APPENDIX I

STRUCTURAL PESTS

POWDERPOST BEETLES

Powderpost Beetle

Powderpost Beetle Damage

Powderpost Beetle Larvae

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

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

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

Death-watch Beetle & Damage

If the frass is yellowed or partially caked on the surface where it lies, the infestation is probably old or already managed. It may take ten years or more for infestations to become significant

enough to be noticed. At this point, both large numbers of exit holes and large quantities of whitish frass are observable. Once the infestation is noticed, management, as with lyctids, depends on the extent of the infestation. The options are essentially the same as those listed for management of lyctid beetles.

BOSTRICHID (false) POWDERPOST BEETLES

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

Bostrichid Beetles

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

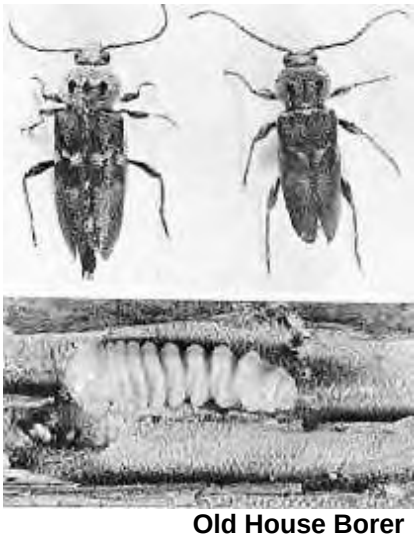
Although this group reinfests wood, it rarely does severe economic damage. Most damage noticed in construction timbers occurs before curing while moisture content of the wood is high. An exception is bamboo and weakened (from moisture or other damage) structural timber, in which considerable damage may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

