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Department of Environmental Conservation

DEER MANAGEMENT IN URBAN AND SUBURBAN NEW YORK

A Report to the New York State Senate and Assembly

December 31, 2018

www.dec.ny.gov

Basil Seggos, Commissioner

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Deer Management in Urban and Suburban Areas of New York State

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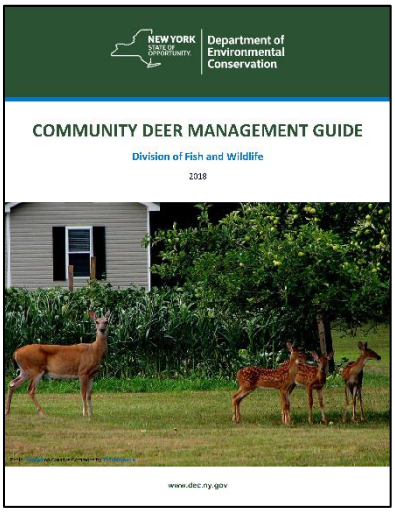
Introduction

White-tailed deer (*Odocoileus virginianus*) play vital roles in the natural and cultural environment of New York and are highly valued for their beauty and grace as well as the utilitarian benefits they provide. However, the abundance of deer in large parts of the state is causing increasing problems, particularly in suburban and urban areas. Common types of human-deer conflict include deer-vehicle collisions on roads, deer damage to landscaping plants and an increase in diseases carried by ticks that feed on deer. High densities of deer also threaten the long-term viability of forest ecosystems.

Because deer are large, highly mobile animals, there is little that individual property owners in developed areas can do to reduce the deer-related problems they face. Enclosing a property in a fence that deer can't jump over can prevent landscaping damage, but it does nothing to reduce the risk of deer-vehicle collisions. Furthermore, such fences around yards have the effect of pushing the deer onto other properties, thus improving the situation for some residents at the cost of making it worse for others. Reducing deer problems for community residents as a whole typically requires approaching deer management at a community level. That means making decisions as a community rather than as individuals and taking actions at a large enough geographic scale that they will affect deer throughout the community.

DEC has created a Community Deer Management Handbook to help people understand the deer problems they're experiencing and guide communities through the process of assessing the need for deer management, evaluating possible approaches and planning a course of action. Community-based deer management is taking place across the country, and another good source of guidance along with information on the experiences of many other communities is the Community Deer Advisor website (deeradvisor.org) developed by Cornell University with DEC input.



History of Deer Overabundance in New York

After rampant deforestation and unregulated hunting wiped out over 95% of the country's deer in the 19th century (McCabe and McCabe, 1984), management in the first half of the 20th century was aimed at increasing deer numbers. New York was highly successful in this effort, as were many other states. Deer numbers increased throughout the 1900s. By mid-century, wildlife managers across the country recognized that deer populations in many areas, including parts of New York, were outstripping their food supply (Leopold et al., 1947; Severinghaus and Brown, 1956). Deer overabundance has been a worsening problem ever since.

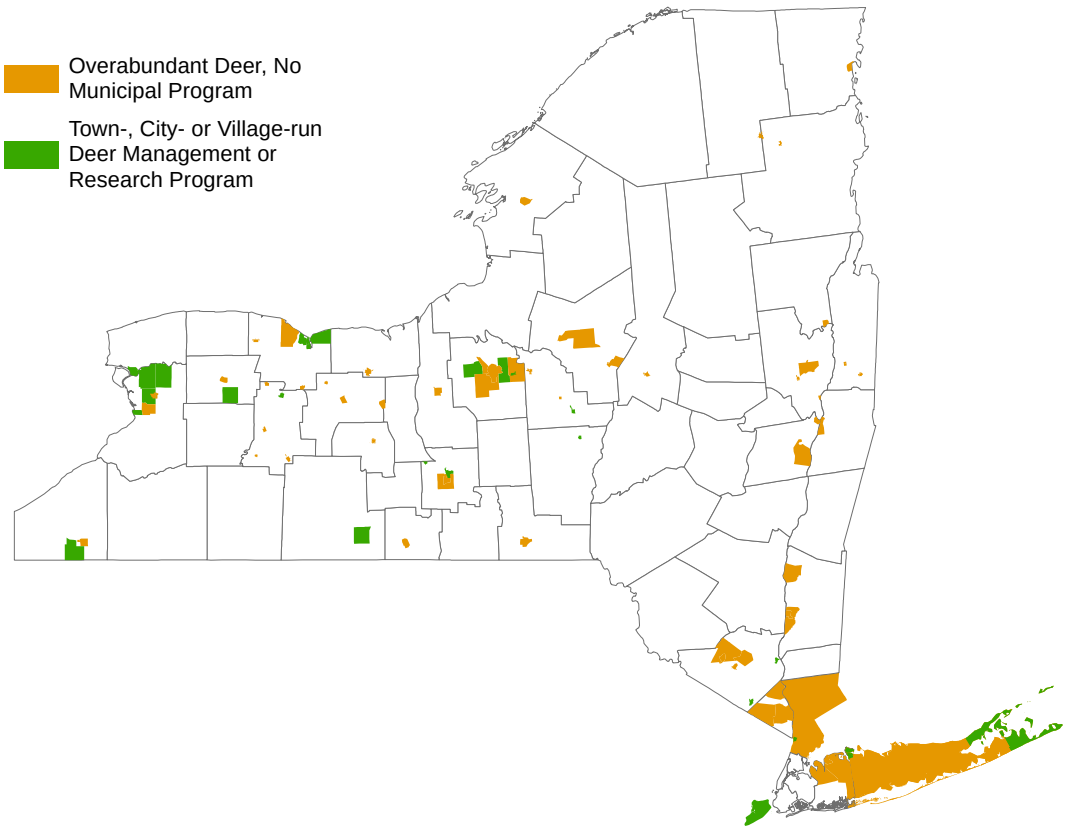
In the 1940s, agricultural damage by deer was reported as a problem throughout the Southern Tier of the state (Severinghaus and Brown, 1956) and in Albany County (NYSDEC, 1944). In 1959, a law was passed allowing a January shotgun season in Westchester County. The text of that legislation described a "critical overabundance of deer" that was causing "severe damage" to agriculture as well as damage to home landscaping (1959 N.Y. Laws, Ch. 738). At the same time, the state wildlife biologists were noting that deer populations in the Catskills and central Adirondacks were larger than the natural food supply could then support and were causing chronic habitat degradation, which, in the case of the Adirondacks, they believed had already been occurring for over 50 years at that point (Severinghaus and Brown, 1956). However, DEC's efforts to loosen hunting restrictions in order to reduce these populations were stymied by lack of public support (Severinghaus and Brown, 1956; NYSDEC, 1980).

