Audubon GREENWICH

# Management Plan for the Control of White-tailed Deer at the Audubon Center in Greenwich, Connecticut

***Endorsed by the***
***Audubon Greenwich Board***

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***The mission of Audubon Connecticut*** *is to further the protection of birds, other wildlife and their habitats through science, education, advocacy and conservation, for the benefit of humanity and the earth's biological diversity.*

# 1. Introduction

The white-tailed deer (*Odocoileus virginianus*) is the most abundant and best known large mammal in the northeastern United States. It is a beloved symbol of wilderness to many North Americans. However, in recent years, the white-tailed deer has become a source of controversy throughout its range. An overabundant deer population has caused increases in the number of car accidents and incidence of Lyme disease. Deer consume landscaping and agricultural crops, and damage forest ecosystems by overgrazing. Connecticut has not escaped these problems as deer population in the state increased from 12 in 1896 to more than 76,000 and growing today. Deer population growth in the last 25 years has been especially concentrated around urban and suburban areas. Fairfield County now has one of the highest deer densities in Connecticut and overpopulation of white-tailed deer has been well documented in Greenwich (Connecticut DEP 2002). Past records, personal anecdotes and observations by Audubon naturalists suggest that the overabundance of white-tailed deer is negatively impacting the forest ecosystem on Audubon lands in Greenwich, undermining their value as biological reserves for the protection of a diverse and balanced population of plants, birds and animals. To sustain the ecological health of our sanctuaries and to protect staff and visitors from the diseases transmitted by deer ticks, implementation of a proactive deer management plan aimed at reducing deer population to ecologically viable levels is urgently required.

# 2. Species Occurrence

Deer abundance in the United States during the pre-settlement period is estimated at 23-34 million, representing a mean density of 8-11 deer per square mile over the most favorable habitat across North America (Stout 2001). Natural deer predators such as wolves, mountain lions, bears, and bobcats, as well as hunting by the Native Americans, kept the deer population under check. Predation, along with winter mortality, caused 50-70% of pre-settlement deer mortality with Native American hunting causing the remainder. Human impacts on the deer population intensified after the arrival of the Europeans as opportunities to trade white-tailed deer products for European goods drove the hunt for the deer. The exploitation era, from about 1850 to 1900, saw dramatic reductions in deer populations. White-tailed deer were sought after for their meat and hide, and their habitat had been virtually eliminated in New England with deforestation and

conversion of land into pasture and agricultural fields. Also during this period, humans completely eliminated non-human deer predators from much of New England. In the early 1900s, growing environmental consciousness, combined with the scarcity of deer and other wildlife, led to enactment of numerous laws to protect the dwindling deer population. These efforts coincided with the improvement of deer habitat by abandonment of agricultural lands and a wave of timber harvesting to support the industrial revolution. Deer found many square miles of tree seedlings and their population quickly rebounded in the absence of natural predators. Estimated deer population for the state of Connecticut was 12 deer in 1896, 19,000 in 1974, and 76,000 in 2000 (Connecticut Agricultural Experiment Station 2002).

The dramatic growth of Connecticut's deer population over the past 25 years can be attributed to creation of edge forests by landscape fragmentation, limited hunter access to private lands, and ability of deer to coexist with humans. Across the entire state of Connecticut today, deer density is around 15 deer per square mile (Connecticut DEP 2000).

In the Town of Greenwich, a 2002 aerial survey by the Connecticut DEP revealed the average current density of white-tailed deer to be 20 deer per square mile, with middle and backcountry Greenwich showing higher densities of 43 and 60 deer per square mile, respectively. In the area just north of the Audubon Center, 60 deer per square mile were physically counted on the photographs. Experts estimate that actual numbers are generally 50% to 100% higher than visible in aerial photographs, so in this case a more accurate assessment is 90-120 deer per square mile. A conservative estimate based on this data places the deer population at the Audubon Center's 298 acre (0.47 sq. mile) main sanctuary, where they are observed daily, to be 45 to 60 deer.

## 3. Deer Ecology

White-tailed deer can live up to 18 years. The mating season starts in late October and extends through early January. In Connecticut, adult females produce an average of 2 fawns annually, usually in June. Deer evolved under heavy predatory pressure. In the absence of natural predation, unmanaged deer populations can double in size in 2-3 years. Male deer can weigh up to 150 pounds while females average 110 pounds. Deer consume 5-10 pounds of forage per day, or up to 2,000 pounds per year. Their favorite foods are grasses and forbs, acorns, apples, twigs and buds from wide variety of hardwood trees, and leaves from conifers such as white pine and hemlock. Their favored habitats are edge and early successional forests with gaps and grassy openings. Clear-cut forest also provides immediate production of slash and browse, and early

successional shade-intolerant tree seedlings provide good summer browse. Long-term studies show that deer are territorial and that females remain on their summer range for life. In one study conducted in New York (McNulty et al 1997), 97% of females remained on their natal range for life, whereas most males dispersed. After the deer were thinned to create a low-density area of 1.4 $km^2$, the low density persisted for several years. No deer from adjacent home ranges moved into this area to fill the void. In urban and suburban Connecticut, deer home ranges are relatively small, at approximately 100-300 acres (Connecticut DEP 2002).