OLD HOUSE BORERS

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

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

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



Old House Borer

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

MISCELLANEOUS BORERS

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

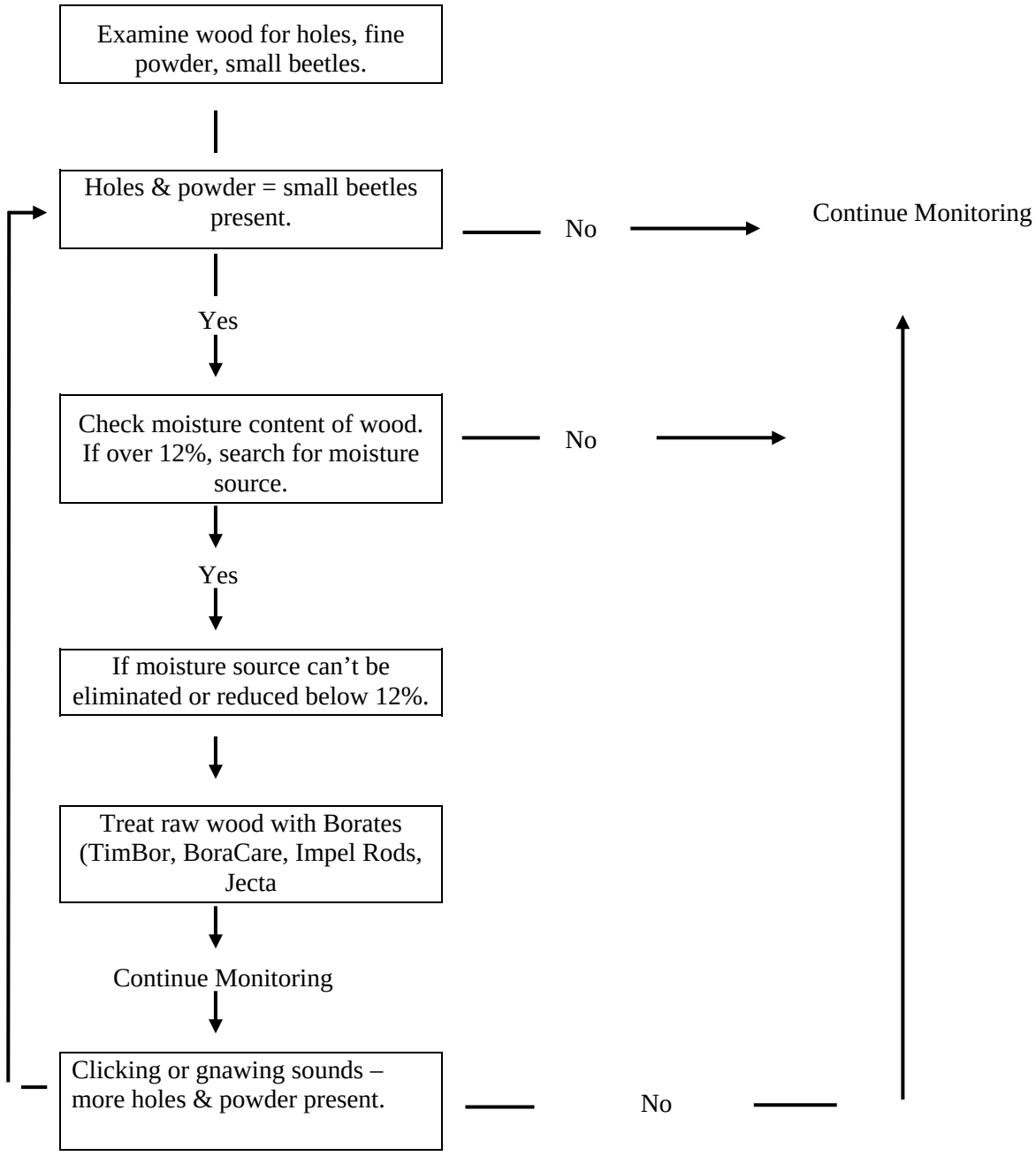
Flat-headed Borer

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

Long-horned Beetles

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

WOOD DESTROYING BEETLES



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

CARPENTER ANTS

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

Carpenter Ant Queen & Workers

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

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

Eggs, Larvae & Pupae

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

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

Carpenter Ant Galleries

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

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

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

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

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

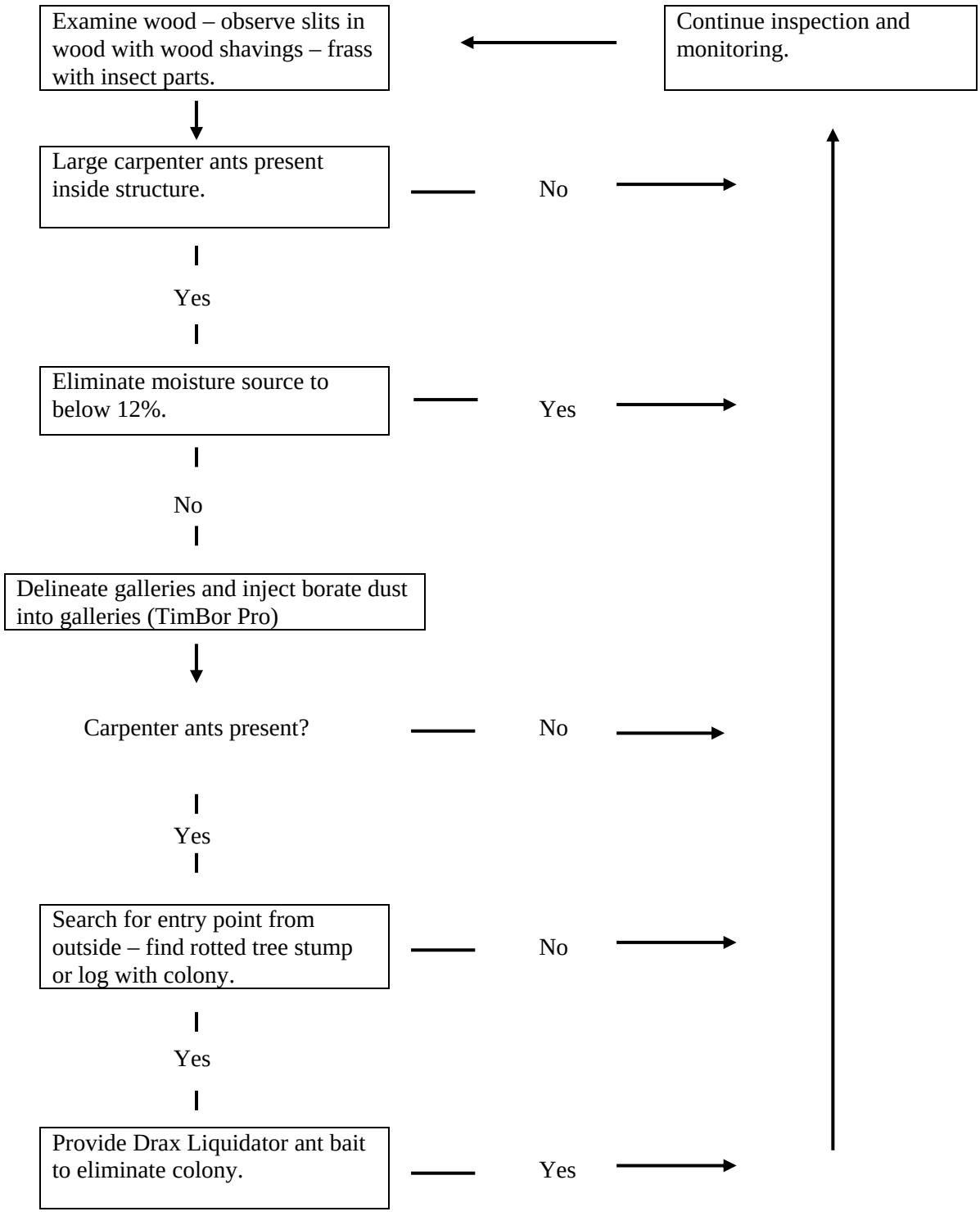
DAMAGE, PREVENTION AND MANAGEMENT

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

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

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

CARPENTER ANTS



CARPENTER BEES

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

Carpenter Bee

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

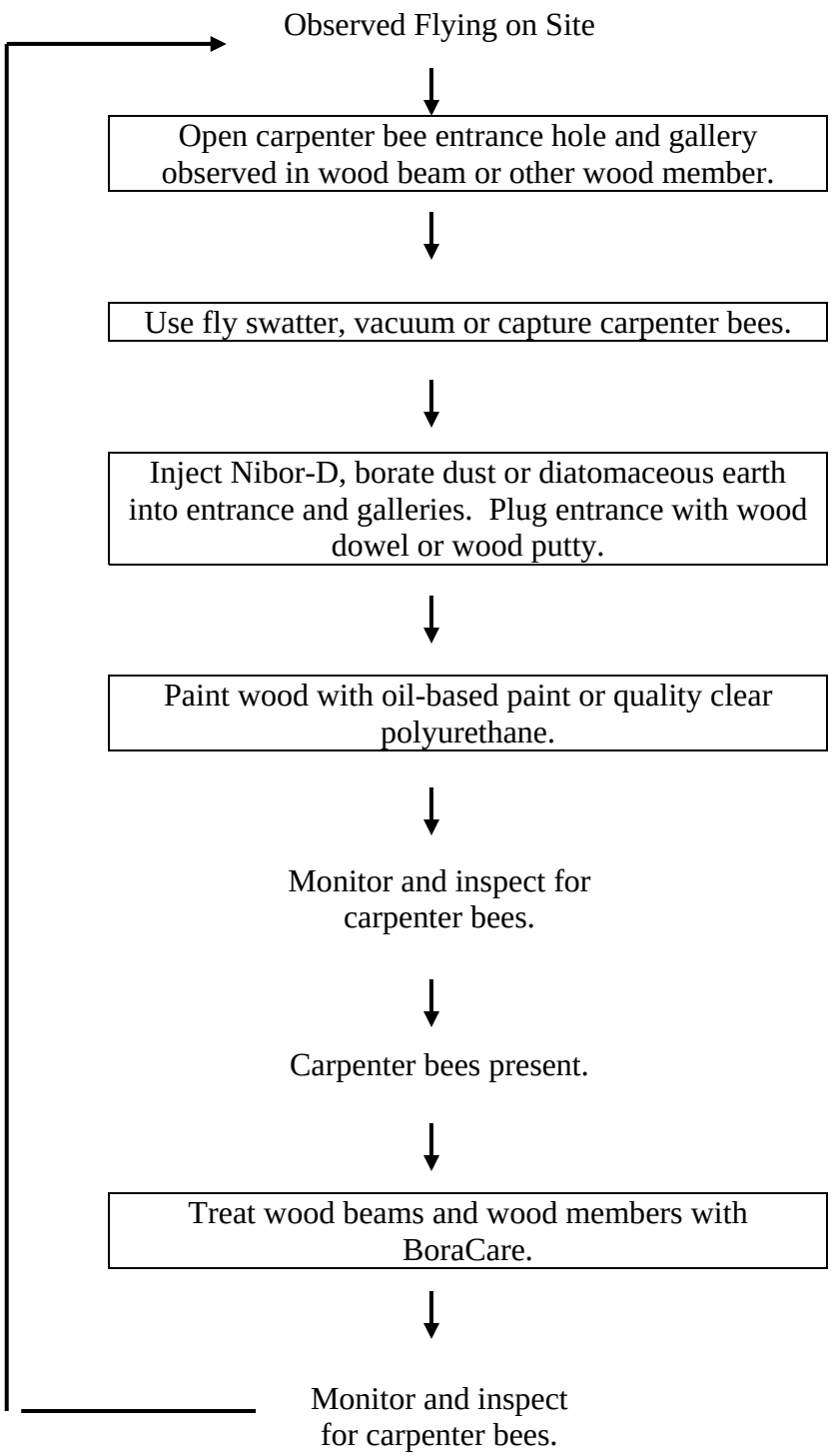
INSPECTION AND MONITORING

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

MANAGEMENT

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

CARPENTER BEES



ARGENTINE ANT (*Iridomyrmex humilus [Mayr])*

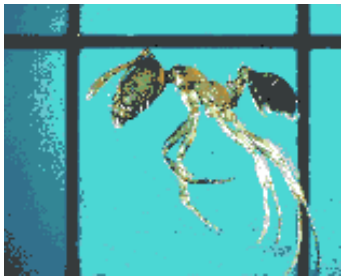
The Argentine ant, native to South America, now widely ranges throughout the United States and the world. This highly adaptable ant is the most common of the trailing ant species that invade structures in search of foods. Its natural range is only limited by cold temperatures. The Argentine ant has one node on the petiole, a musty odor when crushed, carries no known diseases, and has no public-health importance. It is very aggressive, has no natural enemies, and drives other ants away. Although the Argentine ant bites, it doesn't normally attack human beings.