Agricultural damage was more successful than ecological degradation at stimulating change, and throughout the following few decades, as hunting was allowed in more areas and firearms seasons were added in areas that previously only had archery seasons, the memos that accompanied introduced bills gave supporting arguments such as that deer had "become a problem" (NYSDEC, 1968) and that deer were causing "damage to crops, orchards and ornamental shrubs and trees" (NYSDEC, 1973), which escalated to "substantial damage" (NYSDEC, 1976) and "very significant damage" (NYSDEC, 1983a) as the years passed. "Deer-vehicle collisions" (NYSDEC, 1977) were also mentioned during this period as a specific problem in need of alleviation.

A position statement that was drafted by DEC biologists in 1983 declared that all areas of the state that support deer populations should be open to firearms hunting, arguing that restrictions on such hunting codified in statute or local ordinances result in "unacceptable levels of deer damage" and populations that "exceed the carrying capacity of the land." It also noted "serious deer problems" in "'some suburban and urban areas" (NYSDEC, 1983b). However, this recommendation to open the remaining closed areas was not successful, and little progress has been made on this front in the ensuing years. In fact, more areas have effectively become closed to deer hunting as many local governments have passed ordinances forbidding weapons discharge or hunting. People encounter deer on a daily basis now in places where a few decades ago they were never seen, and the highest deer densities in the state can be found in urban and suburban areas.

Current Overabundance Hotspots

Urban and suburban deer overabundance is most common in the parts of the state that are most developed and have the most restrictions on hunting, including Long Island, New York City and Westchester, Onondaga, Monroe and Erie Counties. The map below shows communities that have active deer population reduction programs and municipalities where DEC staff are aware of deer overabundance issues but there is currently no community-based management or research program.



Causes of Overabundance

Deer Biology

White-tailed deer are considered generalists, which means they can thrive in a variety of habitats and eat a variety of foods. They are found in forested and brushy areas from the Northwest Territories in Canada all the way to South America. Primarily browsers and grazers, they eat both woody and herbaceous vegetation. They normally find the most to eat in edges, or transition zones between forest and more open habitat types, where there is an abundance of both kinds of food available. They are also a behaviorally adaptable species that easily adjusts to living in close proximity to people. The current pattern of human land use is ideal for creating and sustaining high-density deer populations because open areas such as residential developments and agricultural fields are interspersed with forested areas, providing plentiful edge habitat as well as a variety of nutritious crops and ornamental

plantings that supplement the natural food available to deer. Suburbs have been referred to as "deer factories" because they provide such good conditions for deer populations to grow.

Deer are a prey species that evolved under high levels of predation mortality. As a result, they have a high reproductive rate; females (does) can produce young at one year of age, and they average two offspring (fawns) per year. Both males (bucks) and females breed with multiple mates each year, so each buck can impregnate several does. Reducing the number of bucks in a population therefore tends not to diminish reproductive rates. Under ideal conditions, deer populations can double in size every two to three years. When there is plenty of food available, an average of 30-40% of the deer in a population have to die every year to keep the population from growing (Matschke et al., 1984).

In fully functional ecosystems, populations would be controlled by a combination of interacting factors, including food supply, predation, disease and weather. This doesn't mean that population density would be stable; it's normal for animal populations to fluctuate due to variable environmental conditions. High population densities would not be sustained across broad geographic areas, because mature forests don't provide enough suitable deer food to support such populations. However, fully functional forest ecosystems don't exist in New York. Even deer in large wild areas such as the Adirondacks are not living in an intact ecosystem, because wolves and mountain lions, historically their principal predators, have been eliminated. Bears, bobcats and coyotes do prey on deer, particularly fawns, but hunting by humans is currently the primary predatory force acting to control population levels in rural and remote areas. In more developed areas, local laws and landowner opinions have severely constrained hunting, and predators are scarce, so the majority of deer deaths are caused by collisions with vehicles. This relatively low mortality combined with abundant food has allowed suburban and urban deer populations to reach extraordinarily high levels. Even if the full suite of natural predators were to return to New York, significant reductions of deer populations in developed areas would not be expected, because wolves and mountain lions would avoid or not be tolerated in such areas.

Public Attitudes

Deer population levels are traditionally managed at the landscape scale with regulated recreational hunting. Since 1990, DEC has used citizen input to help set population target levels. For most of that time, targets were based on recommendations that were developed for each Wildlife Management Unit (WMU) by a small group of residents of that WMU who were chosen to represent a range of stakeholders affected by deer (e.g. farmers, hunters, landowners, motorists). However, broad public awareness of the issues surrounding high-density deer populations has remained low until quite recently, and those recommendations often didn't adequately reflect the negative impacts of deer. Furthermore, there were numerous weaknesses of this citizen input format that became apparent over time, including the difficulty of representing the spectrum of public interests and values with a small group. In 2018 DEC began using a survey-based process to gather the information on citizens' preferences that, in combination with data on forest condition, will be used to guide future deer population management decisions. The survey results will provide input from a broad sample of citizens, better reflecting public priorities.

However, attempts to lower severely overabundant populations with changes in hunting regulations have had limited success. Increasing the mortality rate of does is the key to controlling deer populations, so DEC increases the number of Deer Management Permits (DMPs), also known as antlerless-deer tags or doe tags, made available to hunters in areas where populations are above target levels. In some parts of the state there has been virtually unlimited availability of DMPs in recent years, but even so, the desired harvest levels are not being achieved. Many hunters are opposed to population reduction and are therefore unwilling to shoot does. Those who do shoot does may quickly obtain enough meat for their family and friends, and continuing to hunt and process deer just to donate the meat to food banks requires considerable commitment and altruism. Declining numbers of hunters and limitations on access to huntable land are additional obstacles. Many landowners are unwilling to allow hunting because of concerns about privacy, safety, liability or bad behavior by hunters, or because they are philosophically opposed to killing animals.

Population control through hunting is particularly challenging in urban and suburban areas. Due to local discharge ordinances and restrictions by landowners there is typically little land accessible to recreational hunters in these areas, so localized strategies developed and applied at the community level are usually necessary for effective deer management. These may include controlled hunts and culling with a DEC-issued Deer Damage Permit (DDP). Consensus on deer management is often difficult to achieve, however, and it can become a contentious and controversial issue in a community. Community members may have widely varying perspectives on deer and be passionate about their opinions and priorities. Development of a deer management program in some communities has taken several years and involved legal challenges from residents who disagree with the majority. Other communities have abandoned their planning attempts due to the conflict generated.

