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Preface

Pest problems can be expected wherever humans have manipulated the natural environment. Parks, too, then, will inevitably have pests. However, the mere presence of a particular pest species does not constitute a pest management problem, unless and until those pests interfere with the management objectives of the park. Even then, specific criteria must be met before pest management action is undertaken.

It is National Park Service policy that **integrated pest management (IPM)** is the preferred method for managing pest species. IPM will be used--

> *"to determine when to control pests and whether to use mechanical, physical, chemical, cultural, or biological means...The choice to use a chemical pesticide will be based on a review by regional and Washington office coordinators of all available options and a determination that these options are either not acceptable or not feasible...Chemical pesticides that are not specifically exempt from reporting will be used only with prior approval by the Director on an annual basis.* (NPS *Management Policies* 4:13, 14)

Implementation of an IPM program is the responsibility of the superintendent, as well as the person he or she designates as IPM coordinator. It is the responsibility of all persons involved in the purchase, storage, and application of pesticides in any NPS unit to insure that IPM procedures and NPS policies are followed completely.

This training manual provides National Park Service resource managers, integrated pest management coordinators, maintenance staff, curators, and other NPS employees with detailed instruction on the biology and management of commensal rodents (rats and mice) using integrated pest management (IPM) practices. The manual can be used along with the National Park Service videotape *Integrated Pest Management: Commensal Rodents.*

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Chapter 1

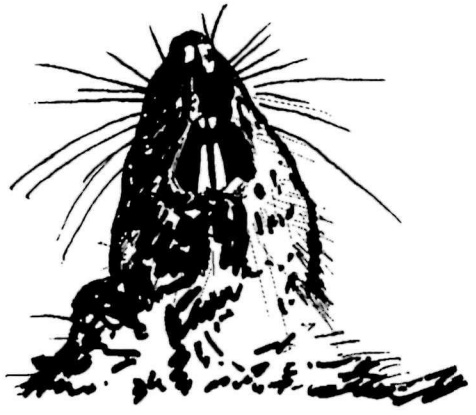
Introduction to Commensal Rodents and Their Management

Learning Objectives

After completion of this chapter, you should be able to

- Name and define "commensal rodents."
- Describe the ways commensal rodents can damage property and affect human health.
- List diseases of human health concern that may be associated with rats and mice.
- List the basic steps of an integrated pest management (IPM) program.

The animal kingdom is divided into a number of classes of animals which are more closely related to each other than they are to other groups. Like us, rodents are placed in the class Mammalia. Like all mammals, they suckle their young with "mammary" glands, have hair, and give birth to live young.



Rodents have prominent incisor teeth

The mammals are further broken down into subclassifications called "orders." The rats and mice are placed in the order Rodentia based primarily on their prominent incisor teeth...two above and two below...used for gnawing.

Many families make up the order Rodentia. The vast majority are native species and are essential components of the natural environment. However, our three most common species of pest rodent—the Norway rat, the roof rat, and the house mouse—are in the family Muridae, the old world rats and mice. As their family name implies, none are native to North America. They were introduced here unintentionally in the ships of explorers and colonists.

Old world rats and mice adapted well to living around people. So well, in fact, that they are commonly called commensal rodents. The word "commensal" comes from the Greek...*com* meaning "with" and *menna* meaning "table." Commensal literally means a "companion at meals," an apt description in many rodent infestations. Wherever there are people, there is food, water, and harborage for commensal rodents. Rats and mice most often become pests when people mismanage trash, provide easy access to food and water, allow entry inside buildings, and practice poor sanitation.

Commensal rats and mice live and breed inside buildings and granaries, in sewers and attics, in agricultural fields and warehouses, in ships and under concrete slabs. Although adapted to people, rats and mice are wary. Hundreds can be living in, under, and around a complex of buildings and few people in the area will be aware of their existence.

While one mission of the National Park Service is to conserve the wildlife within parks, monuments, and reservations, this protection does not extend to exotic species such as commensal rodents when these pests "threaten park resources or public health." And commensal rodents often pose such threats. (For more information and guidelines on management of exotic and native species, see NPS-77: *Natural Resources Management Guideline*, Chapter 2.)

Commensal Rodent Damage

Rats. Rat burrows can cause structural damage by undermining the foundations of buildings, roads, and walkways. The rats' burrowing activities can disfigure landscaping, erode banks of irrigation levies and dams, and disrupt sewer lines.

Rats may also cause harm through their constant gnawing, damaging plastic and lead pipes, door frames, upholstery, and electrical wires.

Rats destroy 20% of the world's food

Rats can be a pest of crops in the field and in storage, if commodities and bulk foods are not properly stored. They may feed upon chickens and even attack the legs of domestic livestock. Rat damage to food in the United States costs consumers an estimated $500 million to $1 billion each year. And rats destroy an estimated 20% of the world's food supply every year directly by feeding and indirectly through contamination.

In some circumstances, commensal rats may also prey on native animals, particularly ground-nesting birds such as terns and quail.

Mice, too, may damage stored food. The greatest loss is not what mice eat, but what is thrown out because of contamination—real or suspected. In six

months, one pair of mice can eat about four pounds of food and deposit about 18,000 droppings. The amount of food contaminated by mice is estimated to be about ten times greater than the amount eaten. Government food inspectors often have to condemn food products because of contamination from house mice.

Losses are not limited to food. Improperly stored family bibles or heirlooms in the attic or garage may be damaged by mice. These kinds of personal possessions are irreplaceable. So are original paintings, manuscripts, tapestries, specimens, and the like, in museums. Mouse-riddled documents in the bottom file drawer of an office cannot generally be valued in dollars and cents, but these losses, too, can be serious. Proper storage is essential.

When electrical wiring is gnawed by rodents it can result in shorts and fires, and many fires listed as "cause unknown" may be caused by house mice. House mice frequently take up residence in electrical appliances and may gnaw into power supplies.

House mice commonly infest homes and other buildings. Part of their pest status is simply due to their emotional effect on people. Many people are either frightened or disgusted or both to find mice living in their homes or offices.

House mice can be pests out-of-doors, too. They sometimes cause crop losses, particularly in orchards, and they may compete with native animals in natural settings. Finally, house mice have the potential, at least, to transmit diseases and parasites to people and domestic animals.

Human Health Concerns

Our health can be affected by rodents directly and indirectly, through bites, by parasites, or by transmission of disease organisms.

Rodent Bites

Rats bite people for two reasons: (1) they are cornered or feel threatened and (2) they are stressed by hunger and are looking for food. An estimated 14,000-24,000 people are bitten each year. Infants and helpless adults (unconscious, invalid and elderly) are most at risk of being bitten by a rat looking for food. A small percentage of those bitten by rats *and by mice* may develop rat-bite fever, a bacterial disease carried in the teeth and gums of many rats (see discussions below). Like any wound caused by an animal, all rodent bites should receive medical attention.

Diseases Transmitted by Rats

Commensal rodents can spread disease. Sometimes they transmit disease directly by contaminating food with their urine or feces or by biting people. Sometimes they transmit disease indirectly, as when fleas bite a disease-infected rat, then a person. Below are some of the more important diseases associated with commensal rats:

Plague. The "Great Plague" of London killed half of the city's population. The "Black Death" of Europe lasted 50 years in the 14th Century and killed 25 million people. In the first quarter of this century, an estimated 11 million people died in Asia from plague.

The disease is transmitted to man predominantly by the oriental rat flea. The flea bites an infected rat and then bites a person, inoculating them with the bacteria that can cause the disease. Poor sanitation, primitive sewer systems, and a lack of medical treatment in the Middle Ages combined with high rat populations and overcrowding to produce massive epidemics.

No major urban outbreak of plague has occurred since 1924. A reservoir of plague exists in some populations of ground squirrels, prairie dogs, and domestic cats in several Western states. Humans contacting these animals may be bitten by infected fleas and contract the disease.

Murine Typhus Fever. Murine typhus occurs in California and in the Southeastern and Gulf Coast states. As with plague, murine typhus can be transmitted from rats to humans by a rat flea. In this case, however, the disease organism enters the bloodstream when feces of infected fleas are scratched into a flea-bite wound. Murine typhus is a relatively mild disease in humans.

Rat-Bite Fever. A small percentage of those bitten by rats develop rat-bite fever. The bacterium that causes the disease is carried in the teeth and gums of many rats. Although in most cases the disease exhibits mild symptoms similar to flu, it can be fatal, particularly to infants.

***Salmonella* Food Poisoning.** Rats frequent sewers, rotting garbage, cesspools, and similar sites where *Salmonella* bacteria thrive. The bacteria also thrive in the intestinal tracts of rats. If infected rats travel to stored food or food preparation surfaces and utensils, both their feet and their droppings can transmit *Salmonella* food poisoning to humans.

Weil's disease or Leptospirosis. The disease organisms are spread from rat urine into water or food, and enter humans through mucous membranes or minute cuts and abrasions of the skin. Human cases of this disease are seldom fatal.

Trichinosis. Trichinosis results from a nematode, or tiny roundworm, that invades intestines and muscle tissue. Both people and rats get the disease from eating raw or undercooked pork infected with the nematode. Rats help spread trichinosis when hogs eat food or garbage contaminated with infected rat droppings.

Diseases Transmitted by Mice

Excluding the spread of food poisoning, house mice are not as important as rats as carriers of disease and parasites. Yet their potential cannot be neglected. House mice and their parasites are implicated in the transmission of a number of diseases:

***Salmonella* Food Poisoning.** Bacterial food poisoning, salmonellosis, can be spread when some foods are contaminated with infected mouse feces. In urban areas, mice are probably more responsible than rats for the spread of this disease.

Rickettsialpox. *Rickettsia akari* is the causal agent of rickettsialpox, a disease causing a rash of the chicken-

pox type. Rickettsialpox is transmitted from house mouse to house mouse, and to people, by the bite of the house-mouse mite.

Lymphocytic choriomeningitis. This disease is a viral infection of house mice that may be transmitted to man (mainly children) through contaminated food or dust.

Weil's Disease or Leptospirosis. The mouse can be a carrier of leptospirosis, although human cases are more commonly caused by rats.

Other Diseases and Medical Conditions. Rat-bite fever is sometimes transmitted by house mice. So is ray fungus, *Actinomyces muris*. Certain tapeworms are spread in house-mouse droppings, and ringworm, a skin fungus disease, can be carried to people directly by mice, or contracted indirectly from mice through cats. Tularemia has also been linked to house mice.

A dermatitis resulting from mite bites has been associated with house mouse infestations. The resulting skin irritation and itching can affect children or adults.

A Note About Rabies. Neither rats nor mice have been found infected with rabies in nature. Rabies transmission from rats or mice to humans has never been documented in the United States. However, local health authorities sometimes recommend anti-rabies treatments for rodent bites in rabies-outbreak areas.

Native Rodents

Many species of rodent are native to the United States. Their populations typically are more dispersed than exotic commensal rodents, and they mostly avoid humans. There are a few exceptions such as deer mice and white-footed mice (*Peromyscus* sp.) and meadow mice (*Microtus* sp.), which sometimes live around and even inside buildings. Native rodents are much less likely to be associated with damages or disease, and they are afforded a higher degree of protection under NPS policy. Identification of species is essential before any management effort is begun.

Overview of IPM

Successful long-term rodent management is not simple. Rodents are extremely resilient, intelligent, and adaptable. Wherever there are concentrations of people, there will be rodents. Like humans, their adaptability allows them to survive even in the most adverse conditions. We can never completely eliminate them from large urban and rural areas, but we can *manage* them to an acceptable level by applying the principles of **integrated pest management (IPM)**.

The key is to manage rodent **populations**, not individual rats or mice. Rodent management requires an integrated approach that includes regular inspections and monitoring, upgraded sanitation, and rat-proofing structures. Nontoxic management measures such as snap traps or glue boards are combined with habitat

modification, proper storage and, if needed, rodenticide to provide a successful management program.

IPM is a holistic approach to solving pest problems. It coordinates the use of the available pest management methods along with up-to-date biological and environmental information. The goal? To prevent unacceptable levels of pest damage, by the most economical means, and with the least possible hazard to people, property, and the environment.

Most importantly, IPM is a decision-making process for determining if a pest problem exists, if it requires action, how best to treat it, where and when the treatment should be administered, and what strategies should be integrated for immediate and long-term success.

Eradication is unattainable in most situations. In IPM, the goal is to keep pests from reaching levels where they could damage park resources or threaten visitor and employee safety.

One of the advantages of IPM is that it helps you to look at the big picture; to analyze the problems that caused the rodent population to grow in the first place. Another advantage over traditional pest control practices, which are basically "crisis-response," is that IPM is essentially preventive rather than reactive. It is the most effective, cost-efficient, and environmentally compatible way to handle pest problems.

From a practical standpoint, IPM in NPS facilities will consist of a series of steps:

(1) Build consensus on IPM approach

(2) Identify pests

(3) Review NPS policy

(4) Establish priorities

(5) Establish action thresholds

(6) Monitor pests and environment

(7) Implement nonchemical management tactics

(8) Obtain approval for pesticide use and implement chemical tactics if necessary

(9) Evaluate program through continued monitoring

(10) Keep records (such as *Pesticide Use Logs*)

Review Questions for Chapter 1: Introduction to Commensal Rodents and Their Management

1. Native rodents such as ground squirrels and woodrats are given a high degree of protection by NPS regulations because they are native to the United States, while Norway rats, roof rats, and house mice are not. TRUE or FALSE?

2. In six months, one pair of mice can deposit roughly how many droppings?

   a) 18 b) 180 c) 1,800 d) 18,000

3. People bitten by rats or mice may develop rat-bite fever. TRUE or FALSE?

4. Infants and helpless adults are most at risk of attack by rats. TRUE or FALSE?

5. A reservoir of plague exists in ground squirrels and prairie dogs in several Western states. TRUE or FALSE

6. Which of the problems listed below may be caused by commensal rats or mice?

   a) electrical fires
   b) undermined walkways
   c) rat-bite fever
   d) contaminated food
   e) all of the above

7. Which of the following is true about integrated pest management (IPM)?

   a) it is a holistic approach to solving pest problems
   b) it may include the use of pesticides
   c) the goal is not eradication of pests
   d) it is essentially preventative
   e) all of the above
   d) only a, c, and d

8. The key to IPM is to manage individual pests one by one. TRUE or FALSE?

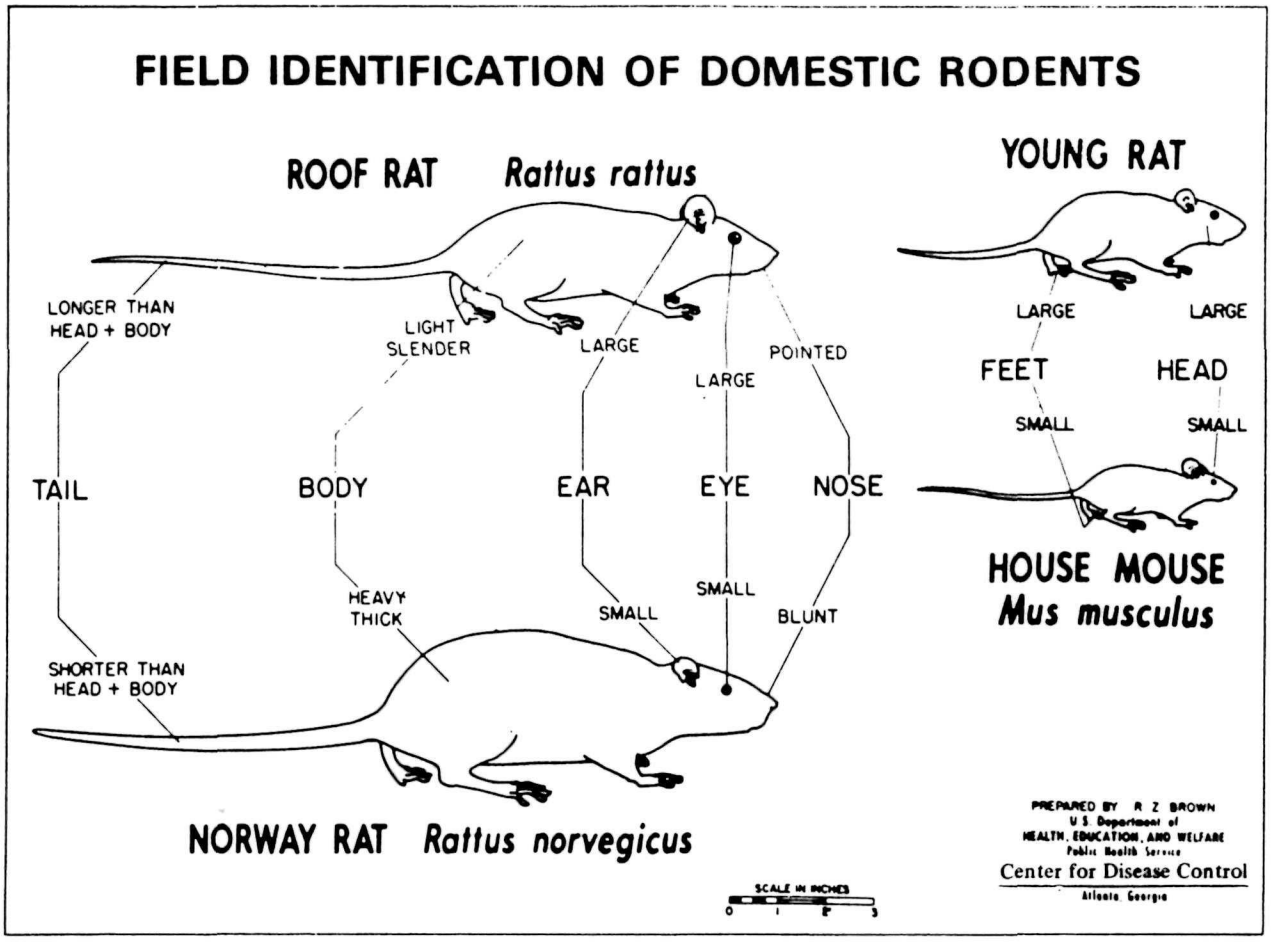
Chapter 2

Identification and Biology of Commensal Rodents

Learning Objectives

After completion of this chapter, you should be able to

- List the three common pest species of commensal rodents.
- Be able to tell the difference between a Norway rat and a roof rat.
- Discuss key biological factors, physical abilities, and behaviors for each of the three commensal rodent species.
- Know the key behavioral differences between the species.