Argentine Ant

Argentine ant nests are usually located in moist areas around refuse piles, under stones or concrete, rotten wood, bird nests, beehives, and in tree holes. In winter, colonies move deep into the soil. Although it seldom nests indoors, nests are sometimes found in buildings near heat sources. This ant is multi-queened, very prolific, and supports large colonies (thousands to tens of thousands) but seldom swarms, because breeding takes place in the nest. The Argentine ant is a major pest in structures, and is commonly seen near baseboards, windows, and water pipes, seeking food or to escape too-wet or too-dry outdoor conditions. It is often found on potted plants because it tends scales, mealy bugs and aphids, from which it obtains honeydew. Indoors they feed on meats, sweets, dairy products, eggs, fats and oils, but prefer sweets. Argentine ants also feed on termites, other ants, fly larvae, and cockroaches. Argentine ant eggs hatch in 28 days, the larval stage lasts 31 days, the pupal stage lasts 15 days, and complete life cycle is 78 days.

PHARAOH ANT (*Monomorium pharaonis L.)*

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



Pharoah Ant

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

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

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

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

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

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

PAVEMENT ANT *Teramorium caespitum (L)*

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

Pavement Ant

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

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

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

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

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

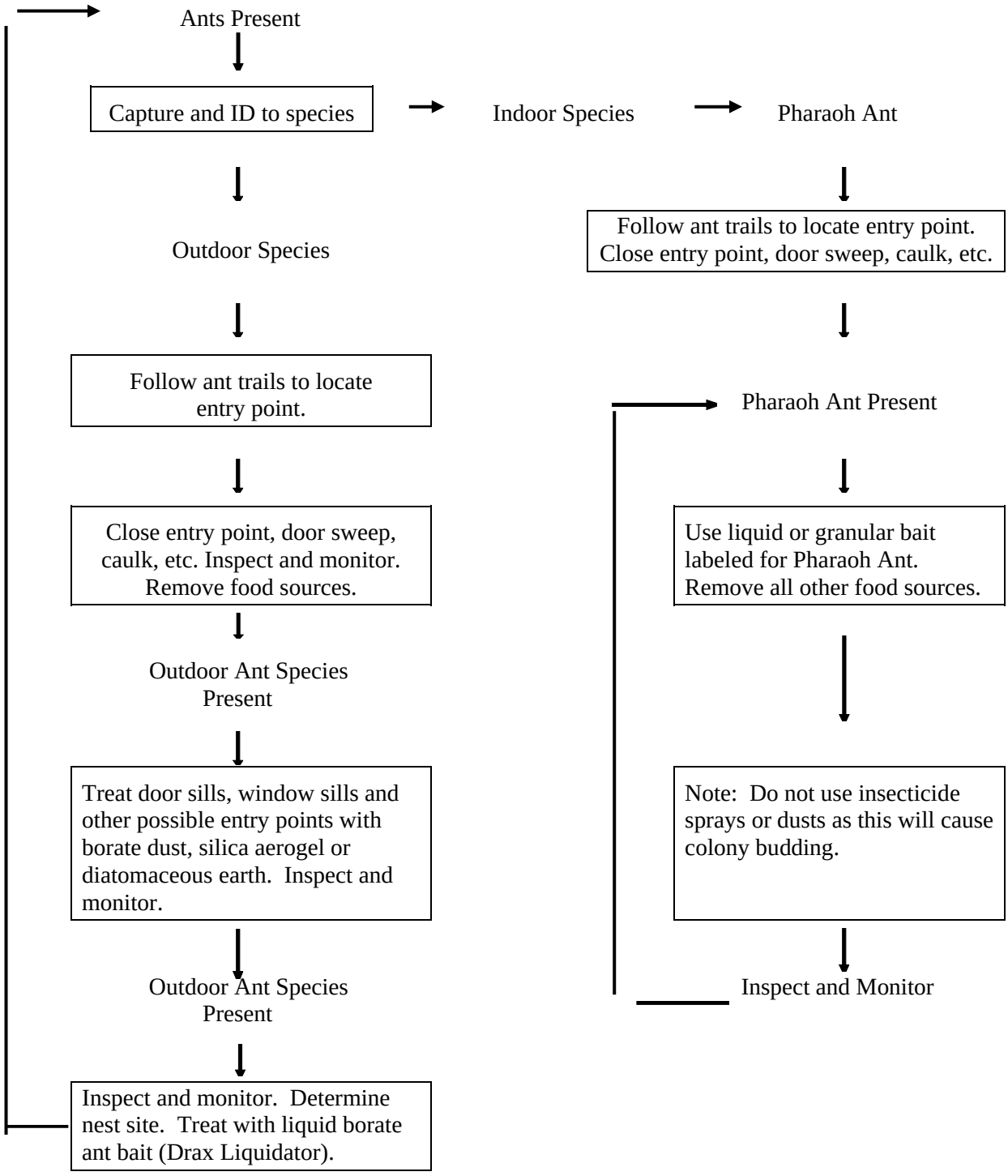
The odorous house ant is a trailing, non-stinging, native species that occurs in all 48 continental states from sea level to over 10,000 feet in elevation. It has a single node on the petiole, is brownish to black in color, and .3 cm (1/8 in) long. Colonies are multi-queened and seldom swarm. The odorous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

