Managing White-Tailed Deer in Suburban Environments

A Technical Guide

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About This Guide

Considerable confusion and controversy surround white-tailed deer management in suburban environments. Availability, efficacy, and humaneness of management options are often misunderstood. As a result, opinions and sentiments differ regarding the management of suburban deer populations. This booklet provides an overview of these complex issues and discusses the usefulness of various management options for resolving localized deer-human conflicts. The manual is intended for professional biologists and managers, community leaders, and others involved or concerned with suburban deer management.

Introduction

White-tailed deer (*Odocoileus virginianus*) are probably the best known and most widespread large mammal in North America. Recognized as a valuable natural resource, deer are a welcome sight until conflicts arise with homeowners, farmers, foresters, motorists, gardeners, or landscapers. Their adaptability, acute senses, and other physical attributes allow them to flourish in metropolitan suburbs as well as in the wilderness. Locally overabundant deer populations are becoming more prevalent, especially where they are not actively managed. This typically occurs in suburban communities or on corporate or protected government properties. The primary reasons for a lack of deer management in suburban communities include: (1) real or perceived safety concerns, (2) conflicting social attitudes and perceptions about wildlife, (3) hunting and firearm-discharge restrictions, and (4) liability or public relations concerns. Overabundance usually is a reflection of human values rather than biological thresholds. When deer numbers approach or exceed human tolerance levels (Decker and Purdy 1988), which leads to conflicts with human priorities, they may be considered overabundant (McCabe and McCabe 1997).

Biologists have conducted extensive research on deer and generally can recommend management practices to manipulate rural deer populations. The success of past management efforts, focused primarily on providing recreational hunting opportunity, is reflected in the current abundance of white-tailed deer (Brown et al. In press, Curtis et al. 2000b). At the turn of the twentieth century, deer numbers were low due to overharvest by market and subsistence hunters and loss of habitat (McCabe and McCabe 1984). Legal protection, regulated harvests, and human-induced changes in the landscape (e.g., high-intensity agriculture, forest protection, suburban development) boosted deer numbers to current levels. Without management intervention, small deer populations can increase rapidly (McCullough 1984) and may lead to problems that can be difficult to control.

As deer and human populations have increased, so have the number of deer-related conflicts. Expanding urban sprawl and suburban environments have created excellent deer habitat with an abundance of food and protection from hunters and nonhuman predators. Homeowners may consider it a nuisance when deer consume garden and landscape plantings (Figure 1). More importantly, an overabundance of deer may cause significant economic losses associated with decreased crops, vehicle collisions, or Lyme disease. Deer also affect forest ecology by feeding on preferred plants and altering the biodiversity in parks and natural woodlands. Human safety can be compromised because increases in deer-vehicle collisions are positively correlated with greater deer abundance (Blouch 1984, Etter et al. In press). For example from 1984 to 1994, as the deer population climbed in the community of Bellvue in Sarpy County, Nebraska, the number of deer-vehicle collisions in that county increased 325 percent (Hygnstrom and VerCauteren 1999). Conover et al. (1995) estimated that more than 1 million deer-vehicle collisions occur annually in the United States, and that annual vehicle repair costs from those accidents exceeded $1.1 billion. They further estimated that each year 29,000 human injuries and 211 human deaths occur as a result of deer-vehicle collisions. Although these numbers are low compared with other sources of human fatalities, they are of concern.

Figure 1. Browsing damage caused by repeated deer feeding on ornamental shrubs.

White-tailed deer also serve as a host for the black-legged tick (Figure 2), *Ixodes scapularis* or *Ixodes pacificus*, that serves as the primary vector for the bacteria *Borrelia burgdorferi* (Lyme disease), *Ehrlichia equi* (human granulocytic ehrlichiosis), and *Babesia microti* (human babesiosis). Lyme disease occurs primarily in the Northeast, Mid-Atlantic, upper midwestern states, and northwestern California. The diagnosis of Lyme disease has increased 25-fold since 1982, and in recent years there have been about 16,000 new cases annually (Centers for Disease Control and Prevention 1997, Dennis 1998). Lowering deer densities may reduce tick abundance (Daniels et al. 1993, Stafford 1993), however, this may not decrease the prevalence of Lyme disease (Wilson et al. 1985, 1988; Duffey et al. 1994; Conover 1997).

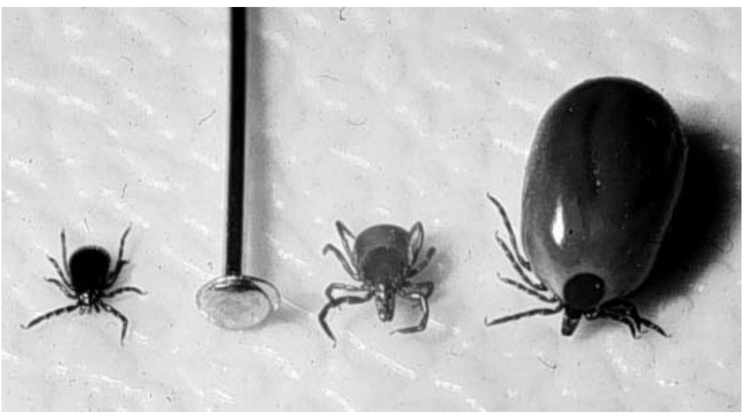

Figure 2. Male, female, and engorged black-legged ticks, with stick pin as reference.

Bovine tuberculosis, although historically rare in wildlife, has been found recently in wild deer. This bacterial disease attacks the respiratory system. Bovine tuberculosis has the potential to infect humans, livestock, and other wildlife and usually is transmitted from one individual to another through sneezing, coughing, or nose-to-nose contact (Schmitt et al. 1997). Bovine tuberculosis is more likely to be transmitted among overabundant deer, especially at feeding stations.

Another deer disease that may be increasing is chronic wasting disease. Though quite uncommon and found primarily in Colorado and Wyoming, chronic wasting disease also may be transmitted among animals at feeding stations (Spraker et al. 1997, Miller et al. 1998).

Agricultural producers have indicated that deer cause more damage than other wildlife species (Conover and Decker 1991, Conover 1994, Wywialowski 1994). Agricultural damage by deer was greatest in the northeastern and northcentral United States, with at least 41 percent of producers reporting damage (Wywialowski 1994). Conover (1997) conservatively estimated annual deer damage to agriculture at $100 million.

Figure 3. Overabundant deer remove vegetation to a height of approximately six feet, creating a browseline.

Wildlife biologists and foresters have been aware of the problems associated with deer overbrowsing (Figure 3) for many years (Leopold et al. 1947, Webb et al. 1956). Overabundant white-tailed deer have the potential to change the plant and animal composition of forest ecosystems (Tilghman 1989, deCalesta 1994, Healy 1997). Stromayer and Warren (1997) and Waller and Alverson (1997) provided excellent summaries of the ecological impacts of deer browsing. Deer can degrade forests and cause the reverse of plant succession, and persistent browsing by deer can lead to climax species of plants being replaced by midlevel and introduced species. Conover et al. (1995) used Marquis' (1981) figures to determine that deer may cause $367 million per year in damage to Pennsylvania's Allegheny hardwood forest.

Despite the magnitude of deer-related impacts, whitetails have a tremendous positive value to society. Many people enjoy observing deer, and as a big game animal, deer also have a high recreational value to hunters. Conover (1997) noted that in 1991 more than 10 million people hunted deer in the United States, and their travel and equipment expenditures totaled $5.1 billion. Adding $1.8 billion for the value of viewing and photography, Conover (1997) estimated that $7 billion was spent on deer-related recreation each year. Consequently, because both the positive and negative values associated with deer are very high, setting management goals can be very difficult.

As human and deer populations simultaneously have expanded and merged, dramatic increases in deer-related concerns have occurred. Extensive overlap in landscape use by people and deer has led to the enormous challenge of managing abundant deer populations in human-dominated environments, with a complex mix of human expectations, concerns, and values.

Biology of the White-Tailed Deer

Description and General Behavior

White-tailed deer are so named because when alarmed, they hold their tails erect, baring their white underside and rump. They also have a prominent white throat patch that complements their thin brown-red summer coat and thick grey-brown winter coat. Males (bucks) begin growing bone-like antlers early each spring, and by early fall the antlers stop growing and harden. Antlers are used for fighting and establishing rank in the social hierarchy. The antlers of white-tailed deer have a main beam with tines erupting from the top and are shed in late winter each year.

White-tailed deer vary extensively, with as many as 38 different subspecies described (Smith and Rhodes 1994). Across their range, which extends from central Canada to northern South America, body weights vary from 50 to 300 pounds with body size increasing from south to north. In the United States, weights average about 100 pounds for adult females (does), and 150 pounds for adult males. Adult deer have an average height of 36 inches at the shoulder (Sauer 1984). Although deer can have a lifespan of eight to twelve years in unhunted populations, most do not live beyond four or five years of age in areas with regulated hunting (Severinghaus and Cheatum 1956, Matschke et al. 1984).

White-tailed deer have excellent senses and physical abilities. A combination of smell, hearing, and sight is used to monitor their surroundings and locate potential danger. Deer have evolved as a prey species and can detect many potential threats and avoid them. When threatened, deer can attain speeds of 36 miles per hour and easily jump an eight-foot obstacle (Sauer 1984). A well-developed sense of smell also is important for recognizing individuals and allowing males to identify females in estrous.

Habitat and Habits

White-tailed deer are extremely adaptable, both in habitat and diet selection. Deer are an edge species, faring well in transitional areas between forests, agriculture, grasslands, and even suburban landscapes. Forests, thickets, and grasslands provide deer with protective cover and natural foods, and agricultural fields can contribute abundant, high-quality forage. The diets of white-tailed deer often depend on the

Figure 4. Feeding deer increases the potential for conflicts by making deer less wary of people.

agricultural activities and land-use practices of humans. Suburban areas provide high-quality foods in the form of gardens, ornamental plantings, and fertilized lawns (Swihart et al. 1995), while nearby woodlands offer daytime refugia. Swihart et al. (1995) found plant species richness to be higher in residential areas than in wooded habitats. Suburban areas are often free of hunting and natural predation. Further, suburban residents sometimes feed deer and other wildlife (Figure 4), restricting deer movements and enhancing their reproduction and survival.

Since the 1930s, white-tailed deer densities have increased and their range has expanded (Halls 1984) due to human-induced landscape changes. Deer densities are often highest in locations with suitable habitat where hunting is not permitted. Such sites could include the suburban-rural fringe of metropolitan areas that contain a mix of wooded habitat and agricultural fields, parks or nature reserves, and corporate complexes.

Reproduction

Mating behavior (rutting) occurs primarily from mid-October through December in most of the white-tailed deer's range. Female white-tailed deer generally breed for the first time when they are yearlings (14 to 18 months in age). In areas with good forage, six-month-old fawns may breed, but older females will produce more offspring (Nixon et al. 1991). Yearling does typically produce one fawn, whereas adults (2.5 years in age or older) commonly produce twins or sometimes triplets, when conditions are favorable (Verme and Ullrey 1984).

Fawns are born mid-May through July and spend the first few weeks of their life hiding. They begin to follow their mothers within a few weeks (Marchinton and Hirth 1984). At birth fawns have spotted pelage that blends with the patterns of sun and shade. This spotted fur is replaced with a gray-brown winter coat during August and September.

Deer have a high reproductive potential and populations can increase quickly. In the fenced George Reserve in Michigan, McCullough (1979, 1984) documented an introduced population of six deer growing to an estimated 222 deer in seven years. Reproductive output is associated with deer population density. In general as deer populations increase, the quantity and quality of forage available decreases and reproductive output declines. This density-dependent effect is related to deer condition and is called biological carrying capacity.

Biological Carrying Capacity

The number of deer that can be sustained in a given area of land is a function of food resources and the availability of winter cover. Biological Carrying Capacity (BCC) is defined as the number of deer that a parcel can support over an extended period of time (Ellingwood and Caturano 1988). When deer numbers approach BCC, habitat quality decreases and physical condition of the herd declines (Swihart et al. 1998). Biologists use indices of deer health and population density to assess the status of a herd relative to BCC. When overbrowsing persists, a long-term reduction in BCC can occur. Neither herd health nor habitat quality will improve unless deer densities are reduced. Such circumstances enhance the likelihood of winter mortality due to poor nutrition and/or disease (Eve 1981).