# 4. Ecological Impacts of White-tailed Deer

***a) Overview***

The evidence is overwhelming that unrestricted deer populations have a dramatic impact on forest ecosystems. Overabundant deer have been shown to:

- Reduce or eliminate forest regeneration
- Slow or stop succession
- Alter forest composition and structure
- Eliminate or reduce other wildlife species through direct or indirect competition
- Shift species dominance and equitability
- Drive some local plant species to extinction (Shissler 1999)

The impact of deer on vegetation can be divided into three stages. The first stage is the selective feeding on plants for which deer have a high preference. This stage is characterized by elimination of highly preferred plants such as wildflowers, some other herbaceous plants and tree seedlings. The second stage is the development of a browse line. At this stage, deer are much less selective and eat everything within their reach, which extends 5-6 feet above the ground. Most herbaceous and shrub species are eliminated and all tree seedlings are susceptible to browsing. When the second stage continues for an extended period of time, it will turn into the third stage, in which the browse line is not apparent because there is not enough vegetation at low and intermediate levels to show it. At this stage, the forest composition becomes simplified and consists only of the upper canopy and the layer of resistant vegetation of the forest floor. Understory and mid-canopy layers are noticeably absent.

At the Audubon Center forest, browsing damage is evident on virtually all seedlings and saplings within deer reach. Saplings are scarce, but where they are present, browse line is apparent at a height of about 5 feet from the ground. Most of the Audubon Center sanctuary, with its park-like open understory, has apparently reached the third stage of deer impact. Its gallery-type forests

are simplified ecosystems with reduced biological diversity and lack the resilience to bounce back from pest attacks and other environmental stresses.

The weight of evidence accumulated over the past decades points to specific impacts by deer on vegetative communities. These studies do not have consistent objectives or methodologies, but yield surprisingly consistent results. In contiguous forests, problems with tree regeneration arise consistently at deer densities exceeding 20 deer per square mile (Stout 2001). The impacts of browsing on shrubs, herbaceous plants and wildlife begin at an even lower threshold. A density of no more than 10-15 deer per square mile is recommended to ensure sustainability of wildflowers, other palatable herbaceous and shrub species, and a full complement of the native forest bird community (Kilpatrick 2002 and Waller et al 1997).

***b) Forest Composition***

Endangered and threatened plants often decline in areas with large deer populations. White-tailed deer have been reported to browse at least 98% of endangered and threatened plant species (The Connecticut Agricultural Experiment Station 2002). Many alien invasive plants such as the Japanese barberry, ailanthus, oriental bittersweet, and winged euonymus, which are resistant to deer browse, increasingly dominate the landscape due to shifting of competitive edge.
In an old growth forest in Pennsylvania, deer browsing has caused a dramatic decline in tree species diversity, from 27 species to 11, and in another Pennsylvania forest, from 41 species to 8 (Stout 2001). At both sites, deer densities were in excess of 20 deer per square mile. A study by Horsley et al (2003) in a Pennsylvania hardwood forest showed a negative linear relationship between species richness and deer density.

The impact of deer browsing on forest regeneration is well demonstrated in a study conducted by the Connecticut Agricultural Experiment Station on Iron Ore Hill Forest Preserve managed by The Nature Conservancy. In 1984, approximately 82,000 seedlings per acre were observed. By 1998, deer density in the area had grown to around 60 deer per square mile, and the number of seedlings per acre had plummeted to 22,000. Sapling density in 1984 was 3,600 stems per acre. In 1998, only 1,400 stems per acre were observed. Oak and conifer regeneration was replaced by other species such as black birch and red maple. In the same study, survival rates of white pine seedlings under protected and unprotected conditions from deer browsing were compared. After 5 years, 0% of the white pine seedlings had survived under unprotected conditions, whereas 80% of protected seedlings had survived. Numerous studies conducted on replicated plots with various deer densities provide evidence that the deer strongly impact abundance, height, growth and species diversity of forest regeneration. Suppression or elimination of

diverse palatable seedlings and saplings results in a slow but steady conversion of the stand to a small variety of less-palatable species.