Odorous House Ant

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

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

ANTS


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

BROWN ROT

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

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

Brown Rot Fungi

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

WHITE ROT

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

White Rot Fungi

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

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

WATER-CONDUCTING FUNGUS, *Poria incrassata*

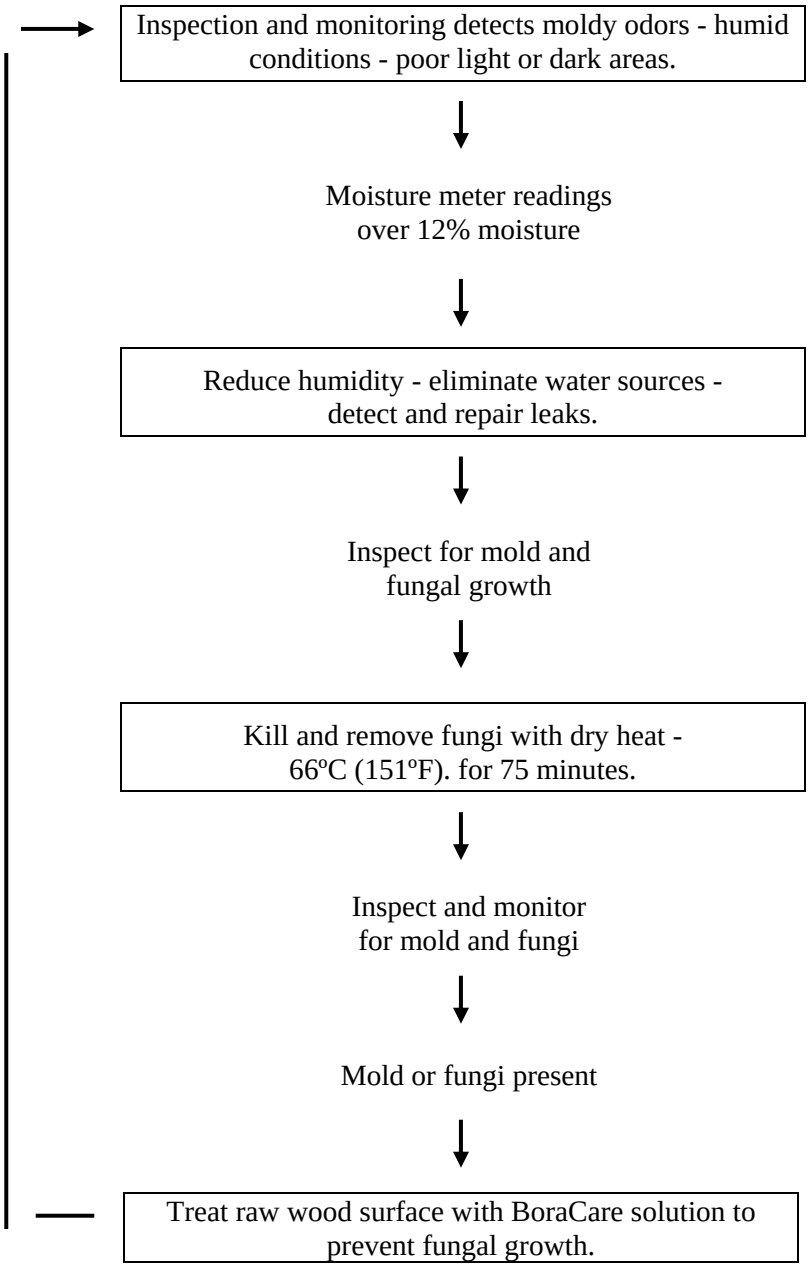
Poria can attack wood without the initial presence of water. This wood rot fungus can transport water for several feet through large root-like structures called rhizomorphs. When established, it can quickly spread through a building and destroy large portions of the structural wood.

Poria incrassata

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

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

MOLDS AND FUNGI



HOUSE MOUSE

INTRODUCTION

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

House Mouse *Mus musculus*

CHARACTERISTICS AND RECOGNITION

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

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

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

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

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

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

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

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

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

HAZARDS OF INFESTATION

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

House mice and their parasites are implicated in the transmission of a number of diseases. Salmonellosis can be spread when some foods are contaminated with infected rodent feces. Mice are probably more responsible than rats for the spread of this disease. *Rickettsia akari* is the causal agent of Rickettsialpox, a disease causing a rash similar to chickenpox. Rickettsialpox is transmitted from mouse to mouse, then to people by the bite of the house-mouse mite. Lymphocytic Choriomeningitis is a virus infection of house mice that may be transmitted to people (mainly to children) through contaminated food or dust. The mouse can also be a major

carrier of Leptospirosis (Weil's disease). Rat-bite fever can be transmitted by house mice, as can ray fungus, *Actinomyces muris*. Certain tapeworms are spread in house-mouse droppings, and ringworm, a skin fungus disease, can be carried to human beings by mice or contracted indirectly from mice through cats. Tularemia has also been linked to house mice.

