top and around the base of the kitchen stove; a medium-sized onion had been gnawed on and moved from one side of the room (where the resident stores onions on the floor) to the other side of the room near the stove.

- Caulk the kitchen pipe chases under the sink.
- There are abundant rodent feces in the floor heater vent. This allows rodent-contaminated dusts to be blown out with warm air. Clean the vents and check the heater ducts and bottom of the furnace under trailer for possible rodent entry.
- Seal up the large holes around the circuit breaker box and caulk electrical line chases at the floor level.
- Remove rusted steel wool and re-caulk bathroom pipe chases under sink and at toilet.
- Seal up the large hole around the clothing washer bibs and caulk pipe chases at floor level.
- Caulk the floor level holes in the east corner of the middle bedroom. Screen around the furnace, the base of the furnace, interior louvers, and around the furnace chimney pipe chase with 3 inch hardware cloth.

Copies of this report were provided to: Site Manager and Chief of Maintenance.

SIGNATURE: *Bill Raticus, Pest Management / Inspector, April 5, 2014.*

Appendix D: Example of Contract Specifications for Inspection

Rodent Exclusion Contract-Joshua Tree National Park

Contract specifications for rodent exclusion and cleanup work to be performed in Joshua Tree National Park, Twenty nine Palms California. Joshua Tree National Park lies 140 miles east of Los Angeles, 175 miles northeast of San Diego and 215 southwest of Los Vegas

1. **CONTRACT WORK LOCATIONS.** Depending upon funding this contract may cover work at up to six separate locations throughout the park. This contract covers the interior and exterior of the following structures located in the park.

1._____

2._____

3._____

4._____

5._____

6._____

1. 1. WORK TO BE PERFORMED. The exclusion work to be performed is to cover, but is not limited to excluding the following rodents from structures: House mouse, Sonoran Deer Mouse, Cactus mouse, Desert Wood rat. In addition the contractor is responsible for cleaning up and disinfecting areas that contain: rodent droppings, rodent urine, body fluids, and nesting material that may contain material that pose a threat to human safety such as Hantavirus, Arenavirus, Salmonella, etc.

1.2 GENERAL

These specifications are part of a comprehensive Integrated Pest Management (IPM) program for the sites listed above. IPM is a process for achieving long-term, environmentally sustainable pest management through the use of a variety of management practices. These practices include structural and procedural modifications that reduce pest access, food, moisture, and harborage within the structures listed above. The contractor shall follow all conditions of this contract to ensure the effectiveness of the rodent management plan for this park. If the contractor fails to follow any or all of these specifications they shall be held accountable for all costs related to correcting the deficiencies.

A. Service Requirements. The contractor shall furnish all supervision, labor, materials, and equipment necessary to accomplish the inspection, rodent proofing and clean-up of said sites. All work shall be done in a professional manner so as the contractor can provide at minimum a five (5) year guarantee of workmanship.

B. All contractor representatives working in or around the buildings specified in this contract shall wear distinctive uniforms identifying the name of their employer.

C. Vehicles used by the Contractor shall be identified in accordance with State and local regulations. At no time is the contractor to operate any vehicles on any unpaved roads, except for the following:

_____

D. Before any work starts, the contractor with a representative from Joshua Tree National Park (JOTR) shall inspect all work sites, including attic spaces. The contractor shall inspect all attic vent screens to ensure they are adequate to prevent rodent entry. The contractor shall submit a written report noting all rodent entry points that are not included in the JOTR Rodent Exclusion Plan.

E. All work shall be done during normal working hours for park staff. Work shall be conducted Monday through Friday excluding holidays unless written approval from JOTR staff is obtained.

F. All work shall be done in compliance with state and federal building codes.

G. All work will be done in a safe manner in compliance with Occupational Safety and Health Administration (OSHA) rules and regulations.

H. All cleanup and disinfection work shall be performed following the guidelines created by the Centers for Disease Control (CDC) for the clean-up of areas contaminated with material that may contain substances that can cause hantavirus.