Local Laws

Because the State has authority over wildlife, local municipalities can't legally specifically restrict hunting or trapping except on land that they own or manage (Kalbaugh, 2015). However, many municipalities have passed ordinances restricting weapons discharge in the name of public safety. These ordinances often prevent hunting of overabundant deer populations on land where hunting could be conducted safely and in full compliance with state laws. Landowners who are experiencing negative impacts of overabundant deer and would like to address their problem by allowing hunting on their property are unable to do so. Communities working to address deer impacts often find themselves hindered by their own ordinances, which they then must rescind, revise, or grant variances to. In some cases, initial community movements toward deer population control spark highly vocal opposition from those opposed to lethal control (including hunting), and the latter group is able to influence public officials to pass a restrictive ordinance. Several more years typically pass before the increasing severity of deer impacts moves the political pendulum back toward enabling lethal methods.

Monroe County, which surrounds the city of Rochester, illustrates multiple facets of the interplay between hunting restrictions and suburban deer overabundance. In the early part of the 20th century, it had no deer population and no hunting. The first hunting season (one week, bucks only) was created in portions of the county in 1945, but the city of Rochester and some neighboring areas remained closed (1945 N.Y. Laws, Ch. 613). In 1976, with the goal of reducing damage to crops and landscaping (NYSDEC, 1976), an archery-only either-sex deer season was established in portions of the formerly closed area,

including the town of Irondequoit (Decker et al., 2004). However, two years later, the Irondequoit town council passed an ordinance prohibiting discharge of a bow and arrow (Decker et al., 2004) and the state Legislature eliminated the archery season in portions of the nearby town of Greece (1978 N.Y. Laws, Ch. 768). As damage problems continued in Irondequoit, the discharge ordinance was revised in 1983 to allow archery-only DDP use (Decker et al., 2004). After a lengthy and contentious community decision-making process, the first municipal deer management program in New York began in 1993, when the town of Irondequoit initiated a culling operation (Porter & Underwood, 2001). Both county and town discharge ordinances were modified to allow firearms use for this cull, which continued for nine years (Decker et al., 2004). Controversy over the use of lethal techniques persisted, so a four-year study of immuno-contraception was conducted concurrently, beginning in 1997 (Porter & Underwood, 2001). A controlled hunt was added to the program before the study ended, and this hunt has continued on as the sole population management method (Decker et al., 2004).

Irondequoit clearly has the authority to restrict firearms discharge for public safety reasons, as it is one of the 20 towns explicitly granted that authority by the Legislature (NY Town Law, § 130(27)). Only one village (Green Island, in Albany County) has been granted similar authority (NY Village Law § 20-2003). Beyond these specific instances, local governments have general authority (and responsibility) to protect public safety, but the extent to which that covers blanket restrictions on weapons discharge is questionable (Kalbaugh, 2015). Some municipalities even pass ordinances specifically limiting or prohibiting hunting, in contravention of state law and legal precedent (Kalbaugh, 2015). The proliferation of questionable restrictions causes confusion for the public, unnecessarily limits opportunities for hunters, complicates the role of DEC biologists, and hinders the management of overabundant deer populations. State action to clarify the legal status of municipal ordinances affecting hunting could enable communities to implement effective management methods more quickly and consistently, possibly preventing their deer problems from reaching such levels of severity.

State Laws

There are several sections of current New York state law that also hinder effective deer population management, particularly in the more heavily developed parts of the state. These laws can prevent DEC from responding fully to local needs and assisting communities in effectively addressing their problems with deer overabundance. Provisions of state law that pose an obstacle in this manner fall primarily into two categories: those that restrict DEC's ability to establish seasons, bag limits and methods of take for hunting and those that limit the methods that can be used to take deer under DDPs.

Some parts of the state, such as Nassau County, New York City and the area around Buffalo, are closed by law to deer hunting. Other areas, such as Westchester and Suffolk Counties and the areas around Albany and Rochester, are primarily or entirely restricted by law to hunting with vertical bows. Parts of the state that are closed to deer hunting or have severe limitations on legal methods of take are, not coincidentally, many of the areas with the worst deer overabundance problems. Deer populations need to be reduced throughout these areas, and regulated hunting is a needed tool to accomplish that reduction. The increasing deer populations and impacts in Westchester County and other bow-only areas demonstrate that bowhunting alone, especially with just vertical bows, is not effective enough to accomplish broad-scale population reduction. Allowing crossbows to be used in all situations where vertical bows may be used, as most Northeastern states have done, would make it easier for hunters to

provide relief to the communities suffering the most from deer overabundance. Allowing DEC to set firearms seasons in all counties would facilitate population reduction at a broader scale, putting less of the burden on individual communities.

For a variety of reasons, vertical bows and crossbows are used more commonly than firearms for hunting in urban and suburban areas. They are quieter, so less likely to disturb residents, and the shorter effective range leads to close shot distances, reducing possible safety concerns. The discharge setbacks in New York state law reflect these differences; bows may be discharged closer to buildings than firearms may. In some states, such as Connecticut, there is no discharge setback for any archery equipment. This can greatly facilitate deer control in developed environments by either hunting or culling.

As described in the "*Conflict Reduction Activities*" section below, DEC is working to develop an extended urban archery season for antlerless deer that municipalities could choose to participate in. This would provide a longer hunting opportunity and allow hunters to take many more does in participating areas. It could be made even more useful to communities if DEC had the ability to allow hunters to use certain strategies to increase their effectiveness. For example, baiting and using lights to hunt at dawn and dusk, when deer are most active, can greatly facilitate deer removal efforts, but by state law, are prohibited during hunting. Connecticut and Pennsylvania both allow hunters to use bait in urban deer management zones. Measures to increase hunter motivation to shoot more deer beyond what they and their families need can also be very helpful. A financial benefit would be one such motivation, but state law currently prohibits DEC from establishing conditions under which hunters could be compensated for taking deer or wild venison could be sold. In Vermont, deer meat can be sold during the hunting season and for 20 days afterward.

A potential barrier to the implementation of the extended urban season is the lack of a cost-effective method for distributing the tags necessary to facilitate it. State law allows only a one-time charge of $10 per hunter for DMPs each year. License-issuing agents (thousands of businesses and local municipalities around the state) keep a small percentage of this fee to compensate them for the time involved in selling the tags. To allow hunters who are interested to keep removing deer in areas of overabundance, DEC's goal is to set up a system in which hunters who fill DMPs in designated zones can get replacement tags as many times as necessary throughout the season. However, the agency has no authority to charge an additional fee, and without additional compensation, license-issuing agents may be unwilling to participate in such a program.