Home Range and Movements

An individual deer must be able to fulfill its requisites of life (i.e., food, water, shelter, mating) within its home range. Deer become very familiar with their home range, which enhances survival, and consequently they seldom leave it. Males generally have larger home ranges than females, and often expand their ranges during the rut or breeding season (Michael 1965; Nelson and Mech 1981, 1984; Root et al. 1988). Home range sizes vary considerably based on the variety and arrangement of habitat types and climate (Wigley et al. 1980, Williamson and Hirth 1985, Dusek et al. 1988). Female deer have relatively compact home ranges and move little between seasons if there is enough habitat diversity to fulfill their needs, especially in suburban environments (Cornicelli 1992, Bertrand et al. 1996, Kilpatrick and Spohr 2000). Conversely, less diverse habitats and more severe winter weather increases the likelihood of larger home ranges and associated movements.

Deer can be classified into three types based on movement behavior: (1) residents, (2) emigrants, and (3) migrants. Residents have an established home range that they seldom leave, and if forced from their home range, they usually return within a few days. Emigrants, or dispersers, leave their natal home range to establish another core area of activity elsewhere. Migrants move away from an area and then return to it again later (i.e., distinct winter and summer ranges). It appears that migration behavior and selection of home range locations can be passed on matrilineally (doe to fawn) through generations (Marchinton and Jeter 1966, Nelson and Mech 1984, Tierson et al. 1985, Nixon et al. 1991).

In regions with moderate seasonal variation throughout the year, a deer will likely remain in one area for its entire life (Thomas et al. 1964, Beier and McCullough 1990, Nixon et al. 1991, VerCauteren and Hygnstrom 1998). In areas where food or cover are limited seasonally, deer may exhibit distinct winter and summer use of their home range (Pietsch 1954, Kammermeyer and Marchinton 1976, Nelson and Mech 1984, VanDeelen et al. 1997). In general, the percentage of deer that migrate seasonally increases on a continuum from south to north. It appears that at lower latitudes in the United States (30 to 35 degrees N), all females are residents (Kammermeyer and Marchinton 1976, Inglis et al. 1979). In mid-latitudes (35 to 45 degrees N) springtime movement occurs in less than 30 percent of females (Gladfelter 1978, Nixon et al. 1991, VerCauteren 1998, Hygnstrom and VerCauteren 1999). At upper latitudes (more than 45 degrees N) the vast majority of deer migrate seasonally, related to yarding during winter (Nelson and Mech 1992). Yarding refers to the winter movement of deer in the northern extent of their range to habitats that offer food and protection from extreme snow depths and temperatures.

Mortality

Hunter harvest is the primary cause of white-tailed deer mortality (Gladfelter 1984, Matschke et al. 1984, Nixon et al. 1994, Hansen et al. 1997). Other factors include vehicle collisions, poaching, disease, predators, malnutrition, accidents, and rarely old age. Across most of the whitetail's range, deer mortality is attributed often either directly (i.e., hunting, vehicle collisions, or poaching) or indirectly (i.e., habitat alteration or loss) to human activity.

Sport hunters often select for males and against females (Nixon et al. 1991). Thus, sex and age ratios in hunted populations are skewed in favor of older females. Even in unhunted areas, the mortality of adult males is higher than that for females because of poor physical condition for bucks after the breeding season and increased susceptibility to predation (Gavin et al. 1984, Jacobson and Guynn 1995, McCullough 1979, Mech 1984). Intense competition for females in estrus also contributes to the shorter lifespan of adult males (Hamilton et al. 1995, Jacobson and Guynn 1995). Finally, there is often a high mortality rate for yearling males associated with the spring and fall dispersal periods (Nixon et al. 1994, Rosenberry et al. 1999).

Regulations Regarding White-Tailed Deer

Deer are protected by game regulations in all states and provinces. Hunters legally harvest deer during designated seasons, usually in fall. The length and timing of seasons may change on an annual basis. State or provincial natural resources departments can provide details on hunting seasons. In cases with severe, persistent property damage or public safety concerns, some states may issue special permits that allow shooting or removal of deer during times other than regulated hunting seasons. Any management or research that involves handling of deer requires permission (i.e., a written permit) from the state or provincial wildlife agency. Some states provide technical assistance and/or direct compensation for deer damage. Products, laws, and registrations change, so check with local wildlife authorities about compliance before taking any action that may harm deer.

Deer Ecology and Management

White-tailed deer have adapted well to suburban environments. A thorough understanding of the biological and behavioral aspects of deer should be incorporated into management decisions. Such information is especially relevant in determining the scale of a management program and its likelihood of success.

White-tailed deer populations are organized into matrilineal (female-led) groups in which related females are accompanied by their immediate offspring (Hirth 1977). Female deer often remain in their natal range (the area in which they were born). Typically, young females establish home ranges that overlap the home range of their mothers (Marchington and Hirth 1984, Porter et al. 1991), whereas males tend to disperse from their mother's home range (Kammermeyer and Marchinton 1976, Holzenbein and Marchinton 1992, Nixon et al. 1994). Strong home range fidelity and the reproductive importance of females allow for effective herd management on relatively small areas (McNulty et al. 1997). Desired management effects may be achieved on small parcels with lasting impacts depending on the degree of isolation (Porter et al. 1991). This micromanagement approach can be implemented on areas as small as 200 acres (Kilpatrick and Walter 1999). Such areas approximate minimum home range sizes for suburban white-tailed deer (Cornicelli 1992, Bertrand et al. 1996, Grund 1998, Kilpatrick and Spohr 1999). Once a population has been reduced, adjacent matrilineal groups do not readily expand or change their home ranges (McNulty et al. 1997). Management efforts must continue to address the reproductive potential of residual females, however. Deer herds on small parcels can be aggressively managed, however the absence of control on neighboring properties may limit effectiveness due to home range overlap and/or dispersal of adjoining deer. Therefore if only small areas are available, adjoining landowners may need to coordinate their actions to maximize the impact of a management program.

Human Dimensions and Deer Management

Suburban areas, by definition, contain relatively high densities of people. Frequently they also contain locally overabundant wildlife populations that create wildlife-human conflicts. Deer-human “problems” are socially defined and vary among different stakeholder groups (Decker and Gavin 1987). Public attitudes regarding deer problems differ according to personal beliefs (Purdy and Decker 1989, Curtis et al. 1997) and may vary depending on whether stakeholders hold individual animal or population-level perspectives.

Most people enjoy viewing deer, and seldom do communities want to entirely eliminate a local herd. Tolerances for deer, however, are quite variable depending on personal preferences, past experiences, ones’ ecological perspective, and land-use priorities (Decker and Purdy 1988, Loker et al. 1999). Differing public views complicate decision making and establishment of deer management goals. In some cases, it may not be possible to achieve community consensus for a single deer management approach. Action may still be required, however, to reduce deer-related conflicts, and the best outcome may be to achieve consent for management from key stakeholder groups (Curtis and Hauber 1997).

Deer management is often undertaken to satisfy diverse human needs and interests. Solving deer conflicts may involve changing stakeholder attitudes or behaviors (Decker et al. 1996), as well as modifying deer behaviors or reducing herd size. A communication plan may be needed to educate suburban landowners about the range of deer management options (Stout et al. 1997). Policy education and development of community capacity to make informed deer management decisions is an important goal for wildlife management agencies (Curtis 1995).

Curtis et al. (1995) recommended using a community-based task force with the guidance of a professional facilitator. Stakeholders should be involved in several steps of the decision-making process and management action, including:

- setting goals and objectives,
- determining appropriate management techniques,
- communicating findings/conclusions to the community,
- evaluating program results, and
- revising goals and objectives as part of an adaptive management program.

Depending on the social and political climate in a given area, the most practical management option for reducing deer conflicts may not have community acceptance or the support of elected officials. For example, in a specific situation professional wildlife managers may recommend lethal means to reduce deer numbers. Some residents, however, may be opposed to killing deer and even the concept of wildlife management. In such situations, a citizen task force with representative stakeholders from the local community may help reduce conflicts and find acceptable deer management approaches (Curtis et al. 1995, Curtis and Hauber 1997). Implementing task forces can be very time-consuming and may exceed the resources available to some wildlife agencies. Kilpatrick and Walter (1997) suggested using a community vote to speed implementation of deer management actions. This approach also has limitations, as minority stakeholder groups may use the legal system to stop proposed actions.

Citizen task forces have been used to reduce deer problems in several communities. This approach requires that all interested stakeholders participate in the development of management plans. Wildlife agency staff may provide technical support or, in some cases, serve as stakeholders in the process. Task forces typically review pertinent deer biology, examine management options, select appropriate management techniques that are both biologically feasible and socially acceptable, identify sources of staff and funding to implement management activities, and coordinate dissemination of information to the community and media. It is important for task force members to understand that state or provincial permits will be needed for any action that requires handling of deer. Based on past experiences, the primary factors that have resulted in viable management recommendations with broad community support include:

- relevant stakeholder representation,
- an external, trained facilitator,
- accurate and complete biological data,

- a survey of community attitudes or other similar social information, and
- technical support from wildlife management agencies.

Wildlife agency personnel who are working with task forces must be knowledgeable about deer biology and the pros and cons of various management options. Wildlife professionals must be credible and objective and avoid confusing personal values with biological recommendations (Decker et al. 1991). When confronted or challenged (Figure 5), agency staff should avoid arguments, be good listeners, maintain objectivity, be well informed, and explain management options in understandable terminology. Law-enforcement personnel who participate in deer conflicts should encourage a calm exchange of ideas.

During the late 1990s, public involvement in deer management decisions evolved beyond citizen task forces and similar transactional approaches (Chase et al. 2000, Curtis et al. 2000a). Communities are now sharing not only the decision-making authority, but also the cost and responsibility for deer management with state and local government agencies under a variety of co-management scenarios. The community scale is appropriate as deer impacts are often recognized by neighborhood groups, and the need for management becomes a local issue. In addition, the success or failure of management actions can be perceived most readily by stakeholders at the community level. Outcomes of co-management are usually perceived as more appropriate, efficient, and equitable than more authoritative wildlife management approaches. Although co-management requires substantial time and effort, this strategy may result in greater stakeholder investment in and satisfaction with deer management.

Figure 5. Animal activist groups may oppose controlled hunts, sharp-shooting programs, and other lethal forms of deer removal.

Developing an Integrated Management Strategy

No single technique or strategy is universally appropriate. Complexities of suburban deer issues and the current limitations of available techniques make quick-fix solutions unlikely. Resolving conflicts associated with suburban deer often requires an integrated management program. Short-term strategies can relieve immediate problems, while long-term approaches will maintain deer populations at target levels. Combining two or more methods may improve results and increase the acceptability of the program for a wider range of stakeholders. An example of a combined approach might be the use of fencing and repellents in concert with selective lethal control.

Important considerations in the evaluation of management techniques include:

- time(s) of year when deer-related conflicts occur,
- available control options given the behavior and biology of the deer and the characteristics of the area(s) involved,
- probable effectiveness and duration of the techniques,
- acceptability, cost, and legality of control methods, and
- community support for taking action.

The community should determine measurable objectives (e.g., number of deer or level of damage that is acceptable) before any management action is taken. Population objectives for the deer herd and control methods should be publicized before implementation to minimize social conflicts. Key stakeholder groups should have participated in the decision-making process and can assist agency staff with community education. Presentations for civic groups and local schools are a good way to disseminate facts and science-related information. Press releases to local news outlets also can maximize media support and help ensure that important data are made available to the community. Call-in radio shows are cost-effective and useful for widespread dissemination of information (Colvin et al. 1983).

Field personnel who implement control techniques should be able to explain community concerns and management goals. Agency staff must realize that multiple wildlife acceptance capacities exist among various stakeholder groups (Decker and Purdy 1988), and strong differences of opinion are unlikely to be resolved while management activities are taking place. Field coordinators should notify local law enforcement agencies of their activities, and staff should keep all necessary permits ready for presentation if requested.

Management programs should be monitored to assess their impacts. Baseline data (i.e., roadkill reports, vegetation impacts, homeowner complaints) will be required to determine accurately the effects of any management action and to evaluate program effectiveness. Keep in mind that the objective of most management programs is the reduction of conflicts to an acceptable level, not the complete elimination of either the problems or the deer herd.

The impacts of a management program on deer abundance can be evaluated based on aerial surveys, spotlight surveys, transect counts, harvest data, trends in herd health, browse surveys, pellet-group counts, deer damage surveys, or any combination of the above (Bookhout 1996). Cultural impacts can be measured by the frequency of deer-vehicle collisions, reductions in browsing damage, and fewer deer complaints.