A description of the Audubon Center forest published in 1966 by the State Geological and Natural History Survey of Connecticut serves as a good reference in determining how the forest composition has changed in the last 40 years. The canopy species are unchanged, although the beech and sugar maple which comprised the lower canopy are now the dominant canopy trees. The most noticeable change is in the 10 to 30-ft understory. Witch-hazel and flowering dogwood were most common in this size class, along with saplings of sugar maple, red maple, and localized colonies of beech originating as root suckers from larger beech trees. In our forest today, saplings are largely absent from the middle-canopy layer except for beech root suckers in our beech stands. Maple seedlings can be observed on the forest floor, but they do not grow past the seedling stage before being browsed by the deer. Oak and hemlock seedlings simply cannot be found in most areas, because they are highly preferred by the white-tailed deer and are plucked as soon as they germinate on the forest floor. In the long-term, the striking lack of regeneration by species destined for position in the canopy will inevitably result in significant structural and compositional shifts in the forest canopy as existing canopy trees die.

***c) Wildflowers and Shrubs***

Most of the plant diversity within our forests exists not as trees but rather as herbaceous understory species. Two studies at the Allegheny National Forest in Pennsylvania and additional research in Wisconsin, Illinois, and Ohio show that deer can have very important impacts on diversity and health of this component of the forest community (Stout 2001). At the Allegheny National Forest, grasses and sedges represented 64% of groundcover outside a deer exclusion fence, while these species represented only 16% of the groundcover inside the fence. A study by Horsley et al (2003) showed that species avoided by deer or resilient to deer browsing increase with increasing deer density. In this study, the percent cover of ferns, grasses, and sedges displayed a positive linear trend with deer density. Herbaceous plants are important food sources for the deer, constituting up to 87% of their summer diets (Waller and Alverson 1997). An old-growth forest in northwestern Pennsylvania lost 59 to 80% percent of its ground flora species between 1929 and 1995 due to deer browsing (Waller and Alverson 1997). Lilies, orchids, species of *Viburnum* and *Trillium*, native yew, and Canada mayflower are favored food sources of deer and are the first to disappear (Rhoads 1999). Deer have a particularly high preference for and devastating impact on wildflowers. Wildflowers are able to hide underground for a few years of intensive browsing pressure. But when browsing pressure lasts for decades or longer, they are simply eliminated due to lack of seed source (Stout 2001).

The effect of deer overgrazing on the herbaceous community is evident in the Audubon Center forest as well. In 1966, the shrubby stratum was described as being well developed, with relatively continuous cover of maple-leaved viburnum reaching to a height of 2 to 3 ft. Where there were openings in the tree canopy, the pink azalea and low-bush blueberry were commonly associated. Together, these three shrubs contributed up to 80% of the shrub layer coverage. Scattered woodland herbs such as Canada mayflower, wild spikenard, wood aster, and Pennsylvania sedge covered less than 10% of the forest floor, with belts of ferns (New York fern and cinnamon fern) recognized in lowlands (Niering et al 1966). The picture is very different today. The understory is sparse of herbaceous cover and is much more open. Maple-leaved viburnum that used to dominate the shrub layer has been entirely eliminated. There has been an increase in groundcover of ferns and some invasive species such as the barberry. Dramatic declines in species diversity of wildflowers have been observed. Canada mayflower, trout lily, lady slippers, and other species of orchids and lilies are much less common. Trilliums have been eliminated altogether. Common spring wildflowers that numbered tens, even hundreds of species in the 1950s can now be counted on two hands. The only species of wildflowers commonly seen today include Jack-in-the-pulpit, blue cohosh, wild leek, mayapple, garlic mustard, and dwarf ginseng.

***d) Birds and Other Wildlife***

Deer exert a strong influence on other animals, both through direct competition with animals that feed on the same foods, and by changing the structure and composition of the forest itself. While expecting deer effects primarily on ground-nesting birds, McShea (1997) found multiple effects on bird species nesting at several levels in the forest, apparently reflecting complex interactions among the forest biotic communities. DeGraaf and others (1991) studied the effects of deer browsing on breeding birds in New England woodlots. They found greater numbers of canopy-gleaning species and individuals in stands with fewer deer. Rufous-sided towhees were more abundant in low deer density stands, but hermit thrushes were more abundant in stands with higher deer densities. The number of migratory bird species was also greater in stands with fewer deer. In an experiment conducted at the Allegheny National Forest, DeCalesta (1994) found that many of the birds that are intermediate canopy nesters disappeared from the study sites with deer densities higher than 20 deer per square mile. As shrub and herbaceous layers disappear due to overgrazing, so do the birds that feed or nest on the forest floor and in shrubs. At higher deer densities, the middle canopy layer disappears over time and songbirds lose their habitat. When the deer density reaches 64 deer per square mile, even adaptable species like robins and phoebes are forced out (deCalesta 1994 and McShea 1997). In autumn, deer switch to a diet heavy in acorns, bringing them into direct competition with many other mammals and

birds, from turkeys to squirrels. In one study, deer consumed nearly three quarters of all the fallen acorns in Pennsylvania red oak stands, largely monopolizing the mast crop (Steiner 1995).