Shooting deer in a non-hunting context requires a DDP and is referred to as culling. State law gives DEC the authority to allow some actions under a DDP that are prohibited for hunting, such as use of bait, shooting deer at night with the aid of lights, shooting deer in parts of the state that are closed to deer hunting, and use of crossbows in areas where crossbow hunting isn't allowed. This flexibility tends to make culling more effective than hunting at reducing deer populations in urban and suburban settings. However, there are other restricted activities that lack provisions in law authorizing DEC to allow them under a DDP. These include use of bait within 300' of a road, shooting deer from a vehicle, shooting within discharge setback distances, and use of rifles on Long Island and in Westchester County. Rifles are more accurate at a greater distance than shotguns are, and the easiest way to get close to a deer is

in a vehicle. Not having such options available makes deer control much more difficult and costly for local municipalities.

Also of relevance to culling programs is the issue of who can be paid for acting as a shooter on a DDP. In some municipal culls, the people shooting are federal wildlife control agents or other nuisance wildlife professionals. In other cases, communities prefer to use local hunters who volunteer their time and services to carry out the actions authorized by the permit. This requires considerable commitment to the cause of population reduction, because it often involves spending long hours sitting in a tree stand on cold winter nights, and if the shooters aren't licensed Nuisance Wildlife Control Operators, state law prohibits them from being compensated for their efforts. If this were changed, local sportsmen rather than commercial companies or government agencies could receive some of the taxpayer dollars being spent on these programs, which should decrease some residents' opposition to them.

Impacts of Overabundance

Impacts on Human Activities

The deer-related problems that directly affect human activities are the ones that receive the most public attention. In recent decades, frequently mentioned concerns have included deer-vehicle collisions (DVCs) on roads, deer eating crops in agricultural areas and landscaping plants in residential areas, and the potential role of deer in the increase of tick-borne illnesses such as Lyme disease.

Based on insurance claims, State Farm estimates that there are over 70,000 DVCs annually in New York (data provided by State Farm Insurance®) and that nationally the average property-damage cost per collision is approximately $4,000. Losses are not limited to property; although the federal highway fatality database (National Highway Traffic Safety Administration Fatality Analysis Reporting System) doesn't separate the data by species, 437 people were killed in the U.S. in 2015 in crashes caused by vehicles striking or attempting to avoid an animal, many of which were doubtless deer. Taking into account additional factors, the average total cost of a DVC has been estimated to be more than $6600 (Huijser et al., 2009). DVCs thus can be estimated to cost the citizens of New York over $462 million per year.

In 2002, New York farmers estimated their deer-related crop damages at $59 million, and about one quarter of farmers indicated that deer damage was a significant factor affecting the profits of their farms (Brown et al., 2004). Deer damage to gardens and landscaping creates considerable unhappiness, extra work and expense for homeowners. The efforts of some residents to protect their property with fencing can lead to conflict between neighbors and throughout communities. Lowered property value due to the inability to maintain landscaping is also a concern in some areas.

Many parts of New York are considered high-risk areas for human infection with Lyme disease (Diuk-Wasser et al., 2012), based on the density of infected black-legged ticks (*Ixodes scapularis*). Reducing deer populations to very low levels can reduce tick densities (Kugeler et al., 2016) and probably Lyme disease rates (Kilpatrick et al., 2014), because deer are the primary food source for adult female black-legged ticks. However, less drastic deer population reductions may not lower the chances of human Lyme infection (Jordan et al., 2007; Kugeler et al., 2016). Small mammals such as rodents and shrews,

not deer, are the main tick hosts that pass on the Lyme-causing bacteria (*Borrelia burgdorferi*). Several other tick-borne diseases are less common but increasing in frequency. Deer are the principal hosts for the lone star tick (*Amblyomma americanum*), which can cause an allergy to the consumption of mammalian meat (Commins et al., 2011) as well as transmit ehrlichiosis and other diseases to humans (Childs and Paddock, 2003).

Impacts on Forest Ecosystems

There is a growing awareness of the ecological impacts of deer overabundance. Deer are altering forests across the state, perhaps permanently. Just as livestock can overgraze a range and reduce it to a barren wasteland, deer can over-browse a forest. Because mature canopy trees aren't affected, deer impacts on a forest may not be immediately evident, but they are profound and long-lasting. Browsing by deer at high densities reduces diversity in the forest understory (Horsley et al., 2003; Nuttle et al., 2014) and enables invasive species to out-compete natives (Knight et al., 2009). It also prevents seedlings of many species from growing into the next generation of trees (Tilghman, 1989), ultimately leading to fewer mature trees in a more open plant community with a different and less diverse species composition (White, 2012): in other words, the gradual disappearance of forests.

In areas with long histories of high deer impacts (as can occur in urban/suburban areas where hunting has been constrained or prohibited), reducing deer population density or removing all deer may not be sufficient for plant diversity to recover (Webster et al., 2005; Royo et al., 2010; Nuttle et al., 2014), even as much as 20 years later. Some species are so thoroughly eliminated by deer that they may have to be planted if they are to be restored to such areas. Impacts on endemic species can be devastating. For example, evidence suggests that current deer population densities in eastern North America will result in the extinction in the wild of ginseng, a valuable medicinal herb, within the next century (McGraw and Furedi, 2005).

The ecological changes brought about by deer also cascade through forest plant communities into wildlife communities, reducing the abundance and diversity of songbird species that use the intermediate levels of a forest (deCalesta, 1994). Furthermore, high-density deer populations interfere with habitat management efforts. Because browsing by deer counteracts the regenerative effects of natural forest disturbances such as fire (Nuttle et al., 2013), attempts to promote forest health through restoration of such disturbances and to increase populations of wildlife species that depend on young forest stands may fail unless deer populations are reduced. Regenerative processes are impaired in many parts of New York, particularly for tree species that are economically valuable, like sugar maple (Shirer and Zimmerman, 2010). Even in the Adirondacks, where deer densities are lower than in much of the rest of the state, both direct and indirect impacts of deer browsing must be counteracted for a diverse forest to regrow (Behrend et al., 1970; Sage et al., 2003). Ecosystem impacts may be magnified in urban and suburban parks and natural areas, which provide important habitat for migrating birds and other wildlife but are often subjected to the highest deer densities.

High-density populations can also harm the deer themselves by increasing competition for food and transmission of diseases and parasites. Deer in lower-density populations tend to be in better physical condition (Keyser et al., 2005), all else being equal, because there is more food available to them. Because they don't come in contact with as many other deer, they are less likely to be infected with

parasites or diseases (Storm et al., 2013). If chronic wasting disease, or CWD, were to reach New York again, its ability to spread within the state could be facilitated by high-density populations.

Setting Deer Population Goals

In 2018, DEC began implementing a new process for setting deer population management directions throughout New York. Staff collaborated with the Center for Conservation Social Sciences at Cornell University to develop a public survey and send it to a sample of homeowners in approximately one-third of the state. The rest of the state will be surveyed in 2019 and 2020. The survey asks respondents questions about their interests and concerns related to deer, how they would like to see the deer population in their area change over the next several years, and how important deer management issues are to them. These responses will be analyzed to determine whether the residents of each part of the state want their local deer population to increase, decrease, or stay at its current level. The results will guide DEC's overall population management decisions, unless the population level desired by area residents would be ecologically unsustainable.