Estimating Deer Population Size

One of the first questions asked by community groups considering deer management is, "How many deer are in the local population?" A baseline population estimate is often helpful in the decision-making process, however this can be very difficult and expensive to obtain. The actual number of deer in a community is nearly impossible to determine and will change seasonally. Therefore, it is often sufficient to estimate the minimum size or approximate density of the deer population.

Deer abundance can be estimated using a variety of techniques. Although more costly than conducting spotlight surveys or pellet-group counts, helicopter surveys (Figure 6) during periods with snow cover or infrared counts can be very reliable (Naugle et al. 1996, Beringer et al. 1998, Havens and Sharp 1998). Counts of deer from aircraft can be limited in application, as a minimum of four inches of complete snow cover is required to achieve accurate estimates.

Infrared counts can be confounded by thermal distractions such as large rocks and standing water that may be mistaken for deer. Presence of a dense tree or understory canopy can affect the relative accuracy of both aerial techniques. In fact, in regions with a moderate to high percentage of evergreen trees, spotlight surveys or pellet group counts should be used. Wildlife agencies or private contractors specializing in these services may provide population estimates for local deer herds.

To complement population estimates, the physical condition, mortality, and reproductive rates for deer should be monitored regularly to more accurately model deer populations over time. In the absence of population estimates, population indices (e.g., pellet-group counts, numbers of complaints or conflicts, etc.) may suffice as indicators of relative changes in deer abundance.

Figure 6. Helicopter surveys can be used to estimate deer abundance in areas with few conifers and four or more inches of snow cover.

Management Techniques

Regulated hunting has proven to be an ecologically sound, socially beneficial, and fiscally responsible method of managing rural deer populations. However, hunting has limited application in some suburban areas because of safety considerations, competing land-use priorities, legal constraints, or social values (McAninch 1995, Warren 1997). The intent of this section is to review nonlethal and nontraditional options for reducing deer populations in situations where deer management is constrained. Each option is evaluated on the basis of cost, efficiency, and social acceptability.

Costs of deer management options have been widely documented and reported (McAninch 1995, Warren 1997). We caution readers that costs vary considerably across the range of potential applications and that in the final analysis, cost represents an unreliable and often misleading basis for option selection. To the extent that cost is an important consideration, we encourage that site-specific estimates be generated and that cost be weighed against other important considerations, including effectiveness, efficiency, acceptability, and humaneness.

The following synopsis describes our current state of knowledge regarding suburban deer management practices. Our primary intent is to provide a list of techniques used to alleviate conflicts with suburban deer. Appendix A includes sources of equipment and suppliers' addresses. State wildlife agency phone numbers and other resource contacts are included in Appendix B.

Certain techniques may require special training, licenses, or permits. Contact local wildlife agencies for assistance in developing a deer management plan, or for permits if the community is interested in trapping or handling deer. Some techniques are highly specialized, site-specific, or best used in combination with other methods. Check with local authorities for information about fencing restrictions or other site-specific methods.

In addition, the response of individual deer to specific management techniques may vary. Thus no attempt was made to rank the techniques and the methods are not listed in order of preference. Always be alert to new techniques or new and creative modifications of existing methods.

Nonlethal Management Options

Nonlethal management techniques are generally well accepted by the public. However, limited effectiveness and/or high cost may prevent their exclusive use to resolve deer conflicts. Cost-benefit analyses, although relevant to all management activities, are particularly important when evaluating nonlethal options. Nonlethal techniques can be justified when the potential financial savings from their application are equal to or greater than the cost for implementation. Effectiveness will be associated with the technique selected, deer densities, alternative food resources, and weather. Some methods provide short-lived relief from deer damage (e.g., frightening devices and repellents), whereas others may permanently prevent conflicts (e.g., well-maintained barrier fencing).

Nonlethal techniques may not affect deer impacts to plants and animals on a community-wide scale because these methods were designed to supplement, not replace, deer population management. As a consequence, nonlethal alternatives are best employed within the context of a comprehensive deer management program.

Habitat Modification

Deer adapt well to nearly all human-modified environments, except for downtown urban locations and other large areas that are devoid of woodland cover. These intensely developed urban areas are usually less aesthetically appealing to people than suburban landscapes that contain a patchwork of woodlots and homes. Therefore, habitat modifications to discourage deer presence are rarely practical.

Ban on Deer Feeding

Many people enjoy providing food for deer and other wildlife during winter (Figure 7). This may contribute to an artificially high deer population, especially during harsh winters when natural food sources are in short supply. Supplemental food can enhance deer reproductive rates, encourage deer to congregate in sensitive areas (Doenier et al. 1997), and make deer more tolerant of people. Also, food provisioning can lead to deer crowding and increased susceptibility to diseases (Davidson and Nettles 1997).

Education and/or regulations may reduce the number of people who feed deer. Unfortunately, law enforcement agencies sometimes consider antifeeding regulations unenforceable, as some people ignore them. Therefore, it may be difficult to discourage or prevent residents from feeding deer unless there is a concerted effort by the community and law enforcement agencies.

Unpalatable Landscape Plants

Although deer are generalist foragers, they do have preferences for certain plant species. Selecting less palatable herbaceous and woody plants can minimize deer browsing to ornamental plants (Cummings et al. 1980, Fargione et al. 1991, Craven and Hygnstrom 1994, Curtis and Richmond 1994). Careful plant selection for home landscapes, combined with the selective use of repellents, may minimize damage if deer feeding pressure is low to moderate. Few ornamental plant varieties, however, are classified as rarely damaged by deer, and application of this technique is limited in areas with high deer densities.

Repellents

Repellents are best suited for use in orchards, nurseries, gardens, and on ornamentals or other high-value plants. High application cost, label restrictions on use, and variable effectiveness make most repellents impractical for row crops, pastures, or other low-value commodities. Success with repellents is measured in reduction of damage; total elimination of damage should not be expected (Craven and Hygnstrom 1994).

Repellents work by reducing the attractiveness and palatability of treated plants to a level lower than that for other available forage. Repellents are more effective on less palatable plant species than for those that are highly preferred (Swihart et al. 1991). Effectiveness also depends on the availability of alternate forage (Conover 1987, Conover and Kania 1988, Andelt et al. 1991), and repellent performance seems to be negatively correlated with deer density.

Repellents have traditionally been classified as odor- or taste-based products. Examples of odor-based repellents include products containing rotten eggs, soap, predator urine, blood meal, and other animal parts. Typically, these repellents are poured onto absorbent cloth or placed in a bag and suspended above the ground at densities of up to 1,150 bags/acre (Conover

Figure 7. Feeding stations for observing deer may increase fawn production from adult females in good condition.

and Kania 1988). Thus, use of some products may be very labor-intensive. Some materials are also sprayed directly on the plants. The primary advantage of odor-based products is that deer usually realize the plants are treated when they approach within a few feet, so the plants remain undamaged. Taste-based repellents are sprayed or dusted on the foliage to protect plants from deer browsing. Examples of these materials include hot sauce (contains capsaicin, the active ingredient in hot peppers) and thiram. The primary disadvantage of taste-based products is that deer must sample and damage the vegetation before they are affected by the repellent.

More recently, scientists have classified repellents by four specific modes of action: fear, conditioned aversion, pain, and taste (Beauchamp 1997, Mason 1997). Fear-inducing repellents emit sulfurous odors that mimic predator scents. Conditioned aversion is an avoidance response associated with a treated item and an illness. Pain-inducing repellents affect the trigeminal receptors located in the mucous membranes of the eyes, nose, mouth, and throat. Taste repellents generally include a bitter agent that makes treated items unpalatable.

In addition to mode of action, several other factors that influence the effectiveness of repellents must be considered. Some repellents weather poorly, so it is usually best to use products that contain a commercial "sticker" or adherent. Also, repellents only protect the foliage to which they are applied. New growth that emerges after the application of the treatment is unprotected (Allan et al. 1984). Therefore, repellents have to be reapplied repeatedly during the growing season to retain their effectiveness (Sullivan et al. 1985, DeYoe and Schapp 1987, Andelt et al. 1991). For peak efficacy, many repellents should be reapplied every four to five weeks as long as deer-feeding pressure remains high (Sayre and Richmond 1992).

Many deer repellents have been evaluated in the scientific literature (Palmer et al. 1985, El Hani and Conover 1997, Wagner and Nolte 2000). Commercial repellents do not perform equally, and research has indicated that odor-based products often out-perform taste-based materials. Always follow label instructions for appropriate application. Most products are registered by the U.S. Environmental Protection Agency only for use on nonfood plants, such as ornamentals, or on fruit trees during the dormant season.

Putrescent whole egg solids are the active ingredient in several odor-based, fear-inducing repellents (e.g., Deer-Away, Deer-Off, Deer Stopper, Big Game Repellent) that have been shown to be effective in

Figure 8. Several commercial repellents may reduce feeding damage for five or more weeks depending on deer foraging pressure and density.

some situations (Swihart and Conover 1990, Sayre and Richmond 1992, El Hani and Conover 1997). They are registered for use on fruit trees before flowering as well as on ornamentals and Christmas trees. Products containing rotten eggs have consistently performed well in research trials and often are used as a standard for comparing other active ingredients.

Ammonium soap of higher fatty acids (e.g., Hinder) is one of the few active ingredients registered for use on edible crops. It can be applied directly to vegetable and field crops, garden plants, livestock forages, ornamentals, and fruit trees. Its effectiveness is usually limited to about four weeks but varies depending on weather and application methods. Hinder has protected Japanese yews at suburban home sites from deer browsing during a spring field trial (Sayre and Richmond 1992).

Thiram (tetramethylthiuram disulfide), a fungicide that induces a conditioned aversion, is sold under several trade names (e.g., Nott's Chew-Not and Gustafson 42-S). It is most often painted or sprayed on dormant trees and shrubs and has been reported to be effective in some experiments (Conover 1984). Thiram-based repellents also may be used to protect trees against bark chewing by rabbits and voles.

Capsaicin is used in several taste-based, pain-inducing, repellents (e.g., Miller's Hot Sauce, Deer-Off, etc.). It is registered for use on ornamentals, Christmas trees, and fruit trees. Adding an antitranspirant, surfactant, or sticker may improve longevity and efficacy of the product. Formulations that contain high concentrations (6.2%) of capsaicin have been more effective than repellents with less active ingedient (0.062%; Andelt et al. 1991, 1994).

Noncommercial or "home-remedy" repellents (e.g., human hair, bar soap) will sometimes deter deer if the feeding pressure is low. These products have not been evaluated or registered by the U.S. Environmental Protection Agency and cannot be sold as deer repellents. Because these materials are low cost and readily available, however, many consumers still apply them in anticipation of some reduction in deer damage.

Human hair does not provide reliable protection in areas with moderate deer feeding pressure (Conover 1984, Conover and Kania 1988). Studies have shown, however, that soap bars applied to trees may reduce deer damage (Parkhurst 1990, Swihart and Conover 1990). Each bar appears to protect a radius of about a half-yard. Any inexpensive brand will work if the soap is tallow-based, and perfumes do not enhance its effectiveness. Application of soap bars to apple trees was less costly than a commercial spray (Hinder, Figure 8) during the first growing season. Rapid tree growth requires multiple-bar applications, however, and commercial spray applications were more cost-effective during the second and future growing seasons (Fargione and Richmond 1992).

Supplemental Feeding

Supplemental feed can be used to draw deer away from specific problem areas. Deer must be concentrated a significant distance (more than 400 meters) from the site with conflicts (Doenier et al. 1997). Deer problems may be created near the baiting station, however, and this should be assessed prior to providing supplemental feed. For example, concentrating deer may result in excessive plant damage in the vicinity of the artificial food source.

In many areas of North America, supplemental feeding would likely increase deer-human conflicts. Feeding would concentrate deer, possibly increasing disease transmission and/or predation of deer by dogs and coyotes. Implementation of a supplemental feeding program to prevent malnutrition would be counterproductive to control efforts directed at free-ranging herds because it could encourage additional population growth. Furthermore, it is costly to provide ad libitum winter feed (Ozoga and Verme 1982, Baker and Hobbs 1985).

Fencing

Fencing is a reliable method to address site-specific problems such as landscape or agricultural damage or airport conflicts (Caslick and Decker 1979, Craven and Hygnstrom 1994, Curtis et al. 1994). Fencing also can be used to protect public health in areas where there is a high prevalence of tick-borne diseases (Daniels et al. 1993, Stafford 1993). Agencies often recommend barrier fencing around schoolyards and other high-risk areas to minimize deer access, tick abundance, and the associated risks of contracting Lyme disease.