2. HISTORIC STRUCTURES

The majority of structures included in this contract are considered by National Park Service and federal standards and are protected by federal law under the Historic Preservation Act. All exclusion work conducted on historic structures in the park must be done in such a manner as to be compliant with Section 106 of the Historic Preservation Act.

A. The contractor and park staff shall inspect each building before exclusion work begins and identify what exclusion procedures are acceptable at each individual structure. If the contractor fails to follow this standard, the contractor will be held financially responsible for corrective work to bring violations in to compliance with park standards.

B. If the contractor encounters a situation where structural conditions (i.e. dry rot, termite damage etc.) may compromise the integrity of the exclusion work, the contractor shall immediately stop work contact JOTR staff to decide the appropriate action(s) to implement to remedy the situation.

C. All exclusion work shall be done in a manner to limit or prevent any unnecessary damage to historic fabric.

D. If non-paintable caulking compounds are to be used on interior or exterior surfaces, JOTR staff will be notified before application occurs to choose the appropriate caulking color for that structure.

E. The contractor shall consult with JOTR staff to identify the proper disinfectant to be used when it is applied to historic fabrics as bleach may discolor historic wood and other materials.

3. CLEAN UP AND DISINFECTION

A. The contractor is responsible for the removal of all rodent droppings, urine, and nesting material in accessible areas. Areas considered inaccessible include tool boxes, lockers, and other personal property.

B. In areas such as attics where there is a possibility of historic or sensitive park service property being present, the contractor will be responsible for notifying JOTR staff of its presence. All NPS property removed from attics and other access limited areas will be disinfected placed in double bagged trash bags and brought to an area agreed upon by the contractor and JOTR staff so park staff can inspect it to assess if the material should be disposed of or kept.

C. The contractor is responsible for the disposal of all material such as rodent droppings, nesting material, urine, and other grossly contaminated material the JOTR has approved for the contractor to dispose of.

D. The contractor shall notify park staff if items such as lockers, storage cabinets, equipment or other heavy objects need to be moved to provide access for cleaning. JOTR staff is responsible for moving these items.

E. The contractor shall give park staff twenty four (24) hour advance notice of plans to clean and disinfect any structure included in this contract.

F. If there is a need to apply disinfectants on / or around the exterior of any building, the contractor shall notify park staff in advance and provide a label of the product they plan to use so park staff can ensure it does not pose a risk to any wildlife in the area.

4. MATERIALS

A. All materials used for exclusion work under this contract must be high quality commercial grade products. At minimum, all material used on this contract must meet the following specifications:

B. The use of steel wool is prohibited.

C. To exclude rats and mice hardware cloth must be woven/welded and be between 19-22 gauges.

D. Galvanized sheet metal used for wall or pipe barriers must be at least 24 gauge or heavier.

E. For kick plates or door edging galvanized sheet metal must be 22 gauge or heavier.

F. Aluminum used for flashing and frames must be at least 22 gauge.

G. Aluminum used for kick plates and guards must be at least 18 gauge.

H. When using concrete to fill holes, reinforced concrete must be at least 2 inches thick. For non-reinforced applications concrete must be at least 3 ¾ inches thick.

I. Caulking compounds must have a life expectancy of at least five (5) years.

J. Any disinfectants used must be disinfectants registered by the U.S. Environmental Protection Agency (EPA).

K. When using bleach to disinfect items, it must be a version registered with the US EPA and less than 6 months old.

Appendix E: Hantavirus Risk Reduction: Worker Protection

This document summarizes the updated recommendations from the Centers for Disease Control and Prevention (CDC) for hantavirus risk reduction for workers. The information is adapted from the Morbidity and Mortality Weekly Report, July 26, 2002; Vol. 51; No. RR09.

Precautions for Workers Frequently Exposed to Rodents

Persons who frequently handle or are exposed to wild rodents are probably at higher risk for hantavirus infection than the general public because of the frequency of their exposures. Such persons include, but are not limited to: wildlife specialists; maintenance workers; employees involved in rodent management; concessions managers; some custodial staff; and building and fire inspectors. Therefore, enhanced precautions are warranted to protect them against hantavirus infection, as described below.