Changes in composition and abundance of bird species as a result of the deer impact on wildlife habitat have been observed at the Audubon Center. The following table summarizes some results from the breeding bird census conducted in the upland beech-maple forest (northern portion of Audubon Center) in 1971 and again in 1998.

**Number of Breeding Bird Pairs**

| | 1971 | 1998 |
|---|---|---|
| Ovenbird | 7 | 0 |
| Rufous-sided Towhee | 4 | 0 |
| Worm-eating Warbler | 3 | 1 |
| Black-and-white Warbler | 2 | + |
| Ruffed Grouse | 1 | 0 |
| Canada Warbler | 1 | 0 |
| | | |
| Total species | 29 | 27 |
| Total territories | 42.5 | 31 |

(+): the bird was observed but breeding could not be confirmed

Dramatic decline in the number of ground nesting/feeding birds during the 27-year period is apparent. Total number of species remained relatively unaffected, but the total number of territories showed a 28% decline due to simplification of the forest structure. In addition, mid-canopy nesters such as the wood thrush, scarlet tanager, and eastern wood pewee are starting to show a decline in numbers associated with the disappearance of the middle canopy layer.

# 5. Conflicts with Humans

### *a) Tick-borne Diseases*

Accumulating evidence from the Connecticut Agricultural Experiment Station scientists and others suggests that the resurging deer population is causing an increase in incidence of Lyme disease in humans. The incidence of Lyme disease has doubled in the U.S. since 1991 (Center for Disease Control and Prevention 2002). A record 3,285 cases of Lyme disease were diagnosed in Connecticut in 2002 (http://www.ci.darien.ct.us). Fairfield County, where the state's highest deer density is found, accounted for over 1/3 of the reported cases of Lyme disease in the state in 2000 (Center for Disease Control and Prevention 2002).

Deer harbor the blacklegged tick (*Ixodes scapularis*), commonly referred to as the deer tick, which transmits the Lyme disease spirochete (a type of bacterium). The deer tick also transmits

pathogens of two other diseases, human babesiosis and human granulocytic ehrlichiosis (HGE). Abundance and distribution of the tick is correlated with deer density. All of the Connecticut Agricultural Experiment Station studies and those conducted elsewhere indicate that the deer population would have to be reduced to low levels to appreciably reduce Lyme disease occurrence. Treating deer with a pesticide using a baited self-application system remains an experimental approach, and it is unlikely that sufficient number of free-ranging deer can be treated to impact the rate of tick-borne disease (Stafford 2001).

Among the staff at the Audubon Center, there have been 9 documented cases of Lyme Disease and 1 confirmed case of Erlichiosis in the last 5 years. There has been additional disease occurrence among our volunteers and visitors, and we know of one confirmed case of Babesiosis on a property which abuts the Audubon Center. Because one of the objectives of the Audubon Center is to provide a safe place where people can enjoy nature, health risks posed by the deer ticks present an immediate concern.

***b) Damage to plantings***

Deer overabundance results in damage to ornamental plantings and agricultural crops, especially fruit trees in orchards. Damage to landscape plantings in suburban areas has been reported in states throughout the population range. At the Audubon Center, we have had to erect fencing around all new apple tree plantings, at considerable expense and labor, to protect them from deer damage.

***c) Deer-vehicle accidents***

Overabundant deer populations in urban areas are associated with high rates of deer-vehicle accidents. An estimated 6,000-8,000 deer are killed every year along Connecticut's roadways, according to reports by the Connecticut Department of Transportation. Deer-vehicle collisions are serious public hazards. Several human fatalities have occurred from deer-vehicle collision over the past 15 years in Connecticut (Connecticut DEP 2002). Deer roadkills in deer management zone 11, which roughly represents Fairfield County, were 2 to 10 times greater than all other deer management zones in the state (Kilpatrick et al. 2002). In 2000, 565 deer road kills were reported in Fairfield County. In Greenwich, roadkills accounted for 81 deer deaths in 2001, a high number when compared to the 113 deer legally harvested here in the same year.

# 6. Management Options

In addressing the problem of an overabundant deer population and its harmful effects, several management options are available: no action, fencing and use of repellents, trapping and relocation, controlling fertility in does and sterilizing males, supplemental feeding, and hunting. The feasibility, advantages and disadvantages of each option are discussed in the following paragraphs.