Before you can manage a pest, you need to identify it and understand its biology and habits. That is why the first steps in any IPM program are to (1) identify the species that is causing the damage and (2) understand its basic biological and behavioral characteristics. These characteristics include the pest species' habitat preferences, the amount of space required for living, food and water requirements, territorial requirements and social structure, life cycle and life span, reproductive capabilities, seasonal abundance, and natural enemies.

Many species of rodents can become pests in particular circumstances. Nevertheless, the three species that concern us most are the commensal rodents: Norway rat, roof rat, and the house mouse. All three are classified by NPS as "*exotic species*." Exotic species are those that occur in a given place as a result of direct or indirect, deliberate or accidental actions by humans. These are the species that most often become pests, and the ones that we most often need to manage.

Native rodents, in contrast, are a part of the natural ecosystem and are protected by NPS policies. Native rodents require pest management actions only in special circumstances.

Norway Rats and Roof Rats

You have to admire rats. They have adapted to nearly all human environments. They live in granaries, in fields, in city sewers, in both urban and rural parks, in ocean-going ships, on roofs, in attics, in basements, in street trees, on top of thirty-story buildings, and inside subway tunnels.

When we speak of rats, we are speaking of many different species. Some are pests, some not. In the United States, the two most important pest rats are the Norway rat and the roof rat.

Norway rat (*Rattus norvegicus*)—note stocky build

Norway rat: The most common pest rat in the United States, the Norway rat (*Rattus norvegicus*) is also called the brown rat, sewer rat, or wharf rat. The adult is a large, stocky rat, from 12-18 inches (30-46 cm) from the nose to the tip of the tail, weighing 12-16 ounces (200-500 grams). In contrast to the roof rat, its tail is shorter than its body, its ears are small (cannot be pulled down to reach its eyes) and covered with hairs, and its nose is blunt.

Roof rat: A common rat of coastal areas, the roof rat (*Rattus rattus*) is also called the black rat or the ship rat. The adult has a slender body, weighs 5-9 ounces (150-250 grams), and measures 13-18 inches (33-46 cm) from the nose to the tip of the tail. In contrast to the Norway rat, its tail is longer than its body, its ears are large (can be pulled down to cover its eyes) and nearly hairless, and its nose is pointed.

Roof rat (*Rattus rattus*)—note long tail

- A Norway rat's tail is shorter than the length of its head and body combined; a roof rat's tail is longer than its head and body.
- A Norway rat's ears are small, covered with short hairs, and can't be pulled over the eyes.
- A roof rat's ears are large, nearly hairless, and can be pulled over the eyes.
- A Norway rat's snout is blunt; the roof rat's snout is pointed.

Geographic Distribution

Norway rat: Found in every state in the United States, and common throughout much of populated North America. Often absent from sparsely inhabited areas, particularly in the western states.

Roof rat: Found mainly in coastal areas, including California, Oregon, Washington, the Gulf States, and the Southeast and Middle Atlantic States.

Physical Differences

As you look at the illustrations of roof and Norway rats, you can see how much alike the two species look. But look more closely. There are noticeable differences:

- A Norway rat looks sturdier than the roof rat, which appears sleeker and more agile.
- A mature Norway rat has a larger body (not including tail) than a roof rat and weighs up to twice as much.

Behavioral Differences

Although the behavior of the two species is similar in many ways, there are important differences. Knowing these differences can help you in your initial identification.

- Roof rats are good climbers, often found in rafters, roofs, and trees; Norway rats like to burrow, and are usually found at or around ground level.
- Outdoors, roof rats prefer to nest above ground in trees, woodpiles, ivy, and attics (although they will on occasion nest in burrows); Norway rats prefer to nest below ground, especially near foundation walls and under concrete slabs.
- Indoors, roof rats nest in attics, roof insulation, false ceilings, rooftop cooling and A/C units; Norway rats nest in wall voids, under pallets and equipment, and in other protected areas, usually on lower floors.
- Roof rats travel along utility lines, fence tops, gutters, and trees; Norway rats usually travel on or below ground along runs or burrows near walls, fences, shrubs.

Biology and Habits of Rats

To manage rats, you must first understand them. You need to learn their life histories, habitat and food requirements, patterns of behavior, range and other factors to determine where rats live, breed, and feed.

Roof rats and Norway rats have similar habits. Most of the discussions below apply to either kind of rat. Where differences are important for management purposes, however, the differences will be highlighted.

Life History. A mature female rat can give birth to about 20 young in a year (4 to 6 at a time), if she lives that long. The average life span of a rat in the field is less than one year, with females living longer than males.

The young are born in a nest. They are hairless and their eyes and ears are closed. Within two weeks their eyes and ears open, they grow fur, and begin exploring the nest area. In the third week they begin to switch to solid food, and imitate their mother to learn pathways to food, escape routes, and danger zones. If the mother rat has become wary of rodenticides or traps, many of her young will learn to avoid them. This learning experience can make management difficult in sites where long-term rodent suppression programs have been unsuccessful in the past.

Young are totally weaned when four or five weeks old. They then weigh about an ounce and a half (45 grams). At three months the young are independent of their mother and able to mate and continue the cycle, either in the same location or after migrating to a new, unoccupied nest area.

Seasonal Abundance. Outdoor rat populations tend to peak in summer to early fall. They're at their lowest levels in late winter to early spring. Indoors, rat populations may remain at the same levels throughout the year, limited only by periodic shortages of food, water, or nesting sites.

Natural Enemies. Rats may be preyed upon by many other animals including dogs, cats, weasels, snakes, and birds of prey such as hawks and owls. Rats are susceptible to a variety of diseases and parasites. Some natural enemies ranging from ferrets to bacterial toxins have been used in the past with varying degrees of success in rat management programs.

Social Behavior. Rats are social animals and live in colonies with well-defined territories that they mark with urine and glandular secretions. The colony has a complex social hierarchy with a dominant male leader and a "pecking order" of subordinate males and ranking females. The strongest and most dominant animals occupy the best nest and resting sites, and feed at their leisure. Weaker, subordinate rats are pushed out to less favorable sites, or forced out of the territory completely. In abnormally crowded and stressed conditions, rats may display aggressive behavior toward each other, including cannibalism and abandonment of young.

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

Senses of Rats. Rats have poor vision. They are nearly colorblind, and react to shapes and movement rather than identifying objects by sight. Thirty to forty-five feet is the limit of their vision. Their eyes are adapted to dim light.

Other senses, however, compensate for poor vision. Rats use their sensitive nose to locate food, follow pathways, tell whether another rat is friend or foe, and identify new objects in their territory. They use long whiskers and guard hairs to "feel" their way through dark burrows, pipe chases and tunnels, wall voids, and other runways. Their ears detect faint sounds that signal danger. Rats can taste certain chemicals at a parts-per-million concentration (this is why rats often reject baits or avoid traps that have been contaminated with insecticides). Finally, rats have an excellent sense of balance which allows them to walk on wires and always land on their feet in a fall.

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

Food & Water. Rats need about one ounce of food daily. Roof rats and Norway rats each prefer a different type of food. Roof rats prefer plant materials such as fruits, nuts, seeds, berries, vegetables, and tree bark. They occasionally feed on garbage and meats. Norway rats prefer protein-based foods such as meat, fish, insects, pet food, nuts, and grain. Household garbage is ideal food for Norway rats. Each rat species, however, will feed on moderately distasteful food if nothing else is available.

Rats often hoard food in hidden areas or caches. This food may or may not be eaten when other food supplies run short. Hoarding is important for three reasons. First, rats can move a toxic bait into a location where you do not want it and where the label doesn't permit it. Second, rats may hoard a poison bait while feeding on their regular food. Thus, a baiting program becomes ineffective. Third, hoarded food may attract and breed pest insects such as dermestid beetles.

Rats need water every day. The amount varies, depending on the moisture content of their food, but is usually around one-half to one fluid ounce. Rats prefer to nest where water is easily available.

Range. Rats usually begin foraging just after dark. Most of their food gathering occurs between dusk and midnight, but short bursts of restlessness and activity can occur anytime, day or night. Rats commonly travel 100 to 150 feet from their nest looking for food and water and patrolling their territory. It's not unusual for a colony of rats nesting outdoors to be feeding inside a building 100 feet away.

Nests. Outdoors, Norway rats usually nest in burrows dug into the ground. The burrows are shallow (less than 18-

inches down) and short (less than 3-feet long), with a central nest. Extra "bolt holes" are used for emergency escapes. The holes are hidden under grass or boards or lightly plugged with dirt. Burrow openings are 2-4 inches in diameter.

Indoors, Norway rats nest inside walls and the space between floors and ceilings, underneath equipment, between and under pallets, and in crawl spaces, storage rooms, and any cluttered area that is normally unoccupied. Norway rats prefer to nest in the lower floors of a building.

Roof rats commonly nest above ground in trees -- particularly untrimmed palm trees, and in piles of wood or debris, vine-covered fences, and stacked lumber. Overgrown landscaping is also a prime nesting area. Roof rats will sometimes nest in burrows if above-ground sites are limited and Norway rats are not nesting in the area.

Indoors, roof rats prefer to nest in the upper levels of a building in the attic and in ceiling and attic voids near the roof line. But at times they also nest in the lower levels of a building like Norway rats.

Both species also nest in sewers and storm drains, and both on occasion can be found in highly unusual and nontypical nest sites.

Both Norway and roof rats can have several "hotel" nest sites in an area. A rat may spend a week in its home base and then move for a day or two into a secondary "hotel" nest site. Norway rats have been shown to have a home range of up to 20 acres when these secondary nest sites were included in the calculations.

Physical Abilities. Rats are marvelous athletes!

- They can leap three feet straight up and four feet horizontally.
- They can scramble up the outside of a pipe three inches in diameter, and climb inside pipes one-and-a-half to four inches in diameter.
- They can walk between buildings on telephone or power lines, and scramble on board a ship on its mooring line.
- They can swim through a half mile of open water, tread water for up to three days, swim against a strong current in a sewer line, and even dive through a sewer trap to pop up inside a toilet.
- Falling, they can drop more than 50 feet and survive.
- They commonly chew through building materials such as cinder block, aluminum siding, sun-dried adobe brick, wall board, wooden cabinets, lead sheathing, and plastic or lead pipes.
- An adult rat can compress its body and squeeze through an opening only a half-inch high.

In most instances, rats are very wary. Hundreds may be nesting in a city block -- in underground burrows, in sewers, on roofs, inside buildings -- with few people in the area realizing it. Populations are dynamic: rats moving in, rats moving out, rats giving birth, and rats dying. Within a population, some rats will be easy to manage, some difficult.

House Mice

House mouse (*Mus musculus*)

The house mouse, *Mus musculus*, is a delicate, agile little rodent. Adult weights vary from region to region and may be linked to the suitability of habitat, but usually range from 1/2 to 1 ounce. Adult house mice vary in color from light brown to dark gray but most often are a dusky gray or medium brown over most of their bodies, except the belly, which may be a slightly lighter shade of their general color or may be cream colored.

The mouse has moderately large ears for its body. The tail is nearly hairless and about as long as the body (2.5 to 4 inches). The feet and eyes are small in proportion to its body.

The house mouse is the most successful rodent in adapting to life with people. It thrives in a wide range of climatic conditions in a great variety of habitats, feeding on nearly any human food, and reproducing at a remarkable rate. It is found in most areas of the world populated by humans.

House mice occur throughout the United States, often intimately associated with people. But house mice are occasionally found living in the wild, competing with native fauna. They are common inhabitants of grassy fields and cultivated grain crops. They have been captured in open tundra in Alaska, miles away from human settlements.

Similar Species. Native rodents are an extremely important part of the food web of natural areas, serving as a food source for birds of prey, coyotes, foxes, snakes, etc. However, our native deer mice and white-footed mice (*Peromyscus* sp.), sometimes become pests by invading buildings adjacent to fields and woodlands.

These mice are about the same size as or slightly larger than house mice. At a distance, they may be hard to tell apart from house mice. Up close, though, they look different. All *Peromyscus* species have white feet, usually white undersides and brownish upper surfaces. Deer mice (*P. maniculatus*) have a distinct, bicolored tail, with a well-defined line where the brownish back fur and white belly fur meet.

Meadow mice or voles (*Microtus sp.*) sometimes invade homes, or may become a pest in ornamental plantings or orchards. These mice should not be confused with house mice. They are less agile, have larger, more chunky bodies, and weigh at least twice as much as house mice. They also have shorter tails and small ears and eyes.

Deer and white-footed mice (*Peromyscus spp.*)

Meadow mice (*Microtus spp.*)

House Mouse Life History. Under optimum conditions, house mice breed year round. Out-of-doors, house mice may tend toward seasonal breeding, peaking in the spring and fall. Environmental conditions, such as the availability and quality of food, can influence frequency of pregnancies, litter sizes, and survival. Under ideal conditions, females may produce as many as ten litters (about 50 young) in a year. At very high densities, however, reproduction may nearly cease despite the presence of excess food and cover.

New-born mice are quite undeveloped, weighing between 0.02 and 0.03 ounce, and are nearly hairless. Eyes and ears are closed, but by the end of 2 weeks, the body is covered with hair and the eyes and ears are open. At about 3 weeks, the young begin short trips away from the nest and begin taking solid food.

Social Behavior. Mice are not the timid, "mousy" creatures of cartoons. They are aggressive protectors of family, territory, and social status. Mice form small "colonies" of related individuals. A typical group might consist of a dominant male, two breeding females, three or four immature sons and half a dozen daughters.

The dominant male will attempt to drive off any invading males, and even his sons as they mature and begin competing for mating rights.

Mice are active mostly at night. Some day activity is common, however. Movements of house mice are largely determined by temperature, food, and hiding places. Home ranges of mice tend to be smallest where living conditions are good.

Curiosity. Mice tend to travel over their entire territory daily, aggressively investigating each change or new object that may be placed there. ***Unlike rats, they show little fear of new objects.***

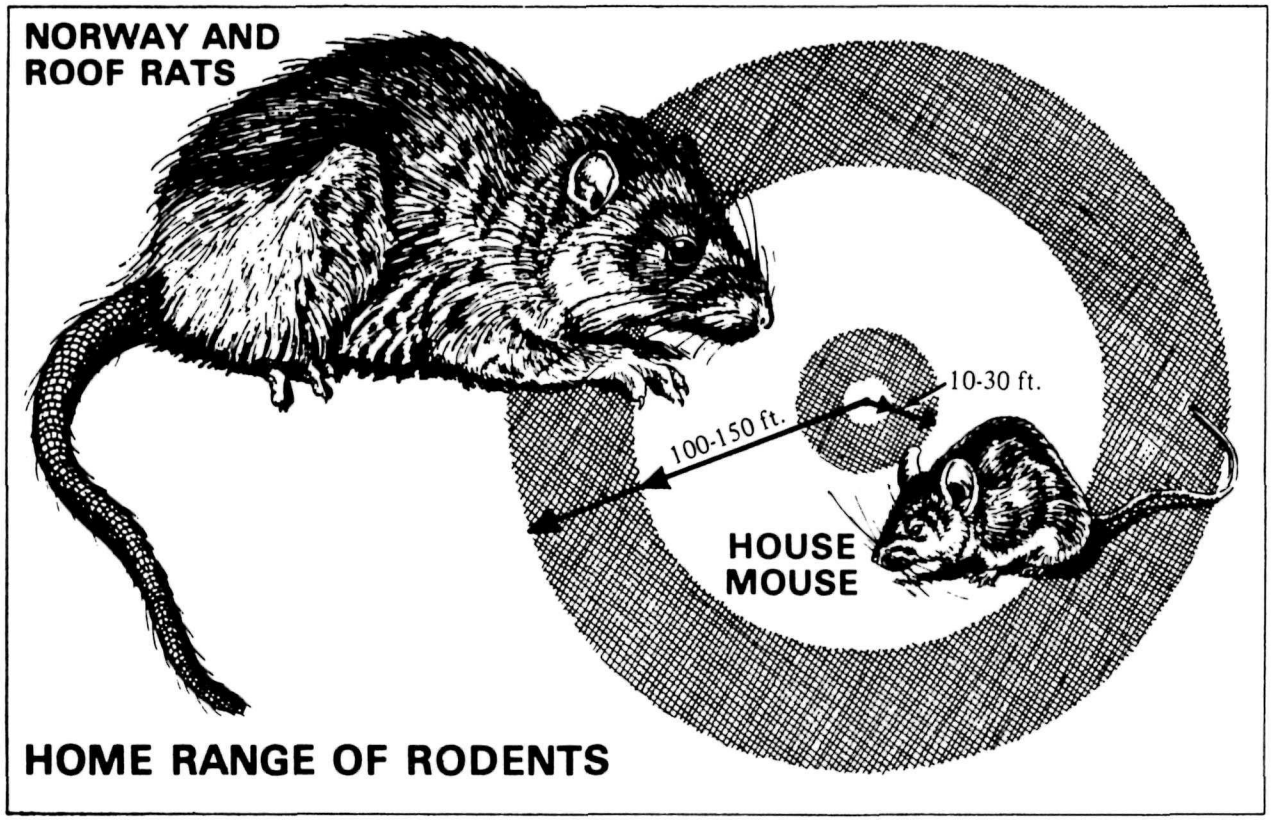
Mice dart from place to place, covering the same route over and over again. This behavior can be used to advantage in management programs. Disturbing the environment at the beginning of a management program by moving boxes, shelves, pallets, and other objects can improve the effectiveness of traps, glue boards, and other controls. Mice will investigate the changed territory thoroughly. Because of the mouse's curiosity, a well-designed mouse management program can

demonstrate success quickly, just the opposite of rat programs.