Several factors should be assessed before using fencing as a deer control option. These include fence design, site history, deer density, crop or landscape value, local ordinances, and size of the area to be protected (McAninch et al. 1983). For example, it would cost approximately three times more to protect an area with an eight-foot-high, woven-wire fence compared to a moderately priced, high-tensile electric fence (Ellingwood and McAninch 1984). Several fence designs can be used to exclude deer from home gardens (Figure 9) and crop areas, including variations on both electric and barrier types (Craven and Hygnstrom 1994, Curtis et al. 1994; see Appendix A for a list of fence suppliers).

For a given deer density, the potential for damage will often be greater on larger plantings than smaller ones (Caslick and Decker 1979, McAninch et al. 1983). Consequently, large areas often require more substantial fencing designs to achieve a level of protection similar to small areas. Based on anecdotal reports and research experiences in New York, vertical electric fence designs seldom provide reliable protection for plantings larger than five acres under intense deer foraging pressure. Slant-wire, electric-fencing systems can protect plantings approximately 50 acres in size. Blocks larger than 50 acres usually require eight-foot-high, woven-wire fencing to reliably prevent deer from entering the area if feeding pressure is high (Figure 10).

Although deer pressure and size of the area to be protected are the primary factors to consider when selecting a fence design, tolerance for deer damage is also important. When a landowner's tolerance for deer damage is low (i.e., even light damage is unacceptable during the anticipated life of the fence) and deer foraging pressure is high, woven-wire fences are the only practical option regardless of area size. If this fence design is not economically feasible due to low landscape or crop value, the best decision may be to avoid planting sites prone to heavy deer damage.

A wide variety of fencing systems, including baited single wires (Porter 1983, Hygnstrom and Craven 1988), three-dimensional outriggers (Tierson 1969), and slanted and vertical fences up to eleven feet in height (Longhurst et al. 1962, Halls et al. 1965, Palmer et al. 1985), have successfully excluded deer under some conditions. Often simple designs are effective only under light deer pressure (Brenneman 1983, McAninch et al. 1983) or for relatively small areas. Low-cost, easily constructed fences may perform quite well for small areas (less than ten acres) during the growing season when alternative foods are available to deer. Low-profile fences, however, are seldom satisfactory for protecting commercial orchards or ornamental plantings in winter, especially if snow restricts deer from using alternative food sources. Landowners must also check local ordinances and covenants to determine if electric fences can be used, or if fences of any kind can be constructed on their property.

Figure 9. High-tensile barrier fence for protecting a home garden from deer damage

Figure 10. Woven-wire fences are the most effective way to protect large areas (>50 acres) of high value crops.

Barrier Fencing
Barrier fences perform well even under intense deer pressure and represent the technique of choice for many deer damage management programs (Caslick and Decker 1979, McAninch et al. 1983). Individual wire cages, at least 1.5 feet in diameter and three to four feet in height, may be used to protect single trees from deer browsing and antler rubbing. Several types of plastic tubes, tree wraps, and bud caps are also available. A high-tensile, woven-wire fence that is eight to ten feet tall is considered the most deer-proof design. The wire should be 11 to 14.5 gauge with breaking strength up to 1,800 pounds (United States Steel 1980). The strong, elastic nature of the wire reduces stretch, sag, and damage when objects contact the fence. In addition, quality high-tensile wire receives Type III galvanizing, which can provide up to 35 years of service in humid climates.

Electrical Fencing
Electrical, smooth-wire fence designs are not complete physical barriers, but rely on electric shock to aversively condition animals to avoid the fence (McKillop and Silby 1988). An electric fence is an unfamiliar object, and a deer investigating it for the first time often will touch the fence with its nose. A deer foraging at night, however, may not see the fence and could touch the wires with its neck, back, or chest. If an animal has almost crossed the fence before an electric pulse is generated, it will likely complete the crossing. Deer are reported to have learned to avoid receiving shocks by jumping through electrified fences (Tierson 1969).

Electric current is supplied by high-voltage chargers that provide regularly timed pulses (45 to 65 per minute) of short duration, followed by a relatively long period without current flow (United States Steel 1980). The short-duration, high-energy pulses provide sufficient energy (more than 3,000 volts) to deter deer while still allowing an adequate period without current to allow humans and animals to free themselves from the electrified wires. Plug-in and battery- or solar-operated chargers are available that can maintain in excess of 5,000 volts on miles of fencing. Electric fences should always be adequately marked with warning signs, and barbed wire should never be electrified. Electric fences require regular maintenance to ensure the wires are secured to the insulators, and that the current has not been grounded by vegetation.

Multistrand, electrified, high-tensile, smooth-wire fences consist of several individual wires fastened to braced wooden assemblies, with wires tightened to 150 to 250 pounds of tension (McAninch et al. 1983, Palmer et al. 1985). Sturdy, well-braced corner and

Figure 11. Deer have poor depth perception and will avoid areas protected by electrified, slanted-wire fences.

end assemblies are needed to oppose these high wire tensions. Posts between brace assemblies can be widely separated (20 to 30 yards), and can be constructed from smaller, less-expensive materials. Vertical, six- or seven-wire, high-tensile fences have been found to effectively control deer damage in small areas (McAninch et al. 1983, WVU Committee on Deer Damage Control 1985).

The seven-wire, slanted, electrified fence (Figure 11) is an effective barrier for protecting large areas (up to 50 acres) with moderate to high deer pressure (McAninch et al. 1983). The fence covers approximately six feet of horizontal space and presents deer with a confusing three-dimensional barrier as well as a shock when touched. Although the slanted design appears to be more effective than comparable vertical electric fences, it is also more complicated to construct and requires additional effort in controlling vegetation.

Combination Fencing

Combining electric fences with either attractants or repellents may encourage deer to touch the fence with their nose or mouth, thereby enhancing the aversive conditioning. Early studies by Kinsey (1976) and Porter (1983) used aluminum flags coated with peanut butter to attract deer to an electrified, single-strand smooth wire. This design was reported to be effective for sites of less than ten acres with light to moderate foraging pressure by deer. Hygnstrom and Craven (1988) used fences constructed from an electrified polytape and treated the entire length with a peanut butter–oil mixture. Jordan and Richmond (1992) evaluated the relative effectiveness of attractants versus repellents for excluding deer with a three-wire, vertical, electric fence system. The electric fence with a repellent was most effective, followed by application of an attractant (peanut butter).

Another type of combination fence was used successfully by an orchardist in British Columbia, Canada. The grower had placed four feet of woven-wire on the bottom portion of the fence and then added electrified, high-tensile, smooth wires at one-foot spacings on posts above the woven-wire to increase the overall fence height to eight feet. This design provides additional protection for sites that experience deep snow during winter, but is lower in cost than a complete physical barrier constructed of woven-wire.

Hazing and Frightening Techniques

Several techniques can be used to frighten deer away from specific areas. Hazing has been effective under some circumstances, however, deer often habituate to novel disturbances (Craven and Hygnstrom 1994, Curtis et al. 1995). Habituation is the process by which animals adjust to and ignore a new sound or smell over time (Bomford and O'Brien 1990). In addition, deer may not leave the general vicinity and complaints may arise from neighbors about the noise made by the devices. Hazing is most effective if implemented either before or at the initial stages of a conflict situation. Deer movements or behavioral patterns are difficult to modify once they have been established.

Pyrotechnics (e.g., fireworks, gunfire, cracker shells, bangers, etc.) provide quick but temporary relief from deer damage on farms near suburban areas. Pyrotechnics and propane cannons, however, have limited application in suburban settings because of disturbance to community members.

Motion-sensing detectors have been used to trigger both audible and ultrasonic devices for frightening deer in an effort to minimize habituation. Strobes, sirens, water sprays, and other devices have been used to frighten deer with limited effectiveness. Although deer can detect ultrasound, they are not repelled by it because they do not associate the disturbance with danger (Curtis et al. 1995).

Dogs as a Deterrent

Agricultural producers (Torrice 1993) and researchers (Beringer et al. 1994) have used invisible fencing systems and dogs for reducing deer damage to crops. Information collected indicated that two dogs contained within an invisible fence afforded protection to apple trees within about 500 yards of their kennel (approximately 60 acres) during summer, but the effective radius was reduced to about ten acres during winter when snow restricted movement of the dogs. Beringer et al. (1994) documented that two dogs within an invisible fence were more effective for protecting five-acre plots of white pine (*Pinus strobus*) seedlings from deer damage than a commercial deer repellent. A buried perimeter wire provided easy equipment access, no gates were needed, snowfall did not affect operation of the electronics, and costs were much lower than other electronic fencing systems.

Dogs restricted by an invisible fence system can keep deer out of an area, however, care and feeding of the dog can be time-consuming and costly (Beringer et al. 1994). The costs may be considered negligible if the dog serves primarily as a pet. A family pet, however, may not provide adequate protection because the dogs need to patrol the area during day and night. The breed and disposition of the dog will influence effectiveness of this technique. Large dogs that aggressively patrol the area appear to work best. The complete protection of plant materials should not be expected, as deer react to dogs similar to other scare devices or repellents. Free-running dogs are not advisable and may be illegal.

Approaches for Minimizing Deer-Vehicle Collisions

Deer-related vehicle accidents (Figure 12) are a major concern in some communities, and collision rates are apparently correlated with deer abundance. Several techniques have been used to reduce deer-car collisions, however few have been documented to be consistently effective, and some have no measurable effect on deer behavior.

Roadside Reflectors

Roadside reflectors (Figure 13) have been used with varying success to reduce deer-vehicle collisions (Gilbert 1982, Gladfelter 1982, Schafer and Penland 1985, Ford and Villa 1993, Reeve and Anderson 1993, Romin and Bissonette 1996). Reflectors deflect the headlights of passing cars, creating a wall of light that shines parallel to the road and thus, possibly discourages the approach of deer. Reflectors provide a warning only when vehicles are present, allowing normal animal movements at other times (Putman 1997). Reflectors function only during low-light levels near dusk, dawn, and at night. It is not clear that deer instinctively avoid or alter their behavior in response to red light (Zacks 1985), and it appears deer may acclimate to reflectors over time (Ujvari et al. 1998). Also, deer in residential areas may respond less favorably to reflectors than rural deer, as suburban deer are more likely accustomed to human activity and lights (Pafko and Kovach 1996).

Wildlife Warning Whistles

Wildlife warning whistles (deer whistles) attached to cars have been used in an attempt to reduce deer-vehicle collisions. These whistles operate at frequencies of 16 to 20 kHz and are intended to warn animals of approaching vehicles. There is no research,

Figure 12. As deer densities increase in suburban areas, deer-vehicle collisions are occuring more frequently.

Figure 13. It is not clear that roadside reflectors will consistently reduce deer-vehicle accidents.

however, that indicates that deer are frightened by a particular frequency or decibel level of sound, and in a Utah study, whistles did not alter deer behavior or prevent them from crossing highways. It appears wildlife warning whistles are not alarming to deer and are not loud enough to be heard above the engine noise associated with moving vehicles (Romin and Dalton 1992). Therefore, cars equipped with warning whistles will not prevent deer from crossing roads or reduce deer-vehicle collisions.

Warning Signs

Roadside areas with relatively high deer activity are often marked with warning signs in an attempt to reduce vehicle accidents (Putman 1997). Motorists, however, often disregard deer crossing signs because they are so common. Unless people experience deer in conjunction with these signs, they often do not respond to future warnings (Putman 1997). Pojar et al. (1975) evaluated lighted, animated deer-crossing signs in Colorado, and concluded mule deer–vehicle accident rates were not reduced. Although motorists reduced their speed by an average of three miles per hour near these animated deer-crossing signs, this was not enough to significantly reduce the number of deer-vehicle collisions.

Fencing

Highway departments install fencing along roadsides for many reasons in addition to preventing deer-vehicle collisions. The effectiveness of fencing for reducing numbers of deer-related accidents is limited unless properly maintained "deer-proof" fences are installed (Falk et al. 1978, Feldhamer et al. 1986). Romin and Bissonette (1996) reported that only ten states used fencing combined with overpasses/underpasses to lower deer-vehicle accidents, but more than 90 percent of state highway departments indicated fencing was effective for preventing animal-vehicle collisions. A 90 percent reduction in deer-vehicle accidents was achieved along a 7.8-mile section of I-70 in Colorado after the construction of an eight-foot-high deer fence (Ward 1982). Accident rates were also reduced in Minnesota (Ludwig and Bremicker 1983) and Pennsylvania (Faulk et al. 1978, Feldhamer et al. 1986) by constructing "deer-proof" fences. It appears that deer rarely jump nine-foot fencing (Feldhamer et al. 1986). Fencing must be frequently inspected with breaks or erosion gullies quickly repaired, because deer will find gaps or weak points where they can cross (Foster and Humhprey 1995, Ward 1982). Bashore et al. (1985) concluded that fencing was the cheapest and most effective method for reducing deer-vehicle collisions along short stretches of highway.

