## OTHER MAMMALS

<table>
<thead>
<tr>
<th>Code</th>
<th>Species</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>D-1</td>
<td>Armadillos</td>
<td>Donald W. Hawthorne</td>
</tr>
<tr>
<td>D-5</td>
<td>Bats</td>
<td>Arthur M. Greenhall and Stephen C. Frantz</td>
</tr>
<tr>
<td>D-25</td>
<td>Deer</td>
<td>Scott R. Craven and Scott E. Hygnstrom</td>
</tr>
<tr>
<td>D-41</td>
<td>Elk</td>
<td>David S. deCalesta and Gary W. Witmer</td>
</tr>
<tr>
<td>D-51</td>
<td>Moles</td>
<td>F. Robert Henderson</td>
</tr>
<tr>
<td>D-59</td>
<td>Opossums</td>
<td>Jeffrey J. Jackson</td>
</tr>
<tr>
<td>D-65</td>
<td>Pigs, Wild</td>
<td>Reginald H. Barrett</td>
</tr>
<tr>
<td>D-71</td>
<td>Pronghorn Antelope</td>
<td>Sanford D. Schemnitz</td>
</tr>
<tr>
<td>D-75</td>
<td>Rabbits, Cottontail</td>
<td>Scott R. Craven</td>
</tr>
<tr>
<td>D-81</td>
<td>Jackrabbits</td>
<td>James E. Knight</td>
</tr>
<tr>
<td>D-87</td>
<td>Shrews</td>
<td>Robert H. Schmidt</td>
</tr>
</tbody>
</table>
ARMADILLOS

Fig. 1. Armadillo, Dasypus novemcinctus

Damage Prevention and Control Methods

Exclusion
Fences or barriers are generally not practical, but a possible option.

Cultural Methods
Clear brush and other cover to reduce habitat.

Repellents
None are registered.

Toxicants
None are registered.

Fumigants
None are registered.

Trapping
Live traps (box traps).
Leghold traps (size No. 1 or 2).
Conibear® 220.

Shooting
One of the most commonly used methods.

Other Methods
Soil insecticides that remove food sources will discourage armadillos from feeding in an area.

Identification
The armadillo (Dasypus novemcinctus) is a rather interesting and unusual animal that has a protective armor of “horny” material on its head, body, and tail. This bony armor has nine movable rings between the shoulder and hip shield. The head is small with a long, narrow, piglike snout. Canine and incisor teeth are absent. The peglike cheek teeth range in number from seven to nine on each side of the upper and lower jaw. The long tapering tail is encased in 12 bony rings. The track usually appears to be three-toed and shows sharp claw marks. The armadillo is about the size of an opossum, weighing from 8 to 17 pounds (3.5 to 8 kg).
Range

The armadillo ranges from south Texas to the southeastern tip of New Mexico, through Oklahoma, the southeastern corner of Kansas and the southwestern corner of Missouri, most of Arkansas, and southwestern Mississippi. The range also includes southern Alabama, Georgia, and most of Florida (Fig. 2).

General Biology, Reproduction, and Behavior

The armadillo is active primarily from twilight through early morning hours in the summer. In winter it may be active only during the day. The armadillo usually digs a burrow 7 or 8 inches (18 or 20 cm) in diameter and up to 15 feet (4.5 m) in length for shelter and raising young. Burrows are located in rock piles, around stumps, brush piles, or terraces around brush or dense woodlands. Armadillos often have several dens in an area to use for escape.

The young are born in a nest within the burrow. The female produces only one litter each year in March or April after a 150-day gestation period. The litter always consists of quadruplets of the same sex. The young are identical since they are derived from a single egg.

The armadillo has poor eyesight, but a keen sense of smell. In spite of its cumbersome appearance, the agile armadillo can run well when in danger. It is a good swimmer and is also able to walk across the bottom of small streams.

Damage and Damage Identification

Most armadillo damage occurs as a result of their rooting in lawns, golf courses, vegetable gardens, and flower beds. Characteristic signs of armadillo activity are shallow holes, 1 to 3 inches (2.5 to 7.6 cm) deep and 3 to 5 inches (7.6 to 12.7 cm) wide, which are dug in search of food. They also uproot flowers and other ornamental plants. Some damage has been caused by their burrowing under foundations, driveways, and other structures. Some people complain that armadillos keep them awake at night by rubbing their shells against their houses or other structures.

There is evidence that armadillos may be responsible for the loss of domestic poultry eggs. This loss can be prevented through proper housing or fencing of nesting birds.

Disease is a factor associated with this species. Armadillos can be infected by the bacterium *Mycobacterium leprae*, the causative agent of leprosy. The role that armadillos have in human infection, however, has not yet been determined. They may pose a potential risk for humans, particularly in the Gulf Coast region.

Legal Status

Armadillos are unprotected in most states.

Damage Prevention and Control Methods

Exclusion

Armadillos have the ability to climb and burrow. Fencing or barriers, however, may exclude armadillos under certain conditions. A fence slanted outward at a 40° angle, with a portion buried, can be effective. The cost of exclusion should be compared to other forms of control and the value of the resources being protected.

Cultural Methods

Armadillos prefer to have their burrows in areas that have cover, so the removal of brush or other such cover will discourage them from becoming established.

Repellents

None are currently registered or known to be effective.

Toxicants

None are currently registered.

Fumigants

None are currently registered; however, there are some that are effective. Since state pesticide registrations vary, check with your local extension office.
or state wildlife agency for information on pesticides that are legal in your area.

**Trapping**

Armadillos can be captured in 10 x 12 x 32-inch (25 x 30.5 x 81-cm) live or box traps, such as Havahart, Tomahawk, or homemade types. The best locations to set traps are along pathways to armadillo burrows and along fences or other barriers where the animals may travel.

The best trap is the type that can be opened at both ends. Its effectiveness can be enhanced by using “wings” of 1 x 4-inch (2.5 x 10-cm) or 1 x 6-inch (2.5 x 15-cm) boards about 6 feet (1.8 m) long to funnel the target animal into the trap (Fig. 3). This set does not need baiting. If bait is desired, use overripe or spoiled fruit. Other suggested baits are fetid meats or mealworms.

Other traps that may be used are leghold (No. 1 or 2) or size 220 Conibear® traps. These types should be placed at the entrance of a burrow to improve selectivity. Care should be taken when placing leghold traps to avoid areas used by nontarget animals.

**Shooting**

Shooting is an effective and selective method. The best time to shoot is during twilight hours or at night by spotlight when armadillos are active. A shotgun (No. 4 to BB-size shot) or rifle (.22 or other small caliber) can be used. Good judgment must be used in determining where it is safe to shoot. Check local laws and ordinances before using shooting as a control method.

**Other Methods**

Since most of the damage armadillos cause is a result of their rooting for insects and other invertebrates in the soil, soil insecticides may be used to remove this food source and make areas less attractive to armadillos.

**Economics of Damage and Control**

There are few studies available on the damage caused by armadillos. The damage they do is localized and is usually more of a nuisance than an economic loss.

**Acknowledgments**

Figure 1 from Schwartz and Schwartz (1981), adapted by Emily Oseas Routman.

Figure 2 adapted from Burt and Grossenheider (1976) by Jill Sack Johnson.

Figure 3 by Jill Sack Johnson.

**For Additional Information**


**Editors**

Scott E. Hygnstrom
Robert M. Timm
Gary E. Larson
**Damage Prevention and Control Methods**

**Exclusion**
Polypropylene netting checkvalves simplify getting bats out.
Quality bat-proofing permanently excludes bats.
Initiate control before young are born or after they are able to fly.

**Repellents**
Naphthalene: limited efficacy.
Illumination.

Air drafts/ventilation.
Ultrasonic devices: not effective.
Sticky deterents: limited efficacy.

**Toxicants**
None are registered.

**Trapping**
Available, but unnecessarily complicated compared to exclusion and bat-proofing.

**Other Methods**
Sanitation and cleanup.
Artificial roosts.

**Removal of Occasional Bat Intruders**
When no bite or contact has occurred, help the bat escape (otherwise submit it for rabies testing).

**Conservation and Public Education**
Information itself functions as a management technique.
Introduction

Conservation and Public Education

Despite their ecological value, bats are relentlessly and unjustifiably persecuted. Bats are often killed because they live near people who needlessly fear them. These actions emphasize the need to educate the public on the reasons for bat conservation and why it is important to use safe, nondestructive methods to alleviate conflicts between people and bats. General sources of information on bats include states’ Cooperative Extension Services, universities, government environmental conservation and health departments, and Bat Conservation International (Austin, Texas). Except where control is necessary, bats should be appreciated from a distance — and not disturbed.

Identification and Range

Bats, the only mammals that truly fly, belong to the order Chiroptera. Their ability to fly, their secretiveness, and their nocturnal habits have contributed to bat folklore, superstition, and fear. They are worldwide in distribution and include about 900 species, second in number only to Rodentia (the rodents) among the mammals.

Among the 40 species of bats found north of Mexico, only a few cause problems for humans (note that vampire bats are not found in the United States and Canada). Bats congregating in groups are called colonial bats; those that live a lone existence are known as solitary bats.

The colonial species most often encountered in and around human buildings in the United States are the little brown bat, *Myotis lucifugus*, the big brown bat *Eptesicus fuscus*, the Mexican free-tailed bat *Tadarida brasiliensis*, the pallid bat *Antrozous pallidus*, the Yuma myotis *Myotis yumanensis*, and the evening bat *Nycticeius humeralis*.

Solitary bats typically roost in tree foliage or under bark, but occasionally are found associated with buildings, some only as transients during migration.

Fig. 2. Little brown bat, *Myotis lucifugus*

Fig. 3. Big brown bat, *Eptesicus fuscus*
These include Keen’s bat (*Myotis keenii*), the red bat (*Lasiurus borealis*),
the silver-haired bat (*Lasionycteris noctivagans*), and the hoary bat
(*Lasiurus cinereus*). Excellent illustrations of all bats discussed herein can be
found in Barbour and Davis (1979),
Tuttle (1988), Geluso et al. (1987), and Harvey (1986).

Several species of bats have been
included here, with significant inter-
specific differences that need to be
clarified if well-planned, comprehen-
sive management strategies are to be
developed. Any problems caused by
bats are limited to species distribution;
thus animal damage control personnel
need not be concerned with every spe-
cies.

Colonial and solitary bats have obvi-
ous differences that serve to separate
the species into groups (refer to Fig. 5).
Much of the descriptive material that
follows is adapted from Barbour and
Davis (1979).

---

**Fig. 4.** Mexican free-tailed bat, *Tadarida brasiliensis*

**Fig. 5.** Anatomy of a typical bat
Colonial Bats

Little brown bat (*Myotis lucifugus*)

**Recognition**

forearm — 1.34 to 1.61 inches (3.4 to 4.1 cm)
wingspan — 9.02 to 10.59 inches (22.9 to 26.9 cm)
ears — 0.55 to 0.63 inches (1.4 to 1.6 cm)
foot — approximately 0.39 inches (1.0 cm); long hairs on toes extend beyond claws.

**Distribution** (Fig. 6a)

**Color**

Pale tan through reddish brown to dark brown, depending on geographic location. The species is a rich dark brown in the eastern United States and most of the west coast. Fur is glossy and sleek.

Confusion may occur with a few other “house” bat species. In the East, it may be confused with Keen’s bat (*M. keenii*), which has longer ears (0.69 to 0.75 inches (1.7 to 1.9 cm)) and a longer, more pointed tragus (the appendage at the base of the ear). In the West, it resembles the Yuma myotis (*M. yumanensis*), which has dull fur and is usually smaller. However, the Yuma myotis and little brown may be indistinguishable in some parts of the northwestern United States where they may hybridize.

**Habits**

This is one of the most common bats found in and near buildings, often located near a body of water where they forage for insect prey. Summer colonies are very gregarious, commonly roosting in dark, hot attics and associated roof spaces where maternity colonies may include hundreds to a few thousand individuals. Colonies may also form beneath shingles and siding, in tree hollows, beneath bridges, and in caves. Litter size is 1 in the Northeast; twins occasionally occur in some other areas. The roost is often shared with the big brown bat (*E. fuscus*) though the latter is less tolerant of high temperatures; *M. keenii* may also share the same site. Separate groups of males tend to be smaller and choose cooler roosts within attics, behind shutters, under tree bark, in rock crevices, and within caves.

In the winter, little brown bats in the eastern part of their range abandon buildings to hibernate in caves and mines. Such hibernacula may be near summer roosts or up to a few hundred miles (km) away. Little is known of the winter habits of *M. lucifugus* in the western United States.

The life span of little brown bats has been established to be as great as 31 years. The average life expectancy, however, is probably limited to only a few years.

**Big brown bat (*Eptesicus fuscus*)**

**Recognition**

forearm — 1.65 to 2.01 inches (4.2 to 5.1 cm)
wingspan — 12.80 to 13.78 inches (32.5 to 35.0 cm)
ears — with rounded tragus

**Distribution** (Fig. 6b)

**Color**

From reddish brown, copper colored, to a dark brown depending on geographic location. This is a large bat without distinctive markings.

Confusion may occur with the evening bat (*Nycticeius humeralis*) though the latter is much smaller.

**Habits**

This hardy, rather sedentary species appears to favor buildings for roosting. Summer maternity colonies may include a dozen or so and up to a few hundred individuals, roosting behind chimneys, in enclosed eaves, in hollow walls, attics, barns, and behind shutters and unused sliding doors. They also form colonies in rock crevices, beneath bridges, in hollow trees, and under loose bark. Litter size is 2 in the East to the Great Plains; from the Rockies westward 1 young is born.

*E. fuscus* frequently shares roosts with *M. lucifugus* in the East, and with *M. yumanensis*, *Taderida*, and *Antrozous* in the West. Males typically roost in smaller groups or alone during the summer.

The big brown bat is one of the most widely distributed of bats in the United States and is probably familiar to more people than any other species. This is partially due to its large, easy-to-observe size, but also to its ability to overwinter in buildings (attics, wall spaces, and basements). Its close proximity to humans, coupled with its tendency to move about when temperature shifts occur, often brings this bat into human living quarters and basements in summer and winter. Big browns also hibernate in caves, mines, storm sewers, burial vaults, and other underground harborage. While *E. fuscus* will apparently travel as far as 150 miles (241 km) to hibernacula, the winter quarters of the bulk of this species are largely unknown.

Big brown bats may live as long as 18 years.

**Mexican free-tailed bat (*Tadarida brasiliensis*)**

**Recognition**

forearm — 1.42 to 1.81 inches (3.6 to 4.6 cm)
wingspan — 11.42 to 12.80 inches (29.0 to 32.5 cm); long narrow wings
tail (interfemoral) membrane — does not enclose the lower one-third to one-half of the tail, hence the name free-tailed
foot — long, stiff hairs as long as the foot protrude from the toes.

**Distribution** (Fig. 6c)

**Color**

Dark brown or dark gray. Fur of some individuals may have been bleached to a pale brown due to ammonia fumes from urine and decomposing guano.

Confusion is not likely to occur with other species that commonly inhabit human buildings.
**Habits**

*T. brasiliensis* forms the largest colonies of any warm-blooded animal, establishing sizable colonies in buildings, particularly on the West Coast and in the Gulf states from Texas east. Hundreds to thousands may be found in buildings or under bridges. It is primarily a cave bat in Arizona, New Mexico, Oklahoma, and Texas; buildings are used as temporary roosts during migrations. Litter size is 1.

*Taderida* often share roosts with other species. In the West, for example, they may be found in buildings with *A. pallidus, M. yumanensis,* and *E. fuscus.* Some males are always present in the large maternity colonies, but they tend to segregate in separate caves.

A few *Taderida* may overwinter in buildings as far north as South Carolina in the East and Oregon in the West. Most of this species migrate hundreds of miles to warmer climes (largely to Mexico) for the winter.

**Pallid bat (Antrozous pallidus)**

Recognition
forearm — 1.89 to 2.36 inches (4.8 to 6.0 cm)
wingspan — 14.17 to 15.35 inches (36.0 to 39.0 cm)
ears — large; widely separated and more than half as broad as long. The ears are nearly half as long as the combined length of the bat’s head and body.
eyes — large

Distribution (Fig. 6d)

Color
pale, upper parts are light yellow, the hairs tipped with brown or gray. Underparts are pale creamy, almost white. This large, light-colored bat is relatively easy to recognize.

Confusion with other species that commonly inhabit human buildings is not likely to occur.

**Habits**

Maternity colony size ranges from about 12 to 100 individuals. Roost sites include buildings, bridges, and rock crevices; less frequently, tree cavities, caves, and mines. Litter size is most commonly 2. The roost is frequently shared with *T. brasiliensis and E. fuscus* in the West. While groups of males tend to segregate during the nursery period (sometimes in the same building), other males are found within the maternity colony.

An interesting feature of pallid bats is that they fly close to the ground, may hover, and take most prey on the ground, not in flight. Prey includes crickets, grasshoppers, beetles, and scorpions. They will also forage among tree foliage.

Pallid bats are not known to make long migrations, though little is known of their winter habits.

**Yuma myotis (Myotis yumanensis)**

Recognition
forearm — 1.26 to 1.50 inches (3.2 to 3.8 cm)
wingspan — about 9.25 inches (23.5 cm)
ears — 0.55 to 0.59 inches (1.4 to 1.5 cm)
foot — 0.39 inches (1.0 cm)

Distribution (Fig. 6e)

Color
Light tan to dark brown; underside is whitish to buffy.

Confusion may occur in the West with *M. lucifugus,* though the latter tends to have longer, glossier fur, and is larger. In the Northwest, hybridization occurs with *M. lucifugus,* making the species indistinguishable.

**Habits**

Maternity colonies, up to several thousand individuals, form in the summer in attics, belfries, under bridges, and in caves and mines. Litter size is 1. Males typically segregate during the nursery period and roost as solitary individuals in buildings and other suitable harborages.

*M. yumanensis* is more closely associated with water than is any other North American bat species. Nearly all roosts have open water nearby. This species is not as tolerant as *M. lucifugus* of high roost temperatures and will move to cooler niches within a building when temperatures rise much above 100°F (37.8°C).

*M. yumanensis* abandons maternity colonies in the fall, but its winter habitat is not known.

**Evening bat (Nycticeius humeralis)**

Recognition
forearm — 1.30 to 1.54 inches (3.3 to 3.9 cm)
wingspan — 10.24 to 11.02 inches (26.0 to 28.0 cm)
ears — with short, curved, and rounded tragus

Confusion may occur with the big brown bat (*E. fuscus,* which can be readily distinguished by its larger size. It bears some resemblance to the somewhat smaller little brown bat (*M. lucifugus* but can be identified by its characteristic blunt tragus.

Distribution (Fig. 6f)

Color
Medium brown with some variation to yellow-brown in subtropical Florida. No distinctive markings.

**Habits**

Summer maternity colonies in buildings may consist of hundreds of individuals. Litter size is usually 2. Colonies also form in tree cavities and under loose tree bark. In the Southeast, *T. brasiliensis* commonly inhabits the same building with *N. humeralis.* This is one of the most common bats in towns throughout the southern coastal states. Very little is known about this species, and virtually nothing is known of its winter habitat except that it almost never enters caves.
Solitary Bats

Keen’s bat (Myotis keenii)

Recognition
forearm — 1.26 to 1.54 inches (3.2 to 3.9 cm)
wingspan — 8.98 to 10.16 inches (22.8 to 25.8 cm)
ears — 0.67 to 0.75 inches (1.7 to 1.9 cm); with a long, narrow, pointed tragus

Distribution (Fig. 6g)

Color
Brown, but not glossy; somewhat paler in the East.

Confusion may occur with M. lucifugus, which has glossy fur, shorter ears, and does not have the long, pointed tragus.

Habits
Excluding small maternity colonies (up to 30 individuals are on record), M. keenii are generally found singly in the East. Roosting sites include: behind shutters, under woodsshingles, sheltered entryways of buildings, in roof spaces, in barns, and beneath tree bark. In the West, this bat is known as a solitary species, roosting in tree cavities and cliff crevices. Litter size is probably 1. The roost is sometimes shared with M. lucifugus. The sexes probably segregate during the nursery period. In winter, these bats hibernate in caves and mines.

Red Bat (Lasiurus borealis)

Recognition
forearm — 1.38 to 1.77 inches (3.5 to 4.5 cm)
wingspan — 11.42 to 13.07 inches (29.0 to 33.2 cm); long, pointed wings ears — short rounded
tail membrane — heavily furred on upper surface, with a distinctive long tail.

Distribution (Fig. 6h)

Color
Bright orange to yellow-brown; usually with a distinctive white mark on the shoulders.

Confusion may occur with the hoary bat (L. cinereus), which is frosted-gray in appearance and larger.

Habits
Red bats live solitary lives, coming together only to mate and migrate. Few people are familiar with this species. They typically spend summer days hidden in the foliage of deciduous trees. The number of young ranges from 1 to 4, averaging 2.3.

These bats often chase insects that are attracted to lights, such as street lamps. It is this behavior that most likely brings them in close proximity to people.

L. borealis is well-adapted for surviving drastic temperature fluctuations; it does not hibernate in caves, but apparently in trees. Some migrate long distances. During migration, red bats have been known to land on high-rise buildings and on ships at sea.

Silver-haired bat (Lasionycteris noctivagans)

Recognition
forearm — 1.46 to 1.73 inches (3.7 to 4.4 cm)
wingspan — 10.63 to 12.20 inches (27.0 to 31.0 cm)
ears — short, rounded, hairless
tail membrane — upper surface is sparsely furred on the anterior one-half.

Distribution (Fig. 6i)

Color
Usually black with silver-tipped fur; some individuals with dark brown, yellowish-tipped fur.

Confusion sometimes occurs with the larger hoary bat (Lasiurus cinereus), which has patches of hair on the ears and wings, heavy fur on the entire upper surface of the tail membrane, and has a distinctive throat “collar.”

Habits
The silver-haired bat roosts in a wide variety of harborage. A typical roost might be behind loose tree bark; other sites include tree hollows and bird nests. This species is solitary except when with young. Additionally, there are unconfirmed reports that it is sometimes colonial (Dalquest and Walton 1970) and may roost in and on buildings. The litter size is 2. The sexes segregate through much of the summer range.

L. noctivagans hibernates in tree crevices, under loose bark, in buildings (including churches, skyscrapers, and wharf houses), hulls of ships, rock crevices, silica mines, and non-limestone caves. It also may migrate, during which time it is encountered in buildings (they favor open sheds, garages, and outbuildings rather than enclosed attics), in lumber piles, and on ships at sea.

Hoary bat (Lasiurus cinereus)

Recognition
forearm — 1.81 to 2.28 inches (4.6 to 5.8 cm)
wingspan — 14.96 to 16.14 inches (38.0 to 41.0 cm)
ears — relatively short, rounded, edged with black, and with fur tail membrane — completely furred on upper surface

Distribution (Fig. 6j)

Color
Dark, but many hairs are tipped in white, giving it a frosted appearance. This bat also has a yellowish or orangish throat “collar.”

Confusion may sometimes occur with the much smaller silver-haired bat (Lasionycteris noctivagans), which lacks the fur patches and markings on the ears, markings on the throat, and has a tail membrane that is only lightly furred on the upper surface.

Habits
Hoary bats generally spend summer days concealed in tree foliage (often in evergreens), rarely enter houses, and are not commonly encountered by people. L. cinereus at their day roosts are usually solitary except when with young. The litter size is 2. The sexes segregate through most of the summer range.

This is one of the largest bats in North America, a powerful flier, and an accomplished migrant. Records indicate that some L. cinereus may hibernate in northern parts of their range.
Figure 6. Distributions of selected bat species in North America:
(a) little brown bat, (b) big brown bat, (c) Mexican free-tailed bat,
(d) pallid bat, (e) Yuma myotis, (f) evening bat, (g) Keen’s bat,
(h) red bat, (i) silver-haired bat, (j) hoary bat.
Food Habits

Bats in North America are virtually all insectivorous, feeding on a variety of flying insects (exceptions among house bats were noted previously). Many of the insects are harmful to humans. While there must be some limitations based on such factors as bats’ body size, flight capabilities, and jaw opening, insectivorous bats apparently consume a wide range of prey (Barbour and Davis 1979). The little brown bat’s diet includes mayflies, midges, mosquitoes, caddis flies, moths, and beetles. It can consume insects equal to one-third of its body weight in 1/2 hour of foraging. The big brown bat may fill its stomach in about 1 hour (roughly 0.1 ounce per hour [2.7 g/hr]) with prey including beetles, moths, flying ants, true bugs, mayflies, caddis flies, and other insects. The nightly consumption of insects by a colony of bats can be extremely large.

General Biology, Reproduction, and Behavior

Most North American bats emit high frequency sounds (ultrasound) inaudible to humans and similar to sonar, in order to avoid obstacles, locate and capture insect prey, and to communicate. Bats also emit audible sounds that may be used for communication between them.

Bats generally mate in the fall and winter, but the female retains the sperm in the uterus until spring, when ovulation and fertilization take place. Pregnant females may congregate in maternity colonies in buildings, behind chimneys, beneath bridges, in tree hollows, caves, mines, or other dark retreats. No nests are built. Births typically occur from May through July. Young bats grow rapidly and are able to fly within 3 weeks. Weaning occurs in July and August, after which the nursery colonies disperse.

Bats prepare for winter around the time of the first frost. Some species migrate relatively short distances, whereas certain populations of the Mexican free-tailed bat may migrate up to 1,000 miles (1,600 km). Bats in the northern United States and Canada may hibernate from September through May. Hibernation for the same species in the southern part of their range may be shorter or even sporadic. Some may fly during warm winter spells (as big brown bats may in the northeastern part of the United States). Bats often live more than 10 years.

In response to a variety of human activities, direct and indirect, several bat species in the United States have declined in number during the past few decades. Chemical pesticides (particularly the use of persistent and bioaccumulating organic pesticides) have decreased the insect supply, and contaminated insects ingested by bats have reduced bat populations. Many bats die when people disturb summer maternity roosts and winter hibernacula. Vandals and other irresponsible individuals may deliberately kill bats in caves and other roosts. Even the activities of speleologists or biologists may unintentionally disturb hibernating bats, which depletes fat reserves needed for hibernation.

Modification and destruction of roost sites has also decreased bat numbers. Sealing and flooding of mineshafts and caves and general quarrying operations may inadvertently ruin bat harbors. Forestry practices have reduced the number of hollow trees available. Some of the elimination of natural bat habitat may contribute to bats roosting in buildings.

Damage and Damage Identification

Bat Presence

Bats often fly about swimming pools, from which they drink or catch insects. White light (with an ultraviolet component), commonly used for porch lights, building illumination, street and parking-lot lights, may attract flying insects, which in turn attract bats. Unfortunately, the mere presence of a bat outdoors is sometimes beyond the tolerance of some uninformed people. Information is a good remedy for such situations.

Bats commonly enter buildings through openings associated with the roof edge and valleys, eaves, apex of the gable, chimney, attic or roof vent, dormers, and siding (see Fig. 7). Other

Fig. 7. Common points of entry and roosting sites of house bats.
openings may be found under loose-fitting doors, around windows, gaps around various conduits (wiring, plumbing, air conditioning) that pass through walls, and through utility vents.

Bats are able to squeeze through narrow slits and cracks. For purposes of bat management, one should pay attention to any gap of approximately 1/4 x 1 1/2 inches (0.6 x 3.8 cm) or a hole 5/8 x 7/8 inch (1.6 x 2.2 cm). Such openings must be considered potential entries for at least the smaller species, such as the little brown bat. The smaller species require an opening no wider than 3/8 inch (0.95 cm), that is, a hole the diameter of a US 10-cent coin (Greenhall 1982). Openings of these dimensions are not uncommon in older wood frame structures where boards have shrunk, warped, or otherwise become loosened.

The discovery of one or two bats in a house is a frequent problem. In the Northeast, big brown bats probably account for most sudden appearances (see Figs. 3 and 8). Common in urban areas, they often enter homes through open windows or unscreened fireplaces. If unused chimneys are selected for summer roosts, bats may fall or crawl through the open damper into the house. Sometimes bats may appear in a room, then disappear by crawling under a door to another room, hallway, or closet. They may also disappear behind curtains, wall hangings, bookcases, under beds, into waste baskets, and so forth. Locating and removing individual bats from living quarters can be laborious but is important. If all else fails, wait until dusk when the bat may appear once again as it attempts to find an exit. Since big brown bats may hibernate in the cooler recesses of heated buildings, they may suddenly appear (flying indoors or outdoors) in midwinter during a warm spell or a cold snap as they move about to adjust to the temperature shift.