Range. Mice are territorial and seldom travel more than 30 feet from their nest. Their range is much smaller than the rats' range of 100 to 150 feet. When food is nearby, mice can restrict their activity to a few feet. Male territories are usually slightly larger than are female territories.

Think in three dimensions. Good climbers, mice can be above a food source in suspended (drop) ceilings, or below in floor voids or crawl spaces.

Food & Water. Mice feed on a wide variety of foods, although cereals seem preferred over other items. Mice sometimes search for foods high in fat and protein, such as lard, butter, nuts, peanut butter (chunky preferred!), bacon, and meat. Sweets, including chocolate, are taken at times. Mice get



HOME RANGE OF RODENTS

much of their water from moisture in their food, but they will drink if water is readily available.

House mice are nibblers, feeding 20 or more times during their evening rounds. In any territory there will be one or two feeding sites, dark and protected, where mice will eat more than usual. Mice have two main feeding periods, at dusk and just before dawn. Mice tend to hold grain kernels, such as oats or wheat, by the long axes, nibbling on them like corn on the cob. They often drop portions of the kernels as they eat, leaving clues to their identification.

Nests. House mice may nest in any dark, sheltered location. Nests are constructed of fibrous, shredded materials such as paper, cloth, burlap, insulation, or cotton and generally look like a loosely woven ball. They are approximately four inches in diameter. Often you will find stored bits of food in the nest.

Outdoors, house mice sometimes excavate and nest in burrows.

Senses of Mice. Like rats, mice have relatively poor vision, and are also colorblind. They rely heavily on smell, taste, touch and hearing. Mice use their keen sense of smell to locate food items and to recognize other individuals, especially those of the opposite sex. Taste perception in mice is good. Mice use their acute hearing to detect and escape danger.

Touch is an important sensory factor for mice. Mice are *thigmotropic* (*Gr.* thigma = touch)—like rats, they prefer to run while touching a wall or object. They use their long, sensitive whiskers near the nose and the guard hairs on the body as tactile sensors to enable them to travel in the dark, scurrying through burrows or pressing against walls and boxes, . (This is the reason traps are so much more effective when set against a wall, storage box, or other object.) Mice also have an excellent sense of balance.

A mouse's ability to quickly carry out actions or movements is governed by constant practice of sequences of muscular movements, sometimes referred to as the *kinesthetic sense.* A mouse essentially programs muscles, tendons, and nerves to follow a set path through the territory. This kinesthetic sense allows mice to quickly escape danger.

Physical Abilities. It is difficult to mouse-proof a building or manage mice without understanding their physical capabilities. For example—

- For their size they are excellent jumpers. Agile individuals can jump 12 inches (30.5 cm) high from the floor onto an elevated flat surface.
- They can jump from a height of 8 feet (2.5 meters) to the floor.
- They can jump against a wall or flat vertical surface using it as a spring board to gain additional height.
- They can run up almost any vertical surface, from wood and brick walls to metal girders, pipes, weathered sheet metal, wire mesh and cables without much difficulty if the surface is rough.
- They can run horizontally along insulated electrical wires, small ropes, and the like, with ease.

- They can squeeze through slot-like openings slightly more than 1/4 inch (6 mm) high.
- They can easily travel for some distance hanging upside down from 1/4-inch (6 mm) hardware mesh.
- They are capable swimmers, although they generally do not take to water as well as do rats and tend not to dive below the surface.
- They can walk or run along ledges too narrow for rats.
- They can survive for generations at a constant temperature of 24° F (-4°C).
- They have been reported to be living 1,800 feet (550 meters) below the ground in a coal mine in England.

The small home range of mice, their curiosity, their physical abilities, and their food preferences and feeding habits are the characteristics that set house mice apart from rats. Keep these characteristics in mind when managing mice. Many failures in mouse management and suppression can be blamed on a pest manager unsuccessfully trying to use rat-management techniques against a population of mice.

Review Questions for Chapter 2: Identification and Biology of Commensal Rodents

1. The roof rat—

   a) is the most common pest rat in the United States
   b) is a common rat of coastal areas
   c) has a tail shorter than its body
   d) all of the above

2. A mature Norway rat often weighs twice as much as a mature roof rat. TRUE or FALSE?

3. Which species of commensal rodent does not exhibit fear of anything new in their territory?

   a) Norway rat
   b) roof rat
   c) house mouse
   d) all rodents are wary of new objects

4. Which of the following is true about rats?

   a) they have good daytime vision
   b) they usually begin foraging just after dark
   c) they often hoard bait
   d) all of the above
   e) b and c

5. Which of the following is true concerning the territory of commensal rodents?

   a) a rat's territory is usually much larger than a house mouse's
   b) mice commonly travel 100 to 150 feet from their nest each night
   c) rats often restrict their foraging activity to a few feet from their nest
   d) none of the above

6. Which of the following is true about house mice?

   a) they can jump from a height of 8 feet (2.5 meters) to the floor
   b) they can squeeze through slot-like openings slightly wider than 1/4-inch
   c) they can swim
   d) all of the above
   e) a and b

Chapter 3

Monitoring Rodent Populations

Learning Objectives

After completion of this chapter, you should be able to

- Establish a basic rodent monitoring program for any site.
- Define "injury levels" and "threshold or action levels."
- Be able to identify the signs of an active rat infestation.
- Be able to identify the signs of an active mouse infestation.
- Estimate the size of a rodent infestation.

Monitoring rodents is an essential step in the IPM process. But calling it a step is probably misleading. It is really an ongoing process throughout an IPM program. It is essential to success.

Monitoring is a systematic survey conducted at regular intervals. It keeps you apprised of all aspects of the pest situation and conditions at the site. For rodent management, monitoring should include:

- Identifying and locating the pest species.
- Identifying nontarget species that could be affected by management actions.
- Estimating the rodent population.
- Identifying the factors that are contributing to the pest problem (poor sanitation, feeding of animals by park visitors, holes in walls, etc.).
- Assessing natural enemies and potential secondary pests.
- Noting weather or seasonal changes.
- Reporting management practices that could affect rodent populations or pest management activities (trash pickup, periods of activity, construction, etc.)

A detailed monitoring system is needed to provide a practical basis for a rodent IPM program. When developing a rodent monitoring program, you will have to do the following:

1. Define the objectives of the monitoring programs. Will it be to establish injury levels, or the frequency of treatment actions, or the effectiveness of an existing management program?

2. Determine which pest and nontarget species to monitor, and how best to monitor (droppings, tracking patches, visual sightings, etc.).

3. Determine the frequency of monitoring.

4. Determine appropriate sampling locations and the number of monitoring sites.

5. Develop the monitoring procedure ("walk-throughs," tracking patch checks, closing and rechecking burrows, etc.)

6. Maintain accurate, detailed records for informed decision-making.

7. Determine who will be involved in the monitoring scheme; assign responsibilities.

8. Evaluate pest management actions for their effects on pest and nontarget species.

Injury Levels and Action Levels

Does finding rodents, even a single rodent, require immediate action? Not necessarily. For any situation, there is a specific level of rodent numbers or damage that should be reached before action is taken.

Essential components of the decision-making process in any IPM program are the *injury levels* and the *threshold (or action) levels*.

Injury level. This is the point at which a pest population causes unacceptable damage. Determination of injury levels depends on how much damage can be tolerated. The importance, value, and significance of the resources at the site helps delineate the injury level. Injury levels may be influenced by seasonal variation of conditions: pest population peaks, visitors to the park, etc.

Action levels. Also called the "threshold level," this is the point at which some management action must be initiated in order to prevent the pest population from reaching the injury level. In most IPM programs, the objective of pest management is to suppress the population below the injury level rather than to attempt eradication.

Rodent action levels will differ depending on the site. For example, mice infesting a horse barn can be tolerated at a much higher population level than mice in a cafeteria kitchen. In the horse barn, even a few dozen mice might not require immediate action, while even one mouse in the cafeteria might require fairly aggressive action.

In a new program, a practical approach is to establish an initial "working injury level" based on an estimate of the current population and evidence of rodent damage (burrows, gnaw marks, visitor complaints, etc.). Later in the program, the injury levels can be revised up or down based on continued observations and experience at a given site.

How to Inspect for Rodents

Before a park manager or pest management specialist can decide if rodent management is necessary, and what combination of actions would be best for a particular infestation, he or she needs to inspect the area, monitor the infestation, and decide which individuals will be involved.

Rats and mice give many signs that they are inhabiting an area. You inspect for these signs, not only to

determine that rodents are present, but to identify where the rodents are feeding and nesting, their patterns of movement, the size of the population, and the extent of the infestation. This helps you decide what management measures to use, where and how to use them, and how much effort you need to put into the program.

Because rat and mouse signs are different, they are discussed separately.

Signs of Rat Infestation

Visual Sightings. An inspection using a powerful flashlight just after dark is the best way to see rats. (If you or others regularly see rats active in daytime, the rat population is probably high.) Dead rats can mean a current or past infestation. If all that you find are old dried carcasses and skeletons, it may mean an old infestation. Many fresh carcasses can mean that someone is using poison baits in the area.

(Note: You should investigate any unauthorized baiting, since improper baiting can pose risks to nontarget species, both directly and through secondary poisoning when animals feed on the carcasses.)

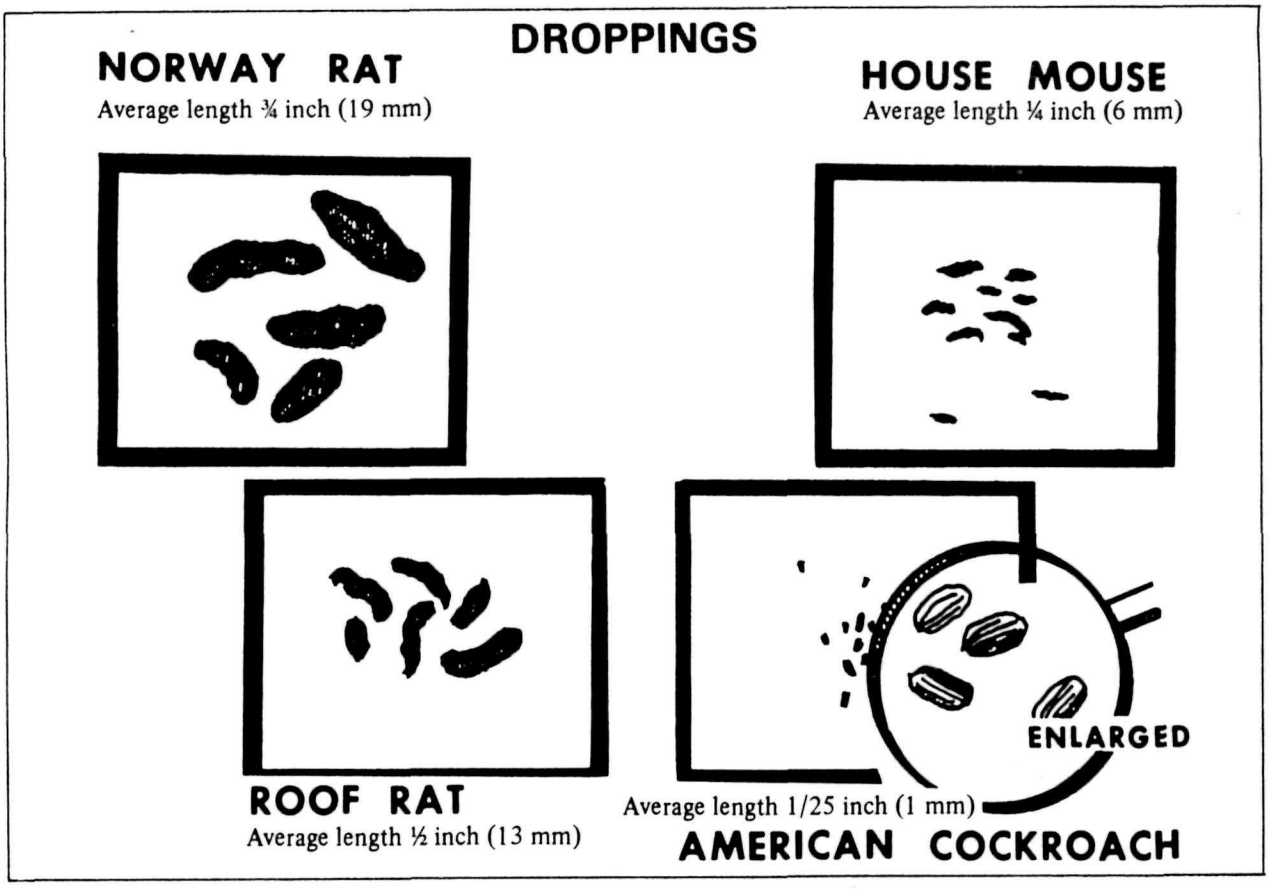
You may sometimes see dermestid beetles, blow flies, and other scavenger insects attracted to rodent carcasses. Check especially on window ledges and inside light fixtures, since many of these scavenger pests also fly to lights. Sticky traps on window ledges can be used to monitor for these "indicator" pests, which may indicate a rodent infestation.

Sounds. If it is quiet in a building, you can sometimes hear squeaks, fighting noises, clawing and scrambling in walls, or gnawing sounds. A stethoscope or electronic listening device can help pinpoint activity.

Droppings. A single rat may produce 50 droppings daily. Roof rat droppings are generally smaller (up to one-half inch) than a Norway rat's (up to three-quarter inch). The highest number of droppings will be found in locations where rats rest or feed. One way to determine if a rat population is active is to sweep up old droppings and reinspect a week later for new droppings.

The appearance of the droppings can also help you determine if rats are currently active. Fresh rat droppings are black or nearly black, they may glisten and look wet, and they have the consistency of putty. After a few days or a week, droppings become dry and hard and appear dull. After a few weeks, the droppings become gray, dusty looking, and crumble easily. Note that sometimes old droppings moistened by rain may look like new droppings, black and shiny. However, if you crush them in your fingers they will crumble and won't feel like soft putty.

Urine. Both wet and dry urine stains will glow blue-white under an ultraviolet light (blacklight). Portable ultraviolet lights are often used in the food industry to identify rat urine on food items. Other substances besides rat urine also glow, which can be confusing, so proper use of this inspection method takes practice. Blacklight inspections work best at night and in dark rooms.



Comparison of droppings (actual size)

Grease Marks. Oil and dirt rub off of a rat's coat when it rubs against things. These grease marks build up in often used runways and soon become noticeable. They are commonly found along wall/floor junctions, on pipes and ceiling joists, and on sill plates where rats swing around obstacles. Grease marks are also found at regularly used openings in walls, floors, and ceilings.

Runways. Outdoors, runways tend to appear as beaten paths on the ground where the rats constantly travel the same route. They may be found next to walls, along fences, under bushes and buildings. Indoor runways are harder to identify, but may appear as well-compacted trails, free of dust and, if outdoors, vegetation.

Tracks. Rat tracks show up in dust or soft, moist soil. A rat's foot print is about three-quarters inch long, and may show four or five toes. Rats may also leave a "tail drag" line in the middle of their tracks.

Track of Norway rat

A *tracking patch* can be placed in suspected rat areas to show footprints and identify species, level of activity, and direction of movement. A tracking patch is a light dusting of an inert

material such as clay, talc (unscented baby powder), or powdered limestone. Don't use flour, which may attract insect pests. A good patch size is 12x4 inches. Apply patches in suspected runways and near grease marks. When inspecting tracking patches, shine a flashlight at an angle that causes the tracks to cast a distinct shadow.