Figure 14. Deer often travel in family groups, so motorists should be cautious if one or more deer are seen on the roadside.

Vegetation Management, Speed Limits, and Public Awareness

In forested areas, highway right-of-ways may provide deer with attractive forage (Feldhamer et al. 1986), especially during the spring flush of new vegetation growth. Establishing unpalatable vegetation along roadsides may reduce deer use of road edges (Bruinderink and Hazebroek 1996). Wood and Wolfe (1988) showed that providing deer with alternative food sources between highway right-of-ways and bedding areas (e.g., intercept feeding) reduced deer-vehicle accidents by 50 percent during short time periods in Utah.

Maintaining low vegetation along roadsides may help motorists see approaching deer. Increased visibility should be complemented with strongly enforced speed limits and public education regarding deer behavior. Specifically, defensive driving should be promoted during periods with peak deer activity both daily (i.e., dawn and dusk) and seasonally (i.e., April through June, October through December). It should also be emphasized that deer often travel in family groups, and motorists should anticipate other deer near the roadside if one animal is observed (Figure 14). Unfortunately, no research has been conducted to evaluate the effectiveness of public education campaigns or reduced speed limits (Romin and Bissonette 1996).

Population Reduction Options

Population control programs have two phases: the initial reduction phase when the number of deer removed is high, and the maintenance phase after deer densities have been lowered and fewer deer are handled. It should be emphasized that any population control effort will require long-term maintenance. Management efforts may occur annually following attainment of population density goals or less frequently depending on program efficiency and local deer management objectives. Regardless of the culling frequency, residents should be committed to a long-term population control program to maintain the deer density near a community-determined goal.

With any technique, the cost per deer handled will increase as the proportion of the population removed or treated increases (Rudolph et al. 2000). High costs associated with diminishing returns may prevent achieving population goals with some techniques. Deer learn to avoid threatening situations, and the use of a variety of methods to capture or kill deer can help maintain program efficiency.

Figure 15. Using netted cages (Clover traps) for capture of deer

Trap and Translocate

Trapping and translocation requires the use of traps, nets, and/or remote chemical immobilization (i.e., darting) to restrain deer and shipping crates to translocate captured animals. Capture and translocation has been demonstrated to be impractical, stressful to the deer handled, and may result in high post-release mortality. Deaths of translocated deer have been attributed to capture myopathy (Beringer et al. 1996), unfamiliarity with the release site, and encounters with novel mortality agents (Jones and Witham 1990, Bryant and Ishmael 1991, Jones et al. 1997, Cromwell et al. 1999). Capture myopathy is a stress-related disease that results in delayed mortality of captured deer. O'Bryan and McCullough (1985) documented 85 percent mortality after one year for deer captured and translocated in California at a cost of \$431 per deer. Other capture and relocation programs have recorded costs ranging from \$400 to \$2,931 per deer (Ishmael and Rongstad 1984, Drummond 1995, Ishmael et al. 1995, Mayer et al. 1995).

Trap and translocation programs also require release sites that are capable of receiving deer, and such areas are often scarce. An additional concern associated with translocation of deer, especially from an overpopulated range, is the potential for spreading disease. The presence of Lyme disease and tuberculosis in some areas of North America makes this a serious consideration. Also, tame deer often seek out comparable residential locations and may create problems similar to those identified at the trapping location (O'Bryan and McCullough 1988). Land-use conflicts and disease concerns caused by relocated deer could lead to questions of liability. Craven et al. (1998) provided an excellent review of issues associated with the translocation of problem wildlife.

Several techniques can be used to capture deer, including box traps, Clover traps, netted cage traps, drive nets, drop nets, rocket nets (Figure 16), corral traps, net guns, and immobilization drugs (Rongstad and McCabe 1994, Schemnitz 1994). VerCauteren et al. (2000) provided suggestions for improving netted cages and Clover traps (Figure 15). Details for chemical immobilization of deer were reported by Scanlon and Brunjak (1994).

If capture and translocation is selected as the most appropriate management option, the following recommendations will minimize stress and subsequent capture myopathy during handling procedures. Only experienced personnel should be involved in deer handling or in the immediate area of the capture site. When physically restraining deer (i.e., net guns, drop nets, rocket nets, Clover traps) it may be advantageous to sedate each animal while extracting them

Figure 16. Rocket net positioned and ready for deer capture at a bait station

from the capture device and transferring them to the transport cages (DeNicola and Swihart 1997). Most deer immobilization drugs are classified as controlled substances, and their use requires U.S. Drug Enforcement Agency licenses. After administering immobilizing drugs, ophthalmic ointment should be applied to prevent ocular desiccation, and masks should be placed over the eyes. During recovery, deer should be positioned sternally or on their right side to avoid bloat. Efforts should be made to minimize noise during handling procedures until the deer is fully immobilized. Deer may be given sodium bicarbonate, selenium/vitamin E supplements, and/or antibiotics before release (although such treatments are not always effective). During transportation, deer should not be over-crowded and should be kept in the dark. Antlers should be removed from males, or they should be contained separately. Prior to release, if the transport time is minimal, immobilizations can be reversed with an intravenous injection of antagonists (Mech et al. 1985, Kreeger et al. 1986). Avoid capturing and handling deer under extreme weather conditions (e.g., cold rain, low temperatures [less than ten degrees Fahrenheit] with high winds, or hot temperatures [more than 85 degrees Fahrenheit]).

Trap and Euthanasia

Capture with box traps, Clover traps, drop nets, or rocket nets followed by euthanasia has been assessed or considered in only a few locations (Jordan et al. 1995). This technique can be used in areas where there is a concern about the discharge of firearms or in areas with very high deer densities to complement a sharpshooting program. This method, however, is inefficient and expensive, with costs likely exceeding $300 per deer.

Physical restraint and euthanasia of deer in traps is sometimes preferred over chemical means because it allows for the consumption of meat from the deer. Deer are greatly stressed, however, during the restraint phase of the capturing process (DeNicola and Swihart 1997). Only trained personnel should euthanize captured deer by administering either a gunshot or a penetrating captive bolt to the head.

Sharpshooting

Several communities have employed trained, experienced personnel to lethally remove deer through sharpshooting (Figure 17) with considerable success (Deblinger et al. 1995, Drummond 1995, Jones and Witham 1995, Stradtmann et al. 1995, Ver Steeg et al. 1995, Butfiloski et al. 1997, DeNicola et al. 1997c). A variety of techniques can be used in sharp-

Figure 17. Blind and rifle on a raised deck used as a sharp-shooting station

shooting programs to maximize safety, humaneness, discretion, and efficiency. The cost per deer for sharpshooting programs has varied, ranging from $91 to $310 per deer.

Human safety concerns are often associated with the discharge of firearms in suburban landscapes. The noise associated with discharging firearms after dark in suburban areas must be considered when developing a sharpshooting program. Often the negative public reaction to sharpshooting is minimal if firearms are fitted with suppressors. Also, perceptions of public safety can be enhanced by having police or other uniformed officials responsible for shooting the deer and/or providing on-site security.

The level of experience of the personnel involved and the program design should be thoroughly assessed. As for any population reduction method, the extent and distribution of access to deer on private or public property will directly affect program efficiency and outcomes. The following methods are recommended for sharpshooting programs: (1) use baits to attract deer to designated areas prior to removal efforts, (2) shoot deer from portable tree stands, ground blinds, or from a vehicle during the day or night, (3) when possible, select head (brain) or neck (spine) shots to ensure quick and humane death, (4) process deer in a closed and sheltered facility, and (5) donate meat to food banks for distribution to needy people in the community.

Archery equipment has been used to remove deer in suburban areas, usually when firearms discharge was not permitted. Compound bows or cross-bows with a minimum peak draw weight of 50 pounds are recommended. In one New York community only a few square miles in size, deer were shot at close range (ten to fifteen yards) while feeding at bait piles, similar to the procedure described for sharpshooting. More than 500 deer were removed from this community using bow and arrows in less than two years.

Controlled Hunting

Another option in controversial management areas is the use of controlled hunts (Ellingwood 1991). Controlled hunting is the application of legal, regulated deer hunting methods in combination with more stringent controls or restrictions as dictated by the landowner or elected officials. Controlled hunts have been successful in several locations (Sigmund and Bernier 1994, Deblinger et al. 1995, Kilpatrick et al. 1997, Mitchell et al. 1997, McDonald et al. 1998, Kilpatrick and Walter 1999).

The potential for intervention and/or interference by activist groups is often high when using hunters to manage locally overabundant deer populations. Thus,

Figure 18. Bowhunters can remove deer from suburban locations where firearm hunts are impractical.

in controversial situations where hunters are used, intensive involvement of state agency and law enforcement personnel is required. The site must be assessed and patrolled to minimize ingress by protesters, trespassers, and vandals. Costs for law enforcement personnel should be considered in the planning process. Examples of indirect costs affiliated with controlled hunts have ranged from $160 per deer harvested (Connecticut) to $622 per deer harvested (New Jersey) (Sigmund and Bernier 1994, Deblinger et al. 1995, Connecticut Department of Environmental Protection 1996).

Selection of hunting techniques will depend on local circumstances, including parcel size, deer numbers, problem severity, and the potential for conflict. Archery hunting for deer (Figure 18) has the advantage of being a relatively discreet and silent activity. The limited shooting range for archery equipment, coupled with the tendency of archers to hunt from tree stands (which ensures a backstop for shots), makes archery hunting a safe and nondisruptive removal technique (Richter and Reed 1998).

Archery has the disadvantage of being less efficient at reducing deer density than firearms hunting because of lower success rates for bowhunters. Special archery seasons may be longer than firearm hunts to allow for sufficient deer harvest over time. The length of the hunt should be thoroughly evaluated if an area is closed to public access because of the incompatibility of archery hunting with other activities. An additional disadvantage, particularly on small parcels, is that even deer that are mortally wounded with an arrow can travel 100 yards or more before succumbing. In developed areas, this could result in fatally struck deer dying on adjacent properties.

When feasible, shotguns loaded with slugs should be used to maximize program efficiency and help ensure that management goals are attained. Shotguns should be equipped with rifle sights or a scope and a rifled barrel to help ensure accurate shot placement. Where legal, rifles are the firearm of choice in expansive rural areas. For a detailed description of suggestions to maximize the efficiency, acceptability, and safety of controlled hunts see Ellingwood (1991) and Kilpatrick and Walter (1999).

Experimental Deer Management

Fertility Control Agents

Recently, much research has focused on alternative, nonlethal techniques to regulate deer populations in suburban areas that are closed to hunting because of safety concerns or social attitudes. Wildlife researchers are attempting to determine if immunocontraception, or some other form of fertility control, can be a practical management alternative. Field studies are under way to determine the feasibility of using contraceptive vaccines to regulate free-ranging deer populations (Rudolph et al. 2000).

Fertility control agents function by reducing the reproductive output so that it equals or is less than the rate of mortality. Because annual mortality rates for suburban deer populations are often very low, a large proportion of the does (70 to 90 percent) need to be effectively treated to curb or reduce population growth (Rudolph et al. 2000).

Unfortunately, much confusion surrounds the status of fertility control agents. The lack of public understanding regarding the availability and practicality of fertility control has caused unnecessary delays in the implementation of effective management programs, because fertility control is perceived as the ideal solution. To put fertility control technology in perspective, after four decades of research, effective antifertility programs for controlling populations of free-ranging wildlife simply do not exist. It is unlikely that a safe and cost-effective fertility control method will be available for managing deer populations in areas larger than a few square miles within the next five to ten years.

Regulatory and Permit Requirements for Antifertility Research

Antifertility agents for wildlife are not commercially available. All antifertility agents are currently classified as experimental drugs and are only produced in a few research laboratories. Experimental drugs can only be administered to deer following U.S. Food and Drug Administration (FDA) guidelines. A federal Investigational New Animal Drug permit and state or provincial wildlife agency approval are necessary to capture or treat any deer with drugs. Consequently, in North America, treatment of deer with contraceptive vaccines is only being conducted in research projects by universities, state and federal wildlife agencies, and the Humane Society of the United States.