- Workers in potentially high-risk settings should be informed by their employers about hantavirus transmission and symptoms of infection, and be given detailed guidance and training on prevention measures. Determining the level of risk for HPS (Hantavirus Pulmonary Syndrome) in each work setting is the responsibility of the park. The Regional Public Health Consultant and Safety Officer may be contacted for assistance, if necessary.
- Workers who develop a febrile or respiratory illness within 7 weeks of the last potential exposure should immediately seek medical attention and inform the attending physician of the potential occupational risk of hantavirus infection.
- When removing rodents from traps, handling rodents, or cleaning heavily infested areas, workers should wear either a NIOSH-approved half-face or full-face, tight-seal, negative-pressure respirator or a positive pressure PAPR (powered air-purifying respirator), both options must be equipped with P-100 or N-100 filters. Employees must be in compliance with NPS Director's Order #50B and Reference Manual #50B for respiratory protection. Requirements include medical clearance and annual training and fit testing for each approved respirator type. Any individual wearing a respirator must be clean shaven.
- Workers should wear rubber, latex, vinyl, or nitrile gloves when cleaning or working in rodent infested areas, handling rodents or handling traps containing rodents. Before removing the gloves, wash gloved hands in a disinfectant or chlorine solution and then wash bare hands in soap and water.
- Mammalogists or wildlife biologists who handle wild rodents for research or management purposes should refer to the published safety guidelines available on CDC's website, All About Hantavirus (http://www.cdc.gov/ncidod/dvrd/spb/mnpages/rodentmanual.htm).

Precautions for Workers Having Potential Contact with Rodents

Persons who work in occupations with unpredictable or incidental contact with rodents or their nesting sites should follow general risk reduction recommendations and seek guidance from their safety manager or the Office of Public Health. Examples of such occupations include: archaeologists; natural resource specialists; utility operators; curators; and certain construction workers. Workers in these jobs may have to enter buildings and crawl spaces, or might otherwise be exposed to sites or materials that are potentially rodent-infested. Recommendations for such circumstances must be made on a case-by-case basis after the specific working environment has been assessed. The Regional Public Health Consultant or the Safety Officer may be consulted as needed to assist in the assessment. Determining the level of risk present and implementing appropriate protective measures is the responsibility of the park.

Areas with evidence of rodent activity (e.g., dead rodents, nests, and droppings) should be thoroughly cleaned to reduce the likelihood of exposure to hantavirus-infected materials. Cleanup procedures must be performed in a manner that limits the potential for dirt or dust from contaminated surfaces to become airborne. Recommendations are listed in this report for cleaning up (1) rodent urine and droppings, and surfaces potentially contaminated by rodents; and (2) dead rodents and rodent nests.

Cleanup

Cleanup of Rodent Urine, Droppings, and Contaminated Surfaces

- During cleaning, wear rubber, latex, vinyl, or nitrile gloves.
- Spray rodent urine and droppings with an EPA registered disinfectant or chlorine solution until thoroughly soaked (see Cleanup of Dead Rodents and Rodent Nests below). Allow disinfectant-soaked area to sit for at least 10 minutes before proceeding.
- To avoid generating potentially infectious aerosols, do not sweep rodent urine, droppings, or contaminated surfaces until they have been disinfected (soaked with disinfectant for at least 10 minutes).
- Use a paper towel to absorb the urine and disinfectant and pick up the droppings. Place the paper towel in the garbage.
- After the rodent droppings and urine have been removed, disinfect items and underlying surfaces that might have been contaminated by rodents or their urine and droppings.
    - Mop floors with a disinfectant or chlorine solution. Allow to sit for 10 minutes before rinsing.
    - Disinfect countertops, cabinets, drawers, and other durable surfaces with a disinfectant or chlorine solution. Allow disinfectant to sit on surface for 10 minutes before wiping down.
    - Spray dirt floors with a disinfectant or chlorine solution.
    - Disinfect carpets with a disinfectant or with a commercial-grade steam cleaner or shampoo.
    - Steam-clean or shampoo rugs and upholstered furniture.