***a) No Action***

The white-tailed deer evolved under heavy predatory pressure and its life history adapted to allow for loss of individuals to predation. In the absence of natural predators and other control methods, deer populations grow until they reach the upper limit of their habitat's carrying capacity. High densities have adverse effects on the deer themselves, exposing them to higher rates of disease and parasites, injuries from car collisions, and to a greater risk of starvation in harsh winters. Overpopulation makes it hard for does, which seek solitude as birth approaches, to set up suitable fawning territories. The result is fawn abandonment and increases in other forms of infant mortality. Deer in high density herds tend to be in relatively poor health, and are prone to cyclic population fluctuations and catastrophic losses in response to environmental stresses. In extreme cases, “hands off” management may even result in local herd extinction. Because humans have greatly altered important functions of the natural ecosystem, including natural deer predation, allowing nature to take its course will not restore the ecosystem to a healthy balance. In the absence of control measures, overgrazing by the white-tailed deer will continue unabated, causing the significant destructive consequences described earlier.

***b) Fencing and Repellents***

Fencing requires a substantial initial investment for materials and installation, followed by regular maintenance. If properly installed, it is effective at excluding deer from specific areas and reducing damage to plantings. Fencing around larger landscapes will restrict the movement of other medium to large sized wildlife species and may have a harmful effect on their natural breeding or feeding activities. Many different types of taste and odor repellents are available to reduce deer damage to plantings. They, too, are costly and labor intensive, requiring repeated applications as weather erodes their effectiveness and rapidly growing shoots outgrow protection. Noxious and unaesthetic product residues further limit their usefulness. The effectiveness of chemical repellents is highly variable and decreases as deer population increases. Neither fencing nor repellents address the underlying problem of deer overpopulation.

***c) Trapping and Relocation***

Trapping, netting and immobilization are used to capture and relocate deer. Studies have shown that 50 to 85% of all trapped and relocated deer will die, mainly from capture-related stress and from roadkills after wandering extensive distances following release (Jones and Witham 1990, O'Bryan and McCollough 1985). Trapping and relocation has also proven to be labor intensive and prohibitively expensive. The Connecticut DEP estimates the costs at $400 to $3,000 per deer. Because deer are abundant throughout most of the United States, there are no suitable places for releasing excess deer, and relocation of deer from overpopulated ranges can spread disease.

***d) Fertility Control and Sterilization***

Fertility control and sterilization to reduce and manage deer populations is still experimental. Four general methods of *controlling fertility in does* have been tested and may be applicable to deer management – surgical sterilization, synthetic steroid hormones, immunocontraception, and contragestation.

*Surgical sterilization* requires capture of individual does and application of field surgery. High cost and difficulty of treating a sufficient number of deer makes this method unfeasible for managing free-ranging herds.

*Synthetic steroid hormones* alter natural reproductive cycles and can reduce the likelihood of pregnancy. They are administered either by treated bait or by implants. The treated bait method requires daily oral exposure, so it is not practical. The effectiveness of steroid hormones in preventing pregnancy has varied in experiments, and each animal requires a new implant at least every 2 years. Currently, no synthetic steroid hormone contraceptives have been approved by the Food and Drug Administration for use in white-tailed deer, other than in controlled experiments.

*Immunocontraception* involves injecting the animal with a vaccine to stimulate its immune system to produce antibodies against a protein involved in reproduction. This technique has advantages over use of synthetic hormone contraceptives, since it can be delivered remotely using darts. The disadvantages of this method are that each female deer requires multiple treatments every year, and that it may prolong breeding season of the deer. Deer are most active during the breeding season and, as a result, deer-vehicle collisions increase dramatically during autumn (Warren 2000). Use of this method could increase deer-vehicle accidents.

Research on *contragestation* in white-tailed deer has focused on the commercially available drug prostaglandin $F_2$ ($PGF_2$). $PGF_2$ is approved by the FDA for use in cattle and swine intended for human consumption. It is applied during the winter, after females are pregnant and it is relatively easy to attract deer to bait stations due to the scarcity of natural food sources. $PGF_2$ can be applied remotely using darts, and this method did achieve some level of success in reducing pregnancy rates in a free-ranging herd in an experiment conducted in South Carolina (Warren 2000). The disadvantages of this method are that females must be treated annually, and that abortion of fawn-like fetuses may not be acceptable in some communities.

In a study conducted in Groton it was demonstrated that, even with good access to a relatively small, isolated deer population, an adequate number of female deer could not be successfully treated for fertility control to limit population growth. The study suggested that 70-90% of females need to be treated with any method to effectively limit population growth. It becomes increasingly difficult and requires greater effort to treat remaining females in the herd as the deer become more cautious. With continued research, there is a potential for fertility control to be applicable in the management of deer in the future, especially smaller herds in urban areas. However, to date, research in this area has not proven fertility control to be effective in reducing free-ranging deer populations.