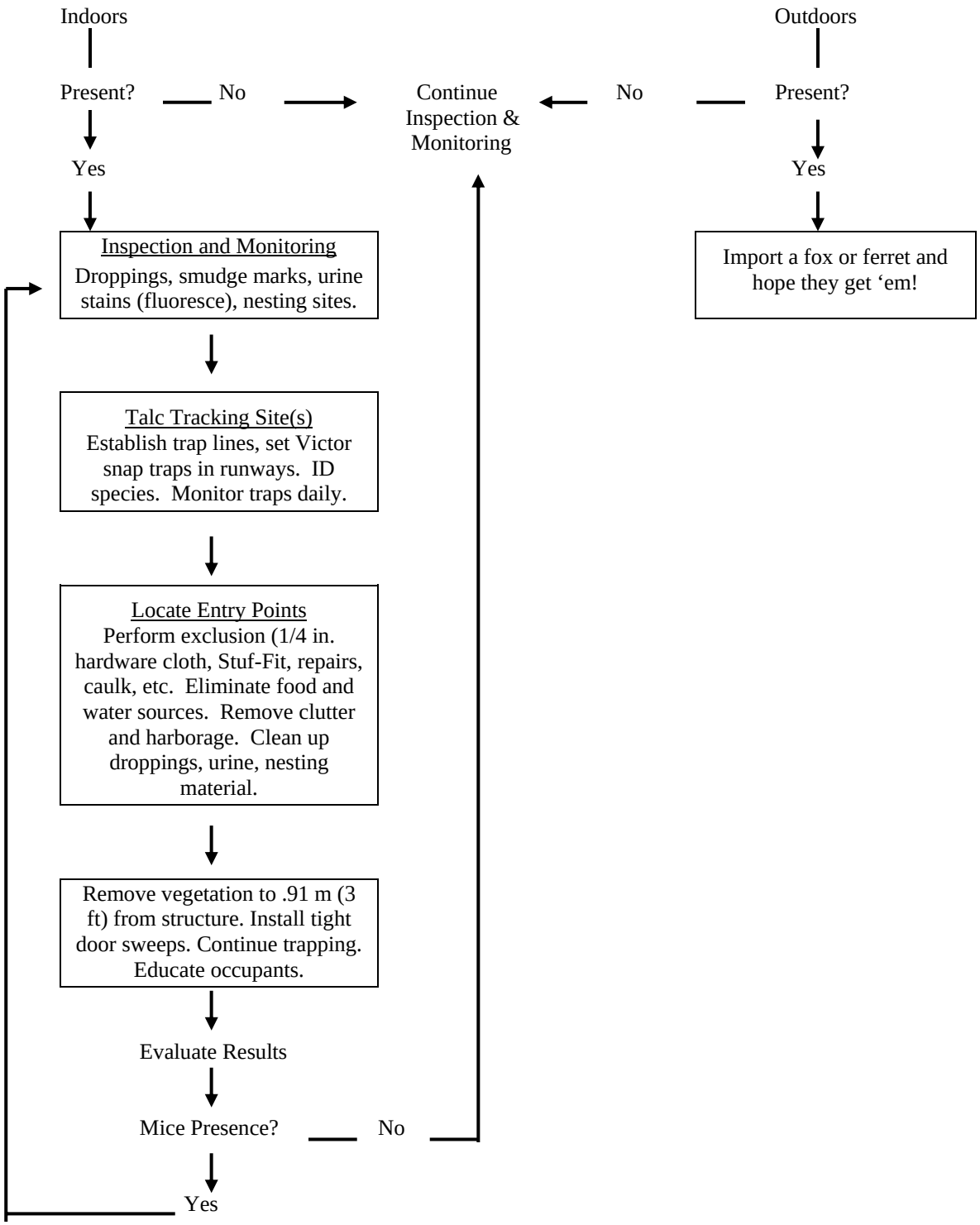
INSPECTION AND MONITORING

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

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

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

HOUSE MICE


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

DEER MOUSE

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

CHARACTERISTICS AND RECOGNITION

Appearance

Deer Mouse *Peromyscus maniculatus*

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

Habitat and Habits

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

INSPECTION AND MONITORING

Droppings

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

Runways

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

Tracks

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

Visual Sightings

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

PEST MANAGEMENT MEASURES

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

Exclusion

If you keep them out, they can't get in! Exclusion may be the most important aspect of native mouse management. All holes, cracks, crevices or other openings larger than .64 cm (1/4 in) must be filled, covered or otherwise blocked to keep mice out.

As the native rodents can gnaw through wood or other soft substances, burrow into soil, and are good climbers, keeping the structure in good repair is important. Use hard material such as metal flashing, concrete and 1/4 in. hardware cloth for exclusion. Doors and windows should also close tightly.

Sanitation

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

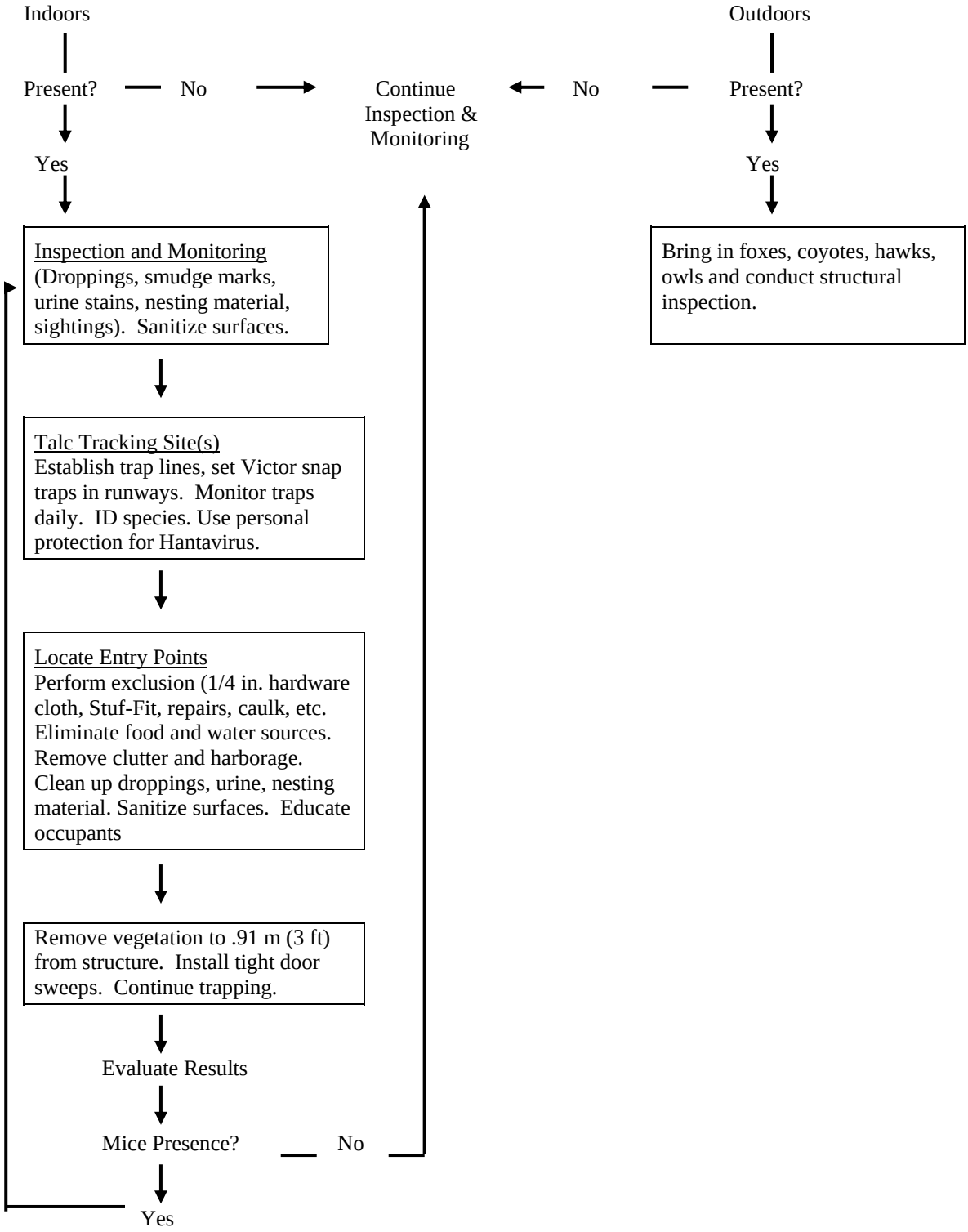
Habitat Modification

Another preventive or remedial measure that can be taken outdoors to reduce the opportunity for rodent/human exposure is to remove brush, weeds and other materials from around structures to reduce protected hiding places for rodents. Modifying protective cover makes native rodents more susceptible to predation by hawks, owls and other natural predators.