The FDA has concerns about the safety of consuming deer treated with experimental drugs and currently requires that all treated, free-ranging deer be marked with warning tags (Figure 19) that stipulate consumption restrictions. It is not clear if or when FDA restrictions on consumption of deer meat treated with experimental drugs will be modified. In addition, fertility control agents are usually delivered to deer using either dart rifles or biobullets. Restrictions on firearms discharge in suburban areas often limits practical delivery of drugs to free-ranging deer. Consequently, there are many aspects of the regulatory and commercialization process and delivery systems that still need to be developed before contraceptive vaccines can be a viable management alternative for communities with overabundant deer herds.

Figure 19. Cattle ear tags and radio collars are used to individually mark deer that are included in a research project.

Figure 20. Dart rifle used for delivery of antifertility agents, vaccines, and immobilizing drugs

Antifertility Agents under Investigation

The two general categories of fertility control agents include: (1) drugs or vaccines that prevent conception (contraception) and (2) chemicals that are administered postconception to terminate pregnancy (abortifacient or contragestation).

Steroid Contraception. Fertility control with steroids (i.e., synthetic progestins and estrogens) has been evaluated for controlling deer reproduction during the past 25 years. Orally delivered steroids have shown limited success in preventing deer reproduction (Matschke 1977, Roughton 1979). However, implants containing synthetic steroids have been effective in some studies (Matschke 1980, Plotka and Seal 1989, Jacobsen et al. 1995, DeNicola et al. 1997a). Regardless of proven efficacy, the FDA will not permit the use of steroidal agents on free-ranging deer because of unresolved questions regarding the effect of long-term steroid exposure on deer, the impact of steroid-treated carcasses on animals in the food chain, and concerns about steroid consumption by humans.

Immunocontraception. Immunocontraceptive vaccines control fertility by stimulating the production of antibodies against proteins and hormones that are essential for reproduction. The antibodies interfere with the normal physiological activity of these reproductive agents (Talwar and Gaur 1987). Immunofertility agents (e.g., Porcine Zona Pellucida [PZP] and Gonadotropin-Releasing Hormone [GnRH]) have been successfully employed to control reproduction in individual deer (Turner et al. 1992, 1996; Miller et al. 1998). Miller et al. (1998) provided an excellent review of immunocontraception technology.

Contragestation. One contragestation agent, prostaglandin ($PGF_{2\alpha}$), has proven to be both safe and highly effective in white-tailed deer (DeNicola 1996, DeNicola et al. 1997b). Risk to secondary consumers is minimal because $PGF_{2\alpha}$ is metabolized readily in the lungs of treated animals (Piper et al. 1970). In addition, prostaglandin can be remotely delivered using the biobullet delivery system (see "Delivery Methods" below). Negative public perception of using "abortion" agents, however, may limit future application of this technique with deer.

Delivery Methods

A limited number of delivery methods are available for antifertility agents. The usefulness of each depends on the site conditions, deer behavior, and number of deer to be treated.

Surgical sterilization or implantation. Implantation is effective, but it requires animal restraint and is stressful to the treated animal, time consuming, and costly (Eagle et al. 1992, Garrott et al. 1992). Surgical sterilization by implants or tubal ligation has been evaluated (Plotka and Seal 1989), however, this approach has significant limitations because of the effort required to capture and handle individual deer. This method may be practical in small (less than two square miles), isolated or enclosed parks, arboretums, and corporate complexes with few deer.

Remote delivery. Antifertility agents have been administered using darts (Figure 20) and biobullets. Biobullets are biodegradable hydroxypropyl cellulose and calcium carbonate projectiles used to administer antifertility agents, vaccines, anthelminthics, antibiotics, and immobilization agents (Herriges et al. 1991, Jessup et al. 1992, DeNicola et al. 1996). The biobullet system allows for the remote delivery of intramuscular treatments. Remote delivery reduces the probability of direct consumption of fertility control agents by nontarget species. The limited life expectancy of implants, the expense involved in treatment, and the difficulty of treating an adequate portion of the herd all suggest that large-scale implant programs would be impractical, yet remote delivery may have value in controlling small, isolated deer herds.

Oral application of antifertility agents. To allow for practical application of fertility control agents to larger populations or areas (two square miles or more), it will be necessary to develop an oral delivery system. Presently no orally active, nonsteroidal, antifertility agent is available. Additional major obstacles to oral contraception in deer include dosage control, absorption of active agents, and ingestion of bait by nontarget wildlife. Based on these concerns and past studies, much research is still required before an oral antifertility agent becomes available.

In conclusion, advances in delivery systems coupled with improvement in the efficacy of antifertility agents improve the prospects of wildlife population control through contraception in the future. Much information is still needed, however, regarding the biological and practical concerns associated with administering immunocontraceptive vaccines. The cost of labor and materials and the practicality of treating an adequate number of deer likely will limit the use of immunocontraceptives to small insular herds that are habituated to humans (Curtis et al. 1998, Walter 2000, Rudolph et al. 2000). Furthermore, with low annual mortality rates for suburban deer, populations will remain at high levels for several years after the initiation of a contraception program. If short-term population reduction is the management goal, it will be necessary to reduce the herd to an acceptable density, and then treat the majority of the remaining females with contraceptive vaccines to stabilize herd growth (Nielsen et al. 1997).

Summary

White-tailed deer occur across much of the United States and provide many desirable recreational and aesthetic benefits. Deer are extremely adaptable and will readily use the food and cover that abounds in suburban landscapes. The number of conflicts between deer and people has increased dramatically in the past 25 years. It is rarely desirable or possible to eliminate all deer from an area. Instead, management programs strive to reduce deer numbers and related problems to a level that a community can tolerate. Conflicts with deer or other wildlife are socially defined and may include nuisance situations and actual or perceived threats to human health and safety. Managing deer problems may involve changing stakeholder attitudes or behavior, as well as modifying deer behavior or directly reducing herd size. Many communities experience difficulty in determining an appropriate herd size and/or an acceptable level of deer conflicts. It is critical to clearly define deer management goals and to determine measurable response variables prior to implementing a deer management program so that the outcomes can be evaluated critically.

Quick-fix solutions seldom reduce problems, and an integrated approach combining several techniques is usually the key to successful deer management programs. Concerns should be addressed at both site-specific and landscape levels. Frightening techniques and/or repellents generally provide short-term relief from deer conflicts on individual properties. Physical barriers (fences) are generally designed for long-term protection, however, they are relatively expensive and visually obtrusive. Long-term solutions often require some form of population management to stabilize or reduce deer numbers.

Problems with suburban deer are likely to increase over time. Because of the low mortality rate for adult deer and favorable habitat conditions for reproduction, suburban deer herds can double in size every two to five years. Some techniques (e.g., frightening devices) that were effective for low to moderate population levels tend to fail as densities increase and deer become more accustomed to human activity.

Communities often debate the merits of lethal versus nonlethal strategies for managing deer conflicts. Although nonlethal control methods can reduce problems at a specific site, they seldom resolve community-wide conflicts. When civic leaders discuss lethal methods such as controlled hunting programs, sharpshooting, or trap-and-kill options, they frequently experience strong resistance from animal activist groups. To develop an effective, long-term management program, community leaders must implement a public education program, facilitate a fair and inclusive decision-making process, and produce clearly defined goals and objectives.

Currently, no federally registered drugs are commercially available for controlling fertility of white-tailed deer. Experimental products are being evaluated and may become available in the future. Contraceptive agents may eventually be useful for small isolated sites, however, community-wide applications of these materials will likely be difficult and expensive.

Overabundant suburban deer populations present a tremendous management challenge for state, provincial, and federal wildlife agencies and local communities. Capable, credible, and professional wildlife agency staff are required to balance the biological and social dimensions of deer management issues. In addition, educators, trained facilitators, and community leaders should participate in wildlife management teams to identify and implement innovative deer management solutions that have broad-based community support.

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Appendix A. Deer Damage Control Supplies and Materials

The following equipment suppliers are categorized by materials provided and listed in alphabetical order. This is an extensive but not exhaustive list. Reference to companies and products is for identification purposes only—it does not imply endorsement nor does exclusion imply criticism of any product or company. Local sources may be found in the yellow pages of your phone book. Contact your state or provincial wildlife agency or Cooperative Extension office for additional information.

Habitat Modification

Deer-Resistant Plants

Deer-Resistant Landscape Nursery
3200 Sunstone Ct.
Clare, MI 48617-8600
(800) 595-3650
(888) 727-3337 FAX
www.deerxlandscape.com

Native American Seed Co.
127 N. 16th St.
Junction, TX 76849
(800) 728-4043
www.seedsource.com

Twombly Nursery
163 Barn Hill Rd.
Monroe, CT 06468
(203) 261-2133
(203) 261-9230 FAX
www.twomblynursery.com

Exclusion

Browsing Mammal Exclusion Devices (budcaps, plastic tubes, tree wraps)

Earl May Seed & Nursery Co.
208 N. Elm
Shenandoah, IA 51603
(712) 246-1020
(712) 246-2201 FAX
www.earlmay.com

Forestry Suppliers, Inc.
205 West Rankin St., Box 8397
Jackson, MS 39284-8397
(800) 647-5368
(800) 543-4203 FAX
www.forestry-supplies.com

International Reforestation Suppliers
2100 Broadway, Box 5547
Eugene, OR 97405
(800) 321-1037
(403) 345-0597
(800) 933-4569 FAX

Orchard Supply Co.
Box 956
Sacramento, CA 95812-0956
(916) 446-7821
(916) 442-7413 FAX
www.orchardsupply.com

Terra Tech
2635 W. 7th Pl., Box 5547
Eugene, OR 97405
(800) 321-1037
www.teratech.net

Texguard Forestry Products, Ltd.
Box 139
Van Anda, BC
Canada V0N 3K0
(604) 486-7316 (FAX same number)
www.prch.org/texguard/

Treessentials Co.
2371 Waters Dr.
Mendota Heights, MN 55120
(800) 248-8239
(651) 681-0011
(651) 681-1951 FAX
www.treessentials.com

Fence Materials (polytape, high-tensile wire, woven wire, energizers)

Benner's Gardens, Inc.
Box 549
Conshohocken, PA 19428
(800) 753-4660
(800) 323-4186
www.deerfencedirect.com

Conwed Plastics
2810 Weeks Ave. SE
Minneapolis, MN 55414
(800) 426-6933
(612) 623-1700
(612) 623-2500 FAX
www.conwedplastics.com

Dairyland Power Fence Co.
N. 3985 Hidden Valley Rd.
Hatley, WI 54440
(715) 446-2297

Deerbusters
9735A Bethel Rd.
Frederick, MD 21702-2017
(888) 422-3337
(301) 694-1238
(301) 694-9254 FAX
www.deerbusters.com

Deer-Resistant Landscape Nursery
3200 Sunstone Ct.
Clare, MI 48617-8600
(800) 595-3650
(888) 727-3337 FAX
www.deerxlandscape.com

Electrobraid Fence Ltd.
Box 3720 Hwy. #2
Fletchers Lake, NS
Canada B2T 1J3
(888) 430-3330
(902) 860-4200
(902) 860-4300 FAX
www.electrobraid.com

Fickle Hill Fence & Supply
(888) 633-3623
(707) 822-0403 FAX
www.northcoastweb.com/deerfence

Gallagher Power Fence, Inc.
Box 708900
San Antonio, TX 78270-8900
(800) 531-5908
(210) 494-5211
(210) 494-9364 FAX
www.gallagher.usa.com

GEOTEK, Inc.
1421 2nd Ave. NW
Stewartville, MN 55976
(800) 533-1680
(507) 533-6076
(507) 533-4784 FAX
www.geotekinc.com

Greenfire, Inc.
2527 A Hwy. 32 W
Chico, CA 95973
(800) 895-8307
(530) 895-8301
(530) 895-8317 FAX
www.greenfire.net

K Fence Systems
Rt. 1, Box 195
Zumbro Falls, MN 55991
(507) 753-2943
(507) 753-2706 FAX

Kencore Farm Fence, Inc.
344 Kendall Rd.
Blairsville, PA 15717
(800) 536-2683
(724) 459-8991
(724) 459-9148 FAX
www.kencore.com

Keystone Steel & Wire
7000 SW Adams St.
Peoria, IL 61641
(800) 447-6444
(309) 697-7487 FAX
www.redbrand.com

Kiwi Fence Systems, Inc.
121 Kiwi Rd.
Waynesburg, PA 15370-8070
(724) 627-8158
(724) 627-9791 FAX
www.kiwifence.com