Reducing deer population by capturing and *sterilizing large males* and retaining them in the population is still experimental. Since white-tailed deer exhibit a distinct hierarchy in which dominant males monopolize most mating, the number of fawns produced may be reduced (Ramakrishnan 2001). Further investigation is being conducted in North Branford, Connecticut. However, this method is expensive and labor-intensive, and the difficulty of treating sufficient number of large males in a free-ranging herd will limit its application.

***e) Supplemental Feeding***

Providing supplemental food for deer herds in order to control their overgrazing effect has been shown to be counterproductive, because it encourages additional population growth. In fact, additional food sources for the deer, such as bird feeders within their reach, should be eliminated in high deer population areas to avoid compounding future population growth.

***f) Hunting***

Regulated hunting has been proven as a practical deer population management tool with high rates of success (Connecticut DEP 2002). It is cost effective, and results in immediate removal of excess animals from the population. It is the principal management tool used by state wildlife agencies throughout the United States.

A common perception is that hunting is unsafe. However, hunting is one of the safest sporting activities in Connecticut (Connecticut DEP 2002). All hunters, both firearms and archery, are required to take a Conservation Education/Firearms Safety (CE/FS) course administered by the state before they can purchase a hunting license. No hunting accidents and no reports of wounded deer have occurred in special deer hunts implemented to reduce deer populations in residential areas (Connecticut DEP 2002).

Numerous examples of successful management of deer populations by hunting have been documented in Connecticut. At the 7,700-acre Yale Forest in the towns of Eastford, Ashford and Woodstock, a controlled deer hunt was implemented in 1984. The forest managers indicated that forest regeneration has improved considerably since. At the Bluff Point Coastal Reserve in Groton, CT DEP's Wildlife Division annually documented severe deer browsing of vegetation and stripping of bark from trees from 1984 to 1996. Controlled deer hunts there in 1996 and 1997 reduced deer population from 284 to 35 deer. Hunting took place again in 2000 and 2001, reducing the deer population to 19, a level compatible with ecological diversity for the first time in 20 years. The removal of excess deer from the reserve has positively affected the overall condition of the deer herd as indicated by improved body weights and fat measurements. Browse surveys conducted before and after the deer removal indicated a 36-45% reduction in browse rates of shrubs and tree seedlings. The presence of oak regeneration was noted for the first time in 1997. Amount of bark stripping on apple trees was reduced from 77% in 1994 to only 4% in 1997. In Groton Long Point, Mumford Cove, and the Town of New Canaan, archery and shotgun/archery hunts successfully reduced white-tailed deer populations. A 3-day hunt removed 82% of the deer population in Mumford Cove, and a 6-day hunt removed 92% in the joint Mumford/Groton Long Beach hunt (Kilpatrick et al 2002).

A multitude of practices for population control and behavior modification have surfaced, but the bottom line remains that removal of animals from the population, specifically adult females, is the only effective way to impact deer numbers. Hunting is the most practical and economic way to accomplish that. It is the method chosen to manage the deer population at the Audubon Center in Greenwich.

## 7. Implementation of Regulated Hunting

Controlled deer hunts have two phases: the initial reduction phase when hunting intensity and deer harvests are high, and the maintenance phase when hunting intensity is lower (McDonald

1998). It is important that an adequate number of antler-less deer – both females and male fawns - be harvested to reduce both the current deer density and the potential for future growth. Typically, the removal of one adult doe during the hunting season results in 3 fewer deer the following spring (Kilpatrick 2002). As deer numbers decrease, the number of deer necessary to be removed also decreases. During the maintenance phase, the number and ecological impact of the remaining deer are regularly assessed, and, depending on the assessment findings, the deer are periodically culled.

Hunting can be controlled by establishing restrictions on: 1) number of hunters; 2) selection of hunters; 3) hunting implements used (shotgun, rifle, bow and arrow); 4) timing of the hunt; 5) duration of hunt; 6) number and sex of deer harvested; and 7) areas open to hunting. These restrictions can be tailored to meet the specific circumstance and objectives of the landowner. In 2001, a total of 11,950 deer were harvested in Connecticut, reducing deer populations via tag limits and season length. According to data published by the Connecticut DEP, success rates among the various hunting methods used in these hunts were: shotgun/rifle hunters (24.7%), followed by archers (19.1%), and muzzleloader (5.3%).

Deer hunting is strictly regulated in Connecticut. Hunting with firearms is usually allowed only from mid-November to late December. Bowhunting is permitted in 2003-2004 from September 15 to January 31. Deer hunting is permitted from one hour before sunrise to sunset, and is not allowed on Sundays. For safety, firearm hunting is prohibited within 500 feet of occupied dwellings. In bowhunting, in which the archers shoot downward on the deer from scaffolds in trees, there are no minimum distance restrictions. Bowhunters with state permits are allocated four tags for deer harvest each year. Two can be used for either a male or a female deer, and two are used only for females. Unlimited numbers of replacement tags are issued by the state for any does harvested. Use of sharpshooters is prohibited.