- Launder potentially contaminated bedding and clothing with hot water and detergent. Use rubber, latex, vinyl, or nitrile gloves when handling contaminated laundry. Machine-dry laundry on a high setting or hang it to air dry in the sun.
- Leave books, papers, and other items that cannot be cleaned with a liquid disinfectant or thrown away, outdoors in the sunlight for several hours, or in an indoor area free of rodents for approximately 3 weeks before cleanup. After that time, the virus should no longer be infectious. However, to further reduce risk, wear rubber, latex, vinyl, or nitrile gloves and wipe the items with a cloth moistened with disinfectant.
- Before removing the gloves, wash gloved hands in a disinfectant or chlorine solution and then wash bare hands in soap and water.

Cleanup of Dead Rodents and Rodent Nests

- Wear rubber, latex, vinyl, or nitrile gloves.
- In the western United States, use insect repellent (containing DEET) on clothing, socks, and arms to reduce the risk of fleabites that might transmit plague, tularemia, or other diseases.
- Spray dead rodents and rodent nests with a disinfectant or a 10% chlorine solution, soaking them thoroughly. Wait 10 minutes before disturbing to ensure inactivation of the virus.
- Place the dead rodent or nest in a plastic bag, or remove the dead rodent from the trap and place it in a plastic bag. When cleanup is complete (or when the bag is full), seal the bag, place it into a second plastic bag, and seal the second bag. Dispose of the material in the double bag discarding it in a covered trash can that is regularly emptied.
- Clean up the surrounding area and area that was underneath the rodent as described in "Cleanup of Rodent Urine and Droppings and Contaminated Surfaces."

Disinfecting Solutions

Two types of disinfecting solutions are recommended to clean up rodent materials:

1. General-Purpose Household Disinfectant: These can be used for light infestations (i.e., rodent droppings present, evidence of chewing, but no extensive nesting or droppings). Prepare according to the label, if not pre-diluted. Almost any agent commercially available in the United States is sufficient as long as the label states that it is a "disinfectant" and it has an EPA registration number on the label. Effective agents include those based on phenols, quaternary ammonium compounds, and hypochlorite solutions at a 1:100 or greater concentration.
2. Hypochlorite Solution: A 10% chlorine solution, freshly prepared by mixing 1½ cups of household bleach in 1 gallon of water (or a 1:10 solution) can be used in place of a commercial disinfectant and should be used for heavily infested areas (i.e., several rodent nests with extensive droppings present). When using chlorine solution, avoid spilling the mixture on clothing or other items that might be damaged by bleach. Wear rubber, latex, vinyl, or nitrile gloves when preparing and using chlorine solutions. Chlorine solutions should be prepared fresh daily.

Cleaning Shed and Other Buildings

Before cleaning closed sheds and other outbuildings, ventilate the building by opening doors and windows for at least 30 minutes. Use cross ventilation if possible. Be sure that you do not stir up any dust when entering to open windows and leave the area during the airing-out period. This airing helps to remove infectious primary aerosols that might be created by hantavirus-infected rodents. In substantially dirty or dusty environments, additional protective clothing or equipment may be worn. Such equipment includes coveralls (disposable when possible) and safety glasses or goggles, in addition to rubber, latex, vinyl, or nitrile gloves. For recommendations regarding precautions for cleanup of outbuildings with heavy rodent infestations, see below.