Trapping

Because of the risk of exposure to the Hantavirus, if native rodents are dwelling inside structures, lethal force in the form of snap traps is recommended. Do not use live traps. Do not use rodenticides or other toxic means for rodents inside structures. Baits that may be used in the snap traps are seeds such as conifer seed (Douglas fir), sunflower seed, oats, or cotton balls (plain or with vanilla flavor). Traps should be placed in observed runways or near resting and feeding sites.

DEER MICE


Indoors
Present?
No
Continue Inspection & Monitoring
No
Outdoors
Present?
Yes
Yes
Inspection and Monitoring (Droppings, smudge marks, urine stains, nesting material, sightings). Sanitize surfaces.
Bring in foxes, coyotes, hawks, owls and conduct structural inspection.
Talc Tracking Site(s) Establish trap lines, set Victor snap traps in runways. Monitor traps daily. ID species. Use personal protection for Hantavirus.
Locate Entry Points Perform exclusion (1/4 in. hardware cloth, Stuf-Fit, repairs, caulk, etc. Eliminate food and water sources. Remove clutter and harborage. Clean up droppings, urine, nesting material. Sanitize surfaces. Educate occupants
Remove vegetation to .91 m (3 ft) from structure. Install tight door sweeps. Continue trapping.
Evaluate Results
Mice Presence?
No
Yes

RATS

INTRODUCTION

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

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

CHARACTERISTICS AND RECOGNITION

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

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

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

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

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

HAZARDS OF INFESTATION

Rats as Disease Carriers

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

Plague

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

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

Murine Typhus Fever

Murine typhus, which occurs in California and in the southeastern and gulf coast states, is a relatively mild disease. Murine typhus is transmitted from rats to people by rat fleas, with the disease organism entering the bloodstream when feces of infected fleas are scratched into a flea-bite wound.

Rat-Bite Fever

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

Salmonella Food Poisoning

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

Leptospirosis or Weil's disease

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

Trichinosis

Trichinosis results from a nematode (a 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 can spread trichinosis when hogs eat food or garbage contaminated with infested rat droppings.

KINDS OF RATS

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

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

Norway Rat Climbing A Wall

Norway Rat (*Rattus norvegicus)*

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

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

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

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

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

HABITS OF RATS

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

Roof Rat *(Rattus rattus)*

Life Cycle

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

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

Roof Rat *(Rattus rattus)*

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

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

Social Behavior

Rats live in colonies with well-defined territories that they mark with urine and glandular secretions. The colony has a complex social hierarchy with a dominant male leader and a "pecking order" of subordinate males and ranking females. The strongest and most dominant

animals occupy the best nest and resting sites, and feed at their leisure. Weaker, subordinate rats are pushed out to less favorable sites, or forced out of the territory completely.

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

Rat Senses

Vision, Touch, Taste, Balance

Rats have poor vision. They are nearly color blind, and react to shapes and movement rather than identifying objects by sight. 9.14 – 13.72 m (30 – 45 ft) is the limit of their vision, and their eyes are adapted to dim light. Other senses, however, compensate for poor vision. They use their sensitive noses to locate food, follow pathways, tell whether another rat is friend or foe, and identify new objects in their territory. They use long whiskers and guard hairs to "touch" their way through dark burrows, pipe chases, wall voids, and other runways. Their ears detect faint sounds that signal danger. Rats can taste certain chemicals at a parts-per-million concentration. This explains why rats often reject baits or avoid traps that have been contaminated with insecticides. Rats have an excellent sense of balance which allows them to walk on wires and always land on their feet in a fall.

Fear of New Objects (Neophobia)

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

Food and Water

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

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

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

Range

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

Nests

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

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

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

INSPECTION AND MONITORING

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

Signs of Rats

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

Sounds

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

Droppings

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

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

Urine

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

Grease Marks

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

Runways

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

Tracks

A rat's footprint is about 1.90 cm (3/4 in) long, and may show four or five toes. Rats may also leave a "tail drag" line in the middle of their tracks. Look in dust or soft moist soil. Place a tracking patch in suspected rat areas to show footprints. A tracking patch is a light dusting of an inert material such as clay, talc (unscented baby powder), or powdered limestone. Don't use flour, which may attract insect pests. A good patch size is 30.48 x 10.16 cm (12 x 4 in). Apply

patches in suspected runways and near grease marks. When inspecting tracking patches, shine a flashlight at an angle that causes the tracks to cast a distinct shadow. Note that a tracking patch is not the same as a toxic tracking powder. Tracking powders are diluted rodenticides in dust form. Tracking patches use nontoxic dust. Do not use a toxic tracking powder to make a tracking patch.

Gnawing Damage

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

Nest Sites

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

Burrows

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

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

Pet Excitement

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

Odor

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

Estimating Rat Numbers

It's not easy to tell how many rats are infesting a site. Rat signs, however, may categorize the population as low, medium, or high. In rat-free or low infestation conditions, no signs are seen.

In the case of medium infestation, old droppings and gnawing can be observed and one or more rats are seen at night. No rats are seen during the day. When there is a high infestation, fresh droppings, tracks, and gnawings are common. Three or more rats are seen at night, and rats may be seen in the daytime as well.

MANAGEMENT

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

Sanitation

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

Eliminate Hiding Places

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

Rat-Proofing (exclusion)

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

Building Exterior

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

Building Interior

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

Trapping

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

Physical Condition of Traps

A trap physically incapable of holding a rodent should never be set out. Staples holding the spring should be firm; the trap jaw should be square and fit inside the trap base. The trigger mechanism should operate smoothly at the slightest touch. Use properly sized traps for the species to be managed: mousetraps for mice; rat traps for roof and Norway rats. The trap base should not be warped or the trap will rock when stepped on. If necessary, working parts should be lightly oiled with mineral or other inorganic oil, not machine oil. Traps should be kept away from pesticides or other strong odors that might be repellent to the rodents. Don't clean a trap bloodied by a catch, since the odors enhance its acceptance. A shiny new trap increases the possibility of rejection in response to the "new object avoidance" instinct. For some situations, the best traps are those with enlarged bait pans (triggers) set for a light touch.

Enlarged Bait Pans

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

Placement of Traps

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

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

can be more easily recovered later or by someone else if necessary. Move traps to other areas after two weeks (the first area can be retrapped after a lapse of several weeks).