Bowhunting is the preferred hunting method in suburban areas due to its quiet nature and safety concerns. In the Town of Greenwich, of the 113 deer harvested in 2000, 112 were taken by bowhunters. Chances of bowhunters wounding, but not killing, the animal are low. A wounding rate of 7% has been reported by the Greenwich Sportsmen and Landowner's Association. It is even less likely that a deer will walk away with an arrow in its body. Controlled archery hunts conducted elsewhere in the state did not result in the sighting of any wounded deer.

# 8. Deer Management Program at Audubon Greenwich

The goal of Audubon's deer management program is not to eliminate the deer population, but to maintain it at a level where deer and their habitat are in balance. Successful implementation of our management plan will result in a healthier deer herd, reduction of health risks from deer tick borne diseases, decrease in number of deer/vehicle accidents, and in the maintenance of a healthy ecosystem.

Our research and consideration of our circumstance has led us to a conclusion that bowhunting is the most feasible method of deer removal. In the initial two years of the plan, hunting will be implemented only on the 300-acre parcel at the Audubon Center. Our goal is to reduce the deer population within the Center Sanctuary to 5 to 7 deer. This number represents an ecologically sustainable deer density of 10-15 per square mile. As noted earlier, based on the 2002 DEP aerial survey of the surrounding neighborhood, the deer population at the Audubon Center is currently estimated to be 45 to 60 deer, so a minimum of 40 deer will need to be removed during the initial reduction stage.

We will be working with a bowhunter group in Greenwich, the Greenwich Sportsmen and Landowner's Association (GSLA), which will implement the deer hunt on the Audubon Center grounds without charge. The mission of the GSLA is to promote and protect bowhunting as a means of deer population control. Its 12 members all reside in Greenwich. Two are close neighbors to the Audubon Center property. The GSLA emphasizes training and ethical methods in all of its hunts and requires the 12-hour National Bowhunter Education Foundation course and proficiency testing of all its members, as well as a formal application and interview.

Due to the nature of bowhunting, it is not feasible to reduce the deer population to our target level in a concentrated hunting effort that spans only a few days. GSLA's expert opinion is that a harvest of 25 or more deer in one season is reasonable, and a harvest of up to 40 deer is possible. We expect to meet our reduction target within the first two years of the hunting program. Once it has been achieved, we will establish a monitoring program, with periodic hunting implemented as necessary to maintain the deer herd at a sustainable level. Hunting by GSLA members will be initially conducted between October 13 and December 6, 2003, with periodic reviews to determine if the season should be extended or abbreviated.

Aerial photos of the Center grounds will be used to divide the property into numbered sections, and scouting for tree stand locations will occur in August and September. The stands will not damage the trees, as no nails or screws are used on the trees. All stands will be located away

from hiking trails. When a deer is hit, the bowhunter will descend from the stand and locate the deer, which may walk up to 100 yards before dropping.

Bowhunters need 2.5 hours of sunlight either after sunrise or before sunset to hunt effectively. Audubon will allow the GLSA bowhunters access to the sanctuary at dawn on three weekday mornings each week during the program, and the Center will remain closed to the public until 9:30 am on the scheduled hunting days, by which time the hunters will have cleared from the sanctuary. The GSLA will inform the Center Manager which sections of the property will be hunted and which of their members will participate each day. The hunt leader for the day will confirm with staff that all hunters have checked out by 9:30 each morning, and report on any deer harvested. The protocol will be monitored continually and adjustments made as necessary to reduce safety risks or increase its effectiveness.

Parking and site access for hunters will not be through the main entrance to the Center. Hunted deer will be gutted on site. Any blood trail will be covered with leaves to conceal it, and the gut will be buried at least 50 yards from any hiking trail. Raccoons and coyotes often consume the buried deer entrails within days. The deer will be taken out on a hand cart, transported to the DEP check station in Greenwich, then butchered by a licensed processor. The cost of butchering is $40 per deer. Audubon will raise money for this cost. All meat will be donated to the Food Bank of Lower Fairfield County.

## 9. Communicating the Selected Action to the Public and Media

The safety of our visitors and neighbors is of utmost concern. Every effort will be made to clearly communicate our management plan to the public and to restrict access to the site during hunting hours. To avoid unduly prolonged public debate on implementation of the deer management plan, public notice will be given two weeks in advance of the first hunt. All adjoining landowners will be notified of the hunt by letters. Local media and our own mailing list and website will be used to communicate the plan to potential visitors in the broader community. Most landowners near the Audubon Center understand the problem of an overabundant deer population and many have tried to reduce deer population by hunting their own properties. Explanation on details of our deer management plan, its goals, rationale and timetable will be conveyed to the media to promote understanding of the issue and inform the community of our slightly reduced hours.