Roosting Sites

Bats use roosting niches that are indoors (human dwellings, outbuildings, livestock quarters, warehouses), semi-enclosed (loading docks, entrance foyers), partially sheltered (porches, carports, pavilions, highway underpasses, bridges), and open structural areas (window shutters, signs). Once there, active bats in and on buildings can have several economic and aesthetic effects, often intertwined with public health issues (Frantz, 1988). Unusual roosting areas include wells, sewers, and graveyard crypts. Before considering control measures, verify that bats are actually the cause of the problem.

Rub Marks

Surface areas on walls, under loose woodwork, between bricks and around other bat entryways often have a smooth, polished appearance. The stained area is slightly sticky, may contain a few bat hairs, and is yellow-brown to blackish brown in color. The smooth gloss of these rub marks is due to oils from fur and other bodily secretions mixed with dust, deposited there as many animals pass repeatedly for a long period over the same surface. Openings marked in this way have been used heavily by bats.

Noise

Disturbing sounds may be heard from vocalizations and grooming, scratching, crawling, or climbing in attics, under eaves, behind walls, and between floors. Bats become particularly noisy on hot days in attics, before leaving the roost at dusk, and upon returning at dawn. Note that rustling sounds in chimneys may be caused by birds or raccoons and scratching and thumping sounds in attics and behind walls may indicate rats, mice, or squirrels.

Guano and Urine

Fecal pellets indicate the presence of animals and are found on attic floors, in wall recesses, and outside the house at its base. Fecal pellets along and inside walls may indicate the presence of mice, rats, or even roaches. Since most house bats north of Mexico are insectivorous, their droppings are easily distinguished from those of small rodents. Bat droppings tend to be segmented, elongated, and friable. When crushed, they become powdery and reveal shiny bits of undigested insect remains. In contrast, mice and rat droppings tend to taper, are unsegmented, are harder and more fibrous, and do not become powdery when crushed (unless extremely aged).

The droppings of some birds and lizards may occasionally be found along with those of bats. However, bat droppings never contain the white chalky material characteristic of the feces of these other animals.

Bat excrement produces an unpleasant odor as it decomposes in attics, wall spaces, and other voids. The pungent, musty, acrid odor can often be detected from outside a building containing a large or long-term colony. Similar odor problems occur when animals die in inaccessible locations. The odor also attracts arthropods which may later invade other areas of a building.

Bat guano may provide a growth medium for microorganisms, some of which are pathogenic (histoplasmosis, for example) to humans. Guano accumulations may fill spaces between walls, floors, and ceilings. It may create a safety hazard on floors, steps, and ladders, and may even collapse ceilings. Accumulations also result in the staining of ceilings, soffits, and siding, producing unsightly and unsanitary conditions.

Bats also urinate and defecate in flight, causing multiple spotting and staining on sides of buildings, windows, patio furniture, automobiles, and other objects at and near entry/exit holes or beneath roosts. Bat excrement may also contaminate stored food, commercial products, and work surfaces.

Bat urine readily crystallizes at room temperature. In warm conditions under roofs exposed to sun and on chimney walls, the urine evaporates so quickly that it crystallizes in great accumulations. Boards and beams saturated with urine acquire a whitish powderlike coating. With large numbers of bats, thick and hard stalactites and stalagmites of crystallized bat urine are occasionally formed.
Although the fresh urine of a single bat is relatively odorless, that of any moderate-sized colony is obvious, and the odor increases during damp weather. Over a long period of time urine may cause mild wood deterioration (Frantz and Trimarchi 1984). As the urine saturates the surfaces of dry wood beams and crystallizes, the wood fibers expand and separate. These fibers then are torn loose by the bats crawling over such surfaces, resulting in wood fibers being mixed with guano accumulations underneath.

The close proximity of bat roosts to human living quarters can result in excreta, animal dander, fragments of arthropods, and various microorganisms entering air ducts as well as falling onto the unfortunate residents below. Such contaminants can result in airborne particles of public health significance (Frantz 1988).

**Ectoparasites and other Arthropods**

Several arthropods (fungivores, detritivores, predators, and bat ectoparasites) are often associated with colonies of bats in buildings. Their diversity depends on the number of bats, age and quantity of excreta deposits, and season. Arthropods such as dermestid beetles (*Attagenus megatoma*) contribute to the decomposition of guano and insect remnants, but may also become a pest of stored goods and/or a nuisance within the living quarters. Cockroaches (for example, *Blatta orientalis*) attracted to guano may invade other parts of a building. Bat bugs (*Cimex* spp.) are sometimes found crawling on the surface of beams or around holes leading to secluded recesses used by bats. Bat ectoparasites (ticks, mites, fleas, and bugs) rarely attack humans or pets and quickly die in the absence of bats. Ectoparasites may become a nuisance, however, following exclusion of large numbers of bats from a well-established roost site. Area fumigation with a total release pyrethrum-based aerosol may be an appropriate solution for arthropod knockdown within an enclosed space, but only after bats have departed. For long-term arthropod control, lightly dust appropriate surfaces (affected attic beams, soffits) with boric acid powder or diatomaceous earth; carefully read all product labels before using any pesticide. Note that neither rabies nor Lyme disease is transmitted by any arthropods associated with bats.

**Public Health Issues**

**Rabies—General Epidemiology.**

Bats are distinct from most vertebrate pests that inhabit human dwellings because of the potential for transmitting rabies — a viral infection of mammals that is usually transmitted via the bite of an infected animal. Rabies does not respond to antibiotic therapy and is nearly always fatal once symptoms occur. However, because of the long incubation period (from 2 weeks to many months), prompt vaccination following exposure can prevent the disease in humans. Dogs, cats, and livestock also can be protected by periodic vaccinations.

Bats are not asymptomatic carriers of rabies. After an incubation period of 2 weeks to 6 months, they become ill with the disease for as long as 10 days. During this latter period, a rabid bat’s behavior is generally not normal—it is relatively odorless, that of any moderate-sized colony is obvious, and the odor increases during damp weather. Over a long period of time urine may cause mild wood deterioration (Frantz and Trimarchi 1984). As the urine saturates the surfaces of dry wood beams and crystallizes, the wood fibers expand and separate. These fibers then are torn loose by the bats crawling over such surfaces, resulting in wood fibers being mixed with guano accumulations underneath.

The close proximity of bat roosts to human living quarters can result in excreta, animal dander, fragments of arthropods, and various microorganisms entering air ducts as well as falling onto the unfortunate residents below. Such contaminants can result in airborne particles of public health significance (Frantz 1988).

**Ectoparasites and other Arthropods**

Several arthropods (fungivores, detritivores, predators, and bat ectoparasites) are often associated with colonies of bats in buildings. Their diversity depends on the number of bats, age and quantity of excreta deposits, and season. Arthropods such as dermestid beetles (*Attagenus megatoma*) contribute to the decomposition of guano and insect remnants, but may also become a pest of stored goods and/or a nuisance within the living quarters. Cockroaches (for example, *Blatta orientalis*) attracted to guano may invade other parts of a building. Bat bugs (*Cimex* spp.) are sometimes found crawling on the surface of beams or around holes leading to secluded recesses used by bats. Bat ectoparasites (ticks, mites, fleas, and bugs) rarely attack humans or pets and quickly die in the absence of bats. Ectoparasites may become a nuisance, however, following exclusion of large numbers of bats from a well-established roost site. Area fumigation with a total release pyrethrum-based aerosol may be an appropriate solution for arthropod knockdown within an enclosed space, but only after bats have departed. For long-term arthropod control, lightly dust appropriate surfaces (affected attic beams, soffits) with boric acid powder or diatomaceous earth; carefully read all product labels before using any pesticide. Note that neither rabies nor Lyme disease is transmitted by any arthropods associated with bats.

**Public Health Issues**

**Rabies—General Epidemiology.**

Bats are distinct from most vertebrate pests that inhabit human dwellings because of the potential for transmitting rabies — a viral infection of mammals that is usually transmitted via the bite of an infected animal. Rabies does not respond to antibiotic therapy and is nearly always fatal once symptoms occur. However, because of the long incubation period (from 2 weeks to many months), prompt vaccination following exposure can prevent the disease in humans. Dogs, cats, and livestock also can be protected by periodic vaccinations.

Bats are not asymptomatic carriers of rabies. After an incubation period of 2 weeks to 6 months, they become ill with the disease for as long as 10 days. During this latter period, a rabid bat’s behavior is generally not normal—it may be found active during the daytime or on the ground incapable of flying. Most human exposures are the result of accidental or careless handling of grounded bats. Even less frequently, bats in this stage of illness may be involved in unprovoked attacks on people or pets (Brass, pers. commun.; Trimarchi et al. 1979). It is during this stage that the rabid bat is capable of transmitting the disease by biting another mammal. As the disease progresses the bat becomes increasingly paralyzed and dies as a result of the infection. The virus in the carcass is reported to remain infectious until decomposition is well advanced.

**Significance.** Rabies is the most important public health hazard associated with bats. Infection with rabies has been confirmed in all 40 North American species of bats that have been adequately sampled in all of the contiguous United States and in most provinces of Canada. Figure 8 shows the frequency of bat species submitted for rabies testing in New York State over the last 12 years. While not a nationwide measure of human encounters with bats, Figure 8 illustrates that bat species are not encountered equally. Note that bats submitted for testing are often ill and/or easily captured. The numbers and species encountered will vary with the region of the country; data are generally available from local and state health authorities.

![Fig. 8. Profile of bat species submitted to the New York State Rabies Laboratory, 1981-1992.](image-url)
Histoplasmosis—General Epidemiology. Histoplasmosis is a very common lung disease of worldwide distribution caused by a microscopic fungus, *Histoplasma capsulatum*. *Histoplasma* exists in nature as a saprophytic mold that grows in soil with high nitrogen content, generally associated with the guano and debris of birds (particularly starlings, *Sturnus vulgaris*, and chickens) and bats. Wind is probably the main agent of dispersal, but the fungus can survive and be transmitted from one site to another in the intestinal contents of bats, and also in the dermal appendages of both bats and birds. The disease can be acquired by the casual inhalation of windblown spores, but infections are more likely to result from visits to point sources of growth of the fungus. Relative to bats, such sources include bat roosts in caves, barns, attics, and belfries, and soil enriched with bat guano.

Numerous wild and domestic animals are susceptible to histoplasmosis, but bats (and perhaps the armadillo) are the only important animal vectors. Unlike bats, birds do not appear to become infected with the fungus. Both the presence of guano and particular environmental conditions are necessary for *H. capsulatum* to proliferate. In avian habitats, the organism apparently grows best where the guano is in large deposits, rotted and mixed with soil rather than in nests or in fresh deposits. Specific requirements regarding bats have not been described, though bat roosts with long-term infestation are often mentioned in the literature.

While histoplasmosis in the United States is particularly endemic to the Ohio-Mississippi Valley region (which is also an area with the greatest startling concentration) and areas along the Appalachian Mountains, it is also found in the lake and river valleys of other states. Outside areas with "appropriate" environmental conditions, there also occur scattered foci containing *H. capsulatum* in soil rather than in nests or in fresh deposits. Specific requirements regarding bats have not been described; however, bat roosts with long-term infestation are often mentioned in the literature.

Significance. When soil or guano containing *H. capsulatum* is physically disturbed, the spores become airborne. Persons at particular risk of histoplasmosis of bat origin include spelunkers, bat biologists, pest control technicians, people who clean out or work in areas where bats have habitually roosted, and people in contact with guano-enriched soil — such as around the foundation of a building where guano has sifted down through the walls.

Infection occurs upon inhalation of spores and can result in a variety of clinical manifestations; severity partially depends on the quantity of spores inhaled. The infection may remain localized in the lungs where it may resolve uneventfully; this is the case for about 95% of the 500,000 infections occurring annually in the United States. Such infections are identified only by the presence of a positive histoplasin skin test and/or calcified lesions on routine radiographs. Other individuals may have chronic or progressive lung disease requiring treatment. Less severe forms of these infections may be accompanied by fever, cough, and generalized symptoms similar to a prolonged influenza. Resolution of the disease confers a degree of immunity to reinfestation. In addition, resolution confers varying degrees of hypersensitivity to *H. capsulatum*; as a consequence, massive reinfestation in highly sensitized lungs may result in a fatal acute allergic reaction.

In a small percentage of chronic histoplasmosis cases, the fungus disseminates to involve multiple organ systems and may be fatal. This form is usually seen in young children (1 year or older) and in immunocompromised adults. In recent years, systemic infections have been increasing in frequency globally as an opportunistic infection of AIDS patients.

Legal Status

The lethal control of bats, even when there is a proven potential danger to humans, often is subjected to careful scrutiny and interagency coordination. A survey of federal legislative actions, court decisions, and agency interpretations concerning bats can be found in *Bat Management in the United States* (Lera and Fortune 1979).

Some states have laws that specifically mention bats, either providing or denying protection. Others have legislation that applies to bats only by interpretation, since bats may be considered nongame wildlife or indigeneous state mammals. Some bats have protection as either federal or state-listed endangered species, but the same state may not protect other species of bats. Enforcement and public education must accompany legislation to accomplish the intended goal of protecting the public and saving endangered bats. Familiarity with the appropriate federal and state laws should precede any nuisance management activities.
## Damage Prevention and Control Methods

### Premanagement Considerations

**Bat Watch for Infestation Confirmation.** To confirm that bats are actually roosting in or on a building, look for bats flying in and out of a site and/or for signs of infestation. A bat watch can be conducted by two people (more may be necessary to observe large or complex sites) posted at opposite corners of a structure. An evening watch begins about 30 minutes before dark and a morning watch begins about 1 hour before dawn. Observations should continue for approximately 1 hour.

Such observations can indicate exit/entry points and the number of bats. With practice, distinguishing some bat species may also be possible. For example, compared to the big brown bat, the little brown bat is noticeably smaller in size, and its flight has more rapid wing beats, and more rapid turning and darting.

It may be necessary to watch for more than one night to compensate for weather conditions, bats' sensitivity to observers, noisy or inexperienced observers, and improper use of light. Observations can be enhanced with a standard flashlight, but be certain to keep the bright part of the beam as far as possible away from the exit hole being observed. Bright light will increase bats' reluctance to exit and may result in an incomplete exit of the colony. A valuable observation aid is a powerful, rechargeable flashlight equipped with a plastic, red pop-off filter (similar to the Kodak Wratten 89B). Also, an electric headlamp, supplied with rechargeable batteries and fitted to a climbing or spelunking helmet, allows hands-off illumination outdoors as well as indoors when exploring roost locations.

Bats are sensitive to light intensity and can visually discriminate shapes and patterns in extremely low light situations. They can only see in black and white; hence, the low-contrast illumination and soft shadows produced by red light has little effect on bats.

**Locating the Roost(s).** It is not always possible or convenient to conduct a bat watch. Thus, a detailed inspection inside the building for bats or bat sign may be necessary to find specific roosts. Daytime is best, especially during the warmer part of the day. Bats roost in the most varied kinds of buildings and in every part from cellar to attic. Some types of buildings appear preferable (older houses, churches, barns, proximity to water) as do certain roost locations therein, especially areas with little disturbance, low illumination, little air circulation, and high temperatures. Often it is easy to locate bats, especially in warm weather in attics or lofts, where they may hang in clusters or side-by-side from the sloping roof lath, beams, and so forth. However, bats have the ability to find crevices and cavities, and if disturbed may rapidly disappear into the angles between converging beams, behind such beams or wallboards, into mortise holes on the underside of beams, and into the multilayered wall and roof fabrications. If bats cannot be openly observed, usually there are various interior and exterior signs of their presence. Often there are multiple roost sites within or on a single building.

**Problem Assessment.** Once it has been confirmed that bats are present, one must determine if there is damage, if there is a health risk, and if some intervention is warranted. There are circumstances in which “no action” is the correct action because of the beneficial role of bats. In cases where there is risk of contact, damage from excreta accumulations, stains, and so on, intervention may be necessary.

**Timing.** With the exception of disease treatment and removal of the occasional bat intruder, timing becomes an important planning consideration. Management procedures must not complicate an already existing problem and should emphasize bat conservation. Therefore, all interventions should be initiated before the young are born or after they are weaned and able to fly. Thus, the annual opportunity extends from about mid-August to mid-May for much of North America. Treatments might otherwise result in the unnecessary death of animals (especially young unable to fly) trapped inside, offensive odors, and attraction of arthropod scavengers.

### Disease Considerations

**Rabies — Preventive Measures.** It should be noted that newspapers, television, and other mass media sometimes misrepresent the role of rabid bats as a risk to humans. However, the unfortunate recent (1983 to 1993) deaths of a 22-year-old man in Texas, a 30-year-old bat scientist in Finland, a university student in British Columbia, a 5-year-old girl in Michigan, a man in Arkansas, an 11-year-old girl in New York, and a woman in Georgia amply underscore the need to pay prompt attention to bat bites and other exposures.

Many rabies exposures could be avoided if people simply refrained from handling bats. Adults and children should be strongly cautioned never to touch bats with bare hands. All necessary measures should be taken to ensure that bats cannot enter living quarters in houses and apartments. Pet cats and dogs should be kept up-to-date in rabies vaccinations. This is also true for pets confined indoors, because contact with bats frequently occurs indoors. Valuable livestock also should be vaccinated if kept in buildings harboring bats or if in a rabies outbreak area (NASPHV 1993). While transmission of rabies from bats to terrestrial mammals apparently is not common, such incidents have been reported (Reid-Sanden et al. 1990, Trimarchi 1987). Dogs, cats, and livestock that have been exposed to a rabid or suspected-rabid animal, but are not currently vaccinated, must be either quarantined or destroyed.

Lastly, pest control technicians, nuisance wildlife control personnel, wildlife biologists, and other individuals at particular risk of contact with rabid bats (or other wildlife) should receive a rabies pre-exposure vaccination. This effective prophylaxis involves only three injections of rabies vaccine, which are administered in the arm during a month's time.
Rabies — Treatment for Exposure. If a person is bitten or scratched by a bat, or there is any suspicion that bat saliva or nervous tissue has contaminated an open wound or mucous membrane, wash the affected area thoroughly with soap and water, capture the bat without damaging the head, and seek immediate medical attention. The incident should be reported promptly to local health authorities in order to arrange rabies testing of the bat.

If the bat is captured and immediate transportation to the testing laboratory is possible, and if immediate testing can be arranged, postexposure treatment may be delayed several hours until the test results are known. Postexposure prophylaxis must be administered immediately, however, if the bat cannot be captured, if prompt transportation to the laboratory is not possible, if the specimen is not suitable for reliable diagnosis, or if the test results prove positive for rabies.

The prophylaxis has little resemblance to that of many years ago. Today, it consists of one dose of rabies immune globulin (human origin) and one dose of rabies vaccine (human diploid cell) administered preferably on the day of exposure, followed by additional single doses of rabies vaccine on days 3, 7, 14, and 28 following the initial injection. This treatment is normally safe, relatively painless, and very effective.

Histoplasmosis — Preventive Measures. Histoplasmosis can most easily be prevented by avoiding areas that harbor H. capsulatum. Since this is not practical for individuals who must work in and around active/inactive bat roosting sites, other measures can be recommended to reduce the risk of infection during cleaning, field study, demolition, construction, and other activities.

Persons working in areas known or suspected to be contaminated with H. capsulatum should always wear protective masks capable of filtering out particles as small as 2 microns in diameter or use a self-contained breathing apparatus. In areas known to be contaminated, wear protective clothing and gloves that can be removed at the site and placed in a plastic bag for later decontamination via formalin and washing. Also, clean footwear before leaving the site to prevent spore dissemination in cars, the office, at home, and elsewhere.

Guano deposits and guano-enriched soils should not be unnecessarily disturbed. Dampening with water or scheduling outdoor work at a time when the ground is relatively wet will minimize airborne dust. Chemically decontaminate known infective foci with a spray of 3% formalin (see CDC 1977). To protect the environment, decontamination must be conducted in accordance with state and local regulations. Chemical decontamination of an “active” bat roost should be conducted only after the bats have been excluded or after bats have departed for hibernation.

Histoplasmosis — Treatment. Most infections in normally healthy individuals are benign and self-limiting and do not require specific therapy (George and Penn 1986; Rippon 1988). Treatment with an antifungal agent may be prescribed in more severe cases; amphotericin B and/or oral imidazole ketoconazole are typically recommended depending on the specific nature of the infection.

Removal of Occasional Bat Intruders

A bat that has blundered into the living quarters of a house will usually find its way out by detecting air movement. When no bite or contact with people or pets has occurred, the simplest solution for “removing” the bat is to try to confine it to one room, then open windows and doors leading outdoors and allow it to escape. If the bat is present at night, the lights should be dimmed to allow the animal to find open doors and windows; some light is necessary if an observer is to insure that the bat finds its way out. If bright lights are kept on, the bat may become confused and may seek refuge behind shelving, curtains, hanging pictures, or under furniture.

Healthy bats normally will not attack people even when chased. Chasing a flying bat with a folded newspaper, tennis racket, or stick will cause the bat to take evasive action, and a bat’s flight reversal to avoid a wall is often misinterpreted as an attack. These flailings, often futile, will cause a bat to seek safety wherever possible, making escape more difficult for the bat and more frustrating for the human.

If the bat has difficulty escaping, it can be captured in a hand net (for example, an insect net [Fig. 9]). Otherwise,
wait for it to come to rest, quickly
cover it with a coffee can or similar
container, and slide a piece of card-
board or magazine under the can to
trap the bat inside (NYSDH 1990).
Take the captured bat outdoors and
release it away from populated areas,
preferably after dark. Note that
reasonably thick work gloves should
be worn at all times when trying to
capture a bat. Also, if a bite or physical
contact occurs, capture the bat without
damaging its head and immediately
contact a physician (see previous
section regarding rabies treatment).
Management of problems involving
bat colonies require more complicated
procedures and a greater time commit-
ment.

Exclusion

Preventive Aspects. The most satis-
factory and permanent method of
managing nuisance bats is to exclude
them from buildings. Locate bats and
their points of exit/entry through bat
watches or other inspection methods.
This is a tedious process to locate all
openings in use, and bats may switch
to alternate ones when normal routes
become unavailable. Thus, consider
“potential” as well as “active” points
of access.

Often it is apparent where bats might
gain entrance even when such open-
ings are not directly observable. By
standing in various locations of a dark-
ened attic during daylight hours, one
often can find leaks of light at the
extreme parts of eaves, in layers of
subroofing, and below chimney
flashings. Seal all gaps of 1/4 x 1 1/2
inches (0.6 x 3.8 cm) and openings 5/8
x 7/8 inch (1.6 x 2.2 cm) or greater.

Bats will also use some of the same
obscure holes in buildings through
which heat (or cooled air) is lost; thus,
bat-proofing often conserves energy.
Simple, homemade devices can be
used to locate air leaks. Bathroom tis-
sue or plastic will wave and flutter
from air movements (Fig. 10). Indoor
air leaks can be found easily by the use
of an air flow indicator (Fig. 11). Small-
volume smoke generators can be used
to locate openings in the floor, ceiling,
attic, and basement. Obscure openings
also may be located from outside the
house by activating smoke candles or
smoke bombs (as within an attic),
which will produce easily observed
dense smoke. Be careful of any fire
hazards.

The easiest time to seal bats out of
buildings in northern latitudes is dur-
ing the cooler part of the year when
colonies are not resident. During this
period, many homeowners need to be
reminded that bats, and bat problems,
return each summer. Basic carpentry,
masonry, and tinsmith skills are valu-
able in bat exclusion and other
pestproofing interventions.

Devices and Methods. Exclusion
becomes “denial of reentry” once the
bats have returned to establish mater-
nity colonies (and before the young are
born), usually from April through
mid-May in the Northeast. Denial of
reentry is also appropriate anytime
after mid-August when young are
capable of flying, as long as bats con-
tinue to utilize the roost.

The traditional way to exclude bats
from an occupied roost involves five
basic steps: (1) identify and close all in-
door openings through which bats
might gain access to human living
quarters; (2) close most confirmed and
all unused potential exterior exits,
leaving only a few major openings (it’s
best to complete this within 1 to 2
days); (3) at night shortly after the bats

---

Fig. 10. Using a clothes hanger/plastic film com-
bination to detect air leaks.

Fig. 11. Smoke from the Sensidyne Air Indicator makes it possible to visually determine the direc-
tional pattern of air currents.
have departed to feed, temporarily close the few remaining, major exits; (4) check the roost for presence of bats and, if any remain, unplug the temporarily closed exits early the next evening to allow the bats to escape, then temporarily replug the exits (it may be necessary to repeat this step more than once); and (5) when the bats are all out, permanently seal the holes (Frantz and Trimarchi 1984, Greenhall 1982).

Patience and timing are very important in this process. Much of this work can be done during daylight hours except steps 3 and 4, which require climbing on ladders and roofs at night, sometimes with bats flying nearby. The danger of such work is obvious and discouraging.

Some of these difficulties have been overcome by use of the Constantine one-way valvelike device which is installed in the last exit(s) during the day, and permits bats to leave after dark but prevents their reentry (Constantine 1982). Eventually the valve should be removed and the hole(s) sealed. Another device, the EX-100 Hanks Bat Excluder, consists of a piece of nylon window screening, a wooden plate with a hole in the middle to which is attached a one-way plastic flappervalve, and a rigid plastic mesh cone (Anon. 1983). The screening, to which the wooden plate is attached, is used to cover an opening that bats use to exit a building. Both devices are designed to be used on the last few exit points. Installation instructions are available, and properly applied they will undoubtedly exclude bats from relatively small, discrete openings.

The devices of Constantine and Hanks involve a one-way, self-closing valve feature and can be readily installed during daylight hours. Such devices are not readily adaptable to situations with large, diffuse and/or widely distributed entryways. Also, bats can be inadvertently trapped inside if an important exit hole is mistakenly identified as a minor one and is sealed in an attempt to limit the number of holes requiring an exclusion device.

To overcome difficulties with exclusion devices, Frantz’ checkvalve was developed using netting made of durable black polypropylene resin (Frantz 1984, 1986). Quality of product is important since the netting should not fray or become misshapen under hot summer conditions. Use only structural grade material that has openings no larger than 1/2 x 1/2 inch (1.3 x 1.3 cm), weighs about 1.3 ounces per square yard (44 g/m²) and is flexible yet stiff enough to maintain the shape of the checkvalve fabricated (Fig. 12). Waterproof duct tape, common staples, and/or wooden lath strips are used to attach the netting to metal, slate, brick, wood, asphalt shingle, or other surfaces. Note that duct tape may stain or discolor painted/enameled surfaces if kept in contact for long periods of time.

Application of checkvalves follows the same two initial steps as traditional bat exclusion. Close interior openings, then close exterior openings except a few major exits. These latter openings will have been confirmed as important via bat watches, and it is here that checkvalves will be fitted during the daylight.

The basic design is to attach the netting around an exit hole except at the bottom where the bats will escape (see Frantz 1986, for details). The width and shape of checkvalves is highly variable so as to embrace the necessary

![Bat on birdnetting showing size relationships.](image)

Fig. 12. Bat on birdnetting showing size relationships.

exit point — a single hole, a series of holes, or a long slitlike opening (Fig. 13). Designs must be open enough not to impede the exiting bats. The top can be much larger than the bottom. It is probably best to restrict the bottom opening to no larger than about 1.6 x 1.6 feet (0.5 x 0.5 m). The length of a checkvalve, that is, the distance from the lowest enclosed point of egress to the bottom of the netting, should be about 3.3 feet (1 m).

The above specifications usually are sufficient to abort bats’ reentry attempts. If netting is applied while young are still in the roost, the “evicted” mothers may be motivated to chew holes in the netting to reenter the roost. Applied at the correct time of year, however, netting will allow all bats to exit at dusk and thereafter deny them reentry.

Checkvalves should be kept in place for 3 to 5 days. It is best to verify (conduct a bat watch) that bats no longer exit at dusk before the checkvalves are dismantled and the holes are sealed permanently. As in any exclusion intervention, the excluded animals will go elsewhere. This shift may be to an alternative roost already in use such as a night roost, or one used in previous years.

**Supplemental Materials and Methods.** While specifications for Frantz’ checkvalve have been
expanding polyurethane foam applied from pressurized containers can be used for openings larger than 3 inches (>7.5 cm). It must be applied with caution so as not to lift clapboards, shingles, and other surfaces. Exposed surfaces should be sealed with epoxy paint to prevent insect infestation and ultraviolet degradation.