Note that a tracking patch is not the same as tracking powder. Tracking powders are rodenticides in dust form, tracking patches use nontoxic dust. *Never use a tracking powder to make a tracking patch. Tracking powders must be placed in inaccessible areas or inside tamper-resistant bait stations to protect people, pets, and wildlife.*

Gnawing Damage. A rat's incisor teeth grow at a rate of about five inches per year. Rats keep their teeth worn down by continuously working them against each other and by gnawing on hard surfaces. Gnawing damage is evidence of a rat infestation. Gnawed holes may be two inches or more in diameter. Rats also like to gnaw on floor joists, ceiling joists, door corners, kitchen cabinets, and around pipes in floors and walls.

Nest Sites. Roof rats, in particular, often nest or store food in the attics of buildings. Roof rat nests may also be found when dense vegetation is trimmed.

Burrows. Outdoors, rat burrows may be found singly or in groups along foundation walls, under slabs and dumpster pads, in overgrown weedy areas, beneath debris, and in embankments.

How do you tell if a burrow is active? The main opening of an active burrow will be free of dirt, leaves, and debris, and often smooth with hard-packed soil. There may be rubmarks at the opening, and soil pushed out in a fan-shaped pattern. The surest way to determine activity, though, is to fill the opening with a ball of wadded-up newspaper or a few leaves and cover it with loose soil. If the rats are still using the burrow, they will reopen and clear the hole overnight.

In fact, this is the most common technique for monitoring rat populations. You count and map the holes, recording data on a rodent monitoring form, then seal the openings and mark them with flags. After waiting a few days or a week, count the sealed tunnels that have been reopened. This number is a baseline indicator of activity.

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

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

Estimating Rat Numbers. It's not easy to tell how many rats are infesting a site. As a rough guide, you can use rat signs to characterize the population as low, medium, or high.

- *Rat-free or low infestation:* No signs seen. The area either has no rats or was invaded recently by a few.
- *Medium infestation:* Old droppings and gnawing seen. One or more rats

seen at night, but no rats seen during the day.

- *High infestation:* Fresh droppings, tracks, and gnaw marks common. Three or more rats seen at night, or rats seen in the daytime.

Signs of Mouse Infestation

Sounds. Squeaks, scrambling, and sounds of gnawing are common at night where large numbers of mice are present.

Droppings. A house mouse leaves about 70 droppings per day along runways, by food, near shelters, and other places it frequents. Droppings are about 1/4-inch long *and usually pointed on the ends*. Fresh droppings are not usually as soft in texture as rat droppings and in a few days become quite hard. Mouse droppings are frequently the first evidence that mice are infesting. Large cockroaches, bats, and other species of mice such as deer mice (*Peromyscus* sp.) and meadow mice (*Microtus* sp.), may produce droppings similar to house mice.

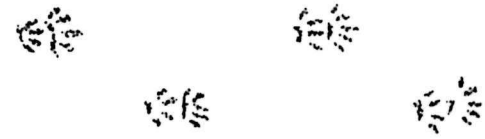
A day's worth of droppings from one mouse, shown actual size.

Urine. House mice occasionally make small mounds known as "urinating pillars." These consist of a combination of grease, urine, and dirt and may become quite conspicuous. Urine stains will fluoresce under ultraviolet (black) light, and such a light is a useful tool for rodent monitoring. Mice tend to dribble many small drops of urine.

Grease Marks. Like rats, mice produce greasy smears where dirt and oil from their fur mark pipes and beams. Such markings cover a smaller area than those made by rats, and house mouse grease marks are not as easy to detect.

Runways. Most house mouse runways are indistinct trails free of dust and thus not readily detectable.

Tracks. House mice leave footprints or tail marks on dusty surfaces or on mud. As discussed in the section on rat tracks, a *tracking patch* made from nontoxic dust can confirm the presence of house mice within buildings.



Typical tracks of a house mouse

Gnawing Damage. Damage around baseboards, doors, basement windows and frames, and food cabinets is often surrounded by wood chips with a consistency like coarse sawdust. Recent gnaw marks on wood are light in color, turning darker with age. Mice often enlarge cracks beneath doors.

The small size of the tooth marks helps to distinguish between the gnaw marks of mice and rats. You will often find mouse hairs stuck in cracks and holes used regularly by mice.

Visual Sightings. Mice are often active in daylight so sightings may not indicate a high population, as is the case with rats. At night, an inspection with a powerful flashlight or spotlight can verify the presence of house mice.

Piles of American cockroach wings also indicate house mice. The mice eat the roaches but leave the wings behind.

Nests. Most nests are often found when cleaning storage areas, attics, basements, closets, and other relatively undisturbed places. Nests vary in appearance. Fine shredded paper or other fibrous materials are commonly used for nest-building. Fresh droppings around the nest indicate an active nest site.

Pet Excitement. Cats and dogs may paw excitedly at a kitchen cabinet door, the floor at the base of a refrigerator, or even at a wall where mice are present, especially if mice have invaded the premise only recently.

Mouse Odors. A characteristic musky odor is produced by mice, and it is a giveaway of their presence. Mouse odor can be distinguished from the odor of rats.

Estimating House Mouse Numbers. Estimates of the numbers of house mice infesting an area are more difficult than for rats. Using the number of mice observed or food consumed as a measure of total population numbers is not a reliable census technique. Instead, since territories are small, simply note the *presence* of mice in a particular area through natural signs like droppings, urine stains, tracks, and damage.

A more precise method is to make nontoxic tracking patches of talc at 20 to 30-foot (5 to 10 meters) intervals throughout a building. The more tracks seen in each patch, and the more patches showing tracks, the larger the population. Unlike rats, which may travel widely within a building leaving tracks on many patches of dust, house mice do not range widely. The percentage of patches showing tracks will reflect the size of the local infestation. Tracking patches are also an excellent means to evaluate a management operation. Compare the number of tracks or patches with mouse tracks before and after implementing a rodent management program.

General Guidelines for a Rodent Monitoring Program

The following items should be part of most rodent monitoring programs:

Map. A map, blueprint, graph, or floor plan is extremely helpful in monitoring. It should note all of the places that offer rodent harborage, food, and water. These include:

- buildings and structures
- upholstered furniture
- drop ceilings
- crawl spaces
- attics and false ceilings

- voids over walk-in coolers
- refrigeration line tunnels in slabs
- steam tunnels
- dense brush and weeds
- heavy ground cover
- food storage
- garbage collection areas
- standing water, leaks, streams, etc.
- firewood and lumber piles
- previous nesting and burrowing sites

At each inspection, the inspector should mark any evidence of rodents, such as droppings, burrows, etc., as well as related information that may prove useful (landscaping activities, sanitation problems, locations of wildlife activity, etc.).

Recordkeeping. Inspection forms should be easy to use. If possible, the forms should be custom designed for conditions at the NPS facility being monitored, so that the information noted will be most useful to the specific IPM program. Sample forms are included at the end of this chapter.

Inspection Kit. You might want to put together a rodent inspection kit to be carried in a small tool box or other portable container. Depending on the site to be monitored, it might include such items as --

- a flashlight or headlamp and extra batteries
- paper flags and wire for marking burrows
- plastic bags, vials, and tweezers for samples of droppings, hair, and the like
- rubber gloves and dust mask or respirator when necessary
- nontoxic talc in a hand-held bulb duster to make tracking patches
- hand-held blacklight
- Polaroid camera
- stethoscope or electronic listening device
- clipboard with monitoring and inspection forms

Form A

Site Visit Record

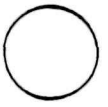
DATE:_____ PLACE: _____ INVESTIGATOR: _____

OBSERVATIONS: (Note location if observed)

Droppings:	Runs:	Tracks:
Smudge Marks:	Gnawing:	Nests and Food Caches:
Urine Stains:	Holes:	Other:

STRUCTURAL DEFECTS: (Note location if observed)

Holes or cracks ½" or greater around pipes or wires:



Open vents or chutes:

Unscreened roof vents:

Unscreened open windows (particularly ground floor):

Wires (electrical or telephone) going to upper floors:

Other:

LANDSCAPE FLAWS: (Note location if observed)

Is heavy shrubbery or tangled vines providing possible cover? Y N

Is ground visible under shrubbery or flower beds to permit monitoring? Y N

Is lumber, fire wood, etc. stored on the ground? Y N

Other:

SANITATION:

How often is refuse collected?

Is refuse stored in the park building overnight?

Is material stored inside stored off the ground and away from walls?

Are refuse receptacles rodent proof?

Are there food consessions in the area?

Other:

UNIVERSAL IPM INSPECTION FORM

PARK:_____ DATE:_____ Inspector:_____ ASSISTED BY:_____

CODE NUMBERS FOR PROBLEMS ON FORM/MAPS

1 ROACHES	4 RODENT SIGN	7 BIRD SIGN
2 FLYING INSECTS	5 HOUSEKEEPING NEEDED	8 _____
3 OTHER INSECTS	6 MAINTENANCE NEEDED	9 _____

ABBREVIATIONS: PTW = pressure treated wood

I. OUTSIDE - CURTILAGE: Pests reported present: _____

Garbage/dumpster conditions..... _____
General area cleanliness..... _____
Dead trees/wood debris (termites)..... _____
Pest harborage (materials on ground).... _____
Pest breeding (water/food, etc)..... _____
Paving/walk drainage/problems..... _____
Firewood stacked too close to house.... _____
Insects in gardens/mulch..... _____
Plants too close to building..... _____
General weed control..... _____
Hazardous trees/limbs..... _____
Shed/outbuilding problems..... _____
Rodent burrows/sign/access present..... _____
Pet/bird feeders/waterers/feces..... _____
Insect evidence/harborage..... _____
Vertebrate pest evidence/holes..... _____
..... _____
..... _____
..... _____
..... _____

II. FOUNDATIONS/GRADE/SIDING: Pests present: _____

A. FOUNDATION:

Building corners square/foundations?... _____
Foundation intact; dirt/wood contact?.. _____
Wood-concrete contact (PTW)..... _____
Wood-soil contact (PTW)..... _____
Foundation cracks ..... _____
36" clear area around foundation ..... _____
..... _____
..... _____
..... _____
..... _____

B. GRADE:

Soil drainage characteristics.....
Grade from house (6-in/10 ft.).....
Grade and water accumulations.....
.....
.....
.....
.....

C. SIDING:

Downspout/drains splash on siding?.....
Splash blocks/perforated pipe.....
Moist siding/peeling paint?.....
Water/air conditioner leaks.....
Rusty nails/wood streaking .....
Discolored/decayed wood siding.....
Results of Pick Test on wood.....
Wood moisture readings.....
Buckled/peeled stained siding.....
Wood junctions caulked .....

Trailer skirting intact?.....
Porch/porch soffit condition.....
Tongue & groove flooring caulked.....
Door sweeps/good door closure.....
Metal kickplates on doors.....
Window frame conditions.....
Vents/exhausts/conduits screened.....
Cracks/holes around pipes/wires.....
Outside lights away from doors/on poles; high pressure sodium bulbs; covers clean.....
Trees touching/overhanging structure....
Plants/plantings/planters/trellises....
Trash/debris accumulations.....
Insect/vert. pest evidence/harborage...
.....
.....
.....
.....

D. FOOD ESTABLISHMENTS (in addition to above):

Loading docks/receiving areas clean.....
Gargage area removed from back door.....
Other outside storage/spills.....
Exterior wall/foundation cracks.....
Storage of rejected goods/returns.....
Outside pallet clean/storage.....
.....
.....
.....
.....

E. STRUCTURAL ROOF: Pests reported :....

Missing shingles/cracks in surface.....
Water leaks around air conditioning....
Moss/lichen/algae/fungus on roof.....
Rusty iron nails in galvanized roofing.
Shingle extension 1"/eave 12-24-36"....
Gutters clean, not clogged.....
Chimney/vents screened.....
Shingles/roof intact.....
Bird problems in eaves.....
Chimney flashings/construction tight....
Dormer flashings/construction tight....
Skylight flashings tight.....
Soffit intact/vents screened.....
Wires from roof pest-protected.....
Insect evidence/harborage.....
Facia tight/painted (carpenter bees)...

III. INSIDE - CRAWLSPACE; Pests reported:
Monitor house twice a year for moisture and damage: (1) end summer from air conditioner; (2) end winter from heating/weather or just before rainy season so corrections can be made before rains come.

Vents screened/open/in wells.....
Height of crawlspace (18-in to joists)..
Wood/soil contacts.....
Wood pick test .....
Termite shields installed?.....
Leaking pipes.....
Structural wood type.....
Wet areas? Why? Moisture readings ...
Mold/fungus/decay/insect damage.....
Wood debris present .....
Evident floor/wood shrinkage.....
Vapor barrier? Intact?.....
Pest access into structure thru floor
Active insect infestations seen?
Vertebrate sign seen?.....
Ventilation: 1 sf/150sf; w/in 3' corner
Crawl space access door clear...

IV. INSIDE - STRUCTURAL; Pests reported: _____

A. BASEMENT CONDITIONS:

Walls dry/moisture readings..... _____
Storage condition/sanitation..... _____
Wood moisture in sill area..... _____
Floor drains clean/screened..... _____
Sticky trap monitoring..... _____
Trash collection practices..... _____
Insect evidence/harborage..... _____
..... _____
..... _____
..... _____
..... _____

B. VISITOR CENTER/EXHIBITS/OFFICES; Pests _____

Reception desk area..... _____
Exhibit area: general pest risks?..... _____
Exterior door conditions?..... _____
Offices: neatness/problem areas..... _____
Eating/storing food at desks..... _____
Computers/elec equipment problems..... _____
Insect attracting items in building?..... _____
Insect evidence/harborage..... _____
Lunchroom/coffee making area..... _____
Vending machines..... _____
Trash collection practices..... _____
Decorative plants..... _____
..... _____
..... _____
..... _____
..... _____

C. SERVICE/JANITORIAL ROOMS; Pests reported present: _____

Janitorial storage area..... _____
Wet mops/rags, sour drains..... _____
Electrical boxes/equipment..... _____
Drains clean/screened..... _____
..... _____
..... _____
..... _____

D. MUSEUM STORAGE; Pests reported..... _____

Storage off floor..... _____
Monitoring schedule & sticky traps..... _____
Temperature/humidity control..... _____
General cleanliness..... _____
Exterior door conditions..... _____
Cracks/crevices present?..... _____
..... _____
..... _____
..... _____
..... _____
..... _____

E. RESIDENCES/LIVING ROOMS, ETC Pests:.. _____

General sanitation/lint..... _____
Clothing/lockers..... _____
Cans/cardboard box storage..... _____
Indoor plants..... _____
Sticky trap monitoring/records..... _____
Condition of aquaria tanks..... _____
Storage off floor..... _____
Floor/wall junction for insect signs... _____
Cracks/holes in floor ..... _____
Interior temperature/humidity..... _____
Suspended ceilings/light fixtures ..... _____
PCO serviced; when/who/records..... _____
Insect evidence/harborage..... _____
..... _____
..... _____

F. RESIDENCES/KITCHEN; Pests:.....

Counter tops caulked/intact.....
Exhaust vents leaking .....
Water leaks/pipe sweating.....
Drains clear/good condition.....
Food stored in cans/glass.....
Pet food conditions/storage.....
Shelves cleaned/no shelf paper.....
Refrigerator pan/motor/gasgets.....
Windows tight/insect presence.....
Condition of walls/grease/moisture.....
Storage off floor.....
Dish washer, cleanliness/pests.....
Stove vent clean/screened.....
Stove/refrigerator doors clean.....
Hollow legs on tables/chairs?.....
Equipment on legs.....
Conditions under lowest drawers.....
Trash covered; out every night.....
Dishes kept in water until cleaned.....
Outside trash covered, cans cleaned weekly
Hot water heater condition .....
Insect evidence/harborage.....
.....
.....
.....
.....

G. RESIDENCES/BATHROOM

Water leaks at tub/shower/toilet.....
Floor strength near toilet.....
Water leaks under sink.....
Moisture under rug.....
Condition of window frames.....
Blistered ceiling/wall paint.....
Insect evidence/harborage.....

H. FOOD ESTABLISHMENTS

Refrigerated/dry storage areas.....
Areas behind false fronts on equipment.....
Loose floor tile/screened drains.....
Elevator pits.....
Regularly emptied trash containers.....
Area around can opener/grease hoods.....
Condition of window frames .....
Employee lockers.....
.....

I. PESTICIDE STORAGE AREA - RESIDENCE/OFFICE/FOOD ESTABLISHMENT

Non-approved materials used.....
Protective equipment/eye wash.....
Warnings/first aid posted.....
Sanitation.....
Shelving.....
Locked/out of childrens' reach.....
.....
.....
.....
.....

J. STRUCTURAL/ATTIC; Pests reported:...

Sufficient ventilation/insulation.....
Insect/pest evidence.....
Vents screened.....
Temperature.....
Exposed/chewed wiring.....
Insect evidence/harborage.....
Frozen condensation/ice dams.....
Appliance venting .....
.....
.....
.....

K. RESIDENCES/GARAGE; Pests reported:...

Kinds storage.....
Physical connection to house.....
Insect/pest evidence.....
Insect evidence/harborage.....
.....
.....
.....
.....