Data on forest regeneration (the process of tree seedlings growing into the canopy to replace trees that have died) will be used to evaluate the condition of forests throughout the state and the effect that deer are having on those forests. DEC is collaborating with researchers at SUNY College of Environmental Science and Forestry (ESF) and Cornell University to assess forest regeneration and deer impacts. A model has been developed based on Forest Inventory Analysis data (collected annually throughout the state by the U.S. Forest Service) and incorporating deer harvest data as an index of deer density. The model will show where deer are a significant factor contributing to poor forest regeneration, indicating that deer populations need to be reduced in those areas.

DEC's deer population management decisions are made at the landscape scale, and the state has been divided up into 23 WMU Aggregates (WMUAs) for this purpose. Since each WMUA is a large area with a diversity of land uses, management applied at the WMUA scale via hunting regulations is not likely to lead to ideal population levels for every locality, particularly urban and suburban communities where little hunting occurs. Communities suffering from deer overabundance need to identify locally appropriate goals, based on deer-related impacts. Direct estimation of deer population density in such areas is difficult, expensive and unreliable, but ecological impact can be used as a density index. DEC has collaborated with Cornell and SUNY ESF to develop an ecological impact monitoring method suitable for non-scientists to use. It's called Assessing Vegetation Impacts from Deer (AVID), and the website (aviddeer.com) contains all of the information necessary to start monitoring. In addition, a smartphone app that will soon be available will allow all of those resources to be carried into the field. Training sessions are offered periodically around the state for people who would like some hands-on instruction. AVID users are encouraged to enter their data into a central database, and in the future those data should also be useful to DEC for evaluating how well overall deer population goals are being met.

Conflict Reduction Activities

DEC's efforts to reduce deer-human conflict start with the population goal-setting process. The public survey is designed to reach a broad cross-section of residents and elicit opinions on appropriate deer population levels that are based on both positive and negative experiences with deer. A population level that is supported by public opinion will therefore be one that reduces negative impacts on people to a point where they are outweighed by benefits of deer. In addition, incorporating impacts on forest regeneration into the decision-making process may frequently lead to populations below the level at which that balance is reached, which will reduce deer-human conflicts even more.

However, for the reasons described in the "*Causes of Overabundance*" section above, DEC's efforts to reduce high-density deer populations are often not very successful, and even when overall deer density in an area is not excessive, localized high densities may occur and create conflict. In these situations, staff provide a wide variety of information and advice to help individuals and communities find ways to address the deer-related problems they are experiencing. DEC biologists respond to telephone calls, e-mails and letters, perform site visits to assess damage and recommend solutions, give public presentations, participate in local committees tasked with developing recommendations for specific communities, maintain informational webpages with links to additional resources, and produce written materials such as a flyer for landowners on forest impacts of deer and a handbook to guide communities through the deer management decision-making and planning process.

DEC also offers a few types of free permits to facilitate localized deer impact reduction using techniques that would be illegal without DEC authorization. Deer Management Assistance Program (DMAP) permits provide antlerless-deer tags to landowners or municipalities so that people hunting on their land can shoot more does than they would otherwise be allowed to. There were 1,929 DMAP permits active in 2017, of which 11 were issued to municipalities. Deer Damage Permits (DDPs) are issued in situations where hunting, even with DMAP, doesn't reduce deer densities enough to alleviate negative impacts. DDPs typically allow taking of deer outside of hunting seasons and may allow techniques that aren't available to hunters, such as baiting and shooting at night. DEC biologists issued 1,636 DDPs in 2017, including 18 in urban/suburban situations. Most DMAP permits and DDPs are used to address deer damage on agricultural properties. Nonetheless, both permit programs also provide opportunity for community-based deer management efforts.

To specifically address very localized tick populations, which are often elevated in urban and suburban areas with high deer densities, DEC issues licenses to municipalities and state parks authorizing use of 4-Poster™ pesticide delivery devices. 4-Posters™ are deer bait stations that apply pesticide to the heads and necks of deer as they eat the bait, killing ticks that are on them. Because of the many negative effects of deer feeding, including the potential to increase deer numbers and exacerbate impacts of deer overabundance, DEC requires that there be a population reduction program active in the area where the 4-Posters™ will be deployed.

Although fertility control methods alone are not effective for reducing open deer populations (see discussion in the "*Management Approaches"* section below), they may still play a valuable role in a multi-faceted, strategic urban/suburban deer management program. If asked, DEC may allow surgical sterilization of does to be conducted under a DDP in a small, densely developed area where lethal

removal doesn't seem feasible, as long as lethal population reduction methods are being employed in the surrounding area. DEC also facilitates the continued development of fertility control techniques by authorizing novel scientific research. Numerous field research projects on both sterilization and immuno-contraception of deer have been and are being conducted in New York communities, beginning with Irondequoit in the 1990s (Porter and Underwood, 2001) and continuing through projects currently ongoing in Hastings-on-Hudson and Staten Island.

Additional programs to facilitate deer management in urban/suburban areas are under development. DEC biologists are designing the regulatory framework for a statewide extended urban antlerless deer hunting season in which municipalities could choose to participate. Similar programs in other states have been quite successful. Staff are also exploring DEC's capacity to offer small grants to communities for deer management planning. However, grants to pay directly for deer population reduction would probably be even more helpful to the communities. Such grants could potentially be sourced from the state general fund or Environmental Protection Fund.

Management Approaches

Increasing Public Awareness and Involvement

DEC works to increase public awareness by providing information on deer biology and management on the agency's website and through press releases, e-mail distribution lists, social media and public meetings. Within the past few months, the Division of Fish and Wildlife has created a new permanent position focusing on outreach and promotion and acquired a temporary Excelsior Fellow who will be working on outreach and marketing. This additional staff capacity should increase DEC's ability to engage the general public in deer management decisions.

Currently, most state wildlife management activities are funded by shooters and hunters through federal excise taxes on sporting arms and ammunition and through sales of hunting licenses. Diversifying the funding base so that a broader cross-section of the public provides financial support for wildlife programs is a long-needed reform (Jacobson et al., 2010) that would reduce the sense of disenfranchisement felt by many non-hunters and foster greater connectivity of diverse beneficiaries. Some states, such as Texas and Virginia, have chosen to dedicate a portion of the state sales tax on outdoor gear to their wildlife management agency budget. This can broaden the support base to at least include all those individuals who pursue nature-related recreation. Other states such as Missouri and Arkansas, recognizing that all citizens of the state are beneficiaries of wildlife management, dedicate a portion of all state sales tax to their wildlife management agency budget (Cerulli, 2013). As hunter numbers continue to decline across the country, approaches such as these will become increasingly necessary from an economic perspective. Social considerations provide additional reasons to adopt them as soon as is feasible.