Conventional draft sweeps (metal, rubber) and other weatherstripping supplies (felt, vinyl, metal) will seal the space between a door bottom and the threshold or around windows (Fig. 14). Remember to treat attic and basement doors whenever the gap exceeds 1/4 inch (0.6 cm). Flashing may be used to close gaps wherever joints occur; for example, where the roof meets a chimney. Materials commonly used include galvanized metal, copper, aluminum, and stainless steel. Self-adhesive stainless steel “tape” is also available. Insulation will provide some degree of barrier to bat movements. It is available in a number of forms and types including fiberglass, rock wool, urethane, vermiculite, polystyrene, and extruded polystyrene foam. Inorganic materials are fire and moisture resistant; the safest appear to be fiberglass and rock wool.

The mesh size of screening must be small enough to prevent access of bats and other species, where desired. Hardware cloth with 1/4-inch (0.6-cm) mesh will exclude bats and mice; screening with 16 meshes per inch (2.5 cm) will exclude most insects. Soffits (underside of overhanging eaves) usually have ventilators of various shapes and sizes. Regardless of type, the slots should not exceed 1/4 x 1 inch (0.6 cm x 2.5 cm) and should be covered inside with insect mesh. To prevent bats from entering chimney flues, completely enclose the flue discharge area with rust-resistant spark arresters or pest screens, secured to the top of the chimney. These should not be permanently attached (for example, with screws) in case they must be rapidly removed in the event of a chimney fire. Review fire codes before installing flue covers. Dampers should be kept closed except in the heating season.
Roof Problems. Bats, particularly the Mexican free-tailed bat, often roost under Spanish or concrete tile roofing by entering the open ends at the lower-most row or where the tiles overlap (Fig. 15). Tight-fitting plugs are difficult to make due to the variation in opening sizes and thermal expansion and contraction. A solution was found by Constantine (1979) in which a layer of coarse fiberglass batting was laid under the tiles so that bats entering holes would contact the fiberglass and be repelled. A layer of knitted wire mesh would undoubtedly work well for this purpose (and would not hold moisture). Bats also may be excluded from the tiles if rain gutters are installed directly under the open ends. Gaps under corrugated and galvanized roofing may be closed with knitted wire mesh, self-expanding foam (avoid causing roofing to lift), or with fiberglass batting (may retain moisture).

Wall Problems. Fiberglass or rock wool insulation blown into wall spaces that are used by bats may be a deterrent, especially when it forms a physical barrier to passage. Such work must be done when bats are absent to avoid their entrapment.

Temporary Roosts. Bats will sometimes temporarily roost on porches and patios, in garages, and behind shutters, shingles, and roof gutters. Roosting behind shutters may also be long-term in duration. Actual control measures may not be necessary unless bat droppings become a problem or the risk of human contact is significant. Coarse fiberglass batting tacked to the surfaces where bats prefer to hang sometimes discourages them. A potentially useful intervention for the wall-ceiling interface is the application of a wide 45° molding strip to eliminate the 90° angle corner and force the bats to roost in a more exposed area.

Repellents

While many chemical aromatics and irritants have been proposed and tested for bat repellency, efficacy has been very limited thus far.
Naphthalene crystals and flakes are the only repellents registered by the US Environmental Protection Agency (EPA) for indoor bat control and are to be applied in attics or between walls. Sometimes the chemical may be placed in loose-mesh cloth bags and suspended from the rafters. About 2.5 pounds per 1,000 cubic feet (1.2 kg/30 m³) is recommended to chronically repel bats as the chemical vaporizes. Dosages of 5 pounds per 1,000 cubic feet (2.4 kg/30 m³) may dislodge bats as the chemical vaporizes. Ultrasonic devices have been tested in broad daylight. Bats will return, however, when the odor dissipates. The prolonged inhalation of naphthalene vapors may be hazardous to human health.

Illumination has been reported to be an effective repellent. Floodlights strung through an attic to illuminate all roosting sites may cause bats to leave. Large attics may require many 100-watt bulbs or 150-watt spotlights to be effective. Fluorescent bulbs may also be used. In some situations such lighting is difficult, costly, and may result in an electrical hazard. Where possible, the addition of windows to brighten an attic will help to reduce the desirability of the roost site and is not likely to introduce additional problems.

Air drafts have successfully repelled bats in areas where it is possible to open doors, windows, or create strong breezes by use of electric fans. Addition of wall and roof vents will enhance this effort, as well as lower roost temperature. These measures will increase the thermoregulatory burden on the bats, thus making the roost less desirable. In a similar fashion, colonies located in soffits, behind cornices, and other close-in areas can be discouraged by opening these areas to eliminate dark recesses. Discourage bats from roosting behind shutters by removing the shutters completely or by adding small blocks at the corners to space them a few inches away from the wall.

Ultrasonic devices have been tested under natural conditions, both indoors and outdoors, to repel little brown and big brown bats either in the roost or as they fly toward an entrance hole (Frantz, unpublished data). The results have not been promising. Numerous ultrasonic devices have been removed from clients’ homes because the bats remained in the roost after the devices were activated. Hurley and Fenton (1980) exposed little brown bats to ultrasound in seminatural roosts with virtually no effect. Largely because of this lack of known scientific efficacy for ultrasonic devices, the New York State Consumer Protection Board has cautioned against the use of such devices (NYSCPB 1988). Part of the concern is that such devices will provide consumers with a false sense of security and, thus, may prevent them from taking effective preventive actions.

Distress cries of bats recorded on tape and rebroadcast can be used to attract other bats to nets or traps, but they do not serve as an effective repellent. Little brown and big brown bats respond to their own distress cries but not to the cries of other species.

Contact repellents, such as sticky-type bird repellents and rodent glues, have been used successfully in situations where roost surfaces and bat accesses may be coated. Apply masking tape to the surface first if you desire to remove the repellent after treatment is finished. Replenish contact repellents occasionally, since dust accumulation causes them to lose their tackiness. Also, caution must be exercised so as to apply coatings that will be sticky, but will not entrap the bats.

**Toxicants (not recommended)**

No toxicants are registered for controlling bats. In 1987 the Centers for Disease Control, United States Department of Health and Human Services, voluntarily withdrew the last registration for DDT use against bats in the United States. Thus, DDT is no longer registered for any use in this country. Although federally registered for rodents, chlorophacinone (RoZol) tracking powder, an anticoagulant, is not registered for bats. Furthermore, it can no longer be registered by individual states for restricted use under Section 24(c) of the Federal Insecticide, Fungicide, and Rodenticide Act D-18 (FIFRA). Lipha Tech, Inc. (the manufacturer of RoZol) has voluntarily cancelled its registration for “RoZol Tracking Powder for Control of Nuisance Bats” — effective December 16, 1991 (Fed. Reg., 1991).

**Trapping**

Kunz and Kurta (1988) reviewed an extensive variety of efficient methods for trapping bats from buildings and other roosting sites or foraging areas. For purposes of wildlife damage control, however, exclusion is less complicated to carry out, less time-consuming, more effective, and requires no handling of bats.

**Other Methods**

**Sanitation and Cleanup.** Once bats have been excluded, repelled, or have departed at the end of the summer, measures must be completed to make reinestation less likely, and to eliminate odor and problematic bioaerosols. As a prelude to such work, it is sometimes useful to apply a pyrethrum-based, total-release aerosol insecticide to eliminate unwanted arthropods.

The safe handling and removal of bat guano has been discussed previously (see the histoplasmosis section in this chapter). In addition to the more bulky accumulations of excreta, there are often diffuse deposits of guano under/among insulation materials, caked urine and guano on roof beams, and splattered urine on windows. Such clean-up work during hot summer weather may be the least desirable activity of a management program, but it is necessary.

All caked, crystallized bat urine and droppings should be scraped and wire-brushed, as necessary, from all roof and attic beams. For this procedure, workers should take the same precautions as outlined for histoplasmosis-related work. Accumulated excreta and contaminated insulation should be sealed in plastic bags and removed for disposal. Remove all remaining droppings and debris with
a vacuum cleaner, preferably one that has a water filter to reduce the amount of dust that escapes from the cleaner’s exhaust.

Where possible, wash with soap and water all surfaces contaminated with urine and guano. Allow the surfaces to dry, then disinfect them by misting or swabbing on a solution of 1 part household bleach and 20 parts tap water. Ventilate the roost site to allow odors and moisture to escape. Installation of tight-fitting window screens, roof and/or wall ventilators in attics will enhance this process. Remember, sanitation and cleanup accompanies bat-proofing and exclusion measures, it does not replace them.

Artificial Roosts. For more than 60 years, artificial bat roosts have been used in Europe. Only recently have they gained some popularity in the United States. Though the results are variable, it appears that artificial roosts, if properly constructed and located, can attract bats that are displaced or excluded from a structure. The Missouri Department of Conservation described a successful “bat refuge” that was quickly occupied by a displaced colony of little brown bats (LaVal and LaVal 1980). Bat houses of a similar design have been successfully used in Minnesota, New York, and elsewhere (see Fig. 16).

Development of an efficient method to relocate bats into alternative roosts after they have been excluded from buildings could be an important intervention in comprehensive bat management. Frantz (1989) found it helpful to “seed” newly constructed bat houses with several bats, a procedure that later resulted in full-scale colonization without further human interventions. Alternative roosts should be located away from human high-use areas. Thus, people can enjoy the benefits of bats without sharing their dwellings with them and with little risk of direct contact with them.

Economics of Damage and Control

Virtually all bats are of some economic importance; those north of Mexico are beneficial because of their insectivorous diet which eliminates many insect pests of humans. The accumulated bat droppings, called guano, is rich in nitrogen and is a good organic fertilizer. At one time, bat guano was commercially mined in the Southwest; but its importance has declined due to reduced bat populations and the development of inorganic fertilizers. Bat guano is still considered a valuable fertilizer resource in some parts of the world (such as Thailand and Mexico).

No figures are available to determine the extent of damage caused by nuisance bats or the cost for their control. The problem is widespread in this and other countries.

Costs for remedial services are highly variable, depending on the nature of the problem and who will do the work. For example, to fabricate a few Frantz’ checkvalves on the “average” two-story house would probably require two workers about one-half day, mostly on stepladders, and less than $50 in materials. Much more time would be required to seal up all the other active and potential bat exit/entry holes. In addition, if a deteriorated roof, eaves, or other woodwork must be replaced, the costs can increase rapidly.

It is often difficult or expensive for the public to obtain the services of reliable, licensed pest control operators (PCOs). Many PCOs have limited knowledge of basic bat biology and are apprehensive to work with bats. They may want to avoid any liabilities should bat-human contact occur. Select a qualified professional service that concentrates on the exclusion of live bats from a structure rather than on use of lethal chemicals.

Acknowledgments

The authors wish to thank the many people who have allowed them and other bat researchers to work in and about their homes, and have, thus, contributed to this effort. We give special thanks to Roger W. Barbour and Wayne H. Davis for permission to reproduce figures from their excellent book, Bats of America (University Press of Kentucky). Charles V. Trimarchi is acknowledged for carefully reviewing this chapter and providing many useful comments. We thank Debra VonZwehl and Christine Borecki for processing the manuscript.

Figures 2 through 4 from Barbour and Davis (1979).

Figure 5 adapted from Harvey (1986).

Figure 6 adapted from Tuttle (1988), except Yuma myotis and Keen’s bat (from Barbour and Davis 1979).

Figure 7 adapted from Trimarchi and Frantz (1985).

Figure 8 by R. Suss.

Figures 12, 15, and 16 by S. C. Frantz.

Figures 9, 10, 11, and 14 from Greenhall (1982).

Figure 13 by S. C. Frantz.
For Additional Information


Editors
Scott E. Hygnstrom
Robert M. Timm
Gary E. Larson
Fig. 1. White-tailed deer, *Odocoileus virginianus*

Damage Prevention and Control Methods

**Exclusion**

Fences provide the most consistent control:
- 8-foot (1.4-m) woven wire fence, Tensar®, or wooden snow fence around small plots or haystacks.

Several configurations of electric fences are available:
- vertical five, seven, or nine-wire, slanted seven-wire, single strand, and others.

Individual tree protectors include:
- woven wire or plastic cylinders.

**Cultural Methods and Habitat Modification**

Plant trees and shrubs that are resistant or less susceptible to deer damage.

Harvest crops as early as possible to reduce vulnerability.

Lure crops may divert deer away from areas that are susceptible to damage.

Habitat modification generally is not recommended.

**Frightening**

Gas exploders, pyrotechnics, gunfire, or tethered dogs provide temporary relief.

**Repellents**

A wide variety of commercial formulations is available:
- area repellents—applied near plants to be protected, repel by smell;
- contact repellents—applied directly to plants to be protected, repel by taste;
- a few, such as Deer-Away®, possess characteristics of both groups.

**Toxicants**

None are registered.

**Live Capture**

Deer can be live-trapped or chemically immobilized for removal by professional biologists—useful only in special cases, such as city parks.

**Shooting**

Sport hunting can reduce deer populations and should be encouraged.

Some states may issue permits to shoot deer outside normal sport hunting seasons.
Introduction

Deer are probably the most widely distributed and best-recognized large mammals in North America. The white-tailed deer (*Odocoileus virginianus*) (Fig. 1) is found throughout much of North America. The mule deer (*O. hemionus*) is primarily a western species restricted to buttes, draws, and stream bottoms with sufficient forage. The black-tailed deer (*O.h. columbianus*) is a subspecies of the mule deer. Both white-tailed and mule deer are very important game animals. In 1974 about 2 million white-tailed deer were harvested by over 8 million hunters. The trend in both harvest and hunter numbers has been generally upward since then. The positive economic value of deer through license fees, meat, and hunter expenditures for equipment, food, and transportation can be measured in hundreds of millions of dollars. Hesselton and Hesselton (1982) estimated the value of each deer harvested in the United States to be $1,250. With the additional aesthetic value of deer to landowners and vacationers, importance of deer as a wildlife resource cannot be disputed.

Despite their economic and aesthetic values, deer also have a variety of negative economic impacts—they damage crops and personal property, and harbor diseases common to humans and livestock. Unlike moles, rats, and other species implicated in damage, deer cannot be casually eliminated when in conflict with humans. But neither can landowners be expected to bear the entire burden of support for this valuable public resource.

These factors often make deer damage control a difficult social and political problem as well as a biological and logistical one. Control methods are built around effective deer herd management. Thus the various state wildlife agencies are often indirectly or directly involved through subsidy of control techniques, direct damage compensation payments, or technical advice.

Scare devices, repellents, and shooting all have a place in deer damage control. Effective control for fields, orchards, and other large areas, however, usually depends on excluding the deer with one of several types of fences, discussed later in this chapter. Toxicants, fumigants, and in most cases, trapping, are not used in deer control.

The volume of literature on deer ecology and management exceeds that for any other wildlife species. The best single reference is Halls (1984). The following review is meant as a brief summary using the white-tailed deer as an example. The mule deer is very similar in all respects.

Identification

Deer are even-toed ungulates of the family *Cervidae*. Adult animals may weigh 50 to 400 pounds (23 to 180 kg) depending on species and location. Their general form is well-known. At birth, fawns are rust-colored with white spots. Their spotted coats are shed in 3 to 4 months and are replaced by a grayish-brown fall and winter coat. The summer coat of adult animals is reddish-brown. Underparts of the tail, belly, chin, and throat are white during all seasons. Antlers grow on males (bucks) from April to August. Antler development is nourished by a layer of soft, vascularized “velvet” on the antlers. The dried velvet layer is rubbed off and the antlers polished during the fall rut (breeding season). Antler size depends on nutrition, age, and genetics. Mule deer antlers are forked while the tines of a white-tailed deer’s antlers arise from a central beam. Both mule deer and white-tails have deciduous antlers that are shed in mid-winter. The rump and tail area and facial features also differ slightly between the species (Fig. 2). Both mule and white-tailed deer lack upper incisors.

Fig. 2. Comparison of antlers and facial characteristics, metatarsal glands, tails, and rump patches in three kinds of deer.
Range

The white-tailed deer is found in every state in the United States except perhaps Alaska and Utah. It occurs throughout the southern provinces of Canada, across the United States, and on into Central and South America (Fig. 3). Mule deer are common throughout western Canada, western United States, and into Mexico (Fig. 4). There are several subspecies of both deer.

Fig. 3. Range of the white-tailed deer in North America.

Fig. 4. Range of the mule deer (light) and black-tailed deer (dark) in North America.
Habitat

Deer are creatures of the forest edge rather than the dense, old-growth forest. They thrive in agricultural areas interspersed with woodlots and riparian habitat. They favor early successional stages which keep brush and sapling browse within reach. Dense cover is used for winter shelter and protection.

Food Habits

Browse (leaves, stems, and buds of woody plants) is generally available all year and is a staple food for deer. An extensive review of food habits can be found in Hesselton and Hesselton (1982) and in Mackie et al. (1982). Plant species vary considerably in quality and regional availability, so a list is not presented here. Forbs are eaten in spring and summer when available. Fruits and nuts (especially acorns) are seasonally very important. Grasses are relatively unimportant. Agricultural crops—corn, soybeans, small grains, alfalfa, vegetables, and fruit trees—are readily eaten when available. Local food habits studies are available in most states—consult your local wildlife agency.

Nutrient requirements and the amount of food consumed vary with age of the animal, season, and the reproductive cycle. Daily dry matter consumption averages 2% to 4% of live body weight. For adult bucks, daily consumption is greatest in spring and averages 4.4 to 6.4 pounds (2.0 to 2.9 kg) of air-dry food per day. Consumption is about half that during winter. For does, greatest daily food consumption occurs in early fall, just prior to the breeding season.

General Biology, Reproduction, and Behavior

Breeding occurs from October to January depending on latitude. Peak activity is in November. Does are in heat for 24 hours every 28 days for 2 to 3 consecutive cycles. One buck may inseminate several does. No pairing takes place. Most does breed during their second fall, although on good range up to 30% of the doe fawns (6 months old) will be bred. Gestation is about 202 days. The peak of fawn drop is in May or June. Most reproducing fawns give birth to a single fawn, but adult does typically bear twin fawns. Reproductive potential is very sensitive to nutrition. Fawns weigh 7 to 8 pounds (3.2 to 3.6 kg) at birth and increase in weight for 5 1/2 to 6 1/2 years. Adult size varies with latitude. In northern states, a mature buck may weigh 200 to 300 pounds (90 to 135 kg). A key deer buck (white-tailed deer subspecies) in Florida may weigh only 50 pounds (22.5 kg). Does average 25% to 40% less than bucks for all subspecies.

Deer are most active in early morning and evening. They have a home range of several hundred acres (ha), but this varies with season, sex, and habitat quality. In northern areas, deer gather ("yard") in dense cover for the winter. They may move long distances from summer range to a winter yard. Life expectancy is dependent on hunting pressure and regulations. Records show whitetails living 20 years, although 10 to 12 years is noteworthy in the wild.

Damage and Damage Identification

Deer damage a wide variety of row crops, forage crops, vegetables, fruit trees, nursery stock, and ornamentals, as well as stacked hay. In addition to the immediate loss of the crop being damaged, there is often residual damage in the form of future yield reduction of fruit trees or forage crops such as alfalfa. Ornamental trees or nursery stock may be permanently disfigured by deer browsing. Under high densities deer may severely impact native plant communities and impair regeneration of some forest tree species. Besides vegetative damage, deer/vehicle collisions pose a serious risk to motorists, and deer have been implicated in the distribution and transmission of Lyme disease.

Damage identification is not difficult. Because both mule deer and white-tailed deer lack upper incisors, deer often leave a jagged or torn surface on twigs or stems that they browse. Rabbits and rodents, however, leave a clean-cut surface. In addition, deer tracks are very distinctive (Fig. 5). The height of damage from the ground (up to 6 feet [1.8 m]) often rules out any mammal other than deer. Deer often are observed "in the act" of causing damage.

Legal Status

Deer are protected year-round in all states and provinces, with the exception of legal harvest during appropriate big-game hunting seasons. In cases of severe or persistent damage, some states may issue farmers special permits to shoot deer at times other than the legal hunting seasons. Regulations vary on the necessary permits and on
disposal of dead animals. The popularity of deer as game animals and the need to curb poaching have led to the development of severe penalties for illegal possession. No lethal deer control can be initiated before consulting your local state wildlife agency. By law, some states provide technical assistance or direct compensation for deer damage. This is discussed under the section on the economics of damage and control.

Damage Prevention and Control Methods

Exclusion

Where deer are abundant or crops are particularly valuable, fencing may be the only way to effectively minimize deer damage. Several fencing designs are available to meet specific needs. Temporary electric fences are simple inexpensive fences useful in protecting garden and field crops during snow-free periods. Deer are attracted to these fences by their appearance or smell, and are lured into contacting the fence with their noses. The resulting shock is a very strong stimulus and deer learn to avoid the fenced area. Permanent high-tensile electric fences provide year-round protection from deer and are best suited to high-value specialty or orchard crops. The electric shocking power and unique fence designs present both psychological and physical barriers to deer. Permanent woven-wire fences provide the ultimate deer barrier. They require little maintenance but are very expensive to build. Fencing in general is expensive. You should consider several points before constructing a fence, such as:

- History of the area — assemble information on past claims, field histories, deer numbers, and movements to help you decide on an abatement method.
- Deer pressure — this reflects both the number of deer and their level of dependence on agricultural crops. If deer pressure in your area is high, you probably need fences.
- Crop value — crops with high market values and perennial crops where damage affects future yields and growth often need the protection fencing can provide.
- Field size — in general, fencing is practical for areas of 40 acres (16 ha) or less. The cost per acre (ha) for fencing usually decreases, however, as the size of the area protected increases.
- Cost-benefit analysis — to determine the cost effectiveness of fencing and the type of fence to install, weigh the value of the crop to be protected against the acreage involved, costs of fence construction and maintenance, and the life expectancy of the fence.
- Rapidly changing fence technology — if you intend to build a fence yourself, supplement the following directions by consulting an expert, such as a fencing contractor. Detailed fencing manuals are also available from most fencing manufacturers and sales representatives.

Temporary Electric Fencing

Temporary electric fences provide inexpensive protection for many crops during periods without snow. They are easy to construct, do not require rigid corners, and materials are readily available. Install fences at the first sign of damage to prevent deer from establishing feeding patterns in your crops. Weekly inspection and maintenance are required. Different types of temporary electric fences are described below.

**Peanut Butter Fence.** The peanut butter fence is effective for small gardens, nurseries, and orchards (up to 3 to 4 acres [1.2 to 1.6 ha]) subject to moderate deer pressure. Deer are attracted by the peanut butter and encouraged to make nose-to-fence contact. After being shocked, deer learn to avoid fenced areas. Cost, excluding labor, is about $0.11 per linear foot ($0.30/m). This fence is not widely used.

To build a peanut butter fence (Fig. 6), follow the steps below.

1. Install wooden corner posts.
2. String one strand of 17-gauge (0.15-cm), smooth wire around the corners and apply light tension.
3. Set 4-foot (1.2-m) 3/8-inch (1-cm) round fiberglass rods along the wire at 45-foot (14-m) intervals.
4. Attach the wire to insulators on the rods 2 1/2 (0.75 m) feet above ground level and apply 50 pounds (22.5 kg) of tension.

![Fig. 6. The peanut butter fence with foil flags.](image)
(5) Attach 3 x 4-inch (7 x 10-cm) foil strips to the wire at 3-foot (1-m) intervals, using 1 x 2-inch (3 x 5-cm) strips of cloth adhesive tape.

(6) Apply a 1:1 mixture of peanut butter and vegetable oil to the adhesive tape strips and fold the foil over the tape.

(7) Connect the wire to the positive (+) post of a well-grounded fence charger.

(8) For fields larger than 1 acre (0.4 ha), it is more practical to apply the peanut butter mixture directly to the wire. You can make a simple applicator by mounting a free-spinning, 4-inch (10-cm) pulley on a shaft inside a plastic ice cream pail. Fill the pail with a peanut butter-vegetable oil mixture that has the consistency of very thick paint. Coat the entire wire with peanut butter by drawing the pulley along the wire. Apply peanut butter once a month. Attach foil flags to the fence near runways or areas of high deer pressure to make the fence more attractive.

Check the fence weekly for damage by deer and grounding by vegetation.

**Polytape Fence.** Various forms of polytape or polywire, such as Visible Grazing Systems® (VGS), Baygard®, and Turbo-tape® are very strong and portable. You can use these fences to protect up to 40 acres (16 ha) of vegetable and field crops under moderate deer pressure. Deer receive shocks through nose-to-fence contact and they learn to avoid fenced areas. Cost, excluding labor, is about $.11 per linear foot ($0.30/m).

To build a polytape fence (Fig. 7), follow the steps below.

1. Drive 5/8-inch (1.6-cm) round fiberglass posts 2 feet (0.6 m) into the ground at the corners.

2. String two strands of polytape (white or yellow are most visible) around the corners and apply light tension (one strand 2 1/2 feet (0.75 m) high can be used).

3. Use square knots or half-hitches to make splices or to secure the polytape to corner posts.

4. Set 4-foot (1.2-cm) 3/8-inch (1-cm) round fiberglass rods along the wires at 45-foot (14-m) intervals.

5. Attach the two strands of polytape to insulators on the rods at 1 and 3 feet (0.3 and 0.9 m) above ground level and apply 50 pounds (22.5 kg) of tension.

6. Connect the polytape to the positive (+) post of a well-grounded fence charger.

To maintain the fence, check it weekly for damage by deer and grounding by vegetation.

**Permanent High-Tensile Electric Fencing**

High-tensile fencing can provide year-round protection from deer damage. Many designs are available to meet specific needs. All require strict adherence to construction guidelines concerning rigid corner assemblies and fence configurations. Frequent inspection and maintenance are required. High-tensile fences are expected to last 20 to 30 years. Different types of high-tensile electric fences are described below.

**Offset or Double Fence.** This fence is mostly for gardens, truck farms, or nurseries up to about 40 acres (0.16 ha) that experience moderate deer pressure. Deer are repelled by the shock and the three-dimensional nature of the fence. You can add wires if deer pressure increases. Cost, excluding labor, is about $.35 per linear foot ($1/m).

To build an offset or double fence (Fig. 8), follow the steps below.

For the outside fence:

1. Install swing corner assemblies where necessary (see the section on fence construction—rigid brace assemblies [Fig. 14]).

2. String a 12 1/2-gauge (0.26-cm) high-tensile wire around the
outside of the swing corner assemblies and apply light tension.

(3) Set 5-foot (1.5-m) line posts along the wire at 40- to 60-foot (12- to 18-m) intervals.

(4) Attach the wire to insulators on the line posts, 15 inches (38 cm) above ground level and apply 150 to 250 pounds (68 to 113 kg) of tension.

(5) String a second wire at 43 inches (109 cm) and apply 150 to 250 pounds (68 to 113 kg) of tension.

For the inside fence:

(6) String a wire around the inside of the swing corner assemblies and apply light tension.

(7) Set 5-foot (1.5-m) line posts along the wire at 40- to 60-foot (12- to 18-m) intervals.

(8) Attach the wire to insulators on the line posts at 30 inches (76 cm) above ground level.

(9) Attach all wires to the positive (+) post of a well-grounded, low-impedance fence charger.

(10) Clear and maintain a 6- to 12-foot (1.8- to 3.6-m) open area outside the fence so deer can see it.

Maintenance includes weekly fence and voltage checks.

**Vertical Deer Fence.** Vertical fences are effective at protecting large truck gardens, orchards, and other fields from moderate to high deer pressures. Because of the prescribed wire spacing, deer either attempt to go through the fence and are effectively shocked or they are physically impeded by the barrier. Vertical fences use less ground space than three-dimensional fences, but are probably less effective at inhibiting deer from jumping over fences. There is a wide variety of fence materials, wire spacings, and specific designs you can use. We recommend that you employ a local fence contractor. Costs, excluding labor, range from $0.75 to $1.50 per linear foot ($2 to $4/m).

To build a 7-wire vertical deer fence (Fig. 9), follow the steps below.

(1) Install rigid corner assemblies where necessary (see the section on fence construction—rigid brace assemblies [Fig. 14]).

(2) String a 12 1/2-gauge (0.26-cm) high-tensile wire around the corner assemblies and apply light tension.

(3) Set 8-foot (2.4-m) line posts along the
the wire at 33-foot (10-m) intervals.

(4) Attach a wire to insulators at 8 inches (20 cm) above ground level and apply 150 to 250 pounds (68 to 113 kg) of tension.

(5) Attach the remaining wires to insulators at the spacing indicated in figure 9 and apply 150 to 250 pounds (68 to 113 kg) of tension.