J. OTHER NOTES; Pests reported:.....

FLOORS:.....
.....
.....
.....

WALLS:.....
.....
.....
.....

WINDOWS/DOORS:.....
.....
.....
.....

CEILING:

....._____

....._____

....._____

....._____

OTHER:....._____

....._____

....._____

....._____

EQUIPMENT CHECK-LIST

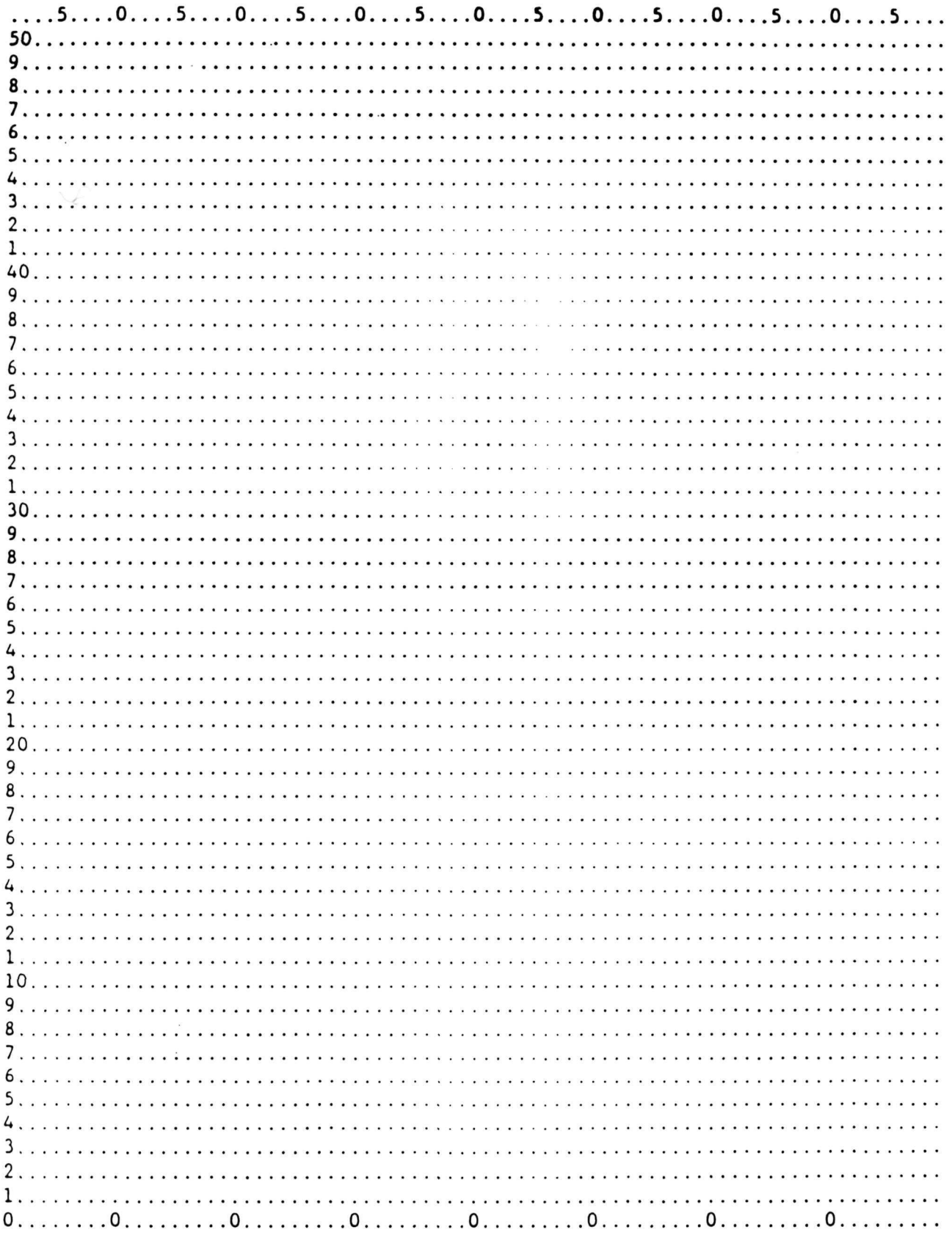
PERSONAL PROTECTIVE EQUIPMENT

HARD HAT
INSECT REPELLENT
KNEE PADS
GLOVES: BOTH HEAVY AND SURGICAL
FACE SHIELD and/or GOGGLES
DUST MASK/RESPIRATOR
OVERALLS and/or BEE SUIT
BEE VEIL
SMOKER and FUEL
WASP-FREEZE
FLY SWATTER

TOOLS TO HAVE WITH YOU FOR SITE INSPECTIONS

CLIPBOARD/GRID & PLAIN PAPER
INSPECTION FORMS / PENCIL
INSECT KEYS / INFORMATION
ASPIRATOR (collecting flies)
FLASHLIGHT / HEAD LAMP / BATTERIES
BELT POUCH for TOOLS
EXTENDABLE MIRROR
TAPE MEASURE and/or HAND RULER
POLAROID & REGULAR CAMERA/FILM/FLASH
BELT KNIFE and/or LEATHERMAN TOOL
HAND LENS / DIS. SCOPE / BINOCULARS
MOISTURE METER / ANEMOMETER
SMALL HAND TROWEL
OPTIVISOR
SCREWDRIVERS (PHILLIPS/SLOT)
CRESCENT / GENERAL WRENCH / PLIERS
KNEE & ELBOW PADS
PORTABLE VACUUM CLEANER
RECHARGABLE DRILL
MASKING & FILAMENT TAPE
LADDER/50-FT ROPE/CARABINER
SHARP PROBE (wood testing)
WHITE COVERALLS (to show dirt)
FORCEPS
HAND DUSTER
VIALS/ALCOHOL; PLASTIC ZIP-LOCKS
STETHOSCOPE
COLORED STICKY LABLES (mark sites)
POCKET TAPE RECORDER
TRI-DIE
FLUSHING CHEMICAL
PT-2 CAULKING COMPOUND
STICKY TRAPS

DIAGRAM OF STRUCTURE



Review Questions for Chapter 3: Monitoring Rodent Populations

1. In IPM, the "action level" is

   a) a pest population level that causes unacceptable damage
   b) the number of pests that triggers a formal inspection
   c) the population level at which some management action must be begun
   d) the percentage of pests killed by rodenticides

2. If rats are active in daytime, the rat population is probably high. TRUE or FALSE?

3. A mature Norway rat's droppings are about _____ inches long.

   a) 1/4 b) 1/2 c) 3/4 d) 1

4. A mature house mouse's droppings are about _____ inches long.

   a) 1/4 b) 1/2 c) 3/4 d) 1

5. A tracking patch is

   a) a light dusting of inert material used to show rodent tracks
   b) a light application of rodenticide tracking powder
   c) a phosphorescent marker for following rodents to nest sites
   d) none of the above

6. Fresh rat droppings are black on the outside and gray and crumbly on the inside. TRUE or FALSE?

7. Grease marks--

   a) are commonly found where rats travel at wall/floor junctions
   b) are found in the center of a rodent's territory
   c) are used in mark/recapture studies
   d) mark the edge of a rodent's territory

8. Odor can be used to tell the difference between populations of rats and mice. TRUE or FALSE?

9. Mice urine stains show up as long heavy stains under UV light (black light). TRUE or FALSE?

10. Mouse droppings can be distinguished from American cockroach droppings because mouse droppings are blunt at both ends. TRUE or FALSE?

Chapter 4

Management of Commensal Rodent Populations

Learning Objectives

After completion of this chapter, you should be able to

- List and describe the four basic categories of management tactics in a rodent IPM program.
- Discuss the role of sanitation in rodent infestations.
- Choose management methods that will provide the longest-lasting results with the least risk to environment and human health.
- Know how to place and bait rodent traps for maximum effect.
- Understand the NPS policies relating to chemical treatments.
- Be able to use rodenticides safely and effectively.
- Know how to evaluate the success of an integrated pest management program.

If monitoring has determined that the rodent population is unacceptably high, it's time for the third step in the IPM process: selection of the management steps to suppress the pest population.

Successful rodent management programs use a combination of tools, procedures, and strategies. This is where understanding the rodent's biology can really help. We can often reduce the population by employing 'preventive techniques' that treat the cause of the problem (spilled food, damaged walls, inadequate trash pick-up, etc.) rather than the symptom--the rodents. In this way, we can suppress the population without simply depending on chemicals, or relying solely on suppressive strategies that fail to provide long-term management.

However, it is important to point out that management of rats will differ in many respects from management of mice. Many program failures can be traced to not understanding the differences between these pests. Remember some of the key differences discussed in the last chapter:

- rats have much larger territories than mice
- rats fear new objects; mice are curious
- mice can fit through much smaller openings than rats

- mice have a higher reproductive capability than rats
- rats need water every day; mice can obtain adequate water from the moisture in their food
- mice are nibblers; rats tend to eat more at each food source

Are these differences important? You bet. During the past few decades, we seem to have gotten better at suppressing populations of Norway and roof rats, while problems with house mice appear worse. This change undoubtedly reflects our increasing ability to rat-proof buildings and the greater emphasis on rat management techniques.

Baiting programs, too, are usually more successful in suppressing rats than they are at suppressing mice. In fact, inside structures, house mice often fill niches formerly occupied by rats. Many failures to manage house mice are due to the pest management specialist's lack of understanding of mouse biology and habits, and particularly of the major differences between mice and rats.

Here are three examples: *First,* mice are much smaller than rats. It is far more difficult to find and seal all openings that a mouse can fit through than it is to rat-proof a structure.

Second, the home range of mice is far smaller than that of rats, so that you must precisely identify each infested mouse site to insure effective management. Because rats travel so much farther in their nightly rounds, you have many more potential sites for trapping or baiting.

Third, because mice have such a high reproductive potential (up to 50 young per year), in large infestations mice can often keep producing offspring faster than lethal management methods can reduce the population.

NPS personnel who do not take these differences into account will fail.

Some management techniques are lethal to rodents, some are not. Lethal procedures include the use of rodenticides, snap traps, and glue boards to quickly reduce a population. Nonlethal procedures include improving sanitation, reducing harborage, and rodent-proofing buildings. Long term, the most important tactics for reducing rat and mouse problems are in this second, nonlethal category, because the procedures (1) reduce the environment's capacity to support rodents or (2) block the rodents' access to buildings.

The IPM process may call on the talents of a variety of professionals including biologists, chemists, architects, landscapers, botanists, and soil specialists. Experts representing the various departments within the National Park Service can work together to determine the best methods to use. For assistance contact one or more of the following resources:

- Regional IPM Coordinator
- Washington Office IPM Coordinator
- County Extension Agent
- Public Health Official—Regional Office

The methods available in a rodent IPM program broadly break into four categories: cultural, physical, mechanical, and, as a last resort, chemical. The sections that follow describe some of the major techniques and tools used against rats and mice. Because of the differences in the management of rats versus mice, we will discuss them separately under each category.

Cultural Methods

Cultural methods involve modifying human activities and behavior to limit the rodents' supply of food, water, and harborage.

RATS

Like all animals, rats need food to survive. Whenever there is a severe problem with rats, rest assured there is an abundance of food somewhere for them to eat. Rats may be getting their food from dumpsters and garbage containers that are damaged or left open. They may be feeding on food spills or food left out overnight, or on food, water, and even manure from horses and livestock. A rat problem might be traced to seeds spilled under bird feeders or to food and even animal feces around doghouses or kennels. Food waste in a compost pile is another favorite rat food source.

Rats often feed on spills around railroad tracks and loading docks. Rats also feed directly on the food in storage, particularly if stock isn't rotated often enough (first in, first out) or is stored on the ground or against walls rather than up on pallets.

If rats have plenty of food, it is difficult to manage them. Baiting programs often fail because the bait can't compete with the rats' preferred food. The rats simply ignore the baits or cache them. Sometimes you can move rats out of an infested area simply by eliminating the food they are feeding on. Reducing the rats' normal food forces them to try for bait in traps or to feed on any rodenticide baits you may have placed in their territory.

Poorly managed dumpsters are frequently a source of rodent food

Public education can help improve sanitation and reduce the ready availability of food. Park visitors can be encouraged to properly dispose of trash. They should also be discouraged from feeding wildlife, which often results in feeding more rats than native animals, and which is prohibited in National Park sites. (According to the Code of Federal Regulations, *"feeding, touching, teasing, frightening or other intentional disturbing of wildlife is prohibited.)"*

In addition to public education, the cooperation of neighbors can be essential. For example, rats can overflow from your neighbor's poorly managed restaurant dumpster into your facility even though your trash is properly contained. You will have to communicate and cooperate with that restaurant manager in order to successfully manage the rats at both sites.

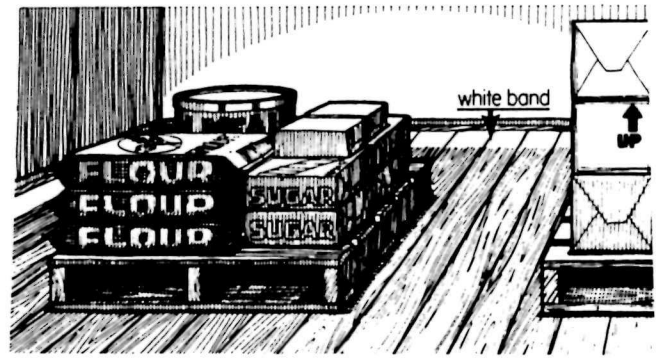
MICE

Even the best sanitation will not eliminate house mice. They require very little space and small amounts of food to flourish. However, good sanitation makes it easier to detect the signs of mouse infestation. For example, it is much easier to detect fresh droppings on a recently swept floor than on a floor full of debris, grease, and old droppings. Good sanitation also can increase the effectiveness of baits and traps by reducing competing food.

In concession areas, candy bars and food needs to be sealed in containers overnight.

Store bulk foods in mouse-proof containers or rooms. In food storage areas, stack packaged foods in orderly rows on pallets so that they can be inspected easily. A family of mice can happily live in a pallet of food without ever having to leave the immediate area.

Keep stored materials away from walls and off the floor. A 12-18 inch yellow or white painted band next to the wall in storage areas permits easier detection of mouse droppings. This band and the areas around pallets should be swept often so that new droppings can be detected quickly.



An 18-inch band next to the wall permits easy detection of rodent droppings

Physical Methods

Physical methods include harborage reduction to eliminate rodent habitat, and rodent-proofing to "exclude" rodents from buildings and other sensitive sites. *Note: Building alterations in historical sites need to go through cultural resource manager for approval using Form XXX (copy provided at end of chapter).*

RATS

Harborage Reduction. Landscaping should not include thick hedges or bushes which obscure the ground. Shrubbery with thorns planted around foundations makes inspection difficult. Ground covers such as ivy, which provide cover or runs for rats, should not be planted adjacent to buildings. Landscapers and soil specialists can design pests out of the system by the selection and mix of plant species that are not favorable to rodents.

High grass, weeds, wood piles, and construction debris also permit rats to live and hide adjacent to buildings and should be removed. Rats avoid open areas.

Timely mowing of dense grass, and active cultivation and pruning of plants, can reduce rodent cover so that rodents are less attracted to a site, while any existing rodent populations are stressed.

Because rats often burrow near their food supply, dumpsters and outside garbage containers should sit on pavement or concrete pads. For "tulip-style" trash containers, galvanized metal disks can be installed at the bottom to prevent rats from chewing through plastic liners.

Cluttered, rarely used rooms—basements, storage rooms, equipment rooms—can provide hiding places for rats. Debris should be discarded. Items should be stacked, organized, and rotated. Food products in storage rooms, warehouses, and restaurants and cafeterias should be on pallets or shelves to keep them off the floor. Pallets should be 18-24 inches from side walls and placed so that aisles permit inspection and cleaning around the stored food. A 12-18 inch yellow or white painted band next to the wall in storage areas permits easier detection of droppings.

Rat-Proofing. Long-term, the most successful form of rat management is to "build them out." Also called rat-proofing, this technique makes it impossible for rats to get into a building or an area of a building. Without rat-proofing, new rats will often reinfest a building that has been cleared by a successful baiting or trapping program.

Rat-proofing isn't always easy. Young rats can squeeze through a slot-like opening 1/2-inch high, and there can be many such 1/2-inch openings into a building.

- Block openings around water and sewer pipes, utility lines, and air vents.
- Doors and windows should be tight-fitting. If not, install metal kick plates or sweeps on doors and metal jambs on windows and doors.
- Screen air vents.
- Seal any cracks or holes in foundations (above and below grade) and exterior walls.
- Repair damaged roof soffits, and seal any openings to the roof.
- Repair any gnaw holes after stuffing them with steel or copper wool.
- Equip floor drains with sturdy metal grates.
- In roof rat areas, cables, trees, and pipes leading to or touching a structure should be rat-proofed with galvanized metal barriers.
- Indoors, too, repair holes in masonry and walls to prevent rat movement within the building.
- Block large openings with 16-19 gauge, 1/2-inch mesh screen.