On a local level, there is often a high degree of resident involvement in community discussions of and decision-making about urban/suburban deer management issues. Considerable conflict may arise during these processes, due in part to differing values and priorities among residents. However, a portion of the discord can be traced to misconceptions about deer population biology and the role of

deer in forest ecosystems, as well as about the safety and humaneness of hunting. Educational outreach that appropriately addresses issues of importance to residents can increase their awareness and thereby affect their views on management approaches (Lauber and Knuth, 2000), potentially reducing conflict within the community and facilitating more timely adoption of effective management methods.

Reducing Vulnerability to Impacts of Deer

Deer-vehicle collisions – Given the economic losses, injuries and deaths associated with DVCs, there has been surprisingly little research on effective methods to reduce them. Some approaches, such as lower speed limits and standard deer crossing signs, are commonly used or recommended despite little evidence of effectiveness (Mastro et al., 2008). However, speed limit does appear to influence the risk of nighttime animal-vehicle collisions, and the effect is strongest for fatal crashes (Sullivan, 2011). In addition, a recent study found a decline in DVCs in the first year after installation of deer crossing signs (Found and Boyce, 2011), suggesting that at least when the signs are novel, they succeed in changing motorist behavior enough to be effective. Similarly, there is evidence from studies involving other wildlife species that temporary (i.e. only installed at high-risk times of year) signs and warning systems (such as lighted signs) that are activated by an animal's presence may be effective at reducing collisions (Mastro et al., 2008). One of the best-studied DVC-prevention methods is the installation of reflectors along roadsides, and the vast majority of these studies indicate that reflectors are ineffective (Mastro et al., 2008).

The most effective approach seems to be the construction of suitably designed wildlife underpasses or overpasses, with deer-proof fencing between the crossing structures (Mastro et al., 2008; McCollister and Van Manen, 2010). However, this is also an expensive method that is only likely to be justified on sections of road where collisions are very frequent or there are additional reasons to construct wildlife crossing structures. A cost-benefit analysis indicated that deer population reduction through hunting or culling is the most cost-effective approach that will reduce DVCs by at least 50% (Huijser et al., 2009). The return of major deer predators such as mountain lions could reduce deer populations, DVCs and the associated societal costs, but the effect would probably be seen mostly in rural areas, not urban and suburban communities (Gilbert et al., 2017).

Tick-borne disease – Tick-borne diseases, particularly Lyme disease, have been the focus of considerable research attention in the past few decades. However, most field studies evaluate methods for reducing tick densities or numbers of infected ticks, because demonstrating a reduction in human disease rates is much harder to do. It is therefore unclear what interventions can actually reduce disease risk (Garnett et al., 2011; Eisen and Dolan, 2016).

Tick ecology is complex, and ticks often depend on multiple host species at various stages of their life cycle, so there is a wide variety of approaches for controlling tick numbers. Tick populations can be reduced by keeping vegetation mowed short and removing leaf litter (White and Gaff, 2018), removing invasive plant species (Williams and Ward, 2010), treating the vegetation or ground with chemical pesticides (Eisen and Dolan, 2016; White and Gaff, 2018), treating the vegetation or ground with a fungus that infects ticks (Eisen and Dolan, 2016), treating small rodents with pesticide (Dolan et al., 2004; Schulze et al., 2017), reducing deer populations (Kugeler et al., 2015), treating deer with pesticide

(Pound et al., 2009; Curtis et al., 2011; Wong et al., 2017), and excluding deer with a fence (Eisen and Dolan, 2016; White and Gaff, 2018). Some of these methods act quickly but are effective for relatively short periods of time, whereas others are long-term approaches. Using a combination of methods may be more effective and ecologically sustainable than relying on a single approach (Mount et al., 1999; Schulze et al., 2007; Williams et al., 2018). However, climate is one of the principal determinants of tick distribution and abundance, so the problem of tick-borne disease can be expected to grow as climate change continues (Stone et al., 2017). Various types of vaccine are under development (Zraick, 2018), and their availability could make a tremendous difference in the effort to reduce disease rates.

One of the deer-related tick reduction methods, treating deer with pesticide by means of 4-Posters™, has been employed by several communities and state parks on Long Island. An appropriately designed 4-Poster™ program can lower tick populations in the area immediately around the devices (Pound et al., 2009; Curtis et al., 2011; Wong et al., 2017), but communities that have used 4-Posters™ have often not been satisfied with the results. For example, although the town of Shelter Island in New York has been using 4-Posters™ for 10 years, residents feel that there is still a serious tick problem there (B. Payne, Shelter Island Animal Control Officer, pers. comm.). Effectiveness can be reduced if alternate food sources such as acorns reduce deer use of the devices (Pound et al., 2009), and it's possible that the long-term availability of abundant food in the 4-Posters™ acts to maintain or even increase high deer densities (Wong et al., 2017), which would tend to make tick population reduction more difficult. In addition, keeping the devices supplied with corn and pesticide is very expensive, and they act as feeders not only for deer but also other wildlife species such as geese, squirrels, raccoons, crows, turkeys and bears.

Plant damage – Deer browsing can create problems in many different contexts, from ecological degradation to crop losses to ornamental plant damage. Information on various ways to reduce plant damage by deer is available from Cornell Cooperative Extension (Curtis and Sullivan, 2001) and many other sources.

The only sure way to keep deer from eating plants is to enclose the plants in a sturdy fence that deer can't jump over, which usually means at least eight feet high (VerCauteren et al., 2010). Shorter fences can be effective (although not 100%) if they are slanted or otherwise create a barrier with depth (VerCauteren et al., 2006; Stull et al., 2011), or if they are electrified (VerCauteren et al., 2006). Individual plants can be protected with small cage-like enclosures (Curtis and Sullivan, 2001).

There are many chemical deer repellents on the market, and some of them are fairly effective at protecting plants, especially if they are reapplied frequently (Ward and Williams, 2010). However, they will be less effective if there are few alternative sources of food for the deer (Curtis and Sullivan, 2001). Many types of frightening devices are also available, but those that have been tested have been found to be only briefly effective at best, because deer quickly habituate to them (Gilsdorf et al., 2002; Gilsdorf et al., 2004; VerCauteren et al., 2005; VerCauteren et al., 2006; Hildreth et al., 2013).