Recommendations for Cleaning Homes or Buildings with Heavy Rodent Infestations

Special precautions are indicated for cleaning homes or buildings with heavy rodent infestations. A rodent infestation is considered heavy if piles of feces or numerous nests or dead rodents are observed. Persons cleaning these homes or buildings should contact their Safety Officer or Public Health Consultant. These precautions also can apply to vacant dwellings that have attracted rodents while unoccupied and to dwellings and other structures that have been occupied by persons with confirmed hantavirus infection. Workers who are either hired specifically to perform the cleanup or asked to do so as part of their work activities should receive a thorough orientation about hantavirus transmission and disease symptoms and should be trained to perform the required activities safely.

- If the building has been closed and unoccupied for a long period (weeks or months), ventilate the building by opening doors and windows for at least 30 minutes before beginning any work. The ventilation helps to remove aerosolized virus inside the structure. Use cross ventilation if possible. Leave the area during the airing-out period.
- Persons involved in the cleanup should wear coveralls (disposable, if possible); rubber boots or disposable shoe covers; rubber, latex, vinyl, or nitrile gloves; protective goggles; and a respirator with appropriate clearance, annual fit-testing, and approvals as detailed in "Precautions for Workers Frequently Exposed to Rodents."
- Personal protective gear should be decontaminated or safely disposed of upon removal at the end of the day. If the coveralls are not disposable, they should be laundered on site. If no laundry facilities are available, the coveralls should be immersed in liquid disinfectant until they can be washed.
- Wash hands thoroughly after personal protective equipment is removed.
- Unless burned on site, all potentially infectious waste material from cleanup operations should be double-bagged in durable plastic bags and then discarded in a covered trash can that is regularly emptied. Contact the local or state health department concerning other appropriate disposal methods.
- Persons involved in the cleanup who develop a febrile or respiratory illness within seven weeks of the last potential exposure should immediately seek medical attention and inform the attending physician of the potential occupational risk of hantavirus infection.

Special Considerations for Historic Structures or Structures with Dirt Floors

- Consult cultural resources staff before beginning any work in historic structures.
- Some disinfectants, such a 10% or greater bleach solutions or repeat use of other disinfectants, can change the color of an organic surface (such as wood, cloth, etc.). If this is a concern for a historic structure, disinfectants such as household disinfectants or isopropyl/ethyl alcohol might be more appropriate.
- Dirt floors should be treated as other hard surfaces, with extra care taken not to stir up dust. Thoroughly wet the area and adjacent area with disinfectant, allow the disinfectant to sit for at least 10 minutes, and use a wetted paper towel to clean up the droppings or material.

Contacts

- Integrated Pest Management (IPM) Program
- Public Health Program
- Risk Management Program
- Wildlife Health Program

Appendix F: Proper Use and Placement of Snap Traps

Snap traps (Figure 40) are used to safely and quickly remove rodents from indoor human occupied areas and must be used in conjunction with a rodent exclusion program. Snap traps will allow the site manager/pest manager to detect and record signs of rodent activity, potential rodent habitat and food sources. Share this information with the site managers to address needed repairs, prevent rodent access, and modify human behavior to reduce available food and harborage.

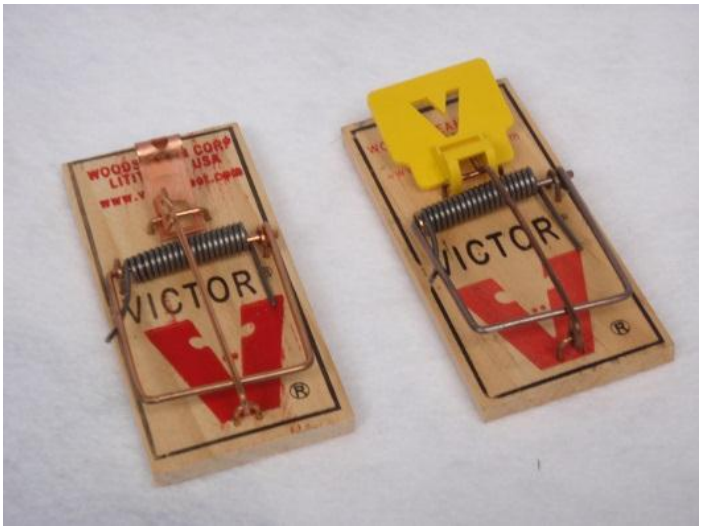

Figure 40: Image of a basic snap trap (left) and expanded trigger mouse trap with large yellow square to hold bait (right). Figure credit: Victor®.