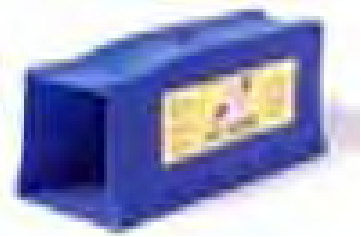
Adhere to good public relations practices, and pick up trapped animals as soon as possible (at least daily). In areas used frequently by the public, use trap stations to cover trapped animals in snap traps. This also protects them from accidental tripping by maintenance personnel. Don't place traps above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

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

Victor Rat Trap

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

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


Rat Zapper

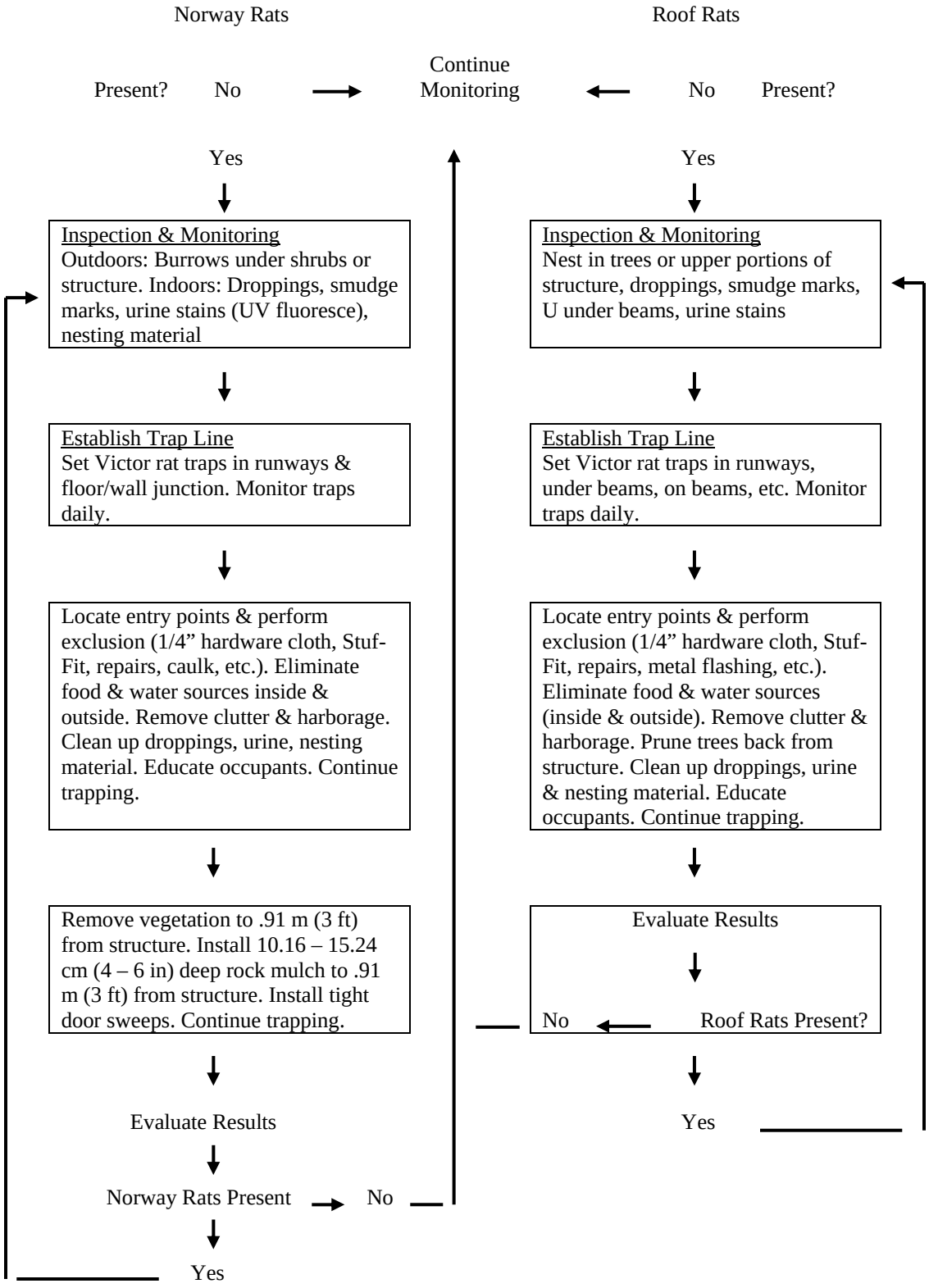
<u>Rat Zapper 2000</u>
The Rat Zapper 2000 is an electronic trap that humanely kills rats and mice. The trap is a battery-powered plastic tunnel that is attractive to rodents and provides a bait placement inside. When the rodent enters the tunnel for the bait and steps on a sensor plate, the rodent is given a lethal shock. Empty the trap by turning it upside down, allowing the dead rodent to slide out. A blinking red light alerts you to the dead rodent in the trap. Remote sensing is also available for multiple traps.

<u>Glue Boards</u>
Glue boards are not humane and must NOT be used on NPS sites.

Rodenticides

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

RATS


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

EASTERN GREY SQUIRREL *Sciurus carolinensis*

Grey Squirrel

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

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

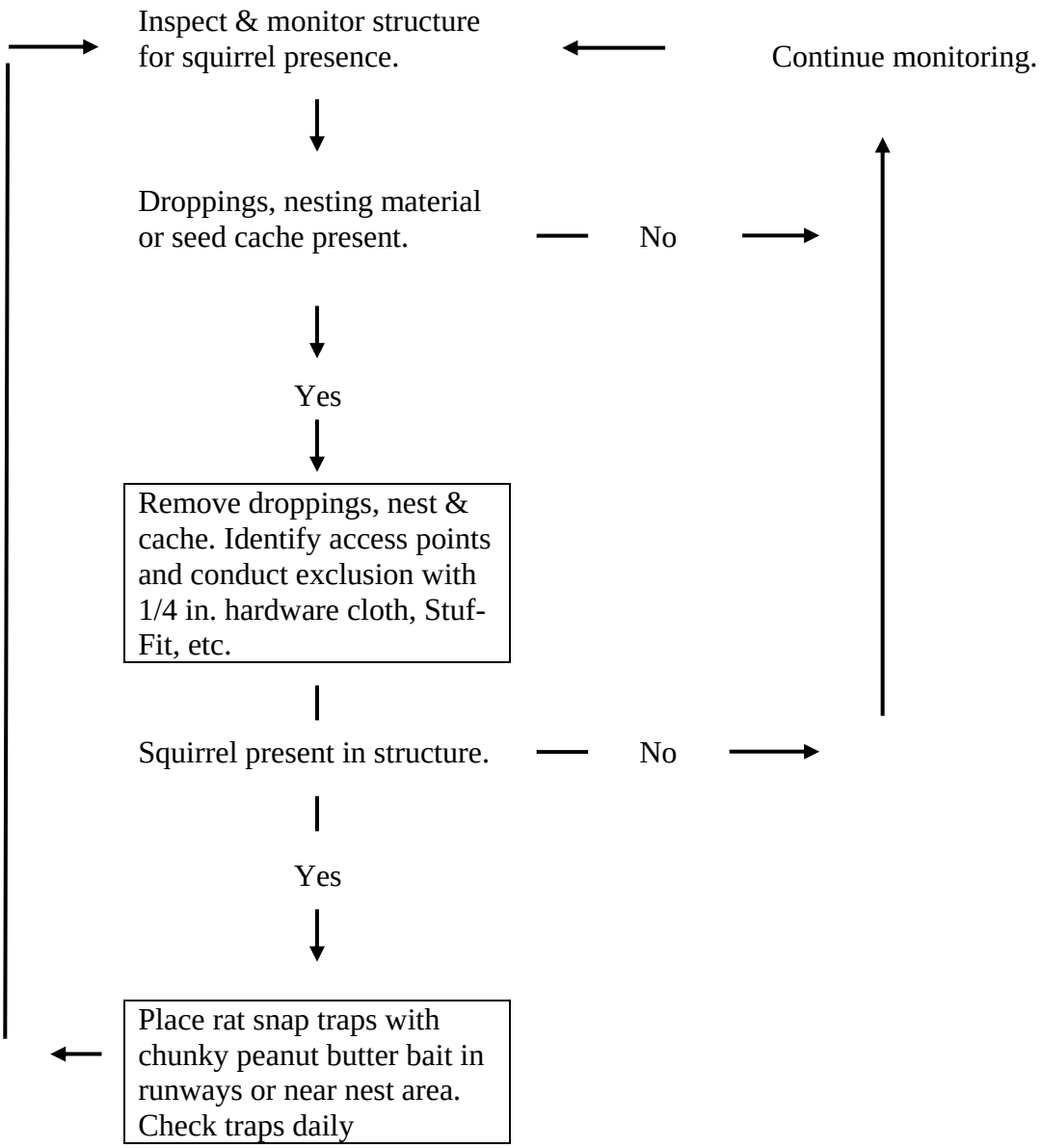
The eastern grey squirrel has two breeding seasons each year, the first in January and February and the second in June and July. Each of the mating periods lasts for about three weeks. Generally, only females over two years of age will breed in both seasons. Gestation takes 40 – 44 days. An average of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