People often claim that landscaping damage from deer can easily be avoided through "deer-resistant" planting – choosing plants that deer don't like to eat, – and an internet search will quickly turn up many lists recommending plants to use. However, those lists should be treated with skepticism. A given species can often be found in a "preferred by deer" category on one list and an "avoided by deer"

category on another. Deer are not all alike; their habits and preferences can vary regionally and on an individual basis. When food is scarce they will eat plants that they normally avoid (Curtis and Sullivan, 2001). Furthermore, some plants that appear on "deer-resistant" lists are non-native plants that become invasive and cause ecological and economic harm, so they should never be planted.

Hazing, which is active physical harassment of the deer, is a labor-intensive way to prevent deer damage to plants. In New York, hazing requires a permit from DEC. The permit may allow shooting deer with non-lethal projectiles such as rubber buckshot or beanbag rounds. Alternatively, hazing can take the form of chasing by a dog that is prevented from leaving the area it is protecting (for example, by an underground electronic fence). The effectiveness of hazing is dependent on the presence and vigilance of the hazer.

Intentionally providing food for deer is sometimes suggested as a way to reduce browsing on plants people wish to protect. However, this approach is just as likely to have the opposite effect. Deer tend to congregate at sites where food is provided, and they continue to eat their natural foods and preferred plants, so in many cases plant damage near feeding locations actually increases (Milner et al., 2014). Furthermore, supplemental feeding increases deer survival and reproduction, leading to population growth (Milner et al., 2014), which increases all negative impacts of deer. Preventing people from feeding deer is therefore an important component of strategies to combat deer impacts.

One of the most significant shortcomings of approaches such as fencing, hazing or the use of repellents is that they can only benefit individuals, not the community as a whole. Any action that decreases one resident's likelihood of damage will increase the pressure on everyone else's plants. The only way to reduce plant damage throughout a community, and the only method that can bring forest ecosystems back into ecological balance, is reduction of the deer population.

Reducing Deer Populations

For deer populations to be reduced, deer deaths must outnumber births. The white-tailed deer is a prey species that evolved under high predation levels, so its natural state includes a high mortality rate. For a healthy deer population to remain stable, on average 30-40% of the animals must die each year (Matschke et al., 1984); otherwise the high reproductive rate will result in population growth. In undeveloped areas of New York, most of this mortality occurs through predation of fawns, hunting of adults, and malnutrition during severe winters. In residential areas most deer deaths result from collisions with vehicles, and those don't usually occur at a high enough rate to offset reproduction (Etter et al., 2002). Hunting and/or culling programs are therefore necessary to increase mortality.

Hunting – Allowing recreational hunters access to as much land as possible in a community is the simplest approach to deer population reduction. Many landowners, including municipalities, currently prohibit hunting on their land, and since hunting is the principal mechanism for deer population control, this practice allows populations to grow to unsustainable levels. In communities that are trying to reduce deer-related impacts, opening more private and public properties up to hunting and encouraging hunters to shoot as many does as they legally can will provide additional recreational opportunities for local hunters while benefiting the entire community. To increase the success of such an effort, communities may wish to conduct outreach to increase local non-hunters' understanding of hunting and

the excellent safety record of New York hunters and raise hunters' awareness of the negative impacts of overabundant deer and the importance of reducing populations.

Both firearms and archery equipment (including crossbows) can be used safely and successfully in residential areas (Kilpatrick et al., 2002; Williams et al., 2013). Under New York state law, archery equipment is allowed to be used closer to houses and other buildings than firearms are, so bowhunting lets hunters utilize areas as small as a suburban backyard, giving better access to all the spaces used by deer. However, despite their great similarity in functional shooting distance, current law still requires a greater setback distance for crossbows than vertical bows. Firearms offer accuracy at longer distances, so they may increase effectiveness in larger parks and other greenspaces, where deer may be farther from the hunter and noise disturbance of residents is less of an issue. Removing municipal restrictions on which hunting implements can be used in an area will increase the likelihood of successful population reduction.

If community residents are uncomfortable with the idea of simply opening up land to hunting under state regulations, a "controlled hunt" may be a way to address their concerns while still accomplishing population reduction through recreational hunting. A controlled hunt is just a way to formalize the authority that all landowners have to restrict how hunting occurs on their land. Individual property owners can choose whether they want their property to be included in a municipal controlled hunt. A set of rules is established that applies to all participating properties and places limits or requirements on hunting on those properties that are stricter than state law requirements (e.g. limiting hunting activity to specific times of day, days of the week, particular locations or designated hunters). Many communities have successfully used controlled hunts to reduce deer numbers and impacts (Kilpatrick and Walter, 1999; Kilpatrick et al., 2002; Williams et al., 2013). Here in New York, the village of Cornwall-on-Hudson in Orange County and the town of Irondequoit in Monroe County both have long-running controlled hunt programs. DEC wildlife biologists can assist with the planning of controlled hunts.

Municipalities in New York can enroll in DMAP to increase the ability of hunters to reduce local deer population densities. Through DMAP, DEC provides an allotment of antlerless-deer tags to be used during deer hunting seasons on designated lands. The municipality distributes these tags to hunters for use on the specified properties. This enables those hunters to shoot more does than they would ordinarily be allowed to.

Culling – In many urban and suburban situations, hunting may not be able to lower deer populations enough to bring impacts down to a sustainable level (Williams et al., 2013). In these cases, the best option may be culling, which is the term for killing deer outside of a hunting framework. In New York, a DEC-issued DDP is necessary for a culling program to occur, and such permits typically allow the use of methods that are not available to hunters, which is why culling is usually more effective for rapid population reduction than hunting.

For example, nearly all municipal culling programs involve the use of bait to attract deer to locations where they can be shot safely and efficiently, and most of the shooting occurs at night, when deer are out searching for food and spotlights can be used to temporarily induce them to "freeze," providing a good opportunity for a shot. Culling usually occurs at a different time of year than hunting, for example

in mid-winter, when deer have less natural food available and can be more easily attracted to bait. Culling is most effective when it can be conducted from vehicles on roads, because deer often let vehicles approach closely without taking alarm, but DEC doesn't have the legal authority to allow this technique to be used.

Culling can be conducted by either volunteers (usually local hunters) or professionals. Any DEC-licensed Nuisance Wildlife Control Operator (NWCO) can be paid to kill deer. There are companies that specialize in urban/suburban deer culling, and the Wildlife Services branch of the Animal and Plant Health Inspection Service of the U.S. Department of Agriculture can also be hired for this purpose. Culling by volunteers is most likely to be done with archery equipment, because of the ability to be quiet and unobtrusive and utilize small habitat patches throughout the community. Professionals usually cull using rifles. They may have considerable experience selecting safe shooting zones in developed areas and typically also have specialized infrared equipment that enables them to detect people and other animals from a distance at night.