MICE

Harborage Reduction. Many of the recommendations made for reducing rat harborage work for mice as well. Reducing clutter indoors is especially important. A rarely used and jam-packed storage room can be a mouse breeding factory--each box, each bag,

and each void becomes a self-contained and protected niche for a family of mice.

Stack stored goods, particularly food, on pallets or shelves so there are plenty of aisles and open spaces. Leave an aisle 18-24 inches from side walls to permit inspection and cleaning.

Mouse-Proofing. It isn't easy to completely mouse-proof a building since mice can squeeze through a slot-like opening as little as 1/4-inch high. Yet, sealing larger holes, as was discussed under rat-proofing, will go a long way towards limiting the easy movement of mice into and through a building. Plugging holes in foundation walls, even just with steel wool or copper mesh, and making sure doors and windows fit tightly, can minimize the influx of new mice from outside.

Sealing holes around pipes, utility lines, vents, and the like, makes it difficult for mice to move in and out of wall and ceiling voids. This confines mice to a smaller area and may make snap traps and glue boards more effective. The more difficult you can make it for mice to move around, the easier it will be to suppress the population. Holes can often be detected by turning off lights, closing windows and doors, and noting where daylight shows.

Holes can be sealed with various materials including ready-mix concrete, spackling compound, steel wool, copper gauze, sheet metal, and even expandable caulking compound. When sealing holes with materials that rodents are capable of chewing through, such as spackling compound or caulking, be sure not to leave a "biteable" edge. If the rodent cannot grab an edge of some sort, it is not likely to gnaw a new hole at the same spot.

Mechanical Methods

Mechanical management tools include the use of various types of traps and glue boards.

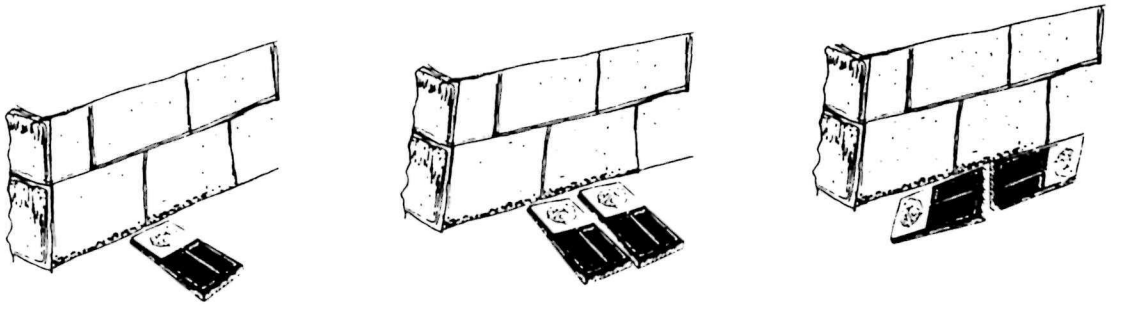
RATS

Trapping. The *snap trap* is an effective method of managing rats when used by people who understand trap placement and rodent habits. Trapping is usually the method of choice in NPS facilities whenever lethal management actions are deemed necessary.

Trapping has several advantages. There is no risk of environmental contamination. Traps permit the pest management specialist to instantly tell whether the trap has been successful. They are effective against both low and high populations. Traps allow for disposal of the carcass so that there are no odor problems, also avoiding the problem of dermestid beetles, blow flies, and other scavengers feeding on carcasses as is the case with poisoning programs.

However, careful attention to detail is necessary to use traps effectively. They need to be set in the proper location, in adequate numbers, and in the right position or rats will simply pass them by.

The best traps are those with expanded triggers (treadles), set for a light touch. Leaving the traps unset for a few days



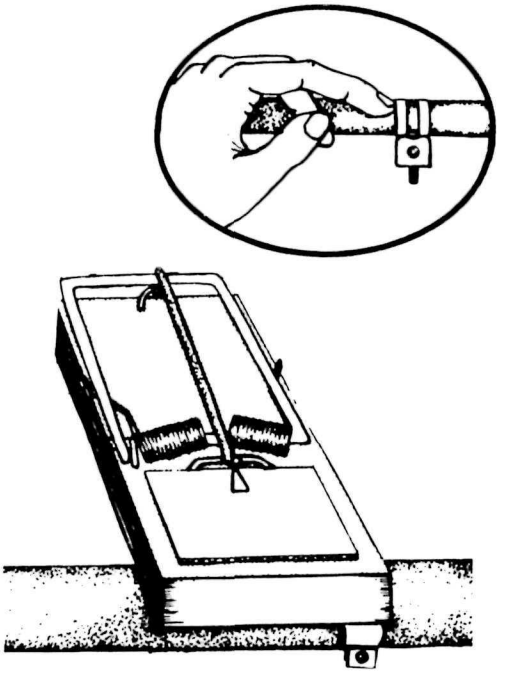
Three effective trap placements (note that triggers are next to wall)

will ultimately increase the catch by reducing the chance that wary rats will trip the traps without capture. Traps work even without being baited. However, if food for rats is in short supply, an attractive bait can greatly increase a trap's effectiveness.

Successful baits for Norway rats include peanut butter, hot dog slices, bacon, canned mackerel and other oily fish, or nut meats. Tie bait to the trigger using string or dental floss to prevent the rat from removing the bait without triggering the trap. Traps can be made more attractive by sprinkling cereal, such as oatmeal, around it. Roof rats can be baited with dried fruits and nuts or fresh fruits such as banana or apple. If one bait isn't working well, switch to another, preferably something they are used to feeding on. ***Outdoors, traps should be set inside trap boxes if pets or non-target wildlife species may be at risk.***

Traps can be set unbaited along runways, the idea being that the rats will step on the trap during their regular travels. Set traps where you find droppings, gnawing damage, grease marks and other evidence of activity. Set traps along walls, behind objects, in dark corners where the rat is forced through a narrow opening. Place the trigger side of the trap next to the wall.

Probably the biggest mistake made when trapping is not using enough traps. Place them wherever you've found active signs of rats. A dozen may be needed for a house, a hundred for a small warehouse. Set five or ten traps in an active corner of a room. Set three traps in a row so the rat, leaping over the first, will be caught in the second or third. If you're not sure about sites of activity, set traps along possible runways spaced 10 to 20 feet apart.



Trap attached to pipe with hose clamp

Rat runways are often located on rafters and pipes. Set expanded trigger traps directly across them, fastening them to pipes with wire, heavy rubber bands, or hose clamps, and to rafters with nails. Don't place traps over food preparation areas.

After a few weeks of trapping you may be left with a few rats that become very difficult to capture. Rats can become trap shy, and you may have to camouflage your traps to get them to work. Traps can be set in a shallow pan of meal, sawdust, or grain so that the trap can't be seen. Place a small piece of cloth or plastic over the trigger to prevent the meal from jamming the mechanism underneath.

In stubborn cases, food may be exposed in shallow pans until the rats begin feeding. Then a buried trap can be added. Or, you can position traps with bait but leave them unset for a few days or weeks until the rats become used to them. You can also improve trapping effectiveness in the long run by moving boxes and objects around to create narrow runways to the traps. (But note that in the short term, the rats will probably become nervous with the changes and avoid the trap area.)

The odor of other rats actually seems to improve a trap's effectiveness, and an old trap will often outperform a new one. In contrast, the odor of insecticide can make a rat steer a wide berth around the trap. Avoid spraying insecticide on the trap, or even storing traps with insecticides or application equipment.

Traditional Live Traps. Live traps are rarely used for commensal rat management because release of these pests in another area is not normally a good idea. However, live traps are sometimes used to capture rats for scientific purposes, such as to see if they are infected with diseases or parasites, or to screen them for resistance to rodenticides. Another potential use for live traps is to trap pest rodents when protected nontarget species are also present. Protected species could be released; while pest species would be destroyed.

Glue Boards. Another way to trap rats is with glue boards. Glue boards use a sticky material to capture rodents. Rodents usually die by asphyxiation when their face is trapped in the glue.

Although most often used against mice, they can sometimes be used effectively against rats. You must, however, use the larger glue boards that have been designed to trap an animal the size of a rat.

Be aware that some people consider glue boards to be inhumane, and will strongly protest their use. Large rats may not die easily or quietly. Snap traps are usually a better choice against rats.

If glue boards are used, place them in the same locations as you would place snap traps. Place them lengthwise flush along the wall, box, or other object that edges a runway. Fasten them overhead along runways on pipes, beams, rafters, and ledges. But don't place the glue boards directly over food products or food preparation areas.

Secure the glue board with a nail or wire so a rat can't drag it away. Install glue boards in a tamper-resistant bait

box (usually used for rodenticide treatment) if people might be upset by a struggling rat, or where children, pets, or nontarget animals could contact the glue, or in areas with excessive dust or moisture. Adding a dab of bait to the center of the glue board can sometimes improve its effectiveness.

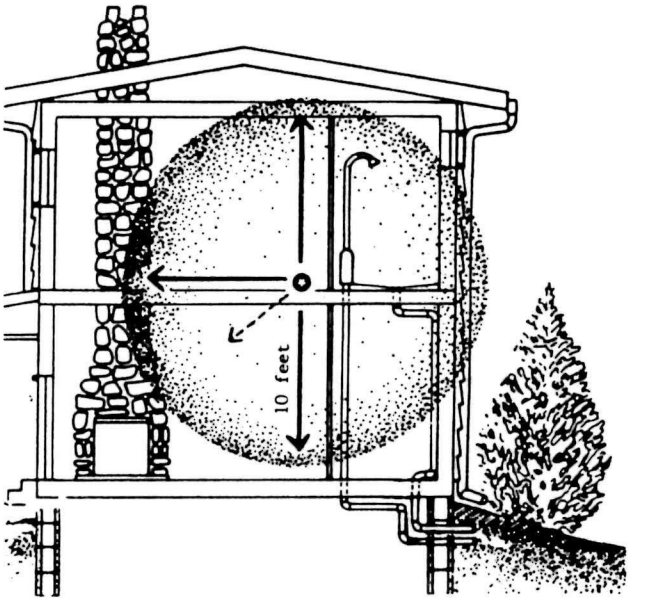
Glue boards should be checked every morning and any live rats should be quickly dispatched.

MICE

Snap Traps. Snap traps will effectively suppress mice if used correctly. But snap traps must be set in the right places, in high numbers, and in the right position or mice will miss them entirely.

Remember that the territory of mice rarely extends farther than 30 feet from the nest, and more often is about 10 feet. If mice are sighted throughout a building it means that there are numerous discrete locations where you will have to set traps. Place snap traps not only wherever you see obvious signs of mice, but look for good trap locations in a three-dimensional sphere about ten feet in diameter around those signs.

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

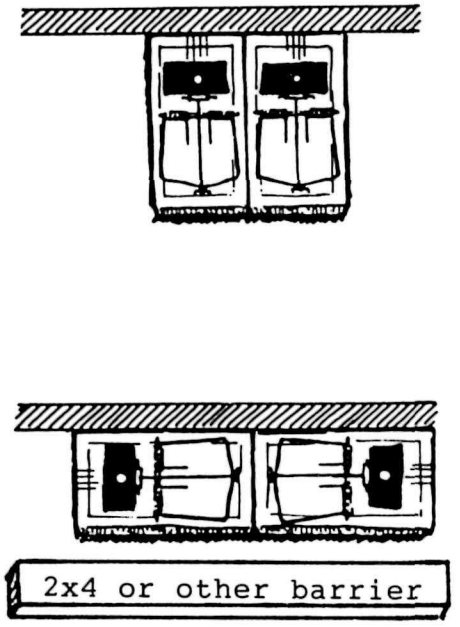


Think of a mouse's territory as a three-dimensional sphere

Good mouse baits increase a trap's effectiveness. Food baits must be fresh to be effective. Peanut butter, bacon, cereal, and nuts are traditional, but one of the best baits is a cotton ball, which the mice like to use for nest material. It works exceptionally well where nesting material is in short supply, but it must be tied securely to the trigger.

Probably the biggest mistake made in mouse trapping is not using enough traps. Use enough to make the trapping campaign short and effective, so that populations are adequately reduced before the remaining mice

become trap shy. A large number of traps set for a short time will be far more effective than a small number of traps set for a long time.



Good trap placement greatly increases the effectiveness of a trapping program

Multiple-Catch Traps. Multiple-catch mouse traps automatically catch up to 15 mice without resetting. Some brands are called "wind-up" traps because you wind a mechanism that "kicks" the mouse into the trap. Others use a treadle door.

The traps depend on a mouse's curiosity. They work because mice investigate new things in their territories. Mice enter the small entrance holes with little hesitation. Odor plays a role too, and traps that smell "mousy" often catch more mice. Sometimes a small dab of peanut butter inside the tunnel entrance can improve the catch.

Mice are captured alive but may die in a day or two so traps should be checked frequently. Some traps have a clear plastic end plate or lid so you can see if any mice have been captured. Mice captured in these types of traps are traditionally destroyed by drowning.

Place the traps right against a wall or object with the opening parallel to the runway. Or, you can point the tunnel hole towards the wall, leaving one or two inches of space between the trap and the wall. If mice are active, place many traps 6-10 feet apart. In some instances you may want to set traps at potential mouse entry points that cannot be adequately "mouse-proofed," such as loading docks and damaged doorways.

Traditional Live Traps. Live traps are rarely used for commensal mouse management because release of these pests in other areas is not normally a good idea. However, live traps are sometimes used to capture mice for scientific purposes, such as to see if they are infected with diseases or parasites, or to screen them for resistance to rodenticides.

Another potential use for live traps is to trap house mice when protected nontarget species are also present. Protected species could be released; while pest species would be destroyed.

Glue Boards. Glue boards are very effective against mice. As with traps, placement is the key. In fact, most locations that would be good trap sites would also be good sites for glue boards. However, don't place glue

boards directly above food products or food preparation areas.

Place glue boards lengthwise and flush against a wall, box, or other object that edges a runway. Moving objects around and creating new, narrow runways six inches wide can greatly increase the effectiveness of glue boards. So can placing a little peanut butter or a cotton ball in the center of the glue board.

Since mice have small territories, place the glue boards 5 to 10 feet apart in infested areas, closer if the population is large. If you haven't captured any mice after three days, move the boards to new locations.

Check glue boards every morning. If a trapped mouse is alive, drown it or otherwise kill it before disposal.

Glue boards don't just capture mice, they capture anything small that may walk across their surface. Replace the boards if they fill up with cockroaches and other insects, or if they become dusty. Check them often.

NOTE: If a nontarget animal such as a cat or a snake gets stuck on a glue board, it can often be removed unharmed by dissolving the glue with cooking oil.

Chemical Methods

Chemical treatments may involve the use of rodenticides (pesticides used against rodents) or fumigants. National Park Service policy states that chemical treatments should only be used as a last resort (*NPS-77* Chapter 2, *Management Policies* Chapter 4).

Regional offices must each year review and approve prior to use all planned pesticide applications (using a Pest Management Report Form 10-21A; see sample at end of chapter). The Washington Office must review and approve or deny all proposed pesticide use on lands or facilities owned, managed, or regulated by NPS. All pesticide use must fully conform to NPS policies and guidelines.

Rodenticides should not be used indoors in NPS facilities, particularly in historic buildings, except under extreme circumstances. Rodents that have ingested a toxic dose of rodenticide may crawl into wall voids and other inaccessible areas to die. The decaying carcass can produce foul odors and attract insects such as dermestid beetles or blowflies, which feed on the dead animal. Once they have consumed the carcass, the insects will seek other food sources, and may become pests themselves, feeding on fabrics, furs, stored foods, and historic artifacts.

RATS

There are three major formulations of rodenticide used against rats: food baits, water baits, and tracking powders.

Food Baits. Rat baits combine a poison effective against rats with a food bait attractive to rats. At one time, applicators mixed their own baits. Now baits are mostly purchased ready-made and packaged. They come in extruded pellets, in a dry meal, or molded into

paraffin blocks for wet sites. Baits may be packaged in 45-pound bulk tubs, in individual place packs containing less than one ounce of bait, or anything in between. For safety, some baits include chemicals that are extremely bad-tasting to humans, but not to rodents.

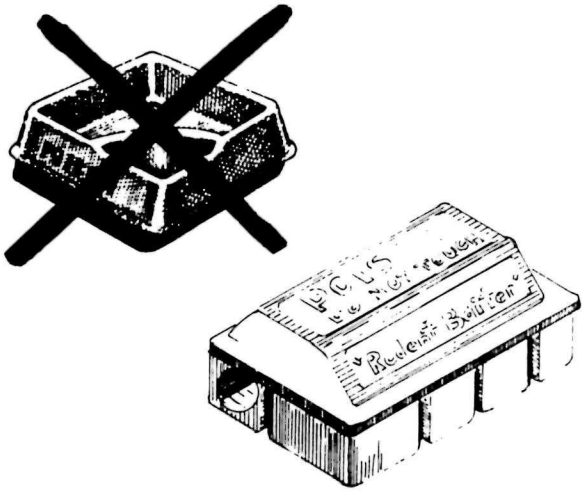
Some baits kill rats after a single feeding, some require multiple feedings. Some are anticoagulants, meaning they cause rats to bleed to death, some affect respiration, and some have totally different modes of action. Some are only slightly toxic to people or pets, some moderately toxic, and some very toxic.