Live Wire Products, Inc.
1127 E St.
Marysville, CA 95901
(800) 272-9045
(530) 743-9045
(530) 743-0609 FAX

Margo Supplies, Ltd.
Site 20, Box 11, Rt. 6
Calgary, Alberta
Canada T2M 4L5
(403) 652-1932
(403) 652-3511 FAX
www.margosupplies.com

Max Flex Fence Systems
U.S. Route 219
Lindside, WV 24951
(800) 356-5458
(304) 753-4387
(304) 753-4827 FAX
www.maxflex.com

Mississippi Valley Forest Products, Inc.
Box 1250
Dubuque, IA 52004
(319) 583-2795
(319) 588-3062 FAX

Parker-McCrory Mfg. Co.
2000 Forest Ave.
Kansas City, MO 64108
(800) 662-1038
(816) 221-2000
(816) 221-9879 FAX
www.parmak.usa

Premier Fence Systems
2031 300th St.
Washington, IA 52353
(319) 653-6631
(800) 346-7992 FAX
www.premiersupplies.com

Qual-Line Fence Corp.
801 S. Division
Waunakee, WI 53597
(608) 849-4654
(608) 849-8605 FAX

South Omaha Supply Co.
3310 H St.
Omaha, NE 68107
(800) 228-9534
(402) 731-3100
(402) 731-8511 FAX

Southwest Power Fence
26321 Hwy. 281 N
San Antonio, TX 78260
(800) 221-0178
(830) 438-4600
(830) 438-4604 FAX
www.swpowerfence.com

TechFence-Advanced Farm Systems
Rt. 1, Box 364
Bradford, ME 04410
(207) 327-1237

Tenax Corp.
4800 E. Monument St.
Baltimore, MD 21205
(800) 356-8495
(410) 522-7000
(410) 522-7015
www.tenax.net

The Country Store & Gardens
20211 Vashon Hwy. SW
Vashon Island, WA 98070
(888) 245-6136
(206) 463-3655
www.countrystoreandgardens.com

Twin Mountain Supply Co., Inc.
Box 2240
San Angelo, TX 76902
(800) 331-0044
(915) 944-8661
(915) 949-2047 FAX

Waterford Corp.
404 N. Link Lane
Box 1513
Fort Collins, CO 80524
(800) 525-4952
(303) 482-0911
(303) 482-0934 FAX

Wildlife Control Technology, Inc.
2501 N. Sunnyside Ave. #103
Fresno, CA 93727
(800) 235-0262
(559) 490-2262
(559) 490-2260 FAX
www.wildlife-control.com

Wildlife Damage Control
PMB 102
340 Cooley St.
Springfield, MA 01128
(413) 796-9916
(413) 796-7819 FAX
www.wildlifedamagecontrol.com

Zeitlow Distributing
Box 424
McPherson, KS 67460
(316) 364-1605
(316) 241-4279 FAX

Netting or Plastic Mesh

Benner's Gardens, Inc.
Box 549
Conshohocken, PA 19428
(800) 753-4660
(800) 323-4186 FAX
www.deerfencedirect.com

Conwed Plastics
2810 Weeks Ave. SE
Minneapolis, MN 55414
(800) 426-6933
(612) 623-1700
(612) 623-2500 FAX
www.conwedplastics.com

Internet, Inc.
7300 49th Ave. N
Minneapolis, MN 55428
(800) 328-8456
(763) 971-0871
(763) 971-0872
www.internetplastic.com

J.A. Cissel Mfg. Co.
Box 2025
Lakewood, NJ 08701
(800) 631-2234
(732) 901-0300
(732) 901-1166 FAX
www.jacisselocs.com

Miller Net Co., Inc.
1674 Getwell Rd.
Memphis, TN 38111
(800) 423-6603
(901) 744-3804
(901) 743-6580 FAX
home.man.net/nmiller

Nalle Plastics, Inc.
220 E St. Elna Rd.
Austin, TX 78745
(800) 531-5112
(512) 477-7000
(512) 447-7444 FAX
www.naltex.com

National Netting, Inc.
202 Tree Trail Pkwy.
Norcross, GA 30093
(800) 233-7896
(770) 925-8811
(770) 925-3420 FAX
www.nationalnetting.com

Nichols Net & Twine Co., Inc.
2200 Hwy. 111
Granite City, IL 62040
(800) 878-6387
(618) 797-0211
(618) 797-0212 FAX

Nylon Net Co.
845 N. Main St.
Box 592
Memphis, TN 38101
(800) 238-7529
(901) 526-6500
(901) 526-6538 FAX
www.nylonnet.com

Prosoco, Inc.
Box 171677
Kansas City, KS 66117
(800) 255-4255
(913) 281-2700
(913) 281-4385 FAX
www.prosoco.com

Sinco, Inc.
701 Middle St.
Middletown, CT 06457
(800) 243-6753
(860) 632-0500
(860) 632-1509 FAX
www.sinco.com

The Tensar Corp.
1210 Citizens Pkwy.
Morrow, GA 30260
(800) 292-4457
(707) 968-3255
(707) 961-8239 FAX

Frightening Devices

Air Horns

Falcon Safety Products, Inc.
25 Chubb Way
Branchburg, NJ 08876
(908) 707-4900
(908) 707-8855 FAX
www.falconsafety.com

Clapper Device

Tomko Enterprises, Inc.
180 Merritt Pond Rd.
Riverhead, NY 11901
(516) 727-3932

Deterrents (rubber slugs, scaredarts)

Margo Supplies, Ltd.
Site 20, Box 11, Rt. 6
Calgary, Alberta
Canada T2M 4L5
(403) 652-1932
(403) 652-3511 FAX
www.margosupplies.com

Pneu-Dart, Inc.
Box 1415
Williamsport, PA 17703
(717) 323-2710
(717) 323-2712 FAX

Dogs (Invisible Fence)

Deerbusters
9735A Bethel Rd.
Frederick, MD 21702-2017
(888) 422-3337
(301) 694-1238
(301) 694-9254 FAX
www.deerbusters.com

Innotek Pet Products
One Innoway
Garrett, IN 46738
(800) 826-5527
(219) 357-3160 FAX
www.pet-products.com

Invisible Fence Co., Inc.
355 Phoenixville Pike
Malvern, PA 19355-9603
(800) 538-3647
(610) 651-0999
(610) 651-0986 FAX
www.ifco.com

Pet Guardians Underground Fencing
8003 Meade
Montague, MI 49437
(888) 738-7577
(616) 894-9458
www.petguardians.com

Radio Fence Distributors, Inc.
1133 Bal Harbor Blvd. Suite 1151
Punta Gerda, FL 33950
(800) 941-4200
(941) 505-8220
(941) 505-8229 FAX
www.radiofence.com

Electronic Guard

Pocatello Supply Depot
USDA-APHIS-Wildlife Services
238 E. Dillon St.
Pocatello, ID 83201
(208) 236-6920
(208) 236-6922 FAX
www.pocsplydepot@gemstate.net

Exploders, Automatic Gas (propane canon, Zon gun)

Agricultural Supply, Inc.
1435 Simpson Way
Escondido, CA 92029
(800) 527-6699
(619) 741-9412 FAX
agsupply@adnc.com

Avian Systems
310 Production Court
Jeffersontown, NY 40299
(502) 499-6545

Margo Supplies, Ltd.
Site 20, Box 11, Rt. 6
Calgary, Alberta
Canada T2M 4L5
(403) 652-1932
(403) 652-3511 FAX
www.margosupplies.com

NASCO
901 Janesville Ave.
Box 901
Fort Atkinson, WI 53538-0901
(800) 558-9595
(920) 563-8296 FAX
www.nascofa.com

Pacific Harvest
1035 N. 10th Ave.
Cornelius, OR 97113
(800) 400-4289
(503) 359-4289
(888) 400-3583 FAX
www.easyrider.com

Pisces Industries
Box 576407
Modesto, CA 95355
(209) 578-5502
(209) 274-4723 FAX

Quality Stores, Inc.
4554 Quantas Ln. Suite 1
Stockton, CA 95206
(800) 221-2884
(209) 983-8484
(209) 983-8449 FAX

Reed-Joseph International Co.
Box 894
Greenville, MS 38702
(800) 647-5554
(602) 335-5822
(662) 335-8850 FAX
www.reedjoseph.com

Sutton Ag Enterprises, Inc.
746 Vertin Ave.
Salinas, CA 93901
(408) 422-9693
(408) 422-4201 FAX

Wildlife Control Technology, Inc.
2501 N. Sunnyside Ave. #103
Fresno, CA 93727
(800) 235-0262
(559) 490-2262
(559) 490-2260 FAX
www.wildlife-control.com

Human Effigies (Scarey Man)

FLR Inc.
Box 108
Midnight, MS 39115
(662) 247-4409
(662) 247-1715 FAX

Pyrotechnics (shellcrackers, bird bangers)

Deerbusters
9735A Bethel Rd.
Frederick, MD 21702-2017
(888) 422-3337
(301) 694-1238
(301) 694-9254 FAX
www.deerbusters.com

Farm and Industrial Supply Co.
Box 31510
Stockton, CA 95213
(800) 221-2884
(209) 983-8449 FAX

Tomsgarden.com
RR 123 & East St.
Vista, NY 10590
(888) 317-6795
(914) 533-6115
(914) 533-6865 FAX
www.garden-shops.com

Margo Supplies, Ltd.
Site 20, Box 11, Rt. 6
Calgary, Alberta
Canada T2M 4L5
(403) 652-1932
(403) 652-3511 FAX
www.margosupplies.com

NASCO
901 Janesville Ave.
Box 901
Fort Atkinson, WI 53538-0901
(800) 558-9595
(920) 563-8296 FAX
www.nascofa.com

Reed-Joseph International Co.
Box 894
Greenville, MS 38701
(800) 647-5554
(662) 335-5822
(662) 335-8850 FAX
www.reedjoseph.com

Stoneco, Inc.
Box 765
Trinidad, CO 81082
(800) 833-2264
(719) 846-2853
(719) 846-7700 FAX

Wildlife Control Technology, Inc.
2501 N. Sunnyside Ave. #103
(800) 235-026
(559) 490-2262
(559) 490-2260 FAX
www.wildlife-control.com

Reflectors (Swareflex)

Strieter Corp.
2100 18th Ave.
Rock Island, IL 61201-3611
(309) 794-9800
(309) 788-5646 FAX
www.strieter-lite.com

Other Sonic/Visual Devices (CritterGitter)

Amtek
11025 Sorrento Valley Ct.
San Diego, CA 92121
(800) 762-7618
(619) 597-6681
(800) 762-7613 FAX
www.amtekpet.com

Benner's Gardens, Inc.
Box 549
Conshohocken, PA 19428
(800) 753-4660
(800) 323-4186 FAX
www.deerfencedirect.com

Bird-X, Inc.
300 N. Elizabeth St.
Chicago, IL 60607
(800) 662-5021
(312) 226-2477
(312) 226-2480 FAX
www.bird-x.com

Chagnon's Enterprises
RR 2 Box 2638B
Manistique, MI 49854
(800) 795-5157
(906) 341-1604
(906) 341-2030 FAX
www.chagnon.hypermart.net

Deerbusters
9735A Bethel Rd.
Frederick, MD 21702-2017
(888) 422-3337
(301) 694-1238
(301) 694-9254 FAX
www.deerbusters.com

Repellents

Ammonium Soaps of Higher Fatty Acids (Hinder)

Deerbusters
9735A Bethel Rd.
Frederick, MD 21702-2017
(888) 422-3337
(301) 694-1238
(301) 694-9254 FAX
www.deerbusters.com

Deer-Resistant Landscape Nursery
3200 Sunstone Ct.
Clare, MI 48617-8600
(800) 595-3650
(888) 727-3337
www.deerxlandscape.com

Forestry Suppliers, Inc.
205 West Rankin St., Box 8397
Jackson, MS 39284-8397
(800) 647-5368
(800) 543-4203 FAX
www.forestry-supplies.com

J. C. Ehrlich Chemical Co.
500 Spring Ridge Dr.
Reading, PA 19612
(800) 488-9495
(610) 372-9700
(610) 378-9744 FAX
www.ehrlichchemco.com

Pace International, Ltd.
Leffingwell Division
111 S. Berry St., Box 1880
Brea, CA 92621
(714) 529-3973
(714) 671-2138 FAX

Animal Protein (Plantskydd)