(6) Connect the second, fourth, fifth, and seventh wires from the top, to the positive (+) post of a well-grounded, low-impedance fence charger.

(7) Connect the top, third, and sixth wires directly to ground. The top wire should be negative for lightning protection.

(8) Clear and maintain a 6- to 12-foot (1.8- to 3.6-m) open area outside the fence so deer can see it.

Maintenance includes weekly fence inspection and voltage checks.

**Slanted Seven-Wire Deer Fence.**

This fence is used where high deer pressures threaten moderate-to-large sized orchards, nurseries and other high-value crops. It presents a physical and psychological barrier to deer because of its electric shock and three-dimensional nature. Cost, excluding labor, is about $0.75 to $2 per linear foot ($2 to $5.50/m).

To build a slanted seven-wire deer fence (Fig. 10), follow the steps below.

1. Set rigid, swing corner assemblies where necessary, (see the section on fence construction—rigid brace assemblies [Fig. 14]).

2. String 12 1/2-gauge (0.26-cm) high-tensile wire around the corner assemblies and apply light tension.

3. Set angle braces along the wire at 90-foot (27-m) intervals.

4. Attach a wire at the 10-inch (25-cm) position and apply 150 pounds (68 kg) of tension.

5. Attach the remaining wires at 12-inch (30-cm) intervals and apply 150 pounds (68 kg) of tension.

6. Place fence battens at 30-foot (9-m) intervals.

7. Connect the top, third, fifth, and bottom wires to the positive (+) post of a well-grounded, low-impedance fence charger.

8. Connect the second, fourth, and sixth wires from the top directly to ground.

9. Clear and maintain a 6- to 12-foot (1.8- to 3.6-m) area outside the fence so deer can see it.

Maintenance includes weekly inspection and voltage checks.

**Permanent Woven-Wire Fencing**

Woven-wire fences are used for year-round protection of high-value crops subject to high deer pressures. These fences are expensive and difficult to construct, but easy to maintain. Before
high-tensile electric fencing, woven-wire fences were used most often to protect orchards or nurseries where the high crop value, perennial nature of damage, acreage, and 20-year life span of the fences justified the initial costs. Cost, excluding labor, is about $2 to $4 per linear foot ($5.50 to $11/m). The high cost has resulted in reduced use of woven-wire fences.

To build a deer-proof woven-wire fence (Fig. 11), follow the steps below.

1. Set rigid corner assemblies where necessary (see the section on Fence Construction—Rigid brace assemblies [Fig. 14]).

2. String a light wire between two corners and apply light tension.

3. Set 16-foot (4.9-m) posts along the wire at 40-foot (12-m) intervals, to a depth of 4 to 6 feet (1.2 to 1.8 m).

4. Roll out an 8-foot (2.4-m) roll of high-tensile woven wire along the line posts. Attach one end at ground level to a corner post with steel staples.

5. Apply 100 pounds (45 kg) of tension to the wire with a vehicle or fence strainers and attach the wire to line and corner posts with steel staples.

6. Repeat steps 4 and 5 as necessary around the perimeter of the fence.

7. Attach two strands of high-tensile smooth wire to the top of the fence to raise the height of the entire fence to 9 to 10 feet (2.7 to 3 m).

Minimal maintenance is required. Inspect for locations where deer can crawl under the fence.

**Fencing Tips**

**Materials.** Do not buy cheap materials to reduce costs. This will only reduce the effectiveness and life span of the fence. We recommend using:

1. Round fiberglass or treated wood posts.

2. High-quality galvanized wire and steel components. For high-tensile fences, use 11- to 14-gauge (0.31- to 0.21-cm) wire (minimum tensile strength of 200,000 pounds [90,000 kg] and a minimum breaking strength of 1,800 pounds [810 kg]), tension springs, and in-line tensioners.

3. Compression sleeves for splicing wires and making electrical connections.

4. Lightning arresters and diverters to protect chargers.

5. High-quality fence chargers. Chargers must be approved by Underwriters Laboratories (UL) or the Canadian Standards Association (CSA). We highly recommend 110-volt chargers. Six- and 12-volt chargers require battery recharging every 2 to 4 weeks. Use solar panels in remote areas to charge batteries continuously. For high-tensile fences, use high-voltage, low-impedance chargers only (3,000 to 5,000 volts and current pulse duration of at most 1/1,000 second).

6. Gates. There is no universal gate design because of the many different fence types. Gates should be electrified, well-insulated, and practical for the type of farming operation. Gates range from single strands of electrified wire with gate handles to electrified panel or tubular gates (Fig. 12).

**Fence Construction.** Fences must be properly constructed—do not deviate from fence construction guidelines.

1. Prepare fencelines before construction. It is easier and less expensive to install and maintain fences on clear, level runs. Minimize corners to increase strength and reduce costs.

2. Ensure that the electrical system is well grounded at the fence charger and every 1/2 mile (880 m) of fenceline. To ground high-tensile fences, drive four to six ground...
rods 5 to 6 feet (1.5 to 1.8 m) deep and 6 feet (1.8 m) apart. Connect the ground post of the fence charger and the negative (-) wires of the fence to the grounding system (Fig. 13).

(3) The wiring system in figure 13 illustrates a positive-negative fence. Such a design is especially useful with dry or frozen ground. A fence with all positive (hot) wires may be advantageous under general crop and soil moisture conditions. Consult with a fencing contractor or expert for the best choice for your needs.

(4) Install the grounding systems and fence charger before fence construction. Energize completed parts of the fence when you are not working on the fence to gain early protection.

(5) Rigid brace assemblies—corners, ends, and gates—make up the backbone of all high-tensile fence systems (Fig. 14). They must be entirely rigid, constructed of the best materials, and strictly conform to design guidelines. The single-span brace assembly is the basis of all high-tensile strainer assemblies, regardless of location in the fence or fence design. This basic design is then modified to create double-"H" braces, swing corners, and gate ends.

(6) Allow wires to slide freely through insulators on fence posts. Fence flexibility is necessary to endure frequent temperature changes, deer hits, and obstructions.

(7) Identify an electric fence with warning signs (Fig. 15) that are affixed at 300-foot (90-m) intervals or less.

Maintenance. Regular inspection and maintenance are necessary to ensure the effective operation and longevity of most fences.

(1) Control vegetation near fences by mowing or applying herbicides to avoid excessive fence grounding by weeds.

(2) On slopes or highly erodible soils, maintain a good sod cover.
Fig. 14. Rigid brace assemblies.

Fig. 15. Remember to attach warning signs to your electric fences.

beneath fences to avoid fenceline erosion.

(3) Always keep the fence charger on. Check the fence voltage weekly with a voltmeter. Maintain at least 3,000 volts at the furthest distance from the fence charger. Disconnect the lower wires if they are covered by snow.

(4) In late fall and early summer, adjust the fence tension (150 to 250 pounds [68 to 113 kg]) for high-tensile fences.

**Tree Protectors**

Use Vexar®, Tubex®, plastic tree wrap, or woven-wire cylinders to protect young trees from deer and rabbits. Four-foot (1.2-m) woven-wire cylinders can keep deer from rubbing tree trunks with their antlers.

**Haystack Protection**

Wooden panels have traditionally been used to exclude deer and elk from haystacks. Stockyards have also been protected by welded wire panels and woven wire. More recently haystacks have been protected by wrapping them with plastic Tensar® snow fence. The material comes in 8-foot (2.4-m) rolls and is relatively light and easy to use.

**Cultural Methods and Habitat Modification**

Damage to ornamental plants can be minimized by selecting landscape and garden plants that are less preferred by deer. In many cases, original landscape objectives can be met by planting species that have some resistance to
Table 1. Ornamental plants, listed by susceptibility to deer damage. 

<table>
<thead>
<tr>
<th>Botanical name</th>
<th>Common name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Berberis spp.</td>
<td>Barberry</td>
</tr>
<tr>
<td>Berberis vulgaris</td>
<td>Common Barberry</td>
</tr>
<tr>
<td>Betula papyrifera</td>
<td>Paper Birch</td>
</tr>
<tr>
<td>Buxus sempervirens</td>
<td>Common Boxwood</td>
</tr>
<tr>
<td>Elaeagnus angustifolia</td>
<td>Russian Olive</td>
</tr>
<tr>
<td>Ilex opaca</td>
<td>American Holly</td>
</tr>
<tr>
<td>Leucothoe fontaneriana</td>
<td>Drooping Leucothoe</td>
</tr>
<tr>
<td>Picea pingens</td>
<td>Colorado Blue Spruce</td>
</tr>
<tr>
<td>Pieris japonica</td>
<td>Japanese Pieris</td>
</tr>
</tbody>
</table>

Plants Rarely Damaged:

<table>
<thead>
<tr>
<th>Botanical name</th>
<th>Common name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Berberis spp.</td>
<td>Barberry</td>
</tr>
<tr>
<td>Berberis vulgaris</td>
<td>Common Barberry</td>
</tr>
<tr>
<td>Betula papyrifera</td>
<td>Paper Birch</td>
</tr>
<tr>
<td>Buxus sempervirens</td>
<td>Common Boxwood</td>
</tr>
<tr>
<td>Elaeagnus angustifolia</td>
<td>Russian Olive</td>
</tr>
<tr>
<td>Ilex opaca</td>
<td>American Holly</td>
</tr>
<tr>
<td>Leucothoe fontaneriana</td>
<td>Drooping Leucothoe</td>
</tr>
<tr>
<td>Picea pingens</td>
<td>Colorado Blue Spruce</td>
</tr>
<tr>
<td>Pieris japonica</td>
<td>Japanese Pieris</td>
</tr>
</tbody>
</table>

Plants Occasionally Severely Damaged:

<table>
<thead>
<tr>
<th>Botanical name</th>
<th>Common name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abies balsamea</td>
<td>Balsam Fir</td>
</tr>
<tr>
<td>Abies fraseri</td>
<td>Fraser Fir</td>
</tr>
<tr>
<td>Acer platanoides</td>
<td>Paperbark Maple</td>
</tr>
<tr>
<td>Cercis canadensis</td>
<td>Eastern Redbud</td>
</tr>
<tr>
<td>Chamaecyparis thyoides</td>
<td>Atlantic White Cedar</td>
</tr>
<tr>
<td>Clematis spp.</td>
<td>Clematis</td>
</tr>
<tr>
<td>Cornus mas</td>
<td>Cornelian Dogwood</td>
</tr>
<tr>
<td>Euonymus alatus</td>
<td>Winged Euonymus</td>
</tr>
<tr>
<td>Euonymus fortunei</td>
<td>Wintercreeper</td>
</tr>
<tr>
<td>Hedera helix</td>
<td>English Ivy</td>
</tr>
<tr>
<td>Malus spp.</td>
<td>Apples</td>
</tr>
<tr>
<td>Prunus spp.</td>
<td>Cherries</td>
</tr>
<tr>
<td>Picea abies</td>
<td>Plums</td>
</tr>
<tr>
<td>Rhododendron spp.</td>
<td>Rhododendrons</td>
</tr>
<tr>
<td>Rhododendron catawbiense</td>
<td>Evergreen Azaleas</td>
</tr>
<tr>
<td>Rosa (x) hybrid</td>
<td>Catawba Rhododendron</td>
</tr>
<tr>
<td>Sorbus aucuparia</td>
<td>Pinksterbloom Azalea</td>
</tr>
<tr>
<td>Taxus spp.</td>
<td>European Mountain Ash</td>
</tr>
<tr>
<td>Taxus baccata</td>
<td>Yews</td>
</tr>
<tr>
<td>Taxus brevifolia</td>
<td>English Yew</td>
</tr>
<tr>
<td>Taxus cuspidata</td>
<td>Western Yew</td>
</tr>
<tr>
<td>Taxus (x) media</td>
<td>Japanese Yew</td>
</tr>
<tr>
<td>Thuja occidentalis</td>
<td>English / Japanese Hybrid Yew</td>
</tr>
<tr>
<td>Tsuga heterophylla</td>
<td>American Arborvitae</td>
</tr>
</tbody>
</table>

Plants Occasionally Severely Damaged (cont.):

<table>
<thead>
<tr>
<th>Botanical name</th>
<th>Common name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acer rubrum</td>
<td>Red Maple</td>
</tr>
<tr>
<td>Acer saccharum</td>
<td>Sugar Maple</td>
</tr>
<tr>
<td>Aesculus hippocastanum</td>
<td>Common Horsechestnut</td>
</tr>
<tr>
<td>Amelanchier arborea</td>
<td>Downy Serviceberry</td>
</tr>
<tr>
<td>Amelanchier laevis</td>
<td>Allegheny Serviceberry</td>
</tr>
<tr>
<td>Campsis radicans</td>
<td>Trumpet Creeper</td>
</tr>
<tr>
<td>Chaenomeles speciosa</td>
<td>Japanese Flowering Quince</td>
</tr>
<tr>
<td>Cornus racemosa</td>
<td>Paniced Dogwood</td>
</tr>
<tr>
<td>Cotinus coggyria</td>
<td>Smokebush</td>
</tr>
<tr>
<td>Cotoneaster spp.</td>
<td>Coteonester</td>
</tr>
<tr>
<td>Cotoneaster apiculatus</td>
<td>Cranberry Cotoneaster</td>
</tr>
<tr>
<td>Cotoneaster horizontalis</td>
<td>Rockspray Cotoneaster</td>
</tr>
<tr>
<td>Cryptomeria japonica</td>
<td>Japanese Cedar</td>
</tr>
<tr>
<td>Forsythia (x) intermedia</td>
<td>Border Forsythia</td>
</tr>
<tr>
<td>Hamamelis virginiana</td>
<td>Common Witch Hazel</td>
</tr>
<tr>
<td>Hibiscus syriacus</td>
<td>Rose of Sharon</td>
</tr>
<tr>
<td>Hydrangea arborescens</td>
<td>Smooth Hydrangea</td>
</tr>
<tr>
<td>Hydrangea anomala petiolaris</td>
<td>Climbing Hydrangea</td>
</tr>
<tr>
<td>Hydrangea paniculata</td>
<td>Panicle Hydrangea</td>
</tr>
</tbody>
</table>

Plants Seldom Severely Damaged:

<table>
<thead>
<tr>
<th>Botanical name</th>
<th>Common name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Betula pendula</td>
<td>European White Birch</td>
</tr>
<tr>
<td>Calastrus scandens</td>
<td>American Bittersweet</td>
</tr>
<tr>
<td>Coriopsis sericea</td>
<td>Red Osier Dogwood</td>
</tr>
<tr>
<td>Cornus florida</td>
<td>Flowering Dogwood</td>
</tr>
<tr>
<td>Cornus kousa</td>
<td>Kousa Dogwood</td>
</tr>
<tr>
<td>Crape myrtle</td>
<td>English Hawthorn</td>
</tr>
<tr>
<td>Enkianthus campanulatus</td>
<td>Redvein Enkianthus</td>
</tr>
<tr>
<td>Fagus Sylvatica</td>
<td>European Beech</td>
</tr>
<tr>
<td>Forsythia spp.</td>
<td>Forsythia</td>
</tr>
<tr>
<td>Gleditsia triacanthos</td>
<td>Honey Locust</td>
</tr>
<tr>
<td>Ilex cornuta</td>
<td>Chinese Holly</td>
</tr>
<tr>
<td>Ilex glabra</td>
<td>Inkberry</td>
</tr>
<tr>
<td>Juniperus chinensis</td>
<td>Chinese Junipers (green)</td>
</tr>
<tr>
<td>Juniperus chinensis</td>
<td>Chinese Junipers (blue)</td>
</tr>
<tr>
<td>Kalmia latifolia</td>
<td>Mountain Laurel</td>
</tr>
<tr>
<td>Kolkwitzia amabilis</td>
<td>Beautybush</td>
</tr>
<tr>
<td>Picea abies</td>
<td>Norwegian Spruce</td>
</tr>
<tr>
<td>Picea glauca</td>
<td>White Spruce</td>
</tr>
<tr>
<td>Pinus nigra</td>
<td>Austrian Pine</td>
</tr>
<tr>
<td>Pinus rigida</td>
<td>Pitch Pine</td>
</tr>
<tr>
<td>Pinus mugho</td>
<td>Mugo Pine</td>
</tr>
<tr>
<td>Pinus resinosa</td>
<td>Red Pine</td>
</tr>
<tr>
<td>Pinus sylvestris</td>
<td>Scots Pine</td>
</tr>
<tr>
<td>Prunus serrulata</td>
<td>Japanese Flowering Cherry</td>
</tr>
<tr>
<td>Salix matsudana tortuosa</td>
<td>Corkscrew Willow</td>
</tr>
<tr>
<td>Sassafras albidum</td>
<td>Common Sassafras</td>
</tr>
<tr>
<td>Spiraea spp.</td>
<td>Common Lilac</td>
</tr>
<tr>
<td>Spiraea cantoniensis</td>
<td>Chinese Purple Spiraea</td>
</tr>
<tr>
<td>Viburnum plicatum tomentosum</td>
<td>Leatherleaf Viburnum</td>
</tr>
<tr>
<td>Viburnum prunifolium</td>
<td>Doublefile Viburnum</td>
</tr>
<tr>
<td>Viburnum carlesii</td>
<td>Korean Spirea Viburnum</td>
</tr>
<tr>
<td>Viburnum opulus</td>
<td>Oldfashioned Weigela</td>
</tr>
<tr>
<td>Viburnum x bodnantense</td>
<td>Deutzia Viburnum</td>
</tr>
</tbody>
</table>

Plants Frequently Severely Damaged:

<table>
<thead>
<tr>
<th>Botanical name</th>
<th>Common name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abies balsamea</td>
<td>Balsam Fir</td>
</tr>
<tr>
<td>Abies fraseri</td>
<td>Fraser Fir</td>
</tr>
<tr>
<td>Acer platanoides</td>
<td>Paperbark Maple</td>
</tr>
<tr>
<td>Cercis canadensis</td>
<td>Eastern Redbud</td>
</tr>
<tr>
<td>Chamaecyparis thyoides</td>
<td>Atlantic White Cedar</td>
</tr>
<tr>
<td>Clematis spp.</td>
<td>Clematis</td>
</tr>
<tr>
<td>Cornus mas</td>
<td>Cornelian Dogwood</td>
</tr>
<tr>
<td>Euonymus alatus</td>
<td>Winged Euonymus</td>
</tr>
<tr>
<td>Euonymus fortunei</td>
<td>Wintercreeper</td>
</tr>
<tr>
<td>Hedera helix</td>
<td>English Ivy</td>
</tr>
<tr>
<td>Malus spp.</td>
<td>Apples</td>
</tr>
<tr>
<td>Prunus spp.</td>
<td>Cherries</td>
</tr>
<tr>
<td>Picea abies</td>
<td>Plums</td>
</tr>
<tr>
<td>Rhododendron spp.</td>
<td>Rhododendrons</td>
</tr>
<tr>
<td>Rhododendron catawbiense</td>
<td>Evergreen Azaleas</td>
</tr>
<tr>
<td>Rosa (x) hybrid</td>
<td>Catawba Rhododendron</td>
</tr>
<tr>
<td>Sorbus aucuparia</td>
<td>Pinksterbloom Azalea</td>
</tr>
<tr>
<td>Taxus spp.</td>
<td>European Mountain Ash</td>
</tr>
<tr>
<td>Taxus baccata</td>
<td>Yews</td>
</tr>
<tr>
<td>Taxus brevifolia</td>
<td>English Yew</td>
</tr>
<tr>
<td>Taxus cuspidata</td>
<td>Western Yew</td>
</tr>
<tr>
<td>Taxus (x) meda</td>
<td>Japanese Yew</td>
</tr>
<tr>
<td>Thuja occidentalis</td>
<td>English / Japanese Hybrid Yew</td>
</tr>
<tr>
<td>Tsuga heterophylla</td>
<td>American Arborvitae</td>
</tr>
</tbody>
</table>

deer damage. Table 1 provides a list of plants, ranked by susceptibility to deer damage. This list, developed by researchers at Cornell University, is applicable for most eastern and northern states. A similar list with a western emphasis was produced by Cummings et al. (1980).

Harvest crops as early as possible to reduce the period of vulnerability to deer. Plant susceptible crops as far from wooded cover as possible to reduce the potential for severe damage. Habitat modification is not recommended. Destruction of wooded or brushy cover in hopes of reducing deer use would destroy valuable habitat for other wildlife. Also, since deer over a large area it is unlikely that all available deer cover would be on a farmer’s or rancher’s land.

Lure crops have been planted to attract deer away from highways and crop fields where deer traditionally caused damage. Their effectiveness has been variable and concern has been raised that an artificial food source may eventually increase deer densities and resultant problems. Specific recommendations are not yet available regarding plant selection, timing, and proximity of lure crops.

Contraception
Promising research on the use of chemosterilants and immunocontraception to reduce or eliminate reproduction is underway. Specificity, efficacy, and delivery of contraceptive agents, however, continue to be problems. The use of contraception for herd control will be best suited to urban parks, refuges, and other discrete areas. It is unlikely that contraception can or will be applied in rural/agricultural landscapes.

Frightening
One of the keys to success with frightening devices and repellents is to take action at the first sign of a problem. It is difficult to break the movements or behavioral patterns of deer once they have been established. Also, use frightening devices and repellents at those times when crops are most susceptible to damage, for example, the silking to tasseling stages for field corn or the blossom stage for soybeans.

Gas exploders set to detonate at regular intervals are the most commonly used frightening devices for deer. They can be purchased for $200 to $500 from several commercial sources (see Supplies and Materials). The devices are sometimes available on loan from wildlife refuges or agencies as they are frequently used to control waterfowl damage. To maximize the effectiveness of exploders, move them every few days and stagger the firing sequence. Otherwise, the deer quickly become accustomed to the regular pattern. The noise level can be increased by raising exploders off the ground. Motion-activated firing mechanisms are now being explored to increase the effectiveness of exploders. Success depends on many factors and can range from good to poor. A dog on a long run or restricted by an electronic invisible fence system can keep deer out of a limited area, but care and feeding of the dog can be time-consuming. Free-running dogs are not advisable and may be illegal.

Shell crackers, fireworks, and gunfire can provide quick but temporary relief from deer damage. Equip mobile units with pyrotechnics, spotlights, and two-way radios. Patrol farm perimeters and field roads at dusk and throughout the night during times of the year when crops are most susceptible to damage. Such tactics cannot be relied on for an entire growing season.

Repellents
Repellents are best suited for use in orchards, gardens, and on ornamental plants. High cost, limitations on use, and variable effectiveness make most repellents impractical on row crops, pastures, or other large areas. Success with repellents is measured in the reduction, not total elimination, of damage.

Repellents are described by mode of actions as “contact” or “area.” Contact repellents, which are applied directly to the plants, repel by taste. They are most effective when applied to trees and shrubs during the dormant period. New growth that appears after treatment is unprotected. Contact repellents may reduce the palatability of forage crops and should not be used on plant parts destined for human consumption. Hinder® is an exception in that it can be applied directly on edible crops.

Area repellents are applied near the plants to be protected and repel deer by odor alone. They are usually less effective than contact repellents but can be used in perimeter applications and some situations where contact repellents cannot.

During the winter or dormant season, apply contact repellents on a dry day when temperatures are above freezing. Treat young trees completely. It will be more economical to treat only the terminal growth of older trees. Be sure to treat to a height of 6 feet (1.8 m) above expected maximum snow depth. During the growing season, apply contact repellents at about half the concentration recommended for winter use.

The effectiveness of repellents will depend on several factors. Rainfall will dissipate some repellents, so reaplication may be necessary after a rain. Some repellents do not weather well even in the absence of rainfall. Deer’s hunger and the availability of other more palatable food will have a great effect on success. In times of food stress, deer are likely to ignore either taste or odor repellents. When using a commercial preparation, follow the manufacturer’s instructions. Don’t overlook new preparations or imaginative ways to use old ones. The following discussion of common repellents is incomplete and provided only as a survey of the wide range of repellent formulations available. The repellents are grouped by active ingredient. Trade names and sample labels for some products are provided in the Supplies and Materials section.

Deer-Away® Big Game Repellent (37% putrescent whole egg solids). This contact (odor/taste) repellent has been used extensively in western conifer plantations and reported in field
studiesto be 85% to 100% effective. It is registered for use on fruit trees prior to flowering, as well as ornamental and Christmas trees. Apply it to all susceptible new growth and leaders. Applications weather well and are effective for 2 to 6 months. One gallon (3.8 l) of liquid or 1 pound (0.45 kg) of powder costs about $32 and covers 400, 3-inch (7.6-cm) saplings or 75, 4-foot (1.2-m) evergreens.

Hinder® (15% ammonium soaps of higher fatty acids). This area repellent is one of the few registered for use on edible crops. You can apply it directly to vegetable and field crops, forages, ornamentals, and fruit trees. Its effectiveness is usually limited to 2 to 4 weeks but varies because of weather and application technique. Replication may be necessary after heavy rains. For small fields and orchards, you can treat the entire area. For larger areas, apply an 8- to 15-foot (2.4- to 4.6-m) band around the perimeter of the field. Apply at temperatures above 32°F (0°C). Four gallons (15.2 l) of liquid cost about $80, and when mixed with 100 gallons (380 l) of water will cover 1 acre (0.4 ha). Hinder is compatible for use with most pesticides.

Thiram (7% to 42% tetrathiomethylthiuram disulfide). Thiram, a fungicide that acts as a contact (taste) deer repellent, is sold under several trade names—Bonide Rabbit-Deer Repellent®, Nott’s Chew-Not, and Gustafson 42-S®, among others. It is most often used on dormant trees and shrubs. A liquid formulation is sprayed or painted on individual trees. Although Thiram itself does not weather well, adhesives such as Vapor Gard® can be added to increase its resistance to weathering. Thiram-based repellents also protect trees against rabbit and mouse damage. Two gallons (7.6 l) of 42% Thiram cost about $50 and when mixed with 100 gallons (380 l) of water will cover 1 acre (0.4 ha). Cost varies with the concentration of Thiram in the product.

Miller’s Hot Sauce® Animal Repellent (2.5% capsaicin). This contact (taste) repellent is registered for use on ornamentals, Christmas trees, and fruit trees. Apply the repellent with a backpack or trigger sprayer to all susceptible new growth, such as leaders and young leaves. Do not apply to fruit-bearing plants after fruit set. Vegetable crops also can be protected if sprayed prior to the development of edible parts. Weatherability can be improved by adding an anti-transpirant such as Wilt-Pruf® or Vapor Gard®. Hot Sauce and Vapor Gard® cost about $80 and $30 per gallon (3.8 l) respectively. Eight ounces (240 ml) of Hot Sauce and two quarts (1.9 l) of anti-transpirant mixed with 100 gallons (380 l) of water will cover 1 acre (0.4 ha).

Tankage (putrefied meat scraps). Tankage is a slaughterhouse by-product traditionally used as a deer repellent in orchards. It repels deer by smell, as will be readily apparent. To prepare containers for tankage, remove the tops from aluminum beverage cans, puncture the sides in the middle of the cans to allow for drainage and attach the cans to the ends of 4-foot (1.2 m) stakes. Drive the stakes into the ground, 1 foot (0.3 m) from every tree you want to protect or at 6-foot (1.8-m) intervals around the perimeter of a block. Place 1 cup (225 g) of tankage in each can. You can use mesh or cloth bags instead of cans. You may have to replace the containers periodically because fox or other animals pull them down occasionally. Tankage is available by bulk ($335 per ton [$302/mt]) or bag ($20 per 50 pounds [$302/mt]). When prepared for hanging on stakes, it costs about $0.20 per 1 ounce (28 g) bag and 300 bags will cover 2 acres (0.8 ha).

Ro-pel® (benzyldiethyl [(2,6 xylylcarbamoyl) methyl] ammonium saccharide (0.065%), thymol (0.035%). Ro-pel® is reported to repel deer with its extremely bitter taste. Apply Ro-pel® once each year to new growth. It is not recommended for use on edible crops. Spray at full strength on nursery and Christmas trees, ornamentals, and flowers. One gallon (3.8 l) costs $50 and covers about 1 acre (0.4 ha) of 8- to 10-foot (2.4- to 3.0-m) trees.

Hair Bags (human hair). Human hair is an odor (area) repellent that costs very little but has not consistently repelled deer. Place two handfuls of hair in fine-mesh bags (onion bags, nylon stockings). Where severe damage occurs, hang hair bags on the outer branches of individual trees with no more than 3 feet (0.9 m) between individual bags. For larger areas, hang several bags, 3 feet (0.9 m) apart, from a fence or cord around the perimeter of the area to be protected. Attach the bags early in spring and replace them monthly through the growing season. You can get hair at local barber shops or salons.