Individual products will not be discussed here. ***Each rodenticide product has different characteristics and you must review the label and supporting information that comes with each product to use it safely.***

Always review the label before using a rodenticide, no matter how many times you have used the product before. Labels change and products change, and sometimes we may think we remember how to use a product when in fact we don't.

There are general guidelines, however, that should be followed when using a poison bait. First and foremost, children, pets, wildlife, and domestic animals must be protected from eating the bait. All rodenticides have warnings on the label telling the applicator to place the bait "in locations not accessible to children, pets, wildlife, and domestic animals, or in tamper-proof bait boxes."

No one can give you a list of safe, inaccessible areas. You have to decide on a case by case basis. Ask yourself—Is possible for a child or nontarget species of wildlife to get at the bait? Do everything possible to prevent that from happening. Place baits deep inside active rodent burrows or inside tamper-resistant bait boxes.



Tamper-resistant bait boxes, <u>not</u> bait trays, must be used in accessible areas

A tamper-resistant bait box is designed so that a child or pet cannot get to the bait inside, but the rat can. A bait tray is not a tamper-proof bait box. Tamper-proof boxes differ in the type and quality of construction, but they are usually metal or heavy plastic with a locking lid. Rat boxes are normally larger than those used for mice. They are not considered to be truly tamper-proof unless they can be secured to the floor, wall, or ground and the lid can be locked into place.

Bait boxes should be clearly labeled with a precautionary statement. They should be checked periodically to see if rats are taking the bait and if the bait is fresh. Rats will rarely feed on bait that has spoiled.

The best locations for baiting rats varies with each job. Don't expect the rats to go out of their way to feed. Bait should be placed wherever the rats are most active as determined by droppings and other signs. Remember, though, that rodenticides are rarely approved for use indoors at NPS sites. Put bait boxes outside near burrows and along travel sites. Put place packs or loose bait *inside* burrows. If a site is damp, such as inside sewers and storm drains, use paraffin bait blocks secured so that they cannot be dragged away. Roof rats often need to be baited in areas above ground such as attics, trees, and roofs.

Put out the amount of bait recommended by the label, and check the bait often. Incomplete baiting can lead to bait shyness and make management difficult. Be sure to limit the rats' normal food supply by eliminating spills, improving sanitation, and upgrading trash handling or your baits may be rejected. Remember that rats fear new objects at first so that your baits may not be taken for a few days to a week. Once bait is taken, do not move the box for a while as the rats will now consider it to be part of their normal surroundings.

Because rats travel far in their journeys through their territories, good bait placements can be effective even when placed 15 to 50 feet apart. Perimeter outdoor placement of bait stations around a commercial building can intercept and kill rats that are moving in from nearby areas.

Water Baits. Rats drink water daily if they can. When rat water supplies are short, water baits -- specially formulated rodenticides that are mixed with water -- can be extremely effective. However, water baits are attractive to most animals. *They should only be used when you are sure that no other animals or children can get to them.*

There are various liquid dispensers available. The best are custom designed for toxic water baits. Some tamper-resistant bait stations include compartments for water baits. *Do not use standard "chick-founts" or other animal watering devices for liquid baits unless they can be made inaccessible to children, pets, and wildlife.*

Tracking Powders. Rats groom themselves by licking their fur. Tracking powder makes use of this behavior. This formulation is simply a rodenticide carried on a talc or powdery clay. It is applied into areas where rats live and travel. The powder sticks to the rats' feet and fur, and is swallowed when the rats groom themselves. The major advantage to tracking powders is that they can kill rats even when food and water is plentiful, or if rats have become bait or trap-shy.

The rodenticide active ingredient in tracking powders is generally 5-40 times more concentrated than that in baits. Tracking powders would rarely, if ever, be approved for use indoors in a park facility.

Tracking powders are best applied with hand-operated bulb or bellows dusters. The powder is applied more heavily than you would apply an insecticide dust, but never deeper than 1/8-inch. Because of the risk to nontarget species at NPS locations, application of tracking powders would be limited mostly to the inside of dry burrows. Note that not

all tracking powders are labeled for this use.

If a tracking powder is to be used indoors, the best application sites are inside wall voids, around rub marks, along pipe and conduit runs. *Never use tracking powders in suspended ceilings, around air ventilators, or near food or food preparation areas.* The powder can become airborne and drift into nontarget areas.

Don't confuse a toxic "tracking powder" with a nontoxic "tracking patch," discussed earlier under monitoring. *Do not apply a tracking powder to monitor for rodent footprints.*

Fumigants. Several fumigants are available for burrow fumigation including aluminum phosphide, carbon bisulfide, and carbon dioxide. All fumigants, with the possible exception of carbon dioxide, are extremely hazardous and should only be used by experienced professionals, *and under an NPS-approved management plan.*

MICE

Food Baits. The same safety guidelines apply for mouse baits as were discussed in the section on rat baits. First and foremost, children, pets, wildlife, and domestic animals must be protected by putting the bait in inaccessible locations or inside tamper-proof bait boxes.

Probably the most important difference in baiting mice in contrast to rats is to apply many small bait placements rather than a few large placements. Here are some other guidelines:

- Use baits labeled for mouse control.
- Place the baits in favorite feeding and resting sites as determined by large numbers of droppings.
- Also place the baits between hiding places and food, up against a wall or object, to intercept the mice.
- Bait in three dimensions (see earlier discussion on trapping).
- Make bait placements 10 feet apart or closer in infested areas.
- If bait is refused, try switching to a different type, and replace the baits often.
- Use small bait stations which are more attractive to mice than the larger rat-type stations.
- Make sure that sanitation is such that other food isn't out-competing your baits.

Liquid Baits. Even though mice get most of their water from their food, they will also drink from a water container. Liquid baits that are labeled for mouse control can be effective in sites without a ready supply of water. The same water bait dispensers that are used for rats can be used for mice. As with food baits and traps though, many water stations will be necessary in order to put the bait into the territory of all of the mice infesting a building.

Tracking Powders. Tracking powders are especially effective against mice since mice groom themselves more than rats do. They will also investigate enclosed areas which can be dusted with tracking powder.

In commercial pest control, the best application site for mouse tracking powders has been shown to be inside in-

fested wall voids, as long as they are dry. In heavily infested apartment or office buildings, dusting a tracking powder into voids can be the most effective mouse management technique.

However, because of safety concerns and risk of odors, dermestids, and other scavenger insects from decaying carcasses, use of tracking powder indoors would not likely be approved in most NPS facilities.

Tracking powder is sometimes applied inside a bait station, PVC tube, cardboard tube, or any small, dark shelter that mice could enter. Mice will almost always explore such a shelter. Apply the tracking powder in a layer less than 1/16-inch deep, and place the shelter in an area inaccessible to children or animals..

Keep in mind when using tracking powder that you must avoid treatment that may cause the tracking powder to drift into nontarget areas.

Don't confuse a toxic "tracking powder" with a nontoxic "tracking patch," discussed earlier under monitoring. And never use a tracking powder to monitor for rodent footprints.

NOTE: *While liquid baits and tracking powders are effective against rodents, they are not usually recommended for National Park Service sites because of risks to nontarget wildlife and visitors.*

Evaluation of Rodent Management Actions

After an integrated pest management plan has been implemented and various pest management actions have been taken, it is time to evaluate the success of those actions:

- Have the program objectives been achieved?
- Does your monitoring program meet your needs?
- Have rodent populations dropped below action levels?
- What changes are necessary?
- Should management activities (such as landscape alterations and trapping) continue, or should other actions be tried, or can the program now be limited to monitoring rather than further management interventions?
- Who should you contact to implement these changes?

Evaluation of a rodent IPM program requires careful and documented inspection of the site to show whether the pests have decreased below their injury levels. The evaluation should also include an assessment of the success or failure of each action taken. All key players should be involved, including technical experts, site manager or decision-makers, and also the site's occupants and neighbors.

Evaluation is really a continuous process, part of the monitoring program essential to any program operating on IPM principles. Through careful analysis, the IPM management procedures can be adjusted or modified for maximum effectiveness. The decisions on future actions are based on progress-to-date, not on a calendar date, and thus management actions put the maximum stress on the pest and a minimum stress on the environment.

A. ORIGINATING OFFICE

1. Park: _____ (include park district, if needed)
   Project number(s):_____ Project location:_____
   (State/County)

2. Work/Project Description:)include area of potential effect and effects on cultural resources; explain *why work/project is needed.*)

3. Has cultural resources survey work been completed for the area of potential effect?
   ___No ___Yes (If yes, source _____)

4. Affected Resource(s): (Name and applicable IDLCS, MMS, CSI number and map coordinates.)

5. National Register Status of Affected Resource:
   ___ Entered-Documented
   ___ Determined Eligible-SHPO
   ___ Determined Ineligible-SHPO
   ___ Undetermined
   ___ Within an eligible district:
   District Name_____
   ___ Entered-Undocumented
   ___ Determined Eligible-Keeper
   ___ Determined Ineligible-Keeper
   ___ NHL

6. The proposed action will: (Check as many as apply.)
   ___ Destroy, remove, or alter features of a historic structure, setting, environment or cultural landscape
   ___ Replace historic features in kind
   ___ Introduce non-historic features (incl. visual, audible, or atmospheric) into a historic setting, structure, environment or cultural landscape
   ___ Disturb, destroy, alter, or make inaccessible archeological resources
   ___ Potentially affect currently unidentified cultural resources

7. Measures to prevent or minimize loss or impairment of historic fabric, character, setting, integrity or data:

8. Supporting Study Data (attach, if feasible; if action is in a plan, give name and project or page number):

9. Attachments:
   [ ] Maps; [ ] Archeological Clearance, if applicable; [ ] Drawings; [ ] Specifications;
   [ ] Photographs; [ ] Scope of Work; [ ] Site Plan; [ ] List of Materials; [ ] Other

10. Prepared by _____ Telephone_____
    Title_____

11. Signature of Superintendent_____ Date_____

B. REGIONAL CULTURAL RESOURCES STAFF REVIEW

I have reviewed this proposal for compliance with the National Historic Preservation Act and, if applicable, the 1990 PA. I have stated below any additional stipulations that should apply.

Stipulations:

Regional Archeologist	Date
Regional Cultural Landscape Architect	Date
Regional Curator	Date
Regional Ethnographer	Date
Regional Historian	Date
Regional Historian	Date
Regional Historian	Date
Regional Historical Architect	Date
Other	Date

COMPLIANCE REQUIREMENTS -- PLEASE INDICATE WHICH OF THE FOLLOWING APPLIES:

[ ] 1. Consultation under 36 CFR Part 800 has been carries out. (If Stipulation F of the 1990 PA applied to this case, please note in Stipulations section above.)

[ ] 2. The above action meets all conditions for a programmatic exclusion under Stipulation C.1 or C.2 of the 1990 pA. APPLICABLE EXCLUSION: C-1 ___ [specify 1-m] or C.2 addition.

[ ] 3. Consultation about the proposed undertaking was previously completed in the context of a plan review process, in accordance with the 1990 PA, Stipulation E or F. (Please note in Stipulations section above if Stipulation F of the 1990 PA applied in this case.)

[ ] 4. Consultation about the proposed action was previously conducted in development of a Memorandum of Agreement or programmatic agreement approved by NPS, the SHPO and the Advisory Council.

Contingent upon stipulations developed in the consultation process or listed aboe, requirements for Section 106 compliance have been met.

Signed: _____ _____
Regional Compliance Coordinator Date

Approved: _____ _____
Regional Director Date

UNITED STATES DEPARTMENT OF THE INTERIOR
NATIONAL PARK SERVICE
PEST MANAGEMENT PROGRAM REPORT

TARGET PEST:

PRODUCT NAME:

EPA REG. #:

ACTIVE INGREDIENT:

% OR #/G (/)
ACTIVE INGREDIENT:

MIX OF PRODUCE
WITH DILUENT:

PRODUCT USAGE RATE:

PRODUCT AMOUNT USED
PER APPLICATION:

METHOD OF TREATMENT:

FORM APPLIED:

AREA OR UNITS
TO BE TREATED:

MANAGEMENT ZONE:

NUMBER OF SITES:

DESCRIPTION OF SITES:

NO. OF APPLICATIONS:

AMT. PRODUCT USED TOT:

REGION:
YEAR:
ORGANIZATION:
PROJECT:
(e.g., YELL-84-01)

PURPOSE:

SEASON OR PERIOD
OF APPLICATION:

AREAS TO BE AVOIDED:

AREAS TO BE TREATED
WITH CAUTION:

PRECAUTIONS:

USE OF TRAINED OR
CERTIFIED PERSONNEL:

MONITORING:

PERSON TO CONTACT:

OTHER REMARKS:

SIGNATURES OF APPROVAL

PARK: _____ DATE: _____

REGION: _____ DATE: _____

PESTICIDE USE PROPOSAL

Proposal
Number _____

U. S. Department of the Interior
Pesticide Use Proposal

BUREAU _____ STATE _____ COUNTY _____ DATE _____

AREA _____ (____)

I. **Pesticide/Application:**

TRADE NAME _____ EPA REGISTRATION # _____

COMMON NAME _____ MANUFACTURER _____

FORMULATION _____ APPLICATION DATE(S) _____

METHOD OF APPLICATION _____ # OF APPLICATIONS _____

APPLICATION RATE (use units on label) _____

II. **Pest:** List specific pests, crop, and reason for application.

III. **Treatment site:** Describe land type or use, size or volume, timing of application, slope and soil type, if relevant.

IV. **Sensitive aspects and precautions:** Describe sensitive areas (e.g., marsh, endangered species habitat) and distance to treatment site. If sensitive area is upstream or beyond one mile from site, indicate "no sensitive areas nearby." List measures to be taken to avoid impact to sensitive areas.

I will ensure that the pesticide will be applied in accordance with label restrictions and the information above.

Signed _____ Phone _____ Date _____

Bureau Approval _____ Date _____

Bureau Recommendations

Departmental Recommendations

____ Approved
____ Disapproved
____ Approved with modifications

_____ Date _____
Director, Office of
Environmental Project Review

DOI - FORM

UNITED STATES DEPARTMENT OF THE INTERIOR
NATIONAL PARK SERVICE
PESTICIDE USE LOG

PARK: SAMPLE PARK REGION: EASTERN
PROJECT NUMBER: SAPA001 YEAR: 1991

DATE APPLIED	APPLI-CATOR	TRADE NAME	ACTIVE INGREDIENT	EPA REG. NUMBER	PEST	AMT.UNDIL PRODUCT	AREA TREATED
2/25/91	J.Smith	Termin-8	CopperNapth	7424-1	Wood Decay	1.0 gal	100 sqft
3/22/91	M.Davis	"	"	"	"	0.5 gal	50 sqft
4/05/91	B.Mathews	"	"	"	"	1.2 gal	120 sqft
4/15/91	M.Davis	"	"	"	"	0.8 gal	90 sqft
					TOTAL	**3.5 gal**	**360 sqft**

CALCULATE POUNDS OF ACTIVE INGREDIENT: TOTAL UNDILUTED PRODUCT x CONVERSIQN CONSTANT

ACTIVE INGREDIENT(S)	TOTAL UNDILUTED PRODUCT	CONVERSION CONSTANT	POUNDS OF ACTIVE INGREDIENT
CopperNaphtena	3.5 gal	1.73 lbs/gal	6.06 lbs
PetroleumDisti	3.5 gal	5.18 lbs/gal	18.13 lbs

Review Questions for Chapter 4: Management of Commensal Rodents

1. Good sanitation is important in managing house mouse infestations because it makes it easier to detect the signs of infestation. TRUE or FALSE?

2. The first choice for rat management should be an anticoagulant rodenticide. TRUE or FALSE?

3. Why choose trapping over rodenticides for NPS sites?

   a) no chance of environmental contamination
   b) instantly demonstrates success
   c) no significant odor problems
   d) all of the above

4. Traps must be baited with food. TRUE or FALSE?

5. Glue boards

   a) usually kill by suffocation
   b) are considered inhumane by many people
   c) work better against mice
   d) may pose risks to nontarget species
   e) all of the above

6. Rodenticides normally should not be used indoors in occupied NPS buildings. TRUE or FALSE?

7. Which of the following is NOT true about rodenticide baits?

   a) some baits can kill after a single feeding
   b) must be inside a tamper-resistant bait station or inaccessible to children, pets, and wildlife
   c) specific use instructions are written on the label
   d) most are relatively nontoxic to humans

8. The active ingredient in tracking powders are up to 40 times more concentrated than in baits. TRUE or FALSE?

9. Application of rodenticides must be made strictly by the calendar. No exceptions. TRUE or FALSE?

10. Many failures to suppress commensal rodents can be traced to someone confusing the habits of rats and mice. TRUE or FALSE?

Appendix A: Sources of Additional Information on Rodent Management

Bennett, G. W., Owens, J. M., and R. M. Corrigan. 1988. Truman's Scientific Guide to Pest Control Operations. (4th Edition). Edgell Communications, Duluth MN. 495 pp.

Center for Disease Control. 1980. CDC pictorial keys; arthropods, reptiles, birds, and mammals of Public Health Significance. U.S. Dept. Health, Education, and Welfare. Public Health Service, Atlanta, GA.