Proper Placement of Snap Traps

- "Saturate with snap traps!" Use 10 traps in a 12X12 room.
- Place traps in any area where rodent activity is detected.
- Place snap traps in potential or confirmed rodent runways. Placing traps on both sides of a door threshold (4 traps per door, two inside, two outside) to increase success.
- Properly placed snap traps do not need to be baited. Rodents create established routes or runways for traveling and use these routes regularly. Look for rodent signs and place your traps in their pathway. These routes are marked with rodent urine and body oils (grease marks).
- Traps can be baited with food or cotton (nesting material) if necessary to attract wary rodents to the trap. Place a small amount of peanut butter the size of a pea on the trap pan on the snap trap (Figure 40). Rats and mice have different food preferences. Note that using bait may attract other animals creating secondary pest issues. Expanded trigger mouse traps, as demonstrated with the larger yellow pan (Figure 40), can greatly increase trap success.

How to Set a Snap Trap

1. Set the snap trap by holding the wooden base of the snap trap firmly in your hand or stabilize against the floor.
2. Carefully pull the spring-loaded bow up then down to the opposite side of the snap trap.
3. Holding the bow down against the opposite side of the snap trap, carefully place the locking bar over the bow and secure the locking bar in the metal loop provided. In Figure 41, the trap on the left is set, and the snap trap on the right is not set.

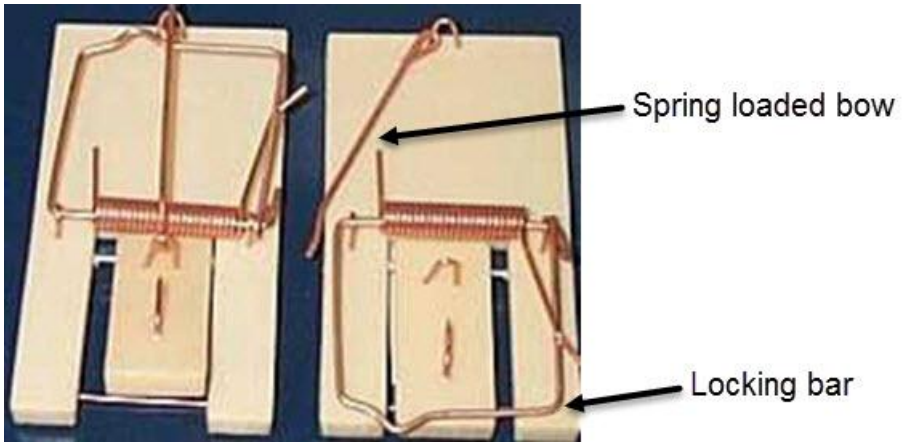

Figure 41: Spring loaded bow and locking bar of a snap trap. Figure credit: NPS Figure.

Place the set trap on the ground against a wall with the bait pan closest to the wall (Figure 42). Mice will avoid crossing open spaces as they prefer to travel along sheltered runways, along walls, under furniture, and in dark areas. Therefore, you should place the snap trap on the floor in areas where rodent activity has been reported. Place the set trap at the end of the day and record the location on a monitoring sheet with location and date (a monitoring form can be found in Appendix J of the Commensal Rodent Training Manual).

Return the next morning prior to people occupying the structure. Bring your monitoring form, pen, and spray bottle with 10% bleach (or disinfectant such as Lysol) with you to inspect the traps. If you catch a mouse, record the catch on the monitoring form with the current date. Spray the snap trap and mouse with 10% bleach solution and allow the sprayed mouse and trap to sit for approximately 15 minutes. This allows the bleach to reduce the risk of airborne disease transmission. Using latex, vinyl, or nitrile gloves with a plastic bag inverted over your hand, carefully pick up the trap and mouse, unfold the bag over the mouse and trap, and tie off or seal the bag. Place the bag into a second plastic bag and dispose of the double-bagged mouse and trap in the garbage.