Bar Soap. Recent studies and numerous testimonials have shown that ordinary bars of soap applied in the same manner as hair bags can reduce deer damage. Drill a hole in each bar and suspend it with a twist tie or soft cord. Each bar appears to protect a radius of about 1 yard (1 m). Any inexpensive brand of bar soap will work. Ready-to-use bars cost about $0.20 each.

Toxicants
No toxicants are registered for deer control. Poisoning of deer with any product for any reason is illegal and unlikely to be tolerated by the public.

Herd Reduction
Overall reduction in a state’s deer population might reduce deer damage, but public opinion generally does not favor this approach. Damage may result from a few problem deer or at locations close to a winter deer yard or other exceptional habitat. Thus, a local reduction in deer population may be appropriate.

Live Capture
In special cases, such as city parks, refuges, or suburban neighborhoods, it may be necessary or desirable to capture deer alive and move them to other areas. Deer can be captured safely with rocket nets, drop-door box traps, or tranquilizer guns, but these techniques are expensive, time-consuming, and require the expertise
of professional wildlife biologists. Live capture and relocation is seldom a practical alternative unless delicate public relations problems mandate live removal as the only choice. During 1982, 15 deer were removed from a Milwaukee, Wisconsin nature area using chemical immobilization. Total cost was about $100 per deer but other more recent removal operations have been more expensive, up to $400 per deer or more. In addition to high costs, the survival of relocated deer is usually low. Live removal is seldom justified.

Shooting

Effective use of the legal deer season is probably the best way to control deer populations. By permitting hunting, landowners provide public access to a public resource while at the same time reducing deer damage problems. Because of the daily and seasonal movements of deer, only rarely does a single landowner control all the land a deer uses. As a result, neighboring landowners should cooperate. Landowners, the state wildlife agency, and local hunters should reach a consensus about a desirable population level for an area before deer are removed.

Mechanisms for managing deer population levels in a specific area already exist in most states. Either-sex seasons, increased bag limits, antlerless-only permits, special depredation seasons, and a variety of other management techniques have been used successfully to reduce deer numbers below levels achieved by traditional “bucks only” regulations.

Shooting permits issued by some states allow for removal of problem deer where they are causing damage during nonhunting season periods. Use of bait, spotlights, and rifles may increase success but techniques must be consistent with the specifications of the permits. In areas where shooting normally is prohibited, such as parks and densely populated areas, a skilled shooter under permit is probably preferable to costly attempts at live removal.

**Economics of Damage and Control**

A national survey conducted by USDA's National Agricultural Statistics Service in 1992 identified deer damage as the most widespread form of wildlife damage. Forty percent of the farmers reporting had experienced deer damage. No estimate exists of nationwide annual crop losses to deer, but damage estimates have been made for some states. In Wisconsin, a 1984 survey of farmers suggested minimum statewide deer damage of $36.7 million annually. A similar study in Pennsylvania estimated the annual crop loss at $16 to $30 million. The situation is similar in most agricultural states with moderate to high deer densities. Estimates by Hesselton and Hesselton (1982) suggest that the cost of deer/vehicle collisions may exceed $100 million each year in the United States and Canada. In fact, the cost of deer/vehicle collisions was estimated at $100 million in Wisconsin alone in 1990.

Deer also damage nurseries, landscape plantings, and timber regeneration. However, as established earlier, deer are a valuable public resource. Cost estimates for control techniques were presented with the appropriate techniques. A cost/benefit analysis is always advisable before initiating a control program.

Two additional economic aspects are worth consideration. One involves farmer tolerance for deer damage. Two summaries of social science research related to deer damage (Pomerantz et al. 1986, and Siemer and Decker 1991) demonstrated that a majority of farmers were willing to tolerate several hundred dollars in deer damage in exchange for the various benefits of having deer on their land. Thus “total damage” figures are misleading because only a small percentage of the farmers statewide or nationwide are suffering sufficient damage to warrant control or compensation.

The second economic consideration involves state-funded programs of subsidies for damage control materials or direct compensation for crop losses. Such programs can be very costly but are probably necessary where large deer herds are maintained in agricultural landscapes. As an example, the Wisconsin Wildlife Damage Program expended $2.25 million in 1992 for abatement materials, claims, and administration. The program is a collaborative effort of the Wisconsin Department of Natural Resources, USDA-APHIS-ADC, and Wisconsin counties and is very effective. Individual states vary greatly, however, in their degree of financial or technical assistance. Consult your state wildlife agency for information on compensation or cost-sharing programs. Also, many states have local publications on deer and deer damage—Pennsylvania, Wisconsin, Minnesota, Michigan, and New York, for example. Consult your local Extension office or state wildlife agency.
Acknowledgments

Figures 1 and 5 from Schwartz and Schwartz (1981).

Figure 2 by Charles W. Schwartz, published in Wallmo (1978), copyrighted by the Wildlife Management Institute and adapted by Emily Oseas Routman.

Figures 3 and 4 adapted from Burt and Grossenheider (1976) by Jill Sack Johnson.


For Additional Information


Editors

Scott E. Hygnstrom
Robert M. Timm
Gary E. Larson
Damage Prevention and Control Methods

Exclusion

Large wooden panels around haystacks are effective but expensive. Wrapping haystacks with plastic sheeting or netting is less expensive but effective for only 1 to 2 years. Tensar snow fence material is inexpensive and effective for many years.

Woven-wire fencing is highly effective, but expensive. Electric fencing is less expensive and almost as effective as woven wire.

Welded-wire cages up to 6 feet (1.8 m) tall effectively prevent elk damage to fruit and ornamental trees.

Vexar® and Tubex® plastic cylinders and paper budcaps effectively prevent elk damage to conifer and hardwood seedlings.

Cultural Methods

Alternative forage plants provide protection under limited conditions.

Planting larger trees, especially conifers, is highly successful.

Alternating grazing by cattle and elk provides increased amounts of nutritious forage for both on the same pasture.

Harvesting timber in large blocks (100 to 200 acres [40 to 80 ha]) promotes increased forage production and overwhelms elk with more forage than they can eat, increasing potential for adequate seedling density.

Frightening

Hazing with aircraft provides short-term and expensive control of damage to range and forage crops.

Propane exploders provide temporary (2 to 4 weeks) relief from elk damage.

Repellents

Moderately effective for short periods (2 to 4 weeks). They usually require multiple applications.

Toxicants

None are registered.

Trapping

Corral-type traps are cumbersome, expensive to erect, and of limited effectiveness.

Shooting

Special hunts designed to reduce local elk numbers are of limited effectiveness.

Selective harvest of individual offending elk may provide relief from localized damage.

Other Methods

Some western states compensate landowners for damage by elk to agricultural crops.
Identification

The elk is a large, powerful animal with an adult weight averaging over 400 pounds (180 kg) (Fig. 1). Pelage (hair coat) is light to dark reddish brown on the body, a darker brown on the neck and legs, and creamy on the large rump patch. Males bear large, impressive antlers with six or more tines branching from two heavy central beams.

Range

The Rocky Mountain elk (*Cervus elaphus nelsoni*) is found in the Rocky Mountain states and in scattered locations in the Midwest and East (Fig. 2). The current distribution of the Roosevelt elk (*C. e. roosevelti*) is the inland coastal areas of northern California, Oregon, Washington, Vancouver Island, British Columbia, and Afognak Island, Alaska. The Tule elk (*C. e. nannodes*) is found only in California and the Manitoban elk (*C. e. manitobensis*) is found in Manitoba and Saskatchewan.

Habitat

Although elk once roamed freely into lower elevation grasslands, they are now found primarily close to heavily forested areas that are dotted with natural or human-made (clear-cut) openings. Typically, elk use the openings to forage for food. Elk seek the shelter of dense stands of conifer and deciduous trees for protection from temperature extremes, predation, and harassment by humans. Elk usually spend their summers at higher, cooler elevations. In fall, they migrate along traditional corridors (2 to 80 miles [3 to 133 km]) long to lower elevations to escape weather extremes and snow depths that prohibit foraging in winter. Some herds are not migratory, spending the entire year within fairly well-defined and restricted areas.

Food Habits

Elk graze on grasses and forbs, and browse on shrubs, tree seedlings, and saplings. Diet is variable, depending on the availability and nutritive con-
Damage

Elk commonly impact agricultural resources by competing with domestic livestock for pasture and damaging cereal and hay crops, ornamental plants, orchards, and livestock fences. Elk also damage forest resources by feeding on seedlings and saplings of coniferous and deciduous trees. During winter, elk concentrate in areas where food is available, including pastures, winter wheat fields, and young conifer plantations. A survey conducted in 1989 indicated that elk caused damage to crops in seven states, mostly to haystacks and pastures. Elk damage appears to be a local problem that usually is dealt with locally.

Elk damage problems are increasing in property developed in traditional elk wintering ranges. This problem can be avoided by zoning regulations that prohibit development in such areas.

Because the elk is a highly desired game animal, management efforts in the last few decades have concentrated on increasing the size of local elk herds. As elk numbers have gradually increased in many parts of their range, the incidence and intensity of damage to agriculture and forestry have also increased.

Damage Identification

Plants browsed by elk have a characteristic appearance. Vegetation is grasped between the lower incisors and the upper palate and ripped or torn, resulting in splintered and fragmented plant parts (Fig. 3). In contrast, rabbits and large rodents clip vegetation off at a sharp 45° angle (Fig. 4). Elk damage to conifer seedlings may appear as a thorough stripping of bark from the upper half of the growing tip or “lateral” (Fig. 5). This damage generally occurs weeks after planting, usually in early to midspring. Meadow mice gnaw or “girdle” rather than clip as larger rodents and rabbits do, or browse as elk and deer do. The appearance of damage to browsed plants is similar for elk, deer, and cattle, but their tracks and scats (droppings) are easily distinguished (Fig. 6).

Elk tend to roam over greater expanses of habitat than deer, so the occurrence of damage by elk is more widespread and sporadic than damage by deer. Also, because elk move in groups instead of singly, the nature of their destruction to crops and pastures includes trampling, much like that of domestic livestock.

Damage by elk is often seasonal. Damage to hay and grain crops generally occurs in spring when these crops are the first succulent vegetation to emerge, and native forages are in short
Elk are completely protected in most areas with small populations. Elk are protected and classified as a game animal in states and provinces where they are sufficiently abundant.

**Legal Status**

Elk are protected and classified as a game animal in states and provinces.

**Damage Prevention and Control Methods**

In some situations, only one technique for controlling elk damage is necessary. In many situations, however, the greatest reduction and prevention of future damage will be accomplished by application of more than one damage control technique.

**Exclusion**

Fencing has provided relief from elk damage where plants cannot be protected individually, such as in hay and grain fields, large orchards, and pastures. Six-foot-high (1.8-m) woven-wire fences, topped with two strands of smooth or barbed wire (Fig. 7) will prevent access, but the cost is high (Table 1). Some states have cost-share programs wherein some or all of the cost of fencing materials may be borne by one or more agencies responsible for managing elk damage.

Recently, high-voltage (3,500- to 7,500-volt) electric fences have proven to be a relatively inexpensive and effective alternative to woven-wire fences. They feature 8 to 11 smooth strands of triple-galvanized, high-tensile steel wire supported by conventional fence post systems (Fig. 8). Considerable expertise is required to construct these fences, but when built properly, they
can provide nearly as much protection from damage as mesh fences.

Researchers in Pennsylvania developed 4- to 5-strand electric fences (Fig. 9) that provided 80% or more protection from deer damage. In Oregon, an 8-foot (2.5-m) electric fence consisting of 11 wires successfully kept elk from entering a rhododendron nursery that previously had sustained persistent trampling damage. A key component of electric fences is the high-voltage charger or “energizer.” These are available as 110 volt or battery-operated units.

For a fence to be effective, it must be seen by elk. In the case of an electric fence, which a herd can easily run through, it must be seen and associated with an electric shock. Place branches along the top of livestock fences and drape light-colored surveyor tape from electric fences to make them more visible to elk. To help “initiate” elk to the shocking power of fences, place peanut butter on tinfoil strips and attach the strips to electric fence wires 3 feet (1 m) above ground. For more details on fencing, see the Deer chapter in this book.

Haystacks have traditionally been protected by wooden panels (Fig. 10). Because panels are expensive to build and unwieldy to place in position, they are no longer recommended except in cases where nothing else is available. With the advent of the effective and less expensive electric fencing, it is now feasible to place perimeter fences around hay yards. They allow ranchers easier access to hay and greater mobility in moving the hay within yards. Electric fences such as those illustrated are permanent installations, lacking the mobility of panel fencing, so placement is a factor in choosing panels or electric fences.

Haystacks can be protected from elk for one or two seasons by wrapping plastic barriers around them. Ten-foot-wide (3-m) sheets of 6-mil black plastic (Visqueen®) or netting made of expanded polyethylene are commonly used. Attach the sheets to standing stacks of hay bales by tying baling twine around pebbles enclosed in a
fold of plastic at the top of the sheet, and tying the loose end of the twine to baling twine on hay bales (Fig. 11). The netting is simply stretched around hay stacks.

The Tensar® snow fence, which comes in 8 x 100-foot (2.6 x 30-m) rolls and has a 30-year life span, can also be wrapped around haystacks. State and federal wildlife agencies have been purchasing it and loaning it to ranchers to use before winter elk damage begins.

For smaller orchards (fewer than 50 trees), protect individual trees with 6-foot (1.8-m) cylinders of welded wire (Fig. 12).

Protectors for individual coniferous and deciduous tree seedlings are effective until the leader (growing tip) or lateral branches grow out of the protectors and are once again exposed to elk browsing. Use rigid diamond-pattern plastic or nylon tubes (Vexar®), netting, and waterproof paper cylinders (bud caps) (Fig. 13) to protect conifer seedlings. Vexar® tubes extend from ground level to above the top of the seedling. Netting and bud caps fit over the growing tips of the leader stem and lateral branches. Vexar® tubes are more expensive than netting and bud caps but have a longer life span (about 5 years).

Tubex® tree shelters (Fig. 14) are translucent, solid-walled cylinders 5 to 6 feet (1.5 to 1.8 m) tall, and 5 to 6 inches (12 to 15 cm) in diameter. The cylinders create a mini-greenhouse that accelerates the growth of seedlings. At $3.25 each, Tubex® protectors are expensive. Vexar® protectors, netting, and bud caps are recommended for conifer seedlings, while Tubex® is recommended for deciduous tree seedlings. Vexar® and Tubex® protectors must be held upright by lashing them to stakes driven into the ground. Both protectors are designed to biodegrade in about 5 years. If support stakes are wooden, they must be treated to prevent rot or they will break off at ground level in 1 to 2 years.

Elk can be excluded from tree regeneration sites by dense slash left after
harvest. Unfortunately, when slash is sufficiently thick to deny elk access to seedlings, it provides protective cover for rodents. Subsequent increases in rodent populations could result in severe rodent damage to seedlings. Usually there is insufficient slash to provide total coverage on sites. Protection is provided to a limited number of seedlings in places where the slash is sufficiently dense.

**Cultural Methods**

Under limited circumstances, elk may be “deferred” from damaging crops by planting other forages that elk prefer. Broadcast legumes and domestic annual and perennial grasses over regeneration sites before planting conifer seedlings. Grasses and legumes that are not sufficiently cropped by elk, however, will provide excellent vole habitat, and damage by these rodents to seedlings may become a problem. Graze sheep in summer on such sites to remove excess forage until elk begin to graze in fall and winter.

Fig. 12. A cylinder of welded wire can protect an individual tree from elk damage.

Fig. 13. Vexar® tubes (left), or netting (middle) can protect seedlings. Bud caps (right) have also been used successfully.

Fig. 14. Tubex® tree shelters are a new individual seedling protector designed for deciduous tree seedlings.
Food plots and salt blocks have been used on public lands adjacent to agricultural fields and pastures to reduce damage by resident and migratory elk. Food plots are maintained in an early successional state (grasses and forbs) by one or more techniques: seeding, mowing, fertilizing, burning, and/or spraying with herbicides. Effectiveness of this approach is still undergoing evaluation. The expense of establishing and maintaining substantial acreages of high-quality food plots limits their use.

Planting taller seedlings can reduce elk damage. Most seedlings are about 18 inches (46 cm) tall. Seedlings 36 inches (90 cm) or taller will provide more browse than elk can crop, and with their greater potential for rapid growth these seedlings can grow out of the reach of elk faster.

The early release of seedlings may also be achieved by eliminating other vegetation. Studies in western Oregon demonstrated that using herbicides to eliminate competing vegetation allowed conifer seedlings to grow sufficiently fast that they outgrew the browsing of deer and elk.

Elk, like deer, are attracted to the edge habitat between openings and forested areas. Their use of openings begins to decline 200 feet (60 m) into openings; by 400 to 600 feet (120 to 180 m), use drops below 50%. Creating larger openings by clear-cutting larger acreages (100 to 200 acres [40 to 80 ha]) as opposed to the 40 to 50 acres (16 to 20 ha) currently practiced on public lands will decrease elk damage in the interior portions of such clear-cuts. Protecting seedlings on the perimeters of larger clear-cuts with repellents or seedling protectors will provide an integrated protection system.

Recent studies with deer in the East suggest that concentrating projected timber harvest into a shortened period of time will overwhelm deer with a surplus of food, reducing the level of damage to seedlings. Instead of spreading out projected harvests over a 10-year period, all timber harvests are conducted within 1 to 2 years and the area is not cut again for 10 years. This system may work in other areas where elk are causing significant damage to seedlings. Placing the cuts in adjoining blocks (“progressive” clear-cutting) rather than scattering them will also reduce the amount of forest fragmentation, which is an emerging concern in forest management.

Where elk and livestock compete for the same forage, a long-term solution is a system of successional cropping. If cattle placed on the pasture from late spring through late summer do not remove all the forage, it will recover, mature in early fall, and provide quantities of high quality forage for elk in winter. The elk, in turn, will crop and stimulate the forage, providing good forage for cattle returning to the pasture in spring. Such a system has increased the availability of forage and numbers of both livestock and elk. Careful planning is required to ensure that proper numbers of livestock and elk use the pasture. Special hunts may be required to ensure that excessive numbers of elk do not occur.

**Frightening (Hazing)**

Propane exploders (Fig. 15) can prevent elk from using sites for several weeks, after which the elk lose interest and go elsewhere. Generally, one exploder will protect 5 to 10 acres (2 to 4 ha). Several may be required for larger areas. Exploders are most effective when their locations are changed every few days so that elk do not habituate to the sound pattern. Exploders may be an unacceptable nuisance to nearby neighbors.

Elk may be temporarily hazed or frightened out of crop fields, orchards, and pastures by the use of fixed-wing aircraft or helicopters, but both are expensive. Elk will return, however, especially if pastures are on their traditional winter range.

**Repellents**

Repellents may reduce elk damage in orchards, vineyards, and conifer plantations. Where frequent washing rains occur, some repellents must be applied more than once. Damage can be prevented without treating the entire area by applying odor repellents to plants...

Fig. 15. Propane exploders may be useful in scaring elk away from particular areas.
within a 25-foot-wide (10-m) strip around field edges where most of the damage occurs.

The US Forest Service has a “20 to 80 percent” rule for determining whether repellents will be successful: If elk damage to conifers is less than 20%, application of the repellent will not pay for itself. If the damage is over 80%, the elk have become too habituated to feeding in the area and will not be deterred by the application of repellents.

Little success is reported with repellents such as human hair, tankage, blood meal, or thiram. Successful repellents include formulations of fermented eggs (Big Game Repellent® or Deer-Away®) and hot sauce containing capsicum. For additional information on repellents, see the Pesticides and Supplies and Materials sections in this book.

Population Reduction

Permits are issued (usually for antlerless elk) to reduce local elk populations to levels of damage that are acceptable. These reductions generally are of two kinds: local herd reduction, and problem-animal elimination. In the former, the herd is usually too large for local resources and a general reduction in population density is required. Special elk damage hunts are established to reduce the size of herds on public lands, and, in some cases, on private property. Such hunts are conducted as extra seasons for which hunters enter drawings. Hunters must have good access to areas for these hunts to be effective for herd reduction and/or problem-animal elimination.

The second kind of reduction is for individual landowners who experience unacceptable losses of crops to one or a few elk. Permits are issued to the individual landowner to eliminate these problem animals; hunters usually are not used to harvest the elk.

Elk-reduction hunts are sensitive management issues. The general hunting public has had difficulty understanding why there is a need to remove individual elk, or to reduce populations when only a limited number of licenses is available to hunt for bulls. Effective public relations programs are essential for acceptance of and support for population reduction.

Special hunts may provide temporary relief from damage, but the conditions conducive to damage remain. Once the population rebuilds, damage is likely to resume, especially in orchards, crop fields, and pastures. Protection of conifer seedlings by hunting to reduce local elk densities is an exception. Seedlings can attain a height sufficient to avoid elk damage within 3 to 5 years, which is well within the period of protection afforded by a series of successful special hunts.

Another form of population reduction is the translocation of problem animals. Capturing and translocating elk was a common procedure in several states as long as there were areas understocked with elk. Small numbers of elk (1 to 10) were captured in large, baited corral traps. Free-ranging individual elk were immobilized by drugs injected by projectiles fired from rifles. These programs are being phased out because states with sufficient elk to cause damage problems no longer have areas of too few elk. Costs of trapping and transporting elk are prohibitive and are not recommended unless outside financial assistance can be obtained.

A final potential population reduction technique is the use of reproductive inhibitors. Effective reproductive inhibitors exist for elk. Unfortunately, there is no effective, selective delivery system available to implant or inject the inhibitors into the bodies of free-ranging elk.

Compensation

Four states pay ranchers directly for crop damage caused by elk. Funding for claims (which have a low upper limit, usually under $5,000) is taken from license fees and tags that hunters pay to hunt elk and other game. Compensation may be temporarily satisfactory to ranchers and farmers, but it does nothing to alter the circumstances favoring damage, so the damage will continue and may even increase. Compensation should be considered as a temporary, stop-gap response requiring a better, permanent solution.

Compensation is not a particularly efficient use of funds for reimbursing individuals with damage. In Colorado’s $1.5 million program, only $300,000 was spent in actual reimbursement to persons with losses. Approximately $350,000 went to administration expenses, and $800,000 to provide damage prevention materials.

Economics of Damage and Control

Before any control program is begun, determine whether the cost of control will exceed the costs of damage. The costs of control methods vary greatly (Table 1).

Cost-effectiveness of damage control efforts may be approximated by dividing the value of elk damage by the cost of control. The result is usually referred to as the benefit-cost ratio. If the ratio is less than 1.0, control is costing more than damage and is not justifiable. More sophisticated benefit-cost models that will allow projection of benefits and costs into the future have yet to be developed for elk.
Acknowledgments

We thank the following individuals for providing pertinent information: H. C. Black, G. E. Burgoyne, J. E. Gillespie, M. Shaw, V. T. Supplee, and D. E. Toweill.

Figure 1 from Schwartz and Schwartz (1981).

Figure 2 adapted from Thomas and Toweill (1982) by L. Bryant and C. Maser.

Figures 3, 4, and 7 through 15 by Jill Sack Johnson.

Figures 5 and 6 by the authors.

For Additional Information


Editors
Scott E. Hygnstrom
Robert M. Timm
Gary E. Larson

Table 1. Costs of methods for controlling elk damage.

<table>
<thead>
<tr>
<th>Method</th>
<th>Cost*</th>
<th>Duration of protection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Woven wire fence</td>
<td>$2/foot</td>
<td>30 years</td>
</tr>
<tr>
<td>Electric fence</td>
<td>$1/foot</td>
<td>40 years</td>
</tr>
<tr>
<td>Panel fence</td>
<td>$3.50/foot</td>
<td>40 years</td>
</tr>
<tr>
<td>Repellent</td>
<td>highly variable</td>
<td>weeks</td>
</tr>
<tr>
<td>Wire cylinders for fruit trees</td>
<td>$4 to $6/tree</td>
<td>5 to 10 years</td>
</tr>
<tr>
<td>Alternate forage</td>
<td>$130/acre</td>
<td>5 years</td>
</tr>
<tr>
<td>Herbicide use</td>
<td>$30 to $40/acre</td>
<td>life of tree</td>
</tr>
<tr>
<td>Plant larger trees</td>
<td>$100 to $200/acre</td>
<td>life of tree</td>
</tr>
<tr>
<td>Plastic/paper cylinders for conifers</td>
<td>$200 to $350/acre</td>
<td>5 years</td>
</tr>
<tr>
<td></td>
<td>$150 to $300/acre</td>
<td>3 years</td>
</tr>
<tr>
<td></td>
<td>$75/acre</td>
<td>1 to 2 years</td>
</tr>
<tr>
<td></td>
<td>(rigid mesh)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(flexible mesh)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(paper bud cups)</td>
<td></td>
</tr>
<tr>
<td>Tree shelters for deciduous trees</td>
<td>$3.25/tree</td>
<td>5 years</td>
</tr>
<tr>
<td>Hazing by aircraft</td>
<td>$200+/hour</td>
<td>weeks</td>
</tr>
<tr>
<td>Exploders</td>
<td>$10/acre</td>
<td>3 to 5 weeks</td>
</tr>
<tr>
<td>Trap &amp; relocate</td>
<td>highly variable</td>
<td></td>
</tr>
<tr>
<td>Special hunts</td>
<td>highly variable</td>
<td></td>
</tr>
<tr>
<td>Visqueen®</td>
<td>$0.50/foot</td>
<td>1 year</td>
</tr>
<tr>
<td>Netting</td>
<td>$0.65/foot</td>
<td>1 to 2 years</td>
</tr>
<tr>
<td>Tensar® snow fence</td>
<td>$1/foot</td>
<td>30 years</td>
</tr>
</tbody>
</table>

*Costs are for materials only and vary from site to site. Labor costs are not included.
MOLES

Damage Prevention and Control Methods

Exclusion
Generally not practical, except in very small, high-value areas where an aboveground and underground barrier (sheet metal, brick, wood) might restrict moles.

Cultural Methods
Packing the soil destroys burrows, and sometimes moles if done in early morning or late evening.
Reduction in soil moisture and food source removal by the use of insecticides discourages moles and generally results in lower populations.

Frightening
Ineffective.

Repellents
None are registered.

Toxicants
Strychnine alkaloid.
Chlorophacinone is registered in some states.

Fumigants
Aluminum phosphide.
Gas cartridges.

Trapping (most effective control method)
Out O’ Sight® Trap.
Bayonet trap or harpoon trap (Victor® Mole Trap).
Nash® (choker-type) mole trap.
Easy-set mole eliminator.
Cinch mole trap.
Death-Klutch gopher trap.

Shooting
Not practical.

Other Methods
None tested have proven effective.
Identification

Yates and Pedersen (1982) list seven North American species of moles. They are the eastern mole (Scapanus aquaticus), hairy-tailed mole (Parascalops breweri), star-nosed mole (Condylura cristata), broad-footed mole (Scapanus latimanus), Townsend's mole (Scapanus townsendii), coast mole (Scapanus orarius), and shrew mole (Neotritichus gibbsii).

The mole discussed here is usually referred to as the eastern mole (Scapanus aquaticus). It is an insectivore, not a rodent, and is related to shrews and bats.

True moles may be distinguished from meadow mice (voles), shrews, or pocket gophers—with which they are often confused—by noting certain characteristics. They have a hairless, pointed snout extending nearly 1/2 inch (1.3 cm) in front of the mouth opening. The small eyes and the opening of the ear canal are concealed in the fur; there are no external ears. The forefeet are very large and broad, with palms wider than they are long. The toes are webbed to the base of the claws, which are broad and depressed. The hind feet are small and narrow, with slender, sharp claws.

Average Dimensions and Weight

Males:
- Average total length, 7 inches (17.6 cm)
- Average length of tail, 1 1/4 inches (3.3 cm)
- Average weight, 4 ounces (115 g)

Females:
- Average total length, 6 5/8 inches (16.8 cm)
- Average length of tail, 1 1/4 inches (3.3 cm)
- Average weight, 3 ounces (85 g)

Range

Out of the seven species that occur in North America, three inhabit lands east of the Rocky Mountains (Yates and Pedersen 1982). The eastern mole is the most common and its range is shown in figure 2. The star-nosed mole is most common in northeastern United States and southeastern Canada, sharing much of the same range as the hairy-tailed mole. The remaining four species are found west of the Rocky Mountains. The Townsend mole and the coast mole are distributed in the extreme northwest corner of the United States and southwest Canada. The broad-footed mole is found in southern Oregon and throughout the coastal region of California excluding the Baja peninsula. Finally, the shrew mole is also found along the West Coast from Santa Cruz County, California, to southern British Columbia (Yates and Pedersen 1982).