Ebeling. W. 1975. Urban Entomology. Univ. Calif., Div. Ag. Sci., 695 pp.

EPA. 1993. Integrated Pest Management: Vertebrates. A Guide for Commercial Applicators. U.S. Environmental Protection Agency, Office of Pesticide Programs.

Frantz, S.C. and D.E. Davis. 1991. Bionomics and integrated management of commensal rodents. In *Ecology and Management of Food-Industry Pests (FDA Tech. Bull. 4)*, J.R. Gorham, ed. Association of Official Analytical Chemists, Arlington VA. pp 243-313.

Howard, W.E. and R.E. Marsh. 1981. The rat, biology and control. Leaflet #2896. Univ. Calif. Div. Ag. Sci.

Mallis, A. 1990. Handbook of Pest Control (7th ed.) Franzak & Foster Co. Cleveland, OH. 1152 pp.

Marsh, R.E. and W.E. Howard. 1981. The house mouse, its biology and control. Leaflet #2945. Univ. Calif. Div. Ag. Sci.

Olkowski, W., Daar, S., and H. Olkowski. 1991. Common-Sense Pest Control. The Taunton Press, Newtown CT. 715 pp.

Pratt, H.D.and R. Z. Brown. 1986. Biological Factors in Domestic Rodent Control. HHS Publ. #(CDC) 86-8396. U.S. Department of Health and Human Services, Public Health Service, Center for Disease Control, Atlanta, GA.

Pratt, H.D., B.F. Bjornson, and K.S. Littig. 1986. Control of domestic rats and mice. HHS Publ. #(CDC) 86-8396. U.S. Department of Health and Human Services, Public Health Service, Center for Disease Control, Atlanta, GA.

Prevention and Control of Wildlife Damage. 1993. Great Plains Agricultural Council, Nebraska Cooperative Extension Service.

Appendix B: Study Problems in Rodent IPM

The problems described below are based on actual incidents. The parks and the personnel are obviously fictitious. However, you could face similar problems someday. Read the descriptions of conditions and problem at each site and use your imagination and knowledge to come up with solutions. Then read the discussions that follow and see how closely you agree. Don't be surprised if you come up with a different approach. There is no one correct answer. The purpose of these discussions is to encourage you to think in terms of integrated pest management approaches to rodent problems.

1. Green Tree National Park

The headquarters building of Green Tree National Park is on the historic register. It has been extensively landscaped using native plants. Lush growth is everywhere: low plants edging the walkways and porches, surrounded by ground covers and low shrubs, interspersed with various specimen trees and large bushes. The grounds are landscaped from the parking lot to the adjacent picnic area and right up to the headquarters building. The Fine Arts Commission helped to design the landscape. The park is visited by local residents who stroll and walk dogs on a regular basis. The building itself blends into the environment and is camouflaged by bushes and climbing vines.

Manager Janet Audubon has a problem, however. She has discovered what looks like rodent droppings in one of the upstairs storage rooms. In addition, two coworkers who sometimes work in the evenings report hearing scratching and scrambling sounds in the ceiling and walls just after sundown. And the trash pick-up crew pointed out that the dumpster was settling far too deep into the soil. They thought it probably had something to do with the animal burrows they could see all around it.

And today, the last straw. A ten-year old visitor from Newark, New Jersey was heard laughing about travelling all the way to Green Tree Park, only to see the same rats that he can see any night scurrying out of the city sewers around his home. Audubon suspects she better do something.

QUESTIONS

1. What should be her first step? _____

2. Identify three conditions that may be contributing to the pest problem:

---

3. From the limited information given above, describe a basic IPM approach to this pest problem.

---

4. Design a monitoring log.

Discussion of Green Tree Park Rodent Problem

You should suspect that the grounds and headquarters building are harboring some kind of rodent. It appears that the rodents are under the dumpsters, foraging in the storage area, and travelling in the ceiling and wall voids, and probably the attic as well.

The first step in the IPM process is to identify the species. Is it a Norway rat or a roof rat, a house mouse or a field mouse, or perhaps a complex of different native and pest species? The droppings should provide the answer. Other options for identification include live-trapping, leaving a tracking patch to obtain identifiable tracks, or a night time inspection with a bright light.

Based on the droppings, manager Audubon decides that the area is infested with Norway rats.

Some of the conditions contributing to the problem were given: (1) the dumpster is on the ground instead of on a concrete pad, allowing rodents to nest near a potential food source, (2) there is rodent harborage under the ground covers and other heavy vegetation extending right up to the building, and (3) the vines on the walls provide easy access up and into the building at the roof line.

Now that the species has been identified, and some of the contributing factors uncovered, the next step would be to start a monitoring program by conducting a careful initial inspection of the building and grounds to:

- Determine the sites of infestation
- Estimate the size of the population
- Determine how they are entering the building
- Identify other species in the area that could be affected by management actions
- Identify other factors that are contributing to the problem (in this example, be sure to check the sanitation at the nearby picnic area)
- Establish injury and action levels

You have to make some initial determination of what population level will require management action. You might, and probably should, establish different action levels for interior and exterior populations. Perhaps the action level inside the headquarters building would be as low as one rat. Outside, a few rats might not be considered enough of a problem to require action.

In this particular case, assume the rat population levels currently exceed the action levels and some management action is required both indoors and out. There could be many different management approaches to this infestation. On the following page is one approach in outline form.

Outline of IPM Program for Green Tree National Park

A. Cultural

1. Upgrade sanitation pick-up around picnic areas
2. Encourage visitors to use trash cans (signs, bulletin board, etc.)
3. Replace any "open-top" trash cans with those having a closed top

B. Physical

1. Remove vines from walls
2. Don't allow tree branches to touch the roof
3. Minimize the use of thick ground covers near the building
4. Leave a three-foot zone empty of vegetation at the foundation
5. Dumpster should be placed on concrete pad
6. Storage rooms should be uncluttered
7. "Rat-proof" the building (by screening soffits and air vents, installing kick plates and sweeps on doors, blocking openings around utility lines, etc.) *Note: any building alterations need to go through the cultural resource manager for approval.*

C. Mechanical

1. Establish a snap-trap program in offices, storage rooms, and attic

D. Chemical control

1. Establish short term baiting program near the dumpster (*if* your cultural, physical, and mechanical actions didn't suppress the rat population to an acceptable level)

The approach outlined above is only one of many possible. Other approaches may work as well or better. What would you do if you were the park manager?

Remember that after the management plan has been implemented, and the management actions have been taken, the monitoring program continues to evaluate the success of those actions. Assuming everything works as planned, the population of Norway rats will quickly drop below the action levels. Then some of the interventions--such as the snap trap program and the baiting--could be discontinued, and the program proceed with only cultural and physical management methods in place.

RODENT MONITORING FORM

SITE: _____

Date	# open burrows and action taken		Pesticides used? type	amount	comments

MONITORED BY:

PHONE:

RODENT MONITORING FORM

SITE: GREEN TRIB - AREA C

Date	# open burrows and action taken	Pesticides used? type	amount	comments
7/12	8	I LOCATED AND MAPPED OPEN BURROWS ON MAP. TRASH CANS ARE OPEN ON TOP, EASY ACCESS. I ORDERED TIGHT-FIT LIDS	NONE	VISITOR complaint: 2 RAT SIGHTINGS BY TURF AREA
7/13	6	PLACED 4oz BAIT, IN PLASTIC BAG, IN OPEN BURROWS. COVERED IT CLOSED WITH SOIL	"RAT RID"	24. oz.	SAW RED TAILED HAWK IN PICNIC AREA
7/18	3	PLACED NEW LIDS ON TRASH CANS BAITED THE 3 OPEN BURROWS COVERED CLOSED WITH SOIL	"RAT RID"	12 oz.	PICKED UP ONE DEAD RAT (AND DISPOSED)
7/23	2	CHANGED TRASH PICK UP FROM NOON TO 4pm. BAITED 2 OPEN BURROWS.	"RAT RID"	8 oz.	NONE
7/28	2	TRASH CANS NOT BEING EMPTIED AFTER LUNCH YET!! PHONED MAINT. BAITED 2 BURROWS, CLOSED WITH SOIL	"RAT RID"	8 oz.	LIDS ARE ON TIGHT.
8/2	1	BAITED 1 BURROW + CLOSED WITH SOIL. SPOKE TO VISITOR FEEDING PEANUTS TO SQUIRRELS. EXPLAINED RAT ISSUE - ASKED FOR COOPERATION!	"RAT RID"	4 oz.	SPOKE TO CONCESSIONS STAFF DISCUSSED RODENT MGMT

MONITORED BY: Joe Bubonic, Site Mgr.

PHONE: 797-1392

2. Gotham City Textile Museum

Gotham City Textile Museum is located in the heart of a major urban center. Around the site are low-income apartment buildings and an old shopping center with a restaurant and a food market. The museum consists of a restored textile mill built in the 1800's. A 10-foot high cast iron fence surrounds the building and an unlandscaped 50-foot buffer zone of dense grass, weeds, and shrubby trees. Old railroad tracks run from the road, through a gate, and up to a loading dock, off-limits to the public because of its deteriorating condition. The museum contains working displays of weaving equipment and a large collection of textiles, both on display and in storage.

Museum manager Earl Weaver has received a number of complaints this summer of foul odors emanating from different areas of the facility. Today, a curator informed him that she had found black carpet beetles on cabinets and window ledges, and serious damage to some of the stored wool fabrics in an old storage cabinet. The same curator had complained of a foul odor in this particular storage area a few months earlier. Manager Weaver wonders if these problems are connected, and whether both may be related to three recent reports of rats on museum grounds.

1. Which of the three problems—foul odors, black carpet beetles, and rat sightings—could be related? Describe *how* they could be related?

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2. From the limited information given above, what steps would you take to solve Manager Weaver's problems?

Discussion of Gotham City Textile Museum Pest Problems

The museum's problems of periodic foul odors, the black carpet beetle damage to stored wool, and the periodic rat sightings are almost certainly related. What has likely occurred is this: Rats infesting the surrounding urban area are foraging into the overgrown museum grounds and then into the museum building itself, probably through the old loading dock or other deteriorated sections. A rat's territory is large (they commonly travel 100-150 feet from their nests looking for food), and the rats may be ranging from the museum to the market to apartment house dumpsters each night.

The foul odors probably result from someone in the neighborhood, perhaps the restaurant or market, instituting a poison bait program. Because of a rat's large territory, this baiting program is directly impacting the textile museum. Here's how: Occasionally, poisoned rats will first feel ill in the museum and will crawl into a hidden area, die, and begin to decompose. Thus, the odor. Worse, scavenging pests like black carpet beetles will soon find the carcass and lay their eggs on it. Soon, a large population develops and, when the carcass is consumed, the larvae will search for a new food source—in this case, wool textiles in storage. Additionally, newly emerged adult beetles will fly off to lay their eggs wherever they can find a potential food supply. Wool, silk, felt, and fur will do just fine.

This problem is complex because the rats causing the problem are not coming from NPS property. The first step is to contact the managers of the surrounding property to make them aware of your concerns and to try and get a consensus that all involved will work to solve the rat problem.

Whatever the result of your attempt at consensus-building, your main goal should be to prevent the rats in the area from freely entering the museum. While you should follow the steps listed at the end of Chapter 1 to design an effective IPM program for rats, your main emphasis will probably be (1) to build them out by "rat-proofing" the museum building and (2) to reduce harborage by eliminating overgrown weeds, grass, and shrubby trees in the buffer zone (see *Physical Control* in Chapter 4). Incidentally, you will also have to design an IPM program to manage the black carpet beetles, which could by now be infesting many other textiles and artifacts at the museum.

3. Canyon Overlook Wildlife Area

Park manager John Powell has had many complaints about mice seen scurrying around the picnic area at Canyon Overlook. Hundreds of people use this area every day for its beautiful view, for a break in a long canyon rim drive, or as a convenient spot to eat lunch. Powell has never had a problem at this site previously except for occasional trash overflows and occasional warnings to visitors not to feed wildlife...which they often do even right by the sign that tells them DO NOT FEED ANIMALS!

When Powell visits the site one evening, sure enough he finds mice scurrying around the picnic area. The mice are about the size of house mice, but the undersides of belly and tail are white, and the tail itself is very long and hairy. Powell is especially concerned because of recent reports of a virus, dangerous and sometimes deadly to people, associated with mice in nearby areas.

1. What should be Powell's first step?

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2. What lethal management tactics would you recommend to suppress the mouse population in this situation?

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3. What other steps would you take?

Discussion of Canyon Overlook Mouse Problem

Because of concerns over the rodent-associated virus in the area, the first step at Canyon Overlook should be to contact the Regional Public Health Consultant for the Park Service. The consultant could help identify the mouse species and determine if the rodents pose a risk of disease to visitors and workers at the site. If so, the consultant would work with park staff to develop a program to minimize risks —perhaps closing the picnic area and designing a brochure to warn the public on entry to the site. Further management actions might be taken after consultation with specialists at the Centers for Disease Control (CDC).

However, let's assume for purpose of this discussion that the virus is not an issue at Canyon Overlook. The first step, then, would be to identify the mouse species. Since it has a hairy tail, it cannot be a house mouse. The old world rodents in the family Muridae, including house mice, Norway rats and roof rats, have hairless, naked tails. In this case, the mouse described is the canyon mouse, *Peromyscus crinitus*, a species native to arid, rocky canyons in the Southwest.

Native species such as the canyon mouse are afforded greater protection under NPS policy, and in this instance ***lethal control should not be authorized nor is it necessary***. The real problem at the site is not the canyon mice, but the fact that visitors have apparently been feeding the animals until they have become acclimated to people. As a consequence, canyon mouse populations have grown unusually high and human/animal interactions have increased.

The "no-feeding rule" should be enforced by increasing visits by rangers and park personnel. More signs should be added, and an explanation of the need for this rule should be provided on a bulletin board in the picnic area. Trash pickup should be upgraded. The site should be put under a monitoring program to evaluate results. Eventually, natural predation should drop canyon mouse populations back to normal levels.

4. Northern Star Wilderness Trail Park

Northern Star is a park that offers trail rides for nine months of the year. Riders have the opportunity to stay overnight at cabins along the trails. Each cabin is primitive but includes a horse shelter nearby complete with hay, horse feed, and other supplies. The trail areas and cabins are closed for three months each winter because of deep snows.

Every year large numbers of mice are found living in the cabins when the first guests arrive in March. Even though the trail is supposed to be a wilderness experience, many guests draw the line at sharing their cabin with the mice, and complain vigorously when they return to headquarters.

New park manager Jan Silverheels has taken the first step to try to manage the mouse problem by identifying the mice as a mixed population of house mice (*Mus musculus*) and white-footed mice (*Peromyscus leucopus*). She is now planning an IPM program to reduce the mouse problem down to an acceptable level.

1. Why does this problem reoccur each spring? _____

_____

_____

_____

2. Describe a workable IPM program for this site. _____

_____

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_____

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_____

_____

_____

Discussion of Northern Star Wilderness Trail Park

The most likely explanation of why the cabins are infested with mice every spring is the following. During nine months of the year the mice are around the horse shelters, sharing the readily accessible food and water provided for the horses. As winter begins, the temperature drops and the cabins stand unused. The mice move into the cabins for protection and relative warmth. When spring and the first guests arrive, both the mice and the guests are surprised to find themselves sharing accommodations.

There are many equally valid IPM programs that could be designed for a problem such as that faced by Northern Star Wilderness Park. Follow the IPM program outline presented at the end of Chapter 1. Here are a few special considerations for this park and the particular problem described:

The action thresholds will likely be fairly high. Most wilderness campers will accept a certain number of mice in their accommodations. It is, after all, a part of the wilderness experience. In fact, simply warning guests to expect such company would most likely raise the threshold. In other words, if you tell guests to expect mice in their cabins beforehand, they will accept more of them than if the mice come as a surprise. An education component would seem to be an important part of this IPM program.

Cultural and physical management tactics would seem to be most useful for this problem. Sealing and otherwise "mouse-proofing" the cabins in late fall would limit the numbers of mice overwintering in the cabins. Following good hay and feed management practices during the season would reduce the amount of food available for the mice. Perhaps the horse shelters could even be moved farther away. Cabins should be inspected each spring before the first guests arrive. Any food should be stored in mouse-proof bins or other containers. If lethal control was considered necessary, a few dozen snap traps baited with food or nesting materials would quickly suppress mouse populations in and around each cabin. Snap traps could also be set inside the entrance of each cabin and checked daily.

Appendix C: Answer Key for Review Questions

Chapter 1

1. TRUE
2. (d)
3. TRUE
4. TRUE
5. TRUE
6. (e)
7. (e)
8. FALSE

Chapter 2

1. (b)
2. TRUE
3. (c)
4. (e)
5. (a)
6. (d)

Chapter 3

1. (c)
2. TRUE
3. (c)
4. (a)
5. (a)
6. FALSE
7. (a)
8. TRUE
9. FALSE
10. FALSE

Chapter 4

1. TRUE
2. FALSE
3. (d)
4. FALSE
5. (e)
6. TRUE
7. (d)
8. TRUE
9. FALSE
10. TRUE