Disinfect the area where the trap and mouse sat on the floor once they are removed. Spray gloves with disinfectant prior to removal; and wash your hands thoroughly.

Figure 42: Proper placement of a snap trap. Note the bait pan is toward the wall. Figure Credit: Centers for Disease Control and Prevention Viral Special Pathogens Branch.

Snap traps can also be set singly or in tandem, placing the traps either side by side along a wall or back to back along a wall with the bait pans facing out (Figure 43).

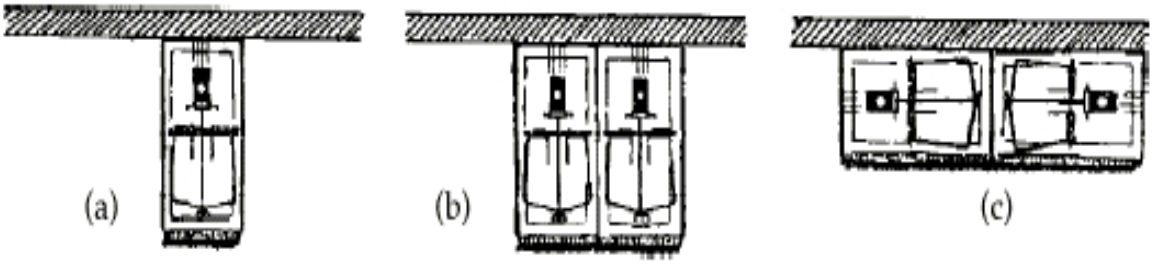

Figure 43: Placement of snap traps: (a) single trap with trigger next to wall; (b) double set, which increases your chance of success; (c) double set placed parallel to the wall with triggers to the outside. Figure credit: NPS Figure

Appendix G: Traps, Exclusion, and Building Materials, and Repellents

The resources listed below serve as examples and are not endorsed by the National Park Service.

Sources for Traps, Exclusion, and Building Materials

Woodstream Corporation
69 N Locust Street
Lititz, PA 17543
Mouse Traps: http://www.victorpest.com/store/mouse-control/snap-traps
Rat Traps: http://www.victorpest.com/store/rat-control/rat-traps

Do My Own Pest Control, Inc.
4260 Communications Drive
Norcross, GA 30093
866-581-7378
www.domyownpestcontrol.com/

Do-It-Yourself Pest Control
800-476-3368
http://www.doyourownpestcontrol.com/

Bell Laboratories, Inc.
3699 Kinsman Blvd.
Madison, WI 53704
1-608-241-0202 (phone)
1-608-241-9631 (FAX)
http://www.belllabs.com

ePestSolutions
6942 FM 1960E
Suite 293
Humble, TX 77346
888-523-7378
http://www.epestsolutions.com/
info@ePestSolutions.com

AP&G Co., Inc.
Brooklyn, NY
Toll-free: 800-458-7454
Fax: 718-860-3502
info@catchmaster.com
http://www.catchmaster.com/

J.T. Eaton
1393 East Highland Road
Twinsburg, OH 44087, USA
Phone: 800-321-3421or 330-425-7801
Fax: 330-425-8353
E-mail info@jteaton.com

Forestry Suppliers, Inc.
Forestry Suppliers Inc.
205 West Rankin Street
P.O. Box 8397
Jackson, MS 39284-8397
www.forestry-suppliers.com

Langley Wire Cloth Products
161 MT Pleasant Road
Collierville, Tennessee 38207
800-664-0748
http://www.iqsdirectory.com/hardware-cloth/

TWP Inc.
2831 Tenth Street
Berkeley, CA
800-227-1570
Mouse Exclusion
List of Pest Exclusion Mesh
Chimney Cap Mesh
General