Squirrels build nests near the tops of large pine, hemlock, maple, birch and oak trees where they are lodged in a large crotch or on a limb near the trunk. Mosses, grasses and shredded bark line the nest, occasionally along with cloth, paper, vegetation and bird feathers.
The newborn young weigh about 15 g (1/2 oz), mature quickly and at about 12 weeks, the young will be almost adult size and independent. The males reach sexual maturity at 15-18 months and

the females at 11 months. The average lifespan is normally less than six years.

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

GREY SQUIRREL



BIG BROWN BAT

Big Brown Bat *(Eptesicus fuscus)*

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

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

LITTLE BROWN BAT

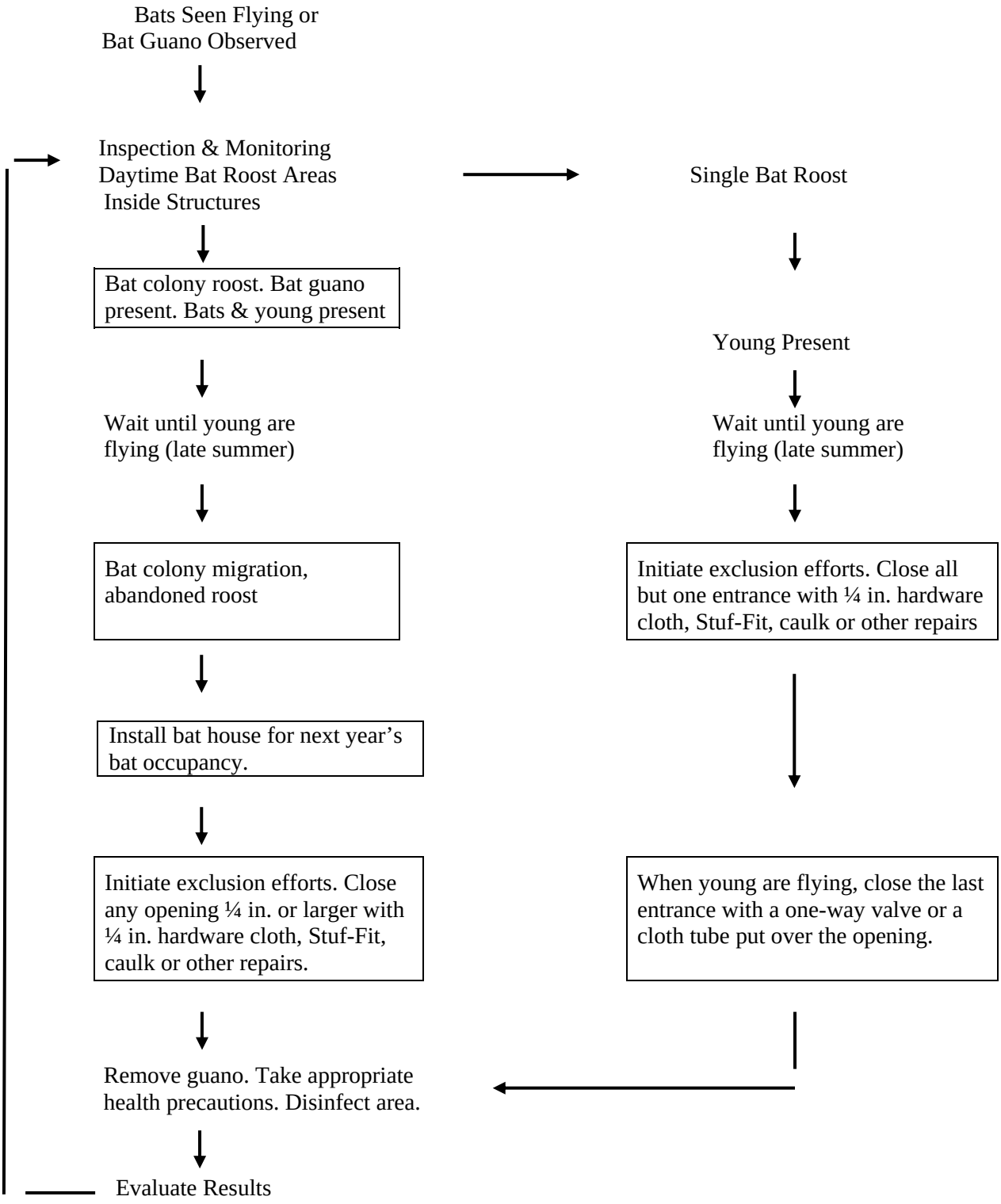
Little brown bat, *Myotis lucifugus* (LeConte), is actually a benefit to the Park except for roosting in attics. Adults are about 7.92 – 9.19 cm (3 1/8 – 3 5/8 in) long, including the tail, with a wingspread of 22 – 27 cm (8 11/16 – 10 5/8 in). They weigh .3.4 – 14 gr (1/8 – 1/2 oz). Little brown bats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

Little Brown Bat *(Myotis lucifugus)*

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

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

BATS


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