DEC works with municipalities to facilitate the development of culling programs that fit each community's individual circumstances. Currently there are communities culling with volunteers in Madison, Suffolk and Tompkins Counties. In a couple of towns in Erie and Suffolk Counties, local hunters have become NWCOs so that they can be compensated for their efforts. USDA APHIS Wildlife Services conducts culls for some communities in Onondaga and Suffolk Counties, while several municipalities in Erie, Orange and Niagara Counties utilize their police officers to cull deer. The village of Cayuga Heights in Tompkins County hires White Buffalo, Inc., a deer management organization, to conduct their cull.

If there are only a few places in a community where deer can be safely shot, or if community members are unwilling to support methods that involve shooting, alternative approaches to population reduction will be necessary. Professionals can be hired to capture deer with traps, nets or anesthetic darts and then kill them with either a captive-bolt gun or injection of potassium chloride (Leary et al., 2013). However, there are several negative consequences of these methods. Trapping causes stress and possible injury for the deer, use of a captive bolt on a wild, unsedated animal is challenging for the operator, and use of chemicals renders the carcasses unsafe for consumption, so the meat is wasted.

Fertility control – People who are disturbed by the idea of killing animals often wish to control deer populations by reducing the birth rate rather than increasing the death rate. Yet, even with effective fertility control, this wouldn't be a good way to reduce impacts of deer because it would just keep populations from growing; it wouldn't lower them. Deer can live to be 20 years old, so population reduction would happen slowly, if at all. Without hunting or culling, most deaths would be from vehicle collisions, which isn't a prudent or humane method of removing deer. (On low-speed roads, DVCs commonly result in considerable suffering followed by slow death or permanent crippling.) Meanwhile, the negative social and ecological impacts of deer would continue at levels which were found to be unacceptable by the community when they decided to initiate deer management efforts.

Currently, however, the lengthy delay in potential impact reduction is a secondary consideration, because effective fertility control on a population-wide scale has not been achieved except in small isolated populations in enclosures or on islands (Rutberg et al, 2013b). The problem is that deer have such a high reproductive rate that a few fertile individuals can produce enough young to replace the

small number of deer that die each year in urban and suburban settings. Wary individuals who are able to avoid capture and treatment, along with immigrants moving in from neighboring areas, provide more than enough reproductive capability to overwhelm fertility control efforts in the majority of cases (Merrill et al., 2006). Even on an island of less than 9 mi^2, a fertility control program that continued for 16 years was hampered by an inability to capture a high enough percentage of the deer, and meaningful population reductions only occurred in certain areas that provided the best access to the animals (Underwood, 2005; National Park Service, 2015).

Surgical sterilization is the most reliable way to render a deer infertile, and for does it can be accomplished by either ovariectomy or tubal ligation. The latter technique doesn't prevent ovulation, so sterilized does will still go into estrus and mate. Because they won't get pregnant, however, they will go through several estrous cycles each year, creating an extended rutting season. This could have a number of negative consequences, including more DVCs, increased stress and lower overwinter survival, and an increase in the local population due to bucks being attracted from neighboring areas (Boulanger and Curtis, 2016). An ovariectomy program is not likely to have these consequences.

Immuno-contraception is the other fertility control method that is often suggested by those seeking alternatives to lethal population reduction. ZonaStat-D is a contraceptive agent for deer that has recently been approved at the federal level by the Environmental Protection Agency. It contains porcine zona pellucida (PZP), which prevents fertilization, not ovulation, so it has the same potential for negative consequences as tubal ligation. GonaCon™, a contraceptive agent developed by the U.S. Department of Agriculture, prevents does from going into estrus, but in field trials it seems to have a slightly lower success rate than PZP (Gionfriddo et al., 2009; 2011; Rutberg et al., 2013a). Unlike surgical sterilization, immuno-contraception is neither effective on all treated animals nor a permanent treatment; does must be re-treated on a regular basis to maintain infertility. This becomes increasingly difficult as experience makes them more wary.

Although fertility control alone is not a viable method for reducing open populations, it may be useful in conjunction with other methods of population control (Raiho et al., 2015). A fertility control program might lead to population stability or reduction in a limited area if immigration from surrounding areas could be minimized. Substantially lowering the populations in those surrounding areas through hunting or culling would be a way to do that. The combination of a core sterilization area surrounded by a lethal control zone reduced the deer population in Cayuga Heights, New York by almost 40% in two years (P. Curtis, Cornell University, pers. comm.). Fertility control might also potentially be used to keep a population stable after it has been lowered to an appropriate level through hunting or culling.

Even in these limited circumstances, though, the logistical and financial burdens entailed in current fertility control methods would present a significant obstacle to implementation of meaningful programs in most communities. All fertility control methods are extremely labor-intensive and expensive, because deer must be captured for treatment and marking and virtually all does must be treated to prevent population growth. Capture, anesthesia and surgery also create stress and may result in injury or death of captured deer. If a community decides that these costs are acceptable to them and they wish to pursue fertility control in a small highly developed area where shooting deer doesn't seem feasible, they may receive a DEC permit to use surgical sterilization as part of a deer management program. However, because of the ineffectiveness of fertility control for reducing

populations or impacts, lethal population reduction methods must also be used concurrently in nearby areas.

Relocation of deer, reintroduction of large carnivores – People who don't want deer to be hunted or culled in their community sometimes suggest capturing the deer and moving them somewhere else or reintroducing large carnivores such as wolves or mountain lions so that they can lower deer numbers. These are not useful methods of reducing deer populations in developed areas. Reintroduction of large carnivores is not ecologically or socially feasible in areas with high human density and no large blocks of natural habitat. Capturing and relocating deer results in significant levels of stress, injury and mortality (O'Bryan and McCullough, 1985; Jones and Witham, 1990; Beringer et al., 2002), and also presents a risk of spreading disease. In most locations, if deer were removed, they would quickly be replaced by immigrants from the surrounding area.

Conclusion

Deer overabundance in urban and suburban areas is challenging community residents, local municipal officials and state agencies across the country. In some respects, New York is at the forefront of management approaches to this problem, but state laws prevent the use of several of the most effective techniques. Removing those legal obstacles would make it easier and more affordable for communities to address their deer-related problems. Because deer in developed areas are occupying and using many small private parcels with different landowners, widespread resident support and participation are usually necessary for effective deer management. In some communities, lack of understanding of deer biology and discomfort with population reduction methods hinder and delay the development of management programs. Expense can also be a significant obstacle.

Many communities are finding ways to address their problems with overabundant deer, but it's important to recognize at the outset that it's a complicated process requiring a long-term commitment. All deer impact management methods have to be continued and/or repeated year after year. Due to the nature of biological systems, reducing deer populations is necessary for long-term impact reduction on a community-wide scale. Successful programs include hunting, culling, or both. Continued research on fertility control methods may produce additional useful options in the future. Actions that are taken to reduce deer populations must be maintained, or the problems will quickly return.

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