Wildlife Control Supplies
P.O. Box 538
East Granby, CT 06026
1-877-684-7262
http://www.wildlifecontrolsupplies.com

Repellents and Sources

(Note: repellents are one potential tool in a Rodent Integrated Pest Management Plan and should be used in coordination with a snap trapping and rodent exclusion program along with education of site occupants to eliminate rodent food sources and access)

Fresh Cab (also known as STAY AWAY Botanical Rodent Repellent)

EPA Reg. #82016-1. This product contains balsam fir oil in balsam fir wood chips. Read MSDS and label (http://www.epa.gov/pesticides/chem_search/ppls/082016-00001-20140506.pdf)

EARTH-KIND, Inc.
2910 E. Broadway Ave. Warehouse #19
Bismarck, ND 58501
P: (800) 583-2921
P: (701) 751-4456
http://www.earthkind.com/products/featured-fresh-cab-rodent-repellent

EVAC Rodent Repellent
This is an EPA registered product made with plant fibers, fragrance oil, and balsam fir oil. Read MSDS and label at http://www.domyownpestcontrol.com/msds/EVAC_MSDS.pdf
Nisus Corporation
100 Nisus Drive
Rockford, TN 37852
800-264-0870
www.nisuscopr.com

DeTour Rodent Repellent Caulk
This product contains white pepper. Read MSDS and label at Bio Repellent Industries PiGNX Inc.
15568 Brookhurst Street # 178
Westminster, CA 92683
208-660-7668
Shake-Away Rodent Repellent Granules (outdoor, basement, attic)
Shake Away Mouse Pack Repellent (indoor human occupied area)
This product contains mint, rosemary, cedar oils and limestone. Read MSDS and label.
2330 Whitney Avenue
Hamden CT 06518
Toll Free 1-800-517-9207

Appendix H: Inspection Forms - Short

-Tailor these forms to reflect you the individual site

Rodent Inspection Short Form

Date_____

Inspected by:_____

Location: _____

Building Number_____

Site contact name and phone:_____

Exterior

Trash can has tight fitting lid and is at least 20 feet away from the structure	Yes___	No___
Firewood stacked and stored directly next to the foundation or structure.	Yes ___	No ___
Foundation free of clutter or vegetation that might attract or harbor rodents	Yes ___	No ___
Tree limbs or vegetation is cut back from structure and away from roof	Yes ___	No ___
Gaps in foundation ¼ inch or larger allowing rodent entry	Yes ___	No ___
Foundation vent screens missing or have holes in them	Yes ___	No ___
Roofing damaged or has holes allowing rodent entry	Yes ___	No ___
Electrical and/or plumbing access points have gaps greater than 1/4 inch	Yes ___	No ___
Exterior doors, no light visible from inside looking out	Yes ___	No ___
Threshold seal and/or door sweep present, in good condition	Yes ___	No ___
No moisture damaged areas	Yes ___	No ___
No debris, vegetation or other items under porch, stairs or structure	Yes ___	No ___
Windows fit tightly, screens are in good condition and fit properly	Yes ___	No ___
Tree or tree stumps with cavities present in area	Yes ___	No ___

Interior

No gaps over ¼. inch in size around plumbing and electrical openings in walls, floors, under sinks, behind appliances that might allow rodents entry into structure	Yes ___	No ___

Cracks and crevices in walls, between cabinets and walls, and cabinets and floors	Yes ___	No ___
Cracks in concrete slab allowing rodent burrowing	Yes ___	No ___
No gaps or holes in heater allowing rodent nesting	Yes ___	No ___
Attic vents are properly screened and screening is in good condition	Yes ___	No ___
Signs of rub marks, gnawing, droppings, tracks and other signs of rodent activity	Yes ___	No ___
Signs of chewed paper, cloth, food containers, and / or seeds	Yes ___	No ___
Gaps or cracks between wall and ceiling	Yes ___	No ___
Ventilation areas properly screened	Yes ___	No ___

Diagram of findings; use numbers from corresponding questions.

Notes

_____

_____