Tree World
RR 1 Mission Point C-78
Sechelt, BC
Canada V0N 3Z0
(800) 252-6051
(604) 885-3535 FAX
www.treeworld.com

Capsaicin (Hot Sauce)

Bonide Products, Inc.
2 Wurz Ave.
Yorkville, NY 13495
(315) 736-8231
(315) 736-7582 FAX

Deerbusters
9735A Bethel Rd.
Frederick, MD 21702-2017
(888) 422-3337
(301) 694-1238
(301) 694-9254 FAX
www.deerbusters.com

Green Screen Products
Envirodyne, Inc., Box 357
Maniste, MI 49660
(800) 968-9453
(231) 723-5905
(231) 723-7417

J. C. Ehrlich Chemical Co.
500 Spring Ridge Dr.
Reading, PA 19612
(800) 488-9495
(610) 372-9700
(610) 378-9744 FAX
www.ehrlichchemco.com

Miller Chemical and Fertilizer Corp.
Box 333, Radio Rd.
Hanover, PA 17331
(800) 233-2040
(717) 632-8921
(717) 632-9638 FAX

Denatonium Saccharide (Ro-pel)

Becker Underwood, Inc.
801 Dayton Ave.
Ames, IA 50010
(800) 232-5407
(515) 232-5907
(515) 232-5961 FAX
www.bucolor.com

Burlington Scientific Corp.
71 Carolyn Blvd.
Farmingdale, NY 11735
(631) 694-4700
(631) 694-9177 FAX
www.ropel.com

Deerbusters
9735A Bethel Rd.
Frederick, MD 21702-2017
(888) 422-3337
(301) 694-1238
(301) 694-9254 FAX
www.deerbusters.com

Forestry Suppliers, Inc.
205 West Rankin St., Box 8397
Jackson, MS 39284-8397
(800) 647-5368
(800) 543-4203 FAX
www.forestry-supplies.com

Orchard Supply Co.
Box 956
Sacramento, CA 95812-0956
(916) 446-7821
(916) 442-7413 FAX
www.orchardsupply.com

Garlic (Plant Pro-Tec)

Forestry Suppliers, Inc.
205 West Rankin St.
Box 8397
Jackson, MS 39284-8397
(800) 647-5368
(800) 543-4203 FAX
www.forestry-supplies.com

Tomsgarden.com
RR 123 & East St.
Vista, NY 10590
(888) 317-6795
(914) 533-6115
(914) 533-6865
www.garden-shops.com

Reed-Joseph International Co.
Box 894
Greenville, MS 38701
(800) 647-5554
(662) 335-5822
(662) 335-8850 FAX
www.reedjoseph.com

Predator Urine

Chagnon's Enterprises
RR 2 Box 2638B
Manistique, MI 49854
(800) 795-5157
(906) 341-1604
(906) 341-2030 FAX
www.chagnon.hypermart.net

Deerbusters
9735A Bethel Rd.
Frederick, MD 21702-2017
(888) 422-3337
(301) 694-1238
(301) 694-9254 FAX
www.deerbusters.com

LegUp Enterprises
3048 Lexington Dr.
Bangor, ME 04401
(800) 218-1749
www.predatorpee.com

The Country Store & Gardens
20211 Vashon Hwy. SW
Vashon Island, WA 98070
(888) 245-6136
(206) 463-3655
www.countrystoreandgardens.com

Wildlife Damage Control
PMB 102
340 Cooley St.
Springfield, MA 01128
(413) 796-9916
(413) 796-7819 FAX
www.wildlifedamagecontrol.com

Putrescent Whole Egg Solids (Deer-Away Big Game Repellent)

Chagnon's Enterprises
RR 2 Box 2638B
Manistique, MI 49854
(800) 795-5157
(906) 341-1604
(906) 341-2030 FAX
www.chagnon.hypermart.net

Forestry Suppliers, Inc.
205 West Rankin St., Box 8397
Jackson, MS 39284-8397
(800) 647-5368
(800) 543-4203 FAX
www.forestry-supplies.com

IntAgra, Inc.
8906 Wentworth S.
Minneapolis, MN 55420
(612) 881-5535
(612) 881-7002 FAX
www.intagra.com

J. C. Ehrlich Chemical Co.
500 Spring Ridge Dr.
Reading, PA 19612
(800) 488-9495
(610) 372-9700
(610) 378-9744 FAX
www.ehrlichchemco.com

Orchard Supply Co.
Box 956
Sacramento, CA 95812-0956
(916) 446-7821
(916) 442-7413 FAX
www.orchardsupply.com

Thiram (Thiram 42-S)

Gustafson, LLC
Box 660065
Dallas, TX 75266-0065
(800) 527-4781
(214) 985-8877
(214) 985-1696 FAX
www.gustafson.com

HACCO, Inc.
Box 7190
Madison, WI 53707
(608) 221-6200
(608) 221-7380 FAX

Nott Products Co.
Box 975
Coram, NY 11727
(631) 563-4455
(631) 563-3950 FAX

Tobacco Dust

Faesy & Besthoff, Inc.
143 River Road
Edgewater, NJ 07020
(201) 945-6200
(201) 945-6145 FAX

Ziram (Rabbit Scat)

Earl May Seed & Nursery Co.
208 N. Elm
Shenandoah, IA 51603
(712) 246-1020
(712) 246-2201 FAX
www.earlmay.com

Multiple Active Ingredients (Bobbex, Deer Blocker, Deerbusters, Deer-off)

Benner's Gardens, Inc.
Box 549
Conshohocken, PA 19428
(800) 753-4660
(800) 323-4186 FAX
www.deerfencedirect.com

Bobbex, Inc.
52 Hattertown Rd.
Newtown, CT 06470
(800) 792-4449
(203) 426-1160 FAX
www.bobbex.com

Champon Millenium Chemicals, Inc.
417 Tangerine Dr.
Oldsmar, FL 34677
(813) 818-7641
www.champon.com

Deerbusters
9735A Bethel Rd.
Frederick, MD 21702-2017
(888) 422-3337
(301) 694-1238
(301) 694-9254 FAX
www.deerbusters.com

Deer-off, Inc.
1492 High Ridge Rd.
Stamford, CT 06903
(800) 333-7633
(203) 968-8485
www.deer-off.com

Deer-Resistant Landscape Nursery
3200 Sunstone Ct.
Clare, MI 48617-8600
(800) 595-3650
(888) 727-3337
www.deerxlandscape.com

Dr. T's Nature Products Co., Inc.
Box 682, U.S. 19 N
Roanoke, VA 24019
(800) 299-6288
(912) 294-9742
(912) 294-3027 FAX
www.animalrepellents.com

Farnam Co., Inc.
Security Products Division
301 W. Osborne Rd.
Phoenix, AZ 85013-3997
(888) 241-9547
(602) 285-1660
(877) 818-4950 FAX

Tomsgarden.com
RR 123 & East St.
Vista, NY 10590
(888) 317-6795
(914) 533-6115
(914) 533-6865
www.garden-shops.com

Greenfire Inc.
2527 A Hwy. 32 W
Chico, CA 95973
(800) 895-8307
(530) 895-8301
(530) 895-8317 FAX
www.greenfire.net

Live Capture

Animal Care Equipment and Services, Inc.
Box 3275
Crestline, CA 92325
(800) 338-2237
(909) 338-1791
(909) 338-2799 FAX
www.animal-care.com

Animal Management, Inc.
Box 140
Heafford, WI 54532
(888) 744-8173
(715) 453-8109
(715) 453-9191 FAX
www.animalmanagement.com

Pneu-Dart, Inc.
Box 1415
Williamsport, PA 17703
(717) 323-2710
(717) 323-2712 FAX

Safe-Capture International, Inc.
Box 206
Mt. Horeb, WI 53572
(608) 767-3071
(608) 767-3072 FAX
www.safecapture.com

Tel-Inject USA, Inc.
9316 Soledad Canyon Rd.
Saugus, CA 91350
(800) 468-5111
(661) 268-0915
(661) 268-1105 FAX
www.telinject.com

Wiley & Sons, Inc.
7007 Country Rd. 2120
Wills Point, TX 75169
(903) 848-7912
(903) 848-7922 FAX

Wildlife Pharmaceuticals
1401 Duff Dr. Suite 700
Ft. Collins, CO 80524
(888) 484-9249
(970) 484-5560
(970) 482-6184 FAX
www.wildpharm.com

Fertility Control

No steroids, chemosterilants, immunocontraceptive agents, or other fertility control chemicals or devices are commercially available.

Shooting Services

USDA-APHIS-Wildlife Services
Room 1624 S. Agricultural Building
Washington, DC 20250-3402
(202) 720-2054
(202) 690-0053 FAX
www.aphis.usda.gov/ws/

White Buffalo, Inc.
54 Grandview Ave.
Hamden, CT 06514
203-245-3425
203-245-7072 FAX
www.whitebuffaloinc.org

Shooting Supplies

Burnham Brothers
Box 1148
Menard, TX 76859
(800) 451-4572
(915) 396-4572
(915) 396-4574 FAX
www.burnhambrothers.com

Margo Supplies, Ltd.
Site 20, Box 11, Rt. 6
Calgary, Alberta
Canada T2M 4L5
(403) 652-1932
(403) 652-3511 FAX
www.margosupplies.com

Rocky Mountain Products
4620 Moccasin Circle
Laporte, CO 80535
(303) 484-2768

2000 Shooterstore.com, Inc.
One Court St.
Box 990
Exeter, NH 03833
(603) 778-4720
(603) 778-7265 FAX
www.shooterstore.com

Appendix B. Resource Contacts

Journals including *Crop Protection, Journal of Wildlife Management, Wildlife Society Bulletin, Journal of Applied Ecology,* and others provide a source of scientifically-tested management techniques. Additional information can be found in the proceedings of the *Eastern Wildlife Damage Management Conference, Great Plains Wildlife Damage Control Workshop,* and *Vertebrate Pest Conference.* The Internet Center for Wildlife Damage Management (http://wildlifedamage.unl.edu) is available electronically. It serves as a clearinghouse for all information concerning wildlife damage that is currently posted on the web.

State Wildlife Agency Phone Numbers

Alabama	334-242-3465
Alaska	907-465-4190
Arizona	602-942-3000
Arkansas	501-223-6305
California	916-653-7203
Colorado	303-297-1192
Connecticut	860-424-3011
Delaware	302-739-5297
Florida	850-488-3831
Georgia	770-918-6404
Hawaii	808-587-0166
Idaho	208-334-2920
Illinois	217-782-6302
Indiana	317-232-4080
Iowa	515-281-5145
Kansas	785-296-2281
Kentucky	502-564-4406
Louisiana	504-765-2346
Maine	207-287-5252
Maryland	410-974-3195
Massachusetts	617-727-3155
Michigan	517-373-1263
Minnesota	612-296-3344
Mississippi	601-364-2212
Missouri	573-751-4115
Montana	406-444-2612
Nebraska	402-471-5411
Nevada	702-688-1500
New Hampshire	603-271-3422
New Jersey	609-292-9410
New Mexico	505-827-7885
New York	518-457-5690
North Carolina	919-733-7291
North Dakota	701-328-6300
Ohio	614-265-6300
Oklahoma	405-521-2739
Oregon	503-872-5260
Pennsylvania	717-787-5529
Rhode Island	401-277-3075
South Carolina	803-734-3889
South Dakota	605-773-3381
Tennessee	615-781-6610
Texas	512-389-4971
Utah	801-538-4700
Vermont	802-241-3700
Virginia	804-367-9588
Washington	360-902-2504
West Virginia	304-558-2771
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Increasing deer and human populations have resulted in more conflicts. Expanding communities have created excellent deer habitat with an abundance of ornamental shrubs, garden plants, and other deer foods. Wooded homesites offer protection from predators and hunting, allowing deer populations to grow rapidly.

Overabundant herds are associated with an increase in car collisions and Lyme disease, resulting in significant economic losses and health problems. In addition, deer create ecological damage by feeding on preferred plants and altering the biodiversity in parks and natural woodlands.

This 52-page manual, *Managing White-Tailed Deer in Suburban Environments: A Technical Guide,* reviews the biology of the white-tailed deer and discusses methods for reducing deer-related concerns. Comprehensive management strategies are included. Fencing and repellents are covered, as well as options for lowering deer abundance and experimental techniques for deer fertility control.

The authors provide options, suggestions, and additional resources, as well as sources of equipment used for deer management.

The information and applications in this manual are useful across North America in urban, suburban, and rural areas. It is intended for professional biologists, community leaders, homeowners, and others involved or concerned with deer management.

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