Habitat

The mole lives in the seclusion of underground burrows, coming to the surface only rarely, and then often by accident. Researchers believe that the mole is a loner. On several occasions two or even three moles have been trapped at the same spot, but that does not necessarily mean they had been living together in a particular burrow. Networks of runways made independently occasionally join otherwise separate burrows.

Because of their food requirements, moles must cover a larger amount of area than do most animals that live underground. The home range of a male mole is thought to be almost 20 times that of a male plains pocket gopher. Three to five moles per acre (7 to 12 per ha) is considered a high population for most areas in the Great Plains.

Deep runways lead from the mole’s den to its hunting grounds. The denning area proper consists of irregular chambers here and there connected with the deep runways. The runways follow a course from 5 to 8 inches (12.7 to 20.3 cm) beneath the surface of the ground. The chambers from which these runs radiate are about the size of a quart jar.

Most of a mole’s runway system is made up of shallow tunnels ranging over its hunting ground. These tunnels may not be used again or they may be re-traversed at irregular intervals. Eventually, they become filled by the settling soil, especially after heavy showers. In some cases, moles push soil they have excavated from their deep runways into the shallow tunnels. These subterranean hunting paths are about 1 1/4 to 1 1/2 inches (3.2 to 3.8 cm) in diameter. Moles usually ridge up the surface of the soil, so their tunnels can be readily followed. In wet weather, runways are very shallow; during a dry period they range somewhat deeper, following the course of earthworms.

Moles make their home burrows in high, dry spots, but they prefer to hunt in soil that is shaded, cool, moist, and populated by worms and grubs. This preference accounts for the mole’s attraction to lawns and parks. In neglected orchards and natural woodlands, moles work undisturbed. The ground can be infiltrated with runways. Moles commonly make their denning areas under portions of large trees, buildings, or sidewalks.

The maze of passages that thread the soil provides protective cover and traffic for several species of small mammals. Voles (meadow mice), white-footed mice, and house mice live in and move through mole runways, helping themselves to grains, seeds, and tubers. The mole, however, often gets blamed for damaging these plants. Moles “swim” through soil, often near the ground surface, in their
search for worms, insects, and other foods. In doing so, they may damage plants by disrupting their roots (Fig. 3).

**Food Habits**

The teeth of a mole (see Fig. 1) indicate the characteristics of its food and general behavior. In several respects moles are much more closely related to carnivorous or flesh-eating mammals than to rodents. The mole’s diet consists mainly of the insects, grubs, and worms it finds in the soil (Table 1). Moles are thought to damage roots and tubers by feeding on them, but rodents usually are to blame.

Moles eat from 70% to 100% of their weight each day. A mole’s appetite seems to be insatiable. Experiments with captive moles show that they will usually eat voraciously as long as they are supplied with food to their liking. The tremendous amount of energy expended in plowing through soil requires a correspondingly large amount of food to supply that energy. Moles must have this food at frequent intervals.

**Table 1. Stomach contents of 100 eastern moles:**

<table>
<thead>
<tr>
<th>Food item</th>
<th>Number of stomachs</th>
</tr>
</thead>
<tbody>
<tr>
<td>White grubs</td>
<td>64</td>
</tr>
<tr>
<td>Earthworms</td>
<td>49</td>
</tr>
<tr>
<td>Beetles</td>
<td>67</td>
</tr>
<tr>
<td>Beetle larvae</td>
<td>44</td>
</tr>
<tr>
<td>Other larvae</td>
<td>25</td>
</tr>
<tr>
<td>Centipedes</td>
<td>25</td>
</tr>
<tr>
<td>Ants</td>
<td>19</td>
</tr>
<tr>
<td>Wasps</td>
<td>7</td>
</tr>
<tr>
<td>Flies</td>
<td>2</td>
</tr>
<tr>
<td>Plant fibers and rootlets</td>
<td>2</td>
</tr>
<tr>
<td>Seed pods or husks</td>
<td>43</td>
</tr>
<tr>
<td>Crickets</td>
<td>10</td>
</tr>
<tr>
<td>Insect fragments</td>
<td>31</td>
</tr>
<tr>
<td>Puparia</td>
<td>21</td>
</tr>
<tr>
<td>Cocoons</td>
<td>10</td>
</tr>
<tr>
<td>Spiders</td>
<td>23</td>
</tr>
<tr>
<td>Grasshoppers</td>
<td>2</td>
</tr>
<tr>
<td>Bugs</td>
<td>3</td>
</tr>
<tr>
<td>Skin of grain or roots</td>
<td>3</td>
</tr>
<tr>
<td>Hairworm</td>
<td>1</td>
</tr>
</tbody>
</table>

**General Biology, Reproduction, and Behavior**

Moles prefer loose, moist soil abounding in grubs and earthworms. They are most commonly found in fields and woods shaded by vegetation, and are not able to maintain existence in hard, compact, semiarid soil.

The mole is not a social animal. Moles do not hibernate but are more or less active at all seasons of the year. They are busiest finding and storing foods during rainy periods in summer.

The gestation period of moles is approximately 42 days. Three to five young are born, mainly in March and early April.

The moles have only a few natural enemies because of their secluded life underground. Coyotes, dogs, badgers, and skunks dig out a few of them, and occasionally a cat, hawk, or owl surprises one above ground. Spring floods are probably the greatest danger facing adult moles and their young.

**Damage and Damage Identification**

Moles remove many damaging insects and grubs from lawns and gardens. However, their burrowing habits disfigure lawns and parks, destroy flower beds, tear up the roots of grasses, and create havoc in small garden plots.

It is important to properly identify the kind of animal causing damage before setting out to control the damage. Moles and pocket gophers are often found in the same location and their damage is often confused. Control methods differ for the two species.

Moles leave volcano-shaped hills (Fig. 4a) that are often made up of clods of soil. The mole hills are pushed up from the deep tunnels and may be 2 to 24 inches (5 to 60 cm) tall. The number of mole hills is not a measure of the number of moles in a given area. Surface tunnels (Fig. 4b) or ridges are indicative of mole activity.
Pocket gopher mounds are generally kidney-shaped and made of finely sifted and cloddy soil (Fig. 4c). Generally, gophers leave larger mounds than moles do. Gopher mounds are often built in a line, indicative of a deeper tunnel system.

**Legal Status**

Moles are unprotected in most states. See state and local laws for types of traps, toxicants, and other methods of damage control that can be used.

**Damage Prevention and Control Methods**

**Exclusion**

For small areas, such as seed beds, install a 24-inch (61-cm) roll sheet metal or hardware cloth fence. Place the fence at the ground surface and bury it to a depth of at least 12 inches (30 cm), bent out at a 90° angle (Fig. 5).

**Cultural Methods**

In practice, packing the soil with a roller or reducing soil moisture may reduce a habitat’s attractiveness to moles. Packing may even kill moles if done in the early morning or late evening.

Milky-spore disease is a satisfactory natural control for certain white grubs, one of the mole’s major food sources. It may take several years, however, for the milky-spore disease to become established. Treatments are most effective when they are made on a community-wide basis. The spore dust can be applied at a rate of 2 pounds per acre (2.3 kg/ha) and in spots 5 to 10 feet (1.5 to 3m) apart (1 level teaspoon [4 g] per spot). If you wish to try discouraging moles by beginning a control program for white grubs, contact your local extension agent for recommended procedures.

Because moles feed largely on insects and worms, the use of certain insecticides may reduce their food supply, causing them to leave the area. However, before doing so, they may
increase their digging in search of food, possibly increasing damage to turf or garden areas. Check local sources of insecticides for controlling grubs. Follow the label instructions for use.

**Frightening**

Some electronic, magnetic, and vibrational devices have been promoted as being effective in frightening or repelling moles. None, however, have been proven effective.

**Repellents**

No chemical products are registered or effective for repelling moles. Borders of marigolds may repel moles from gardens, although this method has not been scientifically tested.

**Toxicants**

Since moles normally do not consume grain, toxic grain baits are seldom effective. Two poisons are federally registered for use against moles. Ready-to-use grain baits containing strychnine are sold at nurseries or garden supply stores.

Recent work by Elshoff and Dudderar at Michigan State University reported on the use of Orco Mole Bait, a chlorophacinone pellet which is used in Washington and some other states under 24(c) permits for mole damage control. Even though the researchers stated the use of this toxicant is a highly effective and easily applied mole control technique, there are disadvantages. Two or more successive treatments are often required. An average of 21 1/2 days was required to achieve zero damage on treated dry soil and 39 days on treated irrigated soils.

**Fumigants**

Two fumigants, aluminum phosphide and gas cartridges, are federally registered for use against moles (see **Supplies and Materials**). Aluminum phosphide is a Restricted Use Pesticide. These fumigants have the greatest effectiveness when the materials are placed in the mole’s deep burrows, not in the surface runways. Golf course owners, however, report that moles can be repelled from surface tunnels by placing aluminum phosphide pellets in them. Since state pesticide registrations vary, check with your local extension or USDA-APHIS-ADC office for information on toxicants and repellents that are legal in your area. Care should be taken when using chemicals. Read and follow label instructions when using toxicants and fumigants.

**Trapping**

Trapping is the most successful and practical method of getting rid of moles. There are several mole traps on the market. Each, if properly handled, will give good results. The traps are set over a depressed portion of the surface tunnel. As a mole moves through the tunnel, it pushes upward on the depressed tunnel roof and trips the broad trigger pan of the trap. The brand names of the more common traps are: Victor® mole trap, Out O’ Sight®, and Nash® (choker loop) mole trap (Fig. 6). The Victor® trap has sharp spikes that impale the mole when the spikes are driven into the ground by the spring. The Out O’ Sight® trap has scissorlike jaws that close firmly across the runway, one pair on either side of the trigger pan. The Nash® trap has a choker loop that tightens around the mole’s body. Others include the Easy-Set mole eliminator, Cinch mole trap, and the Death-Klutch gopher trap.

These traps are well suited to moles because the mole springs them when following its natural instinct to reopen obstructed passageways.

Success or failure in the use of these devices depends largely on the operator’s knowledge of the mole’s habits and of the trap mechanism.

---

Fig. 6. Mole traps: (a) Out O’ Sight® (scissor-jawed), (b) Victor® (harpoon), and (c) Nash® (choker loop).
To set a trap properly, select a place in the surface runway where there is evidence of fresh mole activity and where the burrow runs in a straight line (Fig. 7). Dig out a portion of the burrow, locate the tunnel, and replace the soil, packing it firmly where the trigger pan will rest (Fig. 8).

To set the harpoon or impaling-type trap, raise the spring, set the safety catch, and push the supporting spikes into the ground, one on either side of the runway (Fig. 9). The trigger pan should just touch the earth where the soil is packed down. Release the safety catch and allow the impaling spike to be forced down into the ground by the spring. This will allow the spike to penetrate the burrow when the trap is sprung later. Set the trap and leave it. Do not tread on or disturb any other portion of the mole’s runway.

To set a scissor-jawed trap, dig out a portion of a straight surface runway, and repack it with fine soil. Set the trap and secure it by a safety hook with its jaws forced into the ground. It should straddle the runway (Fig. 10a) until the trigger pan touches the packed soil between the jaws. The points of the jaws are set about 1 inch (2.5 cm) below the mole’s runway and the trigger pan should rest on the portion as previously described. Care should be taken to see that the trap is in line with the runway so the mole will have to pass directly between the jaws. In heavy clay soils be sure to cut a path for the jaws (Fig. 10b) so they can close quickly. The jaws of this trap are rather short, so be sure the soil on the top of the mole run is low enough to bring the trap down nearer to the actual burrow. Set the triggers on both traps so that they will spring easily (Fig. 11). Remember to release the safety hook before releasing the trap. Be careful when handling these traps.

To set a choker trap, use a garden trowel to make an excavation across the tunnel. Make it a little deeper than the tunnel and just the width of the trap. Note the exact direction of the tunnel from the open ends, and place the set trap so that its loop encircles this course (Fig. 12). Block the...
Fig. 10a. Set the scissor-jawed trap so that the jaws straddle the runway.

Fig. 10b. In heavy soils, make a path for the jaws to travel so they can close quickly.

Fig. 11. Set mole trap triggers so they will spring easily. A hair-trigger setting on the scissor-jawed trap is shown here.

Fig. 12. The choker loop trap is set so that the loop encircles the mole’s runway.

excavated section with loose, damp soil from which all gravel and debris have been removed. Pack the soil firmly underneath the trigger pan with your fingers and settle the trap so that the trigger rests snugly on the built-up soil. Finally, fill the trap hole with enough loose soil to cover the trap level with the trigger pan and to exclude all light from the mole burrow.

If a trap fails to catch a mole after 2 days, it can mean the mole has changed its habits, the runway was disturbed too much, the trap was improperly set, or the trap was detected by the mole. In any event, move the trap to a new location.

If one cares to take the time, moles can be caught alive. Examine tunnels early in the morning or evening where fresh burrowing operations have been noted. Quietly approach the area where the earth is being heaved up. Quickly strike a spade into the ridge behind the mole and throw the animal out onto the surface. A mole occasionally can be driven to the surface by flooding a runway system with water from a hose or ditch. Another method is to bury a 3-pound (1.4-kg) coffee can or a wide-mouth quart (0.95 l) glass jar in the path of the mole and cover the top of the burrow with a board (Fig. 13).

Fig. 13. A mole can be live-captured in a pit trap. Be sure to use a board or other object to shut out all light. Cave in the runway just in front of the jar on both sides.
Other Methods

Nearly everyone has heard of a sure-fire home remedy for controlling moles. In theory, various materials placed in mole tunnels cause moles to die or at least leave the area. Such cures suggest placing broken bottles, ground glass, razor blades, thorny rose branches, bleaches, various petroleum products, sheep dip, household lye, chewing gum, and even human hair in the tunnel. Other remedies include mole wheels, pop bottles, windmills, bleach bottles with wind vents placed on sticks, and similar gadgets. Though colorful and sometimes decorative, these gadgets add nothing to our arsenal of effective mole control methods.

Another cure-all is the so-called mole plant or caper spurge (*Euphorbia latharis*). Advertisers claim that when planted frequently throughout the lawn and flower beds, such plants supposedly act as living mole repellents. No known research supports this claim. Castor beans are also supposed to repel moles. Caution must be used, however, since castor beans are poisonous to humans. Several electromagnetic devices or “repellers” have been marketed for the control of rats, mice, gophers, moles, ants, termites, and various other pests. Laboratory tests have not proven these devices to be effective. Unfortunately, there are no short cuts or magic wands when controlling moles.

Economics of Damage and Control

Perhaps more problems are encountered with moles than with any other single kind of wild animal. Unfortunately, people lack an appreciation of the importance of moles and the difficulty of gaining complete control where habitats are attractive to moles.

Before initiating a control program for moles, be sure that they are truly out of place. Moles play an important role in the management of soil and of grubs that destroy lawns. Moles work over the soil and subsoil. Only a part of this work is visible at the surface. Tunneling through soil and shifting of soil particles permits better aeration of the soil and subsoil, carrying humus farther down and bringing the subsoil nearer the surface where the elements of plant food may be made available.

Moles eat harmful lawn pests such as white grubs. They also eat beneficial earthworms. Stomach analyses show that nearly two-thirds of the moles studied had eaten white grubs.

If the individual mole is not out of place, consider it an asset. If a particular mole or moles are where you do not want them, remove the moles. If excellent habitat is present and nearby mole populations are high, control will be difficult. Often other moles will move into recently vacated areas.

Acknowledgments

Figures 1 and 4 from Schwartz and Schwartz (1981).
Figures 6, 8, 9, 10, 11, 12 and 13 adapted from various sources by Jill Sack Johnson.

For Additional Information


Editors

Scott E. Hygnstrom
Robert M. Timm
Gary E. Larson
Fig. 1. Opossum, Didelphis virginiana

**Damage Prevention and Control Methods**

**Exclusion**
Practical where opossums are entering structures.

**Habitat Modification**
Remove cover and plug burrows to reduce frequency of visits by opossums.

**Frightening**
Generally not practical.

**Repellents**
None are registered.

**Toxicants**
None are registered.

**Fumigants**
None are registered.

**Trapping**
Leghold traps.
Box traps.
Cage traps.
Body-gripping (kill) traps.

**Shooting**
Effective where firearms are permitted. Use a shotgun with No. 6 shot or a .22-caliber rifle.

**Identification**
An opossum (Didelphis virginiana) is a whitish or grayish mammal about the size of a house cat (Fig. 1). Underfur is dense with sparse guard hairs. Its face is long and pointed, its ears rounded and hairless. Maximum length is 40 inches (102 cm); the ratlike tail is slightly less than half the total length. The tail may be unusually short in northern opossums due to loss by frostbite. Opossums may weigh as much as 14 pounds (6.3 kg); males average 6 to 7 pounds (2.7 to 3.2 kg) and females average 4 pounds (6.3 kg). The skull is usually 3 to 4 inches (8 to 10 cm) long and contains 50 teeth — more than are found in any other North

---

**PREVENTION AND CONTROL OF WILDLIFE DAMAGE — 1994**

Cooperative Extension Division
Institute of Agriculture and Natural Resources
University of Nebraska - Lincoln
United States Department of Agriculture
Animal and Plant Health Inspection Service
Animal Damage Control
Great Plains Agricultural Council
Wildlife Committee

D-59
General Biology, Reproduction, and Behavior

Opossums usually live alone, having a home range of 10 to 50 acres (4 to 20 ha). Young appear to roam randomly until they find a suitable home range. Usually they are active only at night. The mating season is January to July in warmer parts of the range but may start a month later and end a month earlier in northern areas. Opossums may raise 2, rarely 3, litters per year. The opossum is the only marsupial in North America. Like other marsupials, the blind, helpless young develop in a pouch. They are born 13 days after mating. The young, only 1/2 inch (1.3 cm) long, find their way into the female's pouch where they each attach to one of 13 teats. An average of 7 young are born. They remain in the pouch for 7 to 8 weeks. The young remain with the mother another 6 to 7 weeks until weaned.

Most young die during their first year. Those surviving until spring will breed in that first year. The maximum age in the wild is about 7 years.

Although opossums have a top running speed of only 7 miles per hour (11.3 km/hr), they are well equipped to escape enemies. They readily enter burrows and climb trees. When threatened, an opossum may bare its teeth, growl, hiss, bite, screech, and exude a smelly, greenish fluid from its anal glands. If these defenses are not successful, an opossum may play dead.

When captured or surprised during daylight, opossums appear stupid and inhibited. They are surprisingly
intelligent, however. They rank above dogs in some learning and discrimination tests.

**Damage**

Although opossums may be considered desirable as game animals, certain individuals may be a nuisance near homes where they may get into garbage, bird feeders, or pet food. They may also destroy poultry, game birds, and their nests.

**Legal Status**

Laws protecting opossums vary from state to state. Usually there are open seasons for hunting or trapping opossums. It is advisable to contact local wildlife authorities before removing nuisance animals.

**Damage Prevention and Control Methods**

**Exclusion**

Prevent nuisance animals from entering structures by closing openings to cages and pens that house poultry. Opossums can be prevented from climbing over wire mesh fences by installing a tightly stretched electric fence wire near the top of the fence 3 inches (8 cm) out from the mesh. Fasten garbage can lids with a rubber strap.

**Traps**

Opossums are not wary of traps and may be easily caught with suitably sized box or cage traps (Fig. 4). No. 1 or 1 1/2 leghold traps also are effective. Set traps along fences or trailways. Dirt hole sets or cubby sets are effective (Fig. 5). A dirt hole is about 3 inches (8 cm) in diameter and 8 inches (20 cm) deep. It extends into the earth at a 45° angle. The trap should be set at the entrance to the hole. A cubby is a small enclosure made of rocks, logs, or a box. The trap is set at the entrance to the cubby. The purpose of the dirt hole or cubby is to position the animal so
that it will place its foot on the trap. Place bait such as cheese, or slightly spoiled meat, fish, or fruit in the dirt hole or cubby to attract the animal. Using fruit instead of meat will reduce the chance of catching cats, dogs, or skunks.

A medium-sized body-gripping (kill type) trap will catch and kill opossums. Place bait behind the trap in such a way that the animal must pass through the trap to get it. Body-gripping traps kill the captured animal quickly. To reduce chances of catching pets, set the trap above ground on a running pole (Fig. 6).

**Shooting**

A rifle of almost any caliber or a shotgun loaded with No. 6 shot or larger will effectively kill opossums. Use a light to look for opossums after dark. If an opossum has not been alarmed, it will usually pause in the light long enough to allow an easy shot. Once alarmed, opossums do not run rapidly. They will usually climb a nearby tree where they can be located with a light. Chase running opossums on foot or with a dog. If you lose track, run to the last place where you saw the animal. Stop and listen for the sound of claws on bark to locate the tree the animal is climbing.

Sometimes opossums can be approached quietly and killed by a strong blow with a club, but they can be surprisingly hard to kill in this manner. They can be taken alive by firmly grasping the end of the tail. If the animal begins to “climb its tail” to reach your hand, lower the animal until it touches the ground. This will distract the opossum and cause it to try to escape by crawling. Opossums can carry rabies, so wear heavy gloves and be wary of bites.

Euthanize unwanted animals humanely with carbon dioxide gas, or release them several miles from the point of capture.
Economics of Damage and Control

No data are available; however, it is usually worthwhile to remove a particular animal that is causing damage.

Acknowledgments

Much of the information on habitat, food habits, and general biology comes from J. J. McManus (1974) and A. L. Gardner (1982). The manuscript was read and improved by Jim Byford and Robert Timm.

Figures 1, 2a, 2c, and 3 from Schwartz and Schwartz (1981).

Figure 2b by Jill Sack Johnson.

Figures 4, 5, and 6 by Michael D. Stickney, from the New York Department of Environmental Conservation publication “Trapping Furbearers, Student Manual” (1980), by R. Howard, L. Berchielli, C. Parsons, and M. Brown. The figures are copyrighted and are used with permission.

For Additional Information


Editors
Scott E. Hygnstrom
Robert M. Timm
Gary E. Larson
WILD PIGS

Reginald H. Barrett
Department of Environmental Science, Policy, and Management
University of California
Berkeley, California 94720

Grant H. Birmingham
USDA-APHIS-
Animal Damage Control (retired)
Modesto, California 95353

Fig. 1. Feral hog (left) and European wild boar (right). Both are the species Sus scrofa.

Identification
Wild pigs (Sus scrofa, Fig. 1) include both feral hogs (domestic swine that have escaped captivity) and wild boar, native to Eurasia but introduced to North America to interbreed with feral hogs. Like domestic hogs, they may be any color. Their size and conformation depend on the breed, degree of hybridization with wild boar, and level of nutrition during their growing period.

Wild boar have longer legs and larger heads with longer snouts than feral hogs.

Damage Prevention and Control Methods

Exclusion
Heavy-mesh wire fences and electric fences may be effective, especially around gardens and other small areas.

Frightening
No methods are effective.

Repellents
None are registered.

Toxicants
None are registered.

Trapping
Stationary corral trap.
Portable drop gate trap.
Leg snare.

Shooting
Sport hunting, especially with dogs, can reduce pig populations in local areas.
hogs. The color of young boar is generally reddish brown with black longitudinal “watermelon” stripes. As the young develop, the stripes begin to disappear and the red changes to brown and finally to black. Both the male feral hog and wild boar have continuously growing tusks. Wild boar and feral hogs hybridize freely; therefore, the term wild pig is appropriate as a generic term for these animals.

**Range**

Christopher Columbus first introduced members of the family Suidae into North America in 1493 in the West Indies (Towne and Wentworth 1950). The first documented introduction to the United States was by Florida de Soto in 1593. More introductions followed in Georgia and the Carolinas, which established free-ranging populations in the Southeast. Free-ranging practices continued until they became illegal in the mid-twentieth century. Populations of unclaimed hogs increased and spread throughout the Southeast. Domestic hogs were released in California in 1769 and free-ranging practices there also resulted in a feral hog population. European wild boar were released at Hooper Bald, North Carolina, in 1912, and from there introduced to California in 1925.

Wild pigs are found throughout the southeastern United States from Texas east to Florida and north to Virginia; and in California, Hawaii, Puerto Rico, and the Virgin Islands. The local introduction of these animals for hunting purposes occurred in North Carolina, Tennessee, Texas, Louisiana, and California. The National Park Service reports feral hogs in 13 National Park Service areas. They occur in many state parks as well (Mayer and Brisbin 1991). Feral hogs are also found in Hawaii, Australia, New Zealand, and several other South Pacific Islands.

**Habitat**

A variety of habitats, from tidal marshes to mountain ranges, are suitable for wild pigs. They prefer cover of dense brush or marsh vegetation. They are generally restricted to areas below snowline and above freezing temperatures during the winter. Wild pigs frequent livestock-producing areas. They prefer mast-producing hardwood forests but will frequent conifer forests as well. In remote areas or where human activities are minimal, they may use open range or pastures, particularly at night. During periods of hot weather, wild pigs spend a good deal of time wallowing in ponds, springs, or streams, usually in or adjacent to cover.

**Food Habits**

Types of food vary greatly depending on the location and time of year. Wild pigs will eat anything from grain to carrion. They may feed on underground vegetation during periods of wet weather or in areas near streams and underground springs. Acorns or other mast, when available, make up a good portion of their diet. Wild pigs gather in oak forests when acorns fall, and their movements will generally not be as great during this period. In the winters of poor mast years, wild pigs greatly increase their range and consume greater quantities of underground plant material, herbaceous plants, and invertebrates (Singer 1981). Stomach analyses indicate that wild hogs ingest flesh from vertebrates, but the extent to which animals are taken as prey or carrion is not known. Wild pigs are capable of preying on lambs (Pavlov et al. 1981), as well as goat kids, calves, and exotic game.

**General Biology, Reproduction, and Behavior**

Wild pigs are intelligent animals and readily adapt to changing conditions. They may modify their response to humans fairly rapidly if it benefits their survival. Wild boar have a greater capacity to invade colder and more mountainous terrain than do other wild pigs. Feral hogs feed during daylight hours or at night, but if hunting pressure becomes too great during the day, they will remain in heavy cover at that time and feed at night. In periods of hot weather, wild pigs remain in the shade in wallows during the day and feed at night.

The wild pig is the most prolific large wild mammal in North America. Given adequate nutrition, a wild pig population can double in just 4 months. Feral hogs may begin to breed before 6 months of age, if they have a high-quality diet. Sows can produce 2 litters per year and young may be born at any time of the year. Wild boar usually do not breed until 18 months of age and commonly have only 1 litter per year unless forage conditions are excellent. Like domestic animals, the litter size depends upon the sow’s age, nutritional intake, and the time of year. Litter sizes of feral hogs in northern California average 5 to 6 per sow (Barrett 1978). Wild boar usually have litter sizes of 4 to 5 but may have as many as 13 (Pine and Gerdes 1973).

**Damage and Damage Identification**

Wild pigs can cause a variety of damage. The most common complaint is rooting (sometimes called grubbing), resulting in the destruction of crops and pastures. Damage to farm ponds and watering holes for livestock is another common problem. Predation on domestic stock and wildlife has been a lesser problem in North America.

Damage to crops and rangeland by wild pigs is easily identified. Rooting in wet or irrigated soil is generally quite visible, but can vary from an area of several hundred square feet (m²) or more to only a few small spots where the ground has been turned over. Rooting destroys pasture, crops, and native plants, and can cause soil erosion. Wallows are easily seen around ponds and streams. Tracks of adult hogs resemble those made by a 200-pound (90-kg) calf. Where ground is soft, dewclaws will show on adult hog tracks (Fig. 2).

Wild pig predation on certain forest tree seedlings has been a concern of...
foresters in the South and West. Wild pigs have destroyed fragile plant communities in Great Smoky Mountains National Park and other preserves. They have been known to damage fences when going into gardens and can do considerable damage to a lawn or golf course in a single night.

In California, wild pigs have entered turkey pens, damaging feeders, eating the turkey feed, and allowing birds to escape through damaged fences. Wild pigs in New South Wales, Australia, reportedly killed and ate lambs on lambing grounds. Producers in Texas and California reported to USDA-APHIS-ADC that 1,473 sheep, goats, and exotic game animals were killed by wild pigs in 1991. Predation usually occurs on lambing or calving grounds, and some hogs become highly efficient predators. Depredation to calves and lambs can be difficult to identify because these small animals may be killed and completely consumed, leaving little or no evidence to determine whether they were killed or died of other causes and then were eaten. Determining predation by wild hogs is possible if carcasses are not entirely eaten, because feral hogs follow a characteristic feeding pattern on lambs (Pavlov and Hone 1982). Photographs and additional information on wild pig predation may be found in the booklet by Wade and Bowns (1982).

Always be aware of the potential for disease transmission when feral hogs are associated with domestic livestock. Cholera, swine brucellosis, trichinosis, bovine tuberculosis, foot and mouth disease, African swine fever, and pseudorabies are all diseases that may be transmitted to livestock (Wood and Barrett 1979). Bovine tuberculosis was transmitted to beef cattle by wild hogs on the Hearst Ranch in California in 1965. Pork that was infected with hog cholera brought into Kosrae Island in the East Carolinas resulted in the decimation of all domestic and feral hogs on the island.

**Legal Status**

Wild pigs are game mammals in California, Texas, Tennessee, North Carolina, Puerto Rico, Hawaii, and Florida (Wood and Barrett 1979, Mayer and Brisbin 1991). In California, a depredation permit is required from the Department of Fish and Game to conduct a control program or to take depredating animals. Contact your state wildlife agency to determine if a permit is required.

**Damage Prevention and Control Methods**

**Exclusion**

Fencing is generally not practical except in small areas around yards and gardens. Heavy wire and posts must be used, but if hogs are persistent, exclusion is almost impossible. Electric fencing on the outside of the mesh may be of some help, but it is difficult to maintain over large areas. Electric fencing has been used effectively in New South Wales, Australia. See the Deer chapter for details on electric fencing.

**Frightening**

No methods are effective.

**Repellents**

None are registered.

**Toxicants**

There are no toxicants currently registered for controlling wild pigs in the United States.

**Trapping**

**Cage Traps.** Trapping, especially where pig densities are high, is probably the most effective control method. Traps may not be effective, however, during fall and winter when acorns or other preferred natural foods are available. Hogs seem to prefer acorns over grain and other baits. Leg snares and hunting may be more productive control methods during fall and winter. Stationary corral-type traps and box traps have been used with success. The corral or stationary trap is permanent and should be constructed in locations where large populations of hogs are evident and where more than one hog can be trapped at a time (Fig. 3). Build the trap out of steel fence posts and 2 x 4-inch (5.1 x 10.2-cm) welded 12-gauge wire fencing. A gate frame can be made from 2 x 4-inch (5.1 x 10.2-cm) boards. Make doors from 3/4-inch (1.9-cm) plywood and mount them so that they open inward and close automatically with screen door springs. Heavier material may be used for the gate and frame in areas where exceptionally large hogs are to be trapped. Also, more steel fence posts may be needed to reinforce the wire fencing. The wire fencing should be put on the ground as well as at the top of the trap to prevent hogs from going under the sides or over the top. Fasten the sides to the top and bottom. One or two small hogs can be left inside the trap with adequate food and water to act as decoys.
A portable trap with a drop gate has been used very effectively and can be moved from one area to another (Fig. 4). It is especially effective where hogs occur intermittently. Build the trap out of 2 x 4-inch (5.1 x 10.2-cm) welded 12-gauge wire over a 2 x 4-inch (5.1 x 10.2-cm) wooden frame using a 3/4-inch (1.9-cm) plywood drop gate. Place loose barbed wire fencing around the outside of the trap to prevent livestock from entering and to protect both the traps and bait material. When traps are not in use make sure trap doors are locked shut to prevent the possibility of trapping livestock.

There are a number of different styles of live or cage traps. The two described here have been used effectively in California. As many as 14 hogs have been trapped during a night in one trap. It is important that the material used in the construction of these traps be strong and heavy enough to prevent escapes. Corral-type traps have captured up to 104 hogs in a single night and may have to be reinforced with extra fence posts and heavier fencing material.

Persistence and dedication are required if a feral hog control program is to be successful. Traps must be checked daily to be reset and to replace bait when needed. Many times control measures fail because operators fail to check their traps or provide bait in adequate amounts. Trapping hogs that are feeding on acorns may be difficult because they seem to prefer acorns to grain or other baits.

Traps should be checked from a distance when possible. If several large hogs are in a trap, the presence of a person or vehicle will frighten them and escapes can occur even out of well-built traps. A well-placed shot to the head from a large-caliber rifle will kill the hog instantly without greatly alarming other hogs in the trap. Shoot the largest hog first, if possible. When a trapping program is being conducted, all hunting in the area should cease, especially the use of dogs, as this may pressure the pigs to move to another area.

A prebaiting program should be conducted before a trapping program is initiated. Grains such as barley, corn, or oats make good attractants, as do vegetables or fruits, if a supply is available. If bait is accepted by hogs, replace it daily. Make sure enough bait is out to induce hogs to return the next day; if no feed is available, they may move on to other feeding areas. A place where hogs have gathered in the
Fig. 4. Portable hog trap with drop gate

- 8 2" x 4" x 6'
- 4 2" x 4" x 3'
- 6 2" x 4" x 2'
- 1 3/4" x 24" x 36" plywood
- 2 3' x 6' welded-wire fencing (12-gauge)
- 2 2' x 6' welded-wire fencing (12-gauge)
- 1 2' x 3' welded-wire fencing (12-gauge)
- 2 3" strap hinges
- 1 12" x 20" plywood
- 2 8' cable or nylon
- 2 1" x 1" steel pin
- 16-penny nails
past and seem to frequent often, is probably a good place to build a corral-type trap. If only one or two hogs are attracted to the prebait, a portable trap should be installed.

If a swing gate corral trap is prebaited, prop the doors open so that hogs can move in and out. When it appears that the number of hogs that are accepting the bait has peaked, position the doors so that they will close after hogs enter the trap.

**Steel Traps.** Steel leghold traps are not recommended for pigs.

**Leg Snares.** Leg snares can be used with success where terrain prohibits the use of cage traps. Snares are not recommended if livestock, deer, or other nontarget animals are in the area. An ideal location for leg snares is at a fence where hogs are entering pens or on trails that hogs are traveling. Fasten the snare to a heavy drag, such as an oak limb, 6 to 12 feet (1.8 to 3.6 m) in length, or longer if large hogs are in the area. Make sure the size of the cable is heavy enough to hold a large hog.

**Shooting**

Sport hunting is used in certain areas to reduce wild pig densities and can be a source of revenue for ranchers. Success is highly dependent on local situations and terrain. Hunting is not recommended if there is a serious depredation or disease problem. Unsuccessful hunting will make wild pigs keep to cover and change their feeding habits. The use of dogs can increase hunter success. Good dogs chase pigs from cover where they can be shot by hunters.

**Economics of Damage and Control**

In most areas it is unlikely that wild pigs can be exterminated. It is theoretically possible, but the cost to do so is usually prohibitive. Landowners must generally accept the fact that they will always have some wild pigs and should therefore plan for a long-term control program.

Feral hog damage can be extensive and costly if not controlled. Control for disease suppression is extremely expensive because many hogs need to be eliminated. Crop depredations may cease after one or two hogs are shot or trapped, or intermittent hunting pressure is put on them. They simply move to new areas. If depredations are heavy enough to require a reduction in the overall population then a program can be very costly, depending on the size of the area involved.

**Acknowledgments**

Figures 1 and 2 by Emily Oseas Routman.

Figures 3 and 4 by Marilyn Murtos, US Bureau of Reclamation, Sacramento, California.

**For Additional Information**


**Editors**

Scott E. Hygnstrom
Robert M. Timm
Gary E. Larson
Identification

The pronghorn (*Antilocapra americana*) is not a true antelope but in a family by itself (*Antilocapridae*). It is native only to North America.

The pronghorn is the only North American big game animal that has branched horns, from which its name derives. Pronghorns have true horns — derived from hair — not antlers. The horns have an outer sheath of fused, modified hair that covers a permanent, bony core. Pronghorns shed the hollow outer sheath each year in October or November and grow a new set by July. Both bucks and does have...
horns, but doe horns are shorter and more slender. Adult pronghorns stand 3 feet (90 cm) high at the shoulders. Bucks weigh about 110 pounds (50 kg); does weigh about 80 pounds (36 kg). Pronghorns have a bright reddish-tan coat marked with white and black. The buck has a conspicuous black neck patch below the ears, which is lacking on the doe. At a distance, their markings break up the outline of their body, making them difficult to see. Their white rump patch is enlarged and conspicuous when they are alarmed. The flash of white serves as a warning signal to other pronghorns and is visible at long distances.

**Range**

Pronghorns currently have a scattered but widespread distribution throughout western North America (Fig. 2).

In the early 1800s, when the Lewis and Clark expedition recorded the presence of large herds of pronghorn, the total population across North America was estimated at 35 million. In less than 100 years, however, intensive market hunting brought pronghorn numbers to a low of approximately 13,000. Quick action by conservation-minded leaders saved the pronghorn from possible extinction.

In the late 1800s and early 1900s most Great Plains state legislatures passed laws making it unlawful to kill, ensnare, or trap pronghorns.

Pronghorns were given complete protection for nearly 50 years. In the 1940s and 1950s, limited hunting seasons were permitted, and pronghorn seasons have been held ever since in most Great Plains states. Populations have shown a notable increase in the last 2 decades.

A game management success story documents an increase from a population low of a few bands of pronghorn in Nebraska during the early 1900s to a current population of about 7,000. Trapping and transplanting programs to reestablish pronghorn populations by the state wildlife agencies and proper management and protection have been major factors in the pronghorn's recovery.

**Habitat**

Pronghorns thrive in short and mixed grasslands and sagebrush grasslands. They prefer rolling, open, expansive terrain at elevations of 3,000 to 6,000 feet (900 to 1,800 m), with highest population densities in areas receiving an average of 10 to 15 inches (25 to 38 cm) of precipitation annually. Vegetation heights on good pronghorn ranges average 15 inches (38 cm) with a minimum of 50% ground cover of mixed vegetation. Healthy pronghorn populations are seldom found more than 3 to 4 miles (4.8 to 6.4 km) from water.

Pronghorns sometimes migrate between their summer and winter ranges. Since they seldom jump over objects more than 3 feet (90 cm) high, most fences stop them unless they can go under or through them. The construction of many highways with parallel fencing has greatly altered the migratory patterns of pronghorns. Woven wire fences, in particular, are a barrier that impede pronghorn movements to water, wintering grounds, and essential forage. Proper spacing of barbed wire in fences (Fig. 3) is essential to allow adequate pronghorn movement.

**Food Habits**

Pronghorns eat a variety of plants, mostly forbs and browse. Sagebrush often makes up a large part of their diet. They are dainty feeders, plucking only the tender, green shoots.

Pronghorns compete with sheep for forbs, but are often found on summer cattle ranges where cattle eat the grasses, leaving the forbs and browse. Dietary overlap of pronghorns with sheep and cattle was 40% and 15%, respectively, in New Mexico. In the winter, pronghorns often feed in winter wheat and alfalfa fields.

**General Biology, Reproduction, and Behavior**

Pronghorns depend on their eyesight and speed to escape enemies. Their eyes protrude in such a way that they can see in a side direction. They prefer to live on the open plains where they can see for long distances. They prefer to live on the open plains where they can see for long distances. Pronghorns are the fastest North American big game animal and can reach speeds of up to 60 miles per hour (96 kph).
Pronghorns are social animals, gathering in relatively large herds. In spring, however, bucks are alone or form small groups. Pronghorns breed during September and October. Bucks are polygamous, collecting harems of 7 to 10 does, which they defend from other bucks. Bucks and does begin breeding at 15 to 16 months of age. Usually 2 kids (young) are born 8 months after mating. The kids are grayish brown at birth and usually weigh 5 to 7 pounds (2.3 to 3.2 kg). Does nurse their kids and keep them hidden until they are strong enough to join the herd, usually at 3 weeks of age. By fall, the kids can take care of themselves and are somewhat difficult to distinguish from adults.

Pronghorns are relatively disease- and parasite-free. Losses occur from predation, primarily coyote, and starvation during severe winters with prolonged deep snow.

Damage
Pronghorns sometimes cause damage to grain fields, alfalfa, and haystacks during the winter. Damage occurs from feeding, bedding, and trampling.

Legal Status
Pronghorns have game-animal status in all of the western states. Permits are required to trap or shoot pronghorns.

Damage Prevention and Control Methods

Exclusion
Woven wire fences of 8-inch (20-cm) mesh, 48 inches (1.2 m) high, near agricultural fields will help to curtail damage. Electric fences with two wires spaced at 8 to 10 inches (20 to 25 cm) and 3 feet (90 cm) above the ground will discourage pronghorns from entering croplands. A single strand of electric wire painted with molasses as an attractant and 30 to 36 inches (76 to 91 cm) above the ground will discourage pronghorn access.

Cultural Methods
Plant tall crops, such as corn, as a barrier between rangelands and small grain fields to help reduce damage. Alfalfa fields adjacent to rangeland are more vulnerable and apt to suffer damage. Pronghorns often move out of pastures that are heavily grazed by cattle to ungrazed areas.

Frightening
Propane or acetylene exploders may provide temporary relief from crop damage. These devices are also used for bird damage control (see Bird Dispersal Techniques and Supplies and Materials).

Repellents
None are registered.

Toxicants
None are registered, and poisoning pronghorns also violates state laws that protect them as game animals.

Trapping
In areas where crop depredation and livestock competition are severe, pronghorns can be readily herded with aircraft into corral traps. After capture, they can be translocated into suitable unoccupied habitat. This technique is for use only by federal or state wildlife agencies.

Shooting
Encourage legal hunting near agricultural fields to help curtail crop damage. Shooting permits are available in some states to remove pronghorns that are causing significant damage outside of the regular hunting season.

Economics of Damage and Control
Competition with livestock and occasional damage to agricultural crops should be weighed against the economic value of pronghorns as game animals. Landowners in Texas and other Great Plains states often charge $200 or more for trespass fees per hunter. Guided hunts may yield $600 to $800 or more per animal taken. In addition, many landowners derive aesthetic pleasure from observing pronghorns. Some states provide economic reimbursement for crop damage. In Wyoming, costs of pronghorn crop damage on private land, including administration (for example, salaries and travel) averaged $169,453 per year (1987 to 1991). Similar antelope crop damage costs in Colorado for the same period averaged $5,510 per year.

Acknowledgments
Figure 1 by Charles W. Schwartz, adapted from Yoakum (1978) by Emily Oseas Routman.
Figure 2 from Burt and Grossenheider (1976), adapted by Jill Sack Johnson.
Figure 3 from the US Bureau of Land Management (1974).

For Additional Information

Editors
Scott E. Hygnstrom
Robert M. Timm
Gary E. Larson
Fig. 1. Eastern cottontail rabbit, *Sylvilagus floridanus*

**Damage Prevention and Control Methods***

**Exclusion**
Low fences are very effective around gardens or shrubs.

Hardware cloth cylinders will protect fruit trees and ornamental plants.

**Habitat Modification**
Removal of brush piles, debris, dumps, and other cover makes an area less suitable for rabbits.

**Frightening**
Several methods are available but none are reliable.

**Repellents**
A wide variety of commercial formulations is available; most are taste repellents based on the fungicide thiram. Home-remedy types may provide some relief.

**Toxicants**
None are registered.

**Trapping**
Commercial live traps or homemade box traps are effective, particularly during winter in northern states.

**Shooting**
Sport hunting and/or routine shooting of problem individuals are very effective methods.

**Other Methods**
Many “gimmick” solutions are available but unreliable. For example, sections of garden hose to simulate snakes, water-filled jugs to create frightening, distorted reflections.

*Most methods apply to all rabbit and hare species.*

---

**Introduction**

Rabbits mean different things to different people. For hunters, the cottontail rabbit is an abundant, sporting, and tasty game animal. However, vegetable and flower gardeners, farmers, and homeowners who are suffering damage may have very little to say in favor of cottontails. They can do considerable damage to flowers, vegetables, trees, and shrubs any time of the year and in places ranging from suburban yards to rural fields and tree plantations. Control is often necessary to reduce damage, but complete extermination is not necessary, desirable, or even possible.

Rabbits usually can be accepted as interesting additions to the backyard or rural landscape if control techniques are applied correctly. Under some unusual circumstances, control of damage may be difficult.
Damage control methods include removal by live trapping or hunting, exclusion, and chemical repellents. In general, no toxicants or fumigants are registered for rabbit control; however, state regulations may vary. Frightening devices may provide a sense of security for the property owner, but they rarely diminish rabbit damage.

Identification

There are 13 species of cottontail rabbits (genus *Sylvilagus*), nine of which are found in various sections of North America north of Mexico. All nine are similar in general appearance and behavior, but differ in size, range, and habitat. Such differences result in a wide variation of damage problems, or lack of problems. The pygmy rabbit (*S. idahoensis*), found in the Pacific Northwest, weighs only 1 pound (0.4 kg), while the swamp rabbit (*S. aquaticus*), found in the southeastern states as far north as southern Illinois, may weigh up to 5 pounds (2.3 kg). Most species prefer open, brushy, or cultivated areas but some frequent marshes, swamps, or deserts. The swamp rabbit and the marsh rabbit (*S. palustris*) are strong swimmers. The eastern cottontail (*S. floridanus*) is the most abundant and widespread species. For the purposes of the discussion here about damage control and biology, the eastern cottontail (Fig. 1) will be considered representative of the genus. Cottontail rabbits must be distinguished from jackrabbits and other hares, which are generally larger in size and have longer ears. Jackrabbits are discussed in another chapter of this book.

The eastern cottontail rabbit is approximately 15 to 19 inches (37 to 48 cm) in length and weighs 2 to 4 pounds (0.9 to 1.8 kg). Males and females are basically the same size and color. Cottontails appear gray or brownish gray in the field. Closer examination reveals a grizzled blend of white, gray, brown, and black guard hairs over a soft grayish or brownish underfur, with a characteristic rusty brown spot on the nape of the neck. Rabbits molt twice each year, but remain the same general color. They have large ears, though smaller than those of jackrabbits, and the hind feet are much larger than the forefeet. The tail is short and white on the undersurface, and its similarity to a cotton ball resulted in the rabbit’s common name.

Range

The eastern cottontail’s range includes the entire United States east of the Rocky Mountains and introductions further west. It extends from southern New England along the Canadian border west to eastern Montana and south into Mexico and South America (Fig. 2). The most common species of the western United States include the desert cottontail (*S. auduboni*, Fig. 3), and mountain cottontail (*S. muttalli*, Fig. 4). Refer to a field guide or suggested readings if other species of the genus *Sylvilagus* are of interest.

Habitat

Cottontails do not distribute themselves evenly across the landscape. They tend to concentrate in favorable habitat such as brushy fence rows or field edges, gullies filled with debris, brush piles, or landscaped backyards where food and cover are suitable. They are rarely found in dense forests or open grasslands, but fallow crop fields, such as those in the Conservation Reserve Program, may provide suitable habitat.

Cottontails generally spend their entire lives in an area of 10 acres or less. Occasionally they may move a mile or so from summer range to winter cover or to a new food supply. Lack of food or cover is usually the motivation for a rabbit to relocate. In suburban areas, rabbits are numerous and mobile enough to fill any “empty” habitat created when other rabbits are removed. Population density varies with habitat quality, but one rabbit per acre is a reasonable average.

Contrary to popular belief, cottontails do not dig their own burrows, as the European rabbit does. Cottontails use natural cavities or burrows excavated by woodchucks or other animals. Underground dens are used primarily in extremely cold or wet weather and to escape pursuit. Brush piles and other areas of cover are often adequate alternatives to burrows.
Food Habits, Damage, and Damage Identification

The appetite of a rabbit can cause problems every season of the year. Rabbits eat flowers and vegetables in spring and summer. In fall and winter, they damage and kill valuable woody plants.

Rabbits will devour a wide variety of flowers. The one most commonly damaged is the tulip; they especially like the first shoots that appear in early spring.

The proverbial carrot certainly is not the only vegetable that cottontails eat. Anyone who has had a row of peas, beans, or beets pruned to ground level knows how rabbits like these plants. Only a few crops—corn, squash, cucumbers, tomatoes, potatoes, and some peppers—seem to be immune from rabbit problems.

Equally annoying, and much more serious, is the damage rabbits do to woody plants by gnawing bark or clipping off branches, stems, and buds. In winter in northern states, when the ground is covered with snow for long periods, rabbits often severely damage expensive home landscape plants, orchards, forest plantations, and park trees and shrubs. Some young plants are clipped off at snow height, and large trees and shrubs may be completely girdled. When the latter happens, only sprouting from beneath the damage or a delicate bridge graft around the damage will save the plant.

A rabbit’s tastes in food can vary considerably by region and season. In general, cottontails seem to prefer plants of the rose family. Apple trees, black and red raspberries, and blackberries are the most frequently damaged food-producing woody plants, although cherry, plum, and nut trees are also damaged.

Among shade and ornamental trees, the hardest hit are mountain ash, basswood, red maple, sugar maple, honey locust, ironwood, red and white oak, and willow. Sumac, rose, Japanese barberry, dogwood, and some woody members of the pea family are among the shrubs damaged.

Evergreens seem to be more susceptible to rabbit damage in some areas than in others. Young trees may be clipped off, and older trees may be deformed or killed.

The character of the bark on woody plants also influences rabbit browsing. Most young trees have smooth, thin bark with green food material just beneath it. Such bark provides an easy-to-get food source for rabbits. The thick, rough bark of older trees often discourages gnawing. Even on the same plant, rabbits avoid the rough bark but girdle the young sprouts that have smooth bark.

Rabbit damage can be identified by the characteristic appearance of gnawing on older woody growth and the clean-cut, angled clipping of young stems. Distinctive round droppings in the immediate area are a good sign of their presence too.

Rabbit damage rarely reaches economic significance in commercial fields or plantations, but there are exceptions. For example, marsh rabbits have been implicated in sugarcane damage in Florida. Growers should always be alert to the potential problems caused by locally high rabbit populations.

Legal Status

In most states, rabbits are classified as game animals and are protected as such at all times except during the legal hunting season. Some state regulations may grant exceptions to property owners, allowing them to trap or shoot rabbits outside the normal hunting season on their own property.

Damage Prevention and Control Methods

Exclusion

One of the best ways to protect a backyard garden or berry patch is to put up a fence. It does not have to be tall or especially sturdy. A fence of 2-foot (60-cm) chicken wire with the bottom tight
rabbits are abundant and food is in short supply, only hardware cloth will guarantee protection. Small mesh (1/4-inch [0.6-cm]) hardware cloth also protects against mouse damage. A dome or cage of chicken wire secured over a small flower bed will allow vulnerable plants such as tulips to get a good start before they are left unprotected.

**Habitat Modification**

One form of natural control is manipulation of the rabbits’ habitat. Although frequently overlooked, removing brush piles, weed patches, dumps, stone piles, and other debris where rabbits live and hide can be an excellent way to manage rabbits. It is especially effective in suburban areas where fewer suitable habitats are likely to be available. Vegetation control along ditch banks or fence rows will eliminate rabbit habitat in agricultural settings but is likely to have detrimental effects on other species such as pheasants. Always weigh the consequences before carrying out any form of habitat management.

**Repellents**

Several chemical repellents discourage rabbit browsing. Always follow exactly the directions for application on the container. Remember that some repellents are poisonous and require safe storage and use. For best results, use repellents and other damage control methods at the first sign of damage.

Most repellents can be applied, like paint, with a brush or sprayer. Many commercially available repellents contain the fungicide thiram and can be purchased in a ready-to-use form (see **Supplies and Materials**).

Some formerly recommended repellents are no longer available. Most repellents are not designed to be used on plants or plant parts destined for human consumption. Most rabbit repellents are contact or taste repellents that render the treated plant parts distasteful. Mothballs are an example of an area or odor repellent that repels by creating a noxious odor around the plants to be protected. Taste repellents protect only the parts of the plant they contact; new growth that emerges after application is not protected. Heavy rains may necessitate reapplication of some repellents.

Mothballs or dried blood meal sometimes keeps rabbits from damaging small flower beds or garden plots. Place these substances among the plants. Blood meal does not weather well, however.

Taste repellents are usually more effective than odor repellents. The degree of efficacy, however, is highly variable, depending on the behavior and number of rabbits, and alternative foods available. When rabbits are abundant and hungry, use other control techniques along with chemical repellents.

**Toxicants**

There are no toxicants or fumigants registered for use against rabbits. Poisoning rabbits is not recommended. Since state pesticide registrations vary, check with your local Cooperative Extension Service or USDA-APHIS-ADC office for information on repellents or other new products available for use in your area.

**Trapping**

Trapping is the best way to remove rabbits in cities, parks, and suburban areas. The first step is to get a well-built and well-designed live trap. Several excellent styles of commercial live traps are available from garden centers, hardware stores, and seed catalogs. Most commercial traps are wire and last indefinitely with proper care. Average cost is about $20 to $30. Live traps can often be rented from animal control offices or pest control companies.

An effective wooden box trap (Fig. 6) can be made. This type of trap has proven itself in the field and has been used in rabbit research by biologists. For best results, follow the plan to the letter because each detail has been carefully worked out.

Place traps where you know rabbits feed or rest. Keep traps near cover so

---

**Fig. 5. A cylinder of hardware cloth or other wire mesh can protect trees from rabbit damage.**
that rabbits won’t have to cross large open areas to get to them. In winter, face traps away from prevailing winds to keep snow and dry leaves from plugging the entrance or interfering with the door. Check traps daily to replenish bait or remove the catch—daily checks are essential for effective control and for humane treatment of the animals. Move traps if they fail to make a catch within a week.

Finding bait is not a problem, even in winter, because cob corn (dry ear corn) or dried apples make very good bait. Impale the bait on the nail or simply position it at the rear of the trap (commercial traps may not have a nail). When using cob corn, use half a cob and push the nail into the pith of the cob; this keeps the cob off the floor and visible from the open door. Dried leafy alfalfa and clover are also good cold-weather baits.

Apples, carrots, cabbage, and other fresh green vegetables are good baits in warmer weather or climates. These soft baits become mushy and ineffective once frozen. A good summer bait for garden traps is a cabbage leaf rolled tightly and held together by a toothpick. For best results, use baits that are similar to what the target rabbits are feeding on.

A commercial wire trap can be made more effective (especially in winter) by covering it with canvas or some other dark material. Be sure the cover does not interfere with the trap’s mechanism.

Release rabbits in rural areas several miles from where they have been trapped if local regulations allow relocation. Do not release them where they may create a problem for someone else.

**Shooting**

Shooting is a quick, easy, and effective method of control, but make sure that local firearms laws allow it and that it is done safely. In some states, the owner or occupant of a parcel of land may hunt rabbits all year on that land, except for a short time before the firearm deer season. Consult your state wildlife agency for regulations. You must be persistent if shooting is the only technique you rely on. Removing rabbits in one year never guarantees that the rabbit population will be low the next year (this is also true for trapping).

**Other Methods**

Encouraging the rabbit’s natural enemies—or at least not interfering with them—may aid in reducing rabbit damage. Hawks, owls, foxes,
mink, weasels, and snakes all help the farmer, gardener, homeowner, and forester control rabbits. These animals should never be needlessly destroyed. In fact, it is against the law to kill hawks and owls; foxes, mink, and weasels are protected during certain seasons as valuable furbearers. Even the family cat can be a very effective predator on young nestling rabbits, but cats are likely to kill other wildlife as well.

Many people have a favorite rabbit remedy. A piece of rubber hose on the ground may look enough like a snake to scare rabbits away. Another remedy calls for placing large, clear glass jars of water in a garden. Supposedly, rabbits are terrified by their distorted reflections. Most home remedies, unfortunately, are not very effective. Inflatable owls and snakes, eyespot balloons, and other commercial products are readily available in garden centers and through mail order catalogues. Feeding rabbits during the winter in much the same way as feeding wild birds might divert their attention from trees and shrubs and thus reduce damage in some areas. There is always the risk that this tactic can backfire by drawing in greater numbers of rabbits or increasing the survival of those present.

Acknowledgments

I thank R. A. McCabe for reviewing this manuscript and providing the trap design.

Figure 1 from Schwartz and Schwartz (1981).

Figures 2 and 3 adapted from Burt and Grossenheider (1976) by Dave Thornhill, University of Nebraska-Lincoln.

Figures 4 and 5 courtesy of the Department of Agricultural Journalism, University of Wisconsin-Madison.

For Additional Information


Editors

Scott E. Hygnstrom
Robert M. Timm
Gary E. Larson
JACKRABBITS AND OTHER HARES

Fig. 1. Blacktail jackrabbit, *Lepus californicus* (left); whitetail jackrabbits, *L. townsendii* (middle); showshoe hare, *L. americanus* (right).

**Damage Prevention and Control Methods**

**Exclusion**
Fencing.
Tree trunk guards.

**Cultural Methods**
Manipulation of habitat.
Planting of less desirable crops.

**Frightening**
Guard dogs.

**Repellents**
Ammonium soaps, capsaicin, naphthalene, thiram, tobacco dust, ziram.

**Toxicants**
Anticoagulants (where registered).

**Fumigants**
None are registered.

**Trapping**
Body-gripping and leghold traps.
Box traps.

**Shooting**
Spotlighting and day shooting are effective where legal.
Hunting.

**Other Methods**
Predators.

---

PREVENTION AND CONTROL OF WILDLIFE DAMAGE — 1994

Cooperative Extension Division
Institute of Agriculture and Natural Resources
University of Nebraska - Lincoln
United States Department of Agriculture
Animal and Plant Health Inspection Service
Animal Damage Control
Great Plains Agricultural Council
Wildlife Committee
Identification

Three major species of jackrabbits occur in North America (Fig. 1). These hares are of the genus *Lepus* and are represented primarily by the blacktail jackrabbit, the whitetail jackrabbit, and the snowshoe hare. Other members of this genus include the antelope jackrabbit and the European hare. Hares have large, long ears, long legs, and a larger body size than rabbits.

The whitetail jackrabbit is the largest hare in the Great Plains, having a head and body length of 18 to 22 inches (46 to 56 cm) and weighing 5 to 10 pounds (2.2 to 4.5 kg). It is brownish gray in summer and white or pale gray in winter. The entire tail is white. The blacktail jackrabbit, somewhat smaller than its northern cousin, weighs only 3 to 7 pounds (1.3 to 3.1 kg) and is 17 to 21 inches (43 to 53 cm) long. It has a grayish-brown body, large black-tipped ears, and a black streak on the top of its tail. The snowshoe hare is 13 to 18 inches (33 to 46 cm) long and weighs 2 to 4 pounds (0.9 to 1.8 kg). It has larger feet than the whitetail and blacktail jackrabbits. The snowshoe turns white in winter and is a dark brown during the summer. Its ears are smaller than those of the other hares.

Range

The whitetail jackrabbit is found mainly in the north central and northwestern United States and no further south than the extreme north central part of New Mexico and southern Kansas (Fig. 2a). The blacktail jackrabbit is found mainly in the southwestern United States and the southern Great Plains, and no further north than central South Dakota and southern Washington (Fig. 2b). Snowshoe hares occupy the northern regions of North America, including Canada, Alaska, the northern continental United States, and the higher elevations as far south as New Mexico (Fig. 2c). Antelope jackrabbits are found only in southern Arizona, New Mexico, and western Mexico. The European hare is found only in southern Quebec, New York, and other New England states.

General Biology, Reproduction, and Behavior

Members of the genus *Lepus* are born well-furred and able to move about. Little or no nest is prepared, although the young are kept hidden for 3 to 4 days. Females may produce up to 4 litters per year with 2 to 8 young per litter. Reproductive rates may vary from year to year depending on environmental conditions.

Damage

Hares consume 1/2 to 1 pound (1.1 to 2.2 kg) of green vegetation each day. Significant damage occurs when hare concentrations are attracted to orchards, gardens, ornamentals, or other agricultural crops. High jackrabbit populations can also damage range vegetation.

Most damage to gardens, landscapes, or agricultural crops occurs in areas adjacent to swamps or rangeland normally used by hares. Damage may be temporary and usually occurs when natural vegetation is dry. Green vegetation may be severely damaged during these dry periods.

Orchards and ornamental trees and shrubs are usually damaged by overbrowsing, girdling, and stripping of bark, especially by snowshoe hares. This type of damage is most common during winter in northern areas.

Rangeland overbrowsing and overgrazing can occur any time jackrabbit numbers are high. Eight jackrabbits are estimated to eat as much as one sheep, and 41 jackrabbits as much as one cow.
Estimates of jackrabbit populations run as high as 400 jackrabbits per square mile (154/km) extending over several hundred square miles. Range damage can be severe in such situations, especially where vegetation productivity is low.

**Legal Status**

Jackrabbits are considered nongame animals in most states and are not protected by state game laws. A few states protect jackrabbits through regulations. Most states in which snowshoe hares occur have some regulations protecting them. Consult local wildlife agencies to determine the legal status of the species before applying controls.

**Damage Prevention and Control Methods**

**Exclusion**

**Fencing.** Exclusion is most often accomplished by the construction of fences and gates around the area to be protected. Woven wire or poultry netting should exclude all hares from the area to be protected. To be effective, use wire mesh of less than 1 1/2 inches (3.8 cm), 30 to 36 inches (76 to 91 cm) high, with at least the bottom 6 inches (15 cm) buried below ground level. Regular poultry netting made of 20-gauge wire can provide protection for 5 to 7 years or more. Although the initial cost of fences appears high—about $1,000 per mile ($625/km)—they are economically feasible for protecting high-value crops and provide year-round protection on farms with a history of jackrabbit problems. Remember to spread the initial cost over the expected life of the fence when comparing fencing with other methods. Exclusion by fencing is desirable for small areas of high-value crops such as gardens, but is usually impractical and too expensive for larger acres of farmland.

Electric fencing has been found to exclude jackrabbits. Six strands spaced 3 inches (7.6 cm) apart alternating hot and ground wires should provide a deterrent to most hares. Modern energizers and high-tensile wire will minimize cost and maximize effectiveness.

**Tree Trunk Guards.** The use of individual protectors to guard the trunks of young trees or vines may also be considered a form of exclusion. Among the best of these are cylinders made from woven wire netting. Twelve- to 18-inch-wide (30.5- to 45.7-cm) strips of 1-inch (2.5-cm) mesh poultry netting can be formed into cylinders around trees. Cylinders should be anchored with lath or steel rods and braced away from the trunk to prevent rabbits from pressing them against the trees and gnawing through them.

Types of tree protectors commercially available include aluminum, nylon mesh wrapping, and treated jute cardboard. Aluminum foil, or even ordinary sacking, has been wrapped and tied around trees with effective results.

Wrapping the bases of hay stacks with 3-foot-high (0.9-m) poultry netting provides excellent protection.

**Cultural Methods**

**Habitat Manipulation.** In areas where jackrabbit or hare damage is likely to occur, highly preferred crops such as alfalfa, young cotton plants, lettuce, and young grape vines are usually most damaged. Crops with large mature plants, such as corn, usually are not damaged once they grow beyond the seedling stage. Where possible, avoid planting vulnerable crops near historically high hare populations.

Overuse of range forage can sometimes lead to high jackrabbit numbers. Jackrabbits are least abundant where grass grows best within their range. Like many rodents, they prefer open country with high visibility to areas where the grass prevents them from seeing far. Thus, control programs accompanied by changes in grazing practices that encourage more vegetative growth may be necessary for long-term relief.

**Frightening**

**Guard Dogs.** Dogs can be chained along boundaries of crop fields or near gardens to deter jackrabbits.
Sprays. Thoroughly cover the upper surfaces of the leaves with spray repellent. If a sprayer is unavailable and only a small number of plants are involved, a small number of plants are involved, a whisk broom or brush can be used to apply the repellent to the plant foliage. The repellents will adhere to the foliage for a longer period if a latex-type adhesive is used. Reapply liquid repellents after a heavy rain and at 10-day intervals to make certain new plant growth is protected.

Some repellents are not registered for application to leaves, stems, or fruits of plants to be harvested for human use. A list of registered commercial repellents can be found in Supplies and Materials. Many of these may be purchased at a reasonable cost from suppliers handling seed, insecticides, hardware, and farm equipment.

Commercial repellents containing thiram are effective and can be applied safely to trees and shrubs. Treat all stems and low branches to a point higher than rabbits can reach while standing on top of the estimated snow cover. One application made during a warm, dry day in late fall should suffice for the entire dormant season.

Coal tar, pine tar, tar paper, and oils have caused damage to young trees under certain conditions. Carbolic acid and other volatile compounds have proved effective for only short periods. For further information on repellents and their availability, see Supplies and Materials.

Toxicants

Since state pesticide registrations vary, check with your local Cooperative Extension or USDA-APHIS-ADC office for information on toxicants legal in your area. Be sure to read the entire label. Use strictly in accordance with precautionary statements and directions. State and federal regulations also apply.

Anticoagulants. In areas where they are legal, anticoagulant baits may be used to control jackrabbits. Varying degrees of success have been reported with diphacinone, warfarin, brodifacoum, and bromadiolone. Anticoagulants control jackrabbits and hares by reducing the clotting ability of the blood and by causing damage to the capillary blood vessels. Death is caused only if the treated bait is consumed in sufficient quantities for several days. A single feeding on anticoagulant baits will not control jackrabbits. Brodifacoum and bromadiolone may be exceptions, but they are not yet registered for use on jackrabbits. Bait must be eaten at several feedings on 5 or more successive days with no periods longer than 48 hours between feedings.

When baiting with anticoagulants, use covered self-dispensing feeders or nursery flats to facilitate bait consumption and prevent spillage. Secure feeding stations so that they cannot be turned over. Place 1 to 5 pounds (0.5 to 2.5 kg) of bait in a covered self-dispensing feeder or nursery flat in runways, resting, or feeding areas that are frequented by jackrabbits. Inspect bait stations daily and add bait as needed. Acceptance may not occur until rabbits become accustomed to the feeder stations or nursery flats, which may take several days. When bait in the feeder is entirely consumed overnight, increase the amount. It may be necessary to move feeders to different locations to achieve bait acceptance. Bait should be available until all feeding ceases, which may take from 1 to 4 weeks. Replace moldy or old bait with fresh bait. Pick up and dispose of baits upon completion of control programs. Dispose of poisoned rabbit carcasses by deep burying or burning.

Fumigants

There are no fumigants registered for jackrabbits.

Trapping

Trapping with box-type traps is not effective because jackrabbits are reluctant to enter a trap or dark enclosure. Snowshoe hares are susceptible to box-type traps.

Body-gripping and leghold traps can be placed in rabbit runways. Trapping in runways may result in unacceptable nontarget catches. Check for tracks in snow or dirt surfaces to be sure only target animals are present. Placement of sticks 1 foot (0.3 m) above the trap will encourage deer and other large animals to step over the trap while allowing access to jackrabbits or other hares. Be sure to check with local wildlife officials on the legality of trapping hares and jackrabbits.

Shooting

Where safe and legal to do so, shooting jackrabbits may suppress or eliminate damage. Effective control may be achieved using a spotlight and a shooter in the open bed of a pickup truck. Driving around borders of crop fields or within damaged range areas and carefully shooting jackrabbits can remove a high percentage of the population. Some states require permits to shoot from vehicles or to use spotlights.

In some states sport hunting of jackrabbits can be encouraged and may keep populations below problem levels.

Other Methods

Predators. Natural enemies of jackrabbits include hawks, owls, eagles, coyotes, bobcats, foxes, and weasels. Control of these predators should occur only after taking into account their beneficial effect on the reduction of jackrabbit populations.

Economics of Damage and Control

Jackrabbits consume considerable vegetation. In cases where their overuse of natural forage results in the reduction of livestock on rangeland, control measures may need to be implemented. Few studies have been conducted on the cost-effectiveness of jackrabbit control on rangelands. Damage must be extreme to justify expenditures for control programs. In most cases, cultural controls and natural mortality will suffice to keep jackrabbit populations in check.

Economic loss on croplands is much easier to measure. In areas with historic jackrabbit or hare damage, farmers should anticipate problems and...
have materials available to use at the first sign of damage. During dry times of the year or times of natural food shortages, preventive measures such as shooting and exclusion may be considered a part of regular operations. Jackrabbits and other hares can be deterred most easily if control measures are implemented before the hares become accustomed to or dependent on crops.

Acknowledgments

Figure 1 of the snowshoe hare by Clint E. Chapman, University of Nebraska.

Figure 2 adapted by David Thornhill, from Burt and Grossenheider (1976).

For Additional Information


Editors

Scott E. Hygnstrom
Robert M. Timm
Gary E. Larson
**SHREWS**

Fig. 1. A masked shrew, *Sorex cinereus*

---

**Damage Prevention and Control Methods**

**Exclusion**

Rodent-proof structures also exclude shrews.

**Cultural Methods**

Mowing may decrease preferred habitat and food.

**Repellents**

None are registered.

**Toxicants**

None are registered.

**Fumigants**

None are registered.

**Trapping**

Mouse trap (snap trap).

Small box trap.

Pit trap.

**Shooting**

Not practical.

**Other Methods**

Cats may reduce densities around structures. Owls consume large numbers of shrews. Mowed grass around structures may increase predation.

---

**Identification**

The shrew is a small, mouse-sized mammal with an elongated snout, a dense fur of uniform color, small eyes, and five clawed toes on each foot (Fig. 1). Its skull, compared to that of rodents, is long, narrow, and lacks the zygomatic arch on the lateral side characteristic of rodents. The teeth are small, sharp, and commonly dark-tipped. Pigmentation on the tips of the teeth is caused by deposition of iron in the outer enamel. This deposition may increase the teeth’s resistance to wear, an obvious advantage for permanent teeth that do not continue to grow in response to wear. The house shrew (*Suncus murinus*) lacks the pigmented teeth. Shrew feces are often corkscrew-shaped, and some shrews (for
example, the desert shrew (Notiosorex crawfordi) use regular defecation stations. Albino shrews occur occasionally. Shrews are similar to mice except that mice have four toes on their front feet, larger eyes, bicolor fur, and lack an elongated snout. Moles also are similar to shrews, but are usually larger and have enlarged front feet. Both shrews and moles are insectivores, whereas mice are rodents.

Worldwide, over 250 species of shrews are recognized, with over 30 species recognized in the United States, the US Territories, and Canada (Table 1). Specific identification of shrews may be difficult. Taxonomists are still refining the phylogenetic relationships between populations of shrews. Consult a regional reference book on mammals, or seek assistance from a qualified mammalogist.

**Range**

Shrews are broadly distributed throughout the world and North America. For specific range information, refer to one of the many references available on mammal distribution for your region. Publications by Burt and Grossenheider (1976), Hall (1981), and Junge and Hoffmann (1981) are particularly helpful.

**Habitat**

Shrews vary widely in habitat preferences throughout North America. Shrews exist in practically all terrestrial habitats, from montane or boreal regions to arid areas. The northern water shrew (Sorex palustris) prefers marshy or semiaquatic areas. Regional reference books will help identify specific habitats. A word of caution is in order, however. Distribution studies based on the results of snap-trapping research have a pronounced tendency to underestimate the abundance of shrews. Studies using pit traps are more successful in assessing the presence or absence of shrews in a particular location.

**Food Habits**

Shrews are in the taxonomic order Insectivora. As the name implies, insects make up a large portion of the typical shrew diet. Food habit studies have revealed that shrews eat beetles, grasshoppers, butterfly and moth larvae, ichneumonid wasps, crickets, spiders, snails, earthworms, slugs, centipedes, and millipedes. Shrews also eat small birds, mice, small snakes, and even other shrews when the opportunity presents itself. Seeds, roots, and other vegetable matter are also eaten by some species of shrews.

**General Biology, Reproduction, and Behavior**

Shrews are among the world’s smallest mammals. The pigmy shrew (Sorex hoyi) is the smallest North American mammal. It can weigh as little as 0.1 ounce (2 g). Because of their small size, shrews have a proportionally high surface-to-volume ratio and lose body heat rapidly. Thus, to maintain a constant body temperature, they have a high metabolic rate and need to consume food as often as every 3 to 4 hours. Some shrews will consume three times their body weight in food over a 24-hour period.

Shrews usually do not live longer than 1 to 2 years, but they have 1 to 3 litters per year with 2 to 10 young per litter. Specific demographic features vary with the species. The gestation period is approximately 21 days.

Shrews have an acute sense of touch, hearing, and smell, with vision playing a relatively minor role. Some species of shrews use a series of high-pitched squeaks for echolocation, much as bats do. However, shrews probably use echolocation more for investigating their habitat than for searching out food. Glands located on the hindquarters of shrews have a pungent odor and probably function as sexual attractants. Blarina brevicauda, and presumably B. carolinensis and B. hylophaga (the short-tailed shrews), have a toxic venom in their saliva that may help them subdue small prey.

Some shrews are mostly nocturnal; others are active throughout the day and night. They frequently use the tunnels made by voles and moles. During periods of occasional abundance, shrews may have a strong, although temporary, negative impact on mouse or insect populations. Many predators kill shrews, but few actually eat them. Owls in particular consume large numbers of shrews.

Some shrews exhibit territorial behavior. Depending on the species and the habitat, shrews range in density from 2 to 70 individuals per acre (1 to 30/hectare) in North America.

**Damage**

Most species of shrews do not have significant negative impacts and are not abundant enough to be considered pests (Schmidt 1984). Shrews sometimes conflict with humans, however. The vagrant shrew (Sorex vagrans) has been reported to consume the seeds of Douglas-fir (Pseudotsuga menziesii), although the seeds constitute a minor part of the diet. The masked shrew (Sorex cinereus) destroyed from 0.3% to 10.5% of white spruce (Picea glauca) seeds marked over a 6-year period (Radvanyi 1970). Lodgepole pine (Pinus contorta) seeds are also eaten by the masked shrew. Radvanyi (1966, 1971) has published pictures of shrew, mouse (Peromyscus, Microtus, and Clethrionomys spp.), and chipmunk (Eutamias spp.) damage to lodgepole pine seeds, and describes shrew damage to white spruce seeds.

The northern water shrew (Sorex palustris) may cause local damage by consuming eggs or small fish at hatcheries. The least shrew (Cryptotis parva), also known as the bee shrew, sometimes enters hives and destroys the young brood (Jackson 1961). The northern short-tailed shrew (Blarina brevicauda) has been reported to damage ginseng (Panax spp.) roots. Short-tailed and masked shrews reportedly can climb trees where they can feed on...
Legal Status

Shrews are not protected by federal laws, with one exception. The southeastern shrew (*Sorex longirostris fischeri*) is protected in the Great Dismal Swamp in Virginia and North Carolina by the Endangered Species Act of 1973. Nowak and Paradiso (1983:131) list the following additional species or populations of concern: *Sorex preblei*, *Sorex trigonoirostri*, and *Sorex merriami* in Oregon; *Sorex trigonoirostri eionis* in Florida along the Homossassee River; and *Sorex palustris punctulatus* in the southern Appalachians.

Some states may have special regulations regarding the collection or killing of nongame mammals. Consult your local wildlife agency or Cooperative Extension office for up-to-date information.

Damage Prevention and Control Methods

Exclusion

Rodent-proofing will also exclude shrews from entering structures. Place hardware cloth of 1/4-inch (0.6-cm) mesh over potential entrances to exclude shrews. The pygmy shrew (*Sorex hoyi*) may require a smaller mesh. Coarse steel wool placed in small openings can also exclude shrews.

Cultural Methods

Regular mowing around structures should decrease preferred habitat and food, and may increase predation. Where shrews are eating tree seeds, plant seedlings instead to eliminate damage.

Repellents

No repellents are registered for use against shrews.

Toxicants

No toxicants are registered to poison shrews.

Table 1. Shrews of the United States, the US Territories, and Canada (from Banks et al. 1987, and Jones et al. 1992).

<table>
<thead>
<tr>
<th>Scientific name</th>
<th>Common name</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Blarina brevicauda</em></td>
<td>Northern short-tailed shrew</td>
</tr>
<tr>
<td><em>Blarina carolinensis</em></td>
<td>Southern short-tailed shrew</td>
</tr>
<tr>
<td><em>Blarina hylophaga</em></td>
<td>Elliot’s short-tailed shrew</td>
</tr>
<tr>
<td><em>Cryptotis parva</em></td>
<td>Least shrew</td>
</tr>
<tr>
<td><em>Notiosorex crawfordi</em></td>
<td>Desert shrew</td>
</tr>
<tr>
<td><em>Sorex alaskanus</em></td>
<td>Glacier Bay water shrew</td>
</tr>
<tr>
<td><em>Sorex arcticus</em></td>
<td>Arctic shrew</td>
</tr>
<tr>
<td><em>Sorex arizonae</em></td>
<td>Arizona shrew</td>
</tr>
<tr>
<td><em>Sorex bairdii</em></td>
<td>Baird’s shrew</td>
</tr>
<tr>
<td><em>Sorex bendirii</em></td>
<td>Pacific water or Marsh shrew</td>
</tr>
<tr>
<td><em>Sorex cinereus</em></td>
<td>Cinereus or Masked shrew</td>
</tr>
<tr>
<td><em>Sorex dispar</em></td>
<td>Long-tailed or Rock shrew</td>
</tr>
<tr>
<td><em>Sorex fontinalis</em></td>
<td>Maryland or Eastern shrew</td>
</tr>
<tr>
<td><em>Sorex fumeus</em></td>
<td>Smokey shrew</td>
</tr>
<tr>
<td><em>Sorex gaspensis</em></td>
<td>Gaspe shrew</td>
</tr>
<tr>
<td><em>Sorex haydeni</em></td>
<td>Hayden’s shrew</td>
</tr>
<tr>
<td><em>Sorex (Microsorex) hoyi</em></td>
<td>Pygmy shrew</td>
</tr>
<tr>
<td><em>Sorex hydrodromus</em></td>
<td>Pribilof Island shrew</td>
</tr>
<tr>
<td><em>Sorex jacksoni</em></td>
<td>St. Lawrence Island shrew</td>
</tr>
<tr>
<td><em>Sorex longirostris</em></td>
<td>Southeastern shrew</td>
</tr>
<tr>
<td><em>Sorex lyelli</em></td>
<td>Mt. Lyell shrew</td>
</tr>
<tr>
<td><em>Sorex merriami</em></td>
<td>Merriam’s shrew</td>
</tr>
<tr>
<td><em>Sorex monticolus</em></td>
<td>Montane or Dusky shrew</td>
</tr>
<tr>
<td><em>Sorex nanus</em></td>
<td>Dwarf shrew</td>
</tr>
<tr>
<td><em>Sorex ornatus</em></td>
<td>Ornate shrew</td>
</tr>
<tr>
<td><em>Sorex pacificus</em></td>
<td>Pacific shrew</td>
</tr>
<tr>
<td><em>Sorex palustris</em></td>
<td>Northern water shrew</td>
</tr>
<tr>
<td><em>Sorex preblei</em></td>
<td>Preble’s shrew</td>
</tr>
<tr>
<td><em>Sorex sonomae</em></td>
<td>Fog shrew</td>
</tr>
<tr>
<td><em>Sorex tenellus</em></td>
<td>Inyo shrew</td>
</tr>
<tr>
<td><em>Sorex trowbridgi</em></td>
<td>Trowbridge’s shrew</td>
</tr>
<tr>
<td><em>Sorex tundrensis</em></td>
<td>Tundra shrew</td>
</tr>
<tr>
<td><em>Sorex ugyunak</em></td>
<td>Barren ground shrew</td>
</tr>
<tr>
<td><em>Sorex vagrans</em></td>
<td>Vagrant shrew</td>
</tr>
<tr>
<td><em>Suncus murinus</em></td>
<td>House shrew</td>
</tr>
</tbody>
</table>

eggs or young birds in a nest or consume suet in bird feeders.

The pugnacious nature of shrews sometimes makes them a nuisance when they live in or near dwellings. Shrews occasionally fall into window wells, attack pets, attack birds or chipmunks at feeders, feed on stored foods, contaminate stored foods with feces and urine, and bite humans when improperly handled. Potential exists for the transmission of diseases and parasites, but this is poorly documented.

The house shrew (*Suncus murinus*) is an introduced species to Guam. It has been reported as a host for the rat flea (*Xenopsylla cheopis*) which can carry the plague bacillus (*Yersinia pestis*) (Churchfield 1990). Compared to rat (*Rattus* spp.) numbers, however, house shrew numbers are usually low, and risk of plague transmission is probably minimal. The house shrew is accustomed to living around humans and houses, which increases its damage potential. It is considered smelly and noisy, making incessant, shrill, clattering sounds as it goes along (Churchfield 1990:149). On occasion it destroys stored grain products.
**Fumigants**

No fumigants are registered for use against shrews. It would be impractical to use fumigants because of the porous nature of typical shrew burrows.

**Trapping**

Mouse traps (snap traps), box traps, and pit traps have been used to collect shrews. Set mouse traps in runways or along walls, with the traps set at a right angle to the runway and the triggers placed over the runway (Fig. 2a). Small box traps can be set parallel to and inside of runways, or parallel to walls around structures (Fig. 2b). Bait the traps with a mixture of peanut butter and rolled oats. A small amount of bacon grease or hamburger may increase the attractiveness of the bait.

A pit trap consists of a gallon jar or a large can sunk into the ground under a runway until the lip of the container is level with the runway itself (Fig. 2c). Bait is not necessary. A small amount of bacon grease smeared around the top of the container may be an effective attractant, but this may also attract large scavengers. Pit traps are more effective for capturing shrews than snap traps, although the increased labor involved in setting a pit trap may not be justified when trying to capture only one or two animals. Monitor pit traps daily, preferably in the morning before the temperature gets hot, although Churchfield (1990) recommends checking traps four times in a 24-hour period. Place cotton wool in the pit trap containers to reduce the mortality of trapped animals. This is especially important to ensure the successful release of nontarget animals. Since shrews are generally beneficial in consuming insects, live-captured animals can be relocated in suitable habitat more than 200 yards (193 m) from the capture site.

The traps and placement procedures described above are also effective for catching mice. Note the identification characteristics given above for determining whether the captured animal is indeed a shrew. Sometimes birds are captured in traps set for shrews. If this

![Fig. 2. Traps and trap placement for capturing shrews: a) mouse trap (snap trap) set perpendicular to wall, with trigger next to wall; b) box trap set parallel to wall; c) pit trap sunk in ground over runway (includes cotton wool).](image)
occurs, try placing a cover over the traps, a cover over the bait, moving the traps to another location, or omitting rolled oats from the bait mixture.

**Shooting**

Shooting is not practical and is not recommended. It is illegal in some states and localities.

**Other Methods**

Owls may reduce local populations of shrews in poor habitats, but this has not been documented. Domestic cats appear to be very good predators of shrews, although they seldom eat them (presumably because of the shrew’s unpleasant odor). Cats may be effective at temporarily reducing localized shrew populations living in poor cover around structures. Cat owners may find dead, uneaten shrews brought inside the home. Rather than reduce the shrew population outside to prevent this, simply monitor locations regularly used by your cat, and dispose of dead shrews by placing a plastic bag over your hand, picking up the dead animal, turning the bag inside out while holding the shrew, sealing the bag, and discarding it with the garbage. Using a plastic bag in this manner reduces the potential for flea, tick, helminth parasite, or disease transmission.

**Economics of Damage and Control**

No studies concerning the economics of shrew damage and control are available. In Finland, shrews appear to play an important role as predators of conifer seeds than they do in North America. Overall, the economics of damage by shrews is not considered great.

**Folklore and Etymology**

Chambers (1979) reviewed some aspects of shrew biology and folklore: At one time in Europe it was thought that if a shrew ran across a farm animal that was lying down, the animal would suffer intense pain. To counteract this, a shrew would be walled up in an ash tree (a ‘shrew ash’), and then a twig taken from the tree would be brushed onto the suffering animal to relieve the pain. The ancient Egyptians believed the shrew to be the spirit of darkness. The shrew has also been mentioned as a Zuni beast god, providing protection for stored grains from raids by rats and mice (Hoffmeister 1967).

At least one tall tale involving shrews has been found to be true. The discovery that some shrews possess a toxic venom confirms stories about the poisonous bite of shrews.

The etymology of the word shrew is also interesting. The Old English form of the word was *screatau*, or shrew-mouse. The Middle English form was *shreave*, meaning an evil or scolding person. Thus shrew has a double meaning. It defines the small mammal as well as an ill-tempered, scolding human (usually female).

Shrews are in the family Soricidae. *Soricis* is the genitive form of *sorex*, a Latin word for shrew-mouse.

**Acknowledgments**

I appreciate the assistance and comments of C. L. Shugart, S. E. Hygnstrom, and four anonymous reviewers while developing this manuscript. L. Thomas and J. Shepard provided up-to-date information on the legal status of *Sorex longirostris* *fischeri*.

Figure 1 is reproduced with permission from Schwartz and Schwartz (1981).

Figure 2 was drawn by Jill Sack Johnson.

**For Additional Information**


Editors

Scott E. Hygnstrom

Robert M. Timm

Gary E. Larson