The only impact on our typical use of the site is that the hiking trails will remain closed an extra half hour three mornings per week during the hunting period. There will be a clear posting at the main entrance of our property as well as all other potential entry points to inform visitors of the hours the Center will be closed for hunting. Access to the Kimberlin Nature Education Center, offices, staff housing, and hawkwatch site need not be restricted. If protesters are expected on the first days of the deer hunt, we will hire police officers and/or other security personnel to ensure safety of the demonstrators, our staff, and the hunters. To gain the support and understanding of our members and the local community, every effort will be made to clearly explain the scientific basis for reducing deer population and the rationale for the chosen method. We will also communicate our plan and its progress to local and state government agencies to engage their support.

## 10. Expected Results from Reduction of the Deer Population

Forest ecosystems are not static but are constantly changing in successional stages and in response to disturbances and environmental conditions. Some of the changes in the vegetative patterns and in the abundance of bird species on Audubon lands can be attributed to forest maturation. However, evidence from numerous studies on ecological impacts of overabundant deer population and observations made at the Audubon Center suggest that the current deer population level may be incompatible with full renewal of the forest community – its trees, wildflowers, shrubs and wildlife, its biodiversity, and its ecological integrity.

Recovery of plant species composition and structure in overpopulated areas after the reduction of deer has been demonstrated through a variety of thoughtful and replicated studies. Deer have a devastating impact on tree seedlings as we have examined earlier. Evidence shows that the abundance and diversity of tree seedlings respond fairly quickly to a reduction of deer population. The successful comeback at the Bluff Point Coastal Reserve is noted above. In research conducted at the Huntington Wildlife Forest Station in New York, a controlled deer hunt was conducted to discern the impact of deer grazing on tree seedlings. When deer density was reduced from 27 per square mile to 12 per square mile, the number of white ash, yellow birch and sugar maple seedlings greater than three feet tall increased from 200 per acre to more than 10,000 over a 3-year period. There are numerous other examples of recovery of tree regeneration following removal or reduction of deer population.

Data suggest that the herbaceous community recovers more slowly than woody species from deer browsing because herbaceous cover and frequency are more closely tied to historic deer densities. Groundstory plants cannot grow past the browse line and remain susceptible to

browsing throughout their life cycles. Heavy grazing by an overabundant deer population will tend to transform a naturally diverse herbaceous community into one dominated by ferns, grasses and sedges which may interfere with the re-establishment of native herbaceous plants and tree seedlings. In these areas, physical removal and site treatment may be necessary to promote recruitment of the native plant community.

Perhaps the most devastating effect of an overabundant deer population is on the spring wildflowers. As noted above, when browsing pressure lasts for a decade or longer, they are simply eliminated due to lack of seed source (Stout 2001). Relieving grazing pressure by the reduction of deer may not restore the wildflower community, in which case active restoration efforts will be necessary to re-establish the representative native wildflower species.

Studies have shown that tick density and the incidence of Lyme disease decrease with reduction of deer population. Tick densities were monitored in Bridgeport and Groton, Connecticut, both areas with deer density of around 200 deer per square mile. When deer populations at these sites were reduced over the past decade to 44 and 27 per square mile, the number of blacklegged ticks collected per 100 $m^2$ declined by 68-93%. Reduction in population of deer ticks can naturally be expected to reduce the risks of human contraction of tick-borne diseases such as the Lyme disease, Erlichiosis and Babesiosis.

# 11. Implementation of a Monitoring Program

The deer management program will need continuous monitoring and adjustment. Besides monitoring the status of the white-tailed deer population, we will develop accurate and convenient indicators of its direct and indirect impacts on components of the ecosystem that are sensitive to high deer density.

*Vegetation monitoring plots* in each representative forest type on our property will be established for measuring and recording herbaceous plant abundance and diversity, the number, growth and species of tree seedlings and saplings, and browse damage. As noted earlier, the herbaceous community is expected to recover more slowly than woody species. Because intensive grazing by deer has persisted for at least the past two decades, any seed bank remaining in the soil may have been extirpated. If viable seed source is no longer present, then wildflowers and other herbaceous species heavily grazed by deer may not come back. In such a case, the abundance and diversity of tree seedlings would serve as a more appropriate indicator. *The annual breeding bird census* can be used to help detect any shifts in abundance and species diversity of the bird community.

Long and short-term monitoring of ecological effects of deer will provide a gauge of appropriate population levels, contribute to a better understanding of the ecological connections between deer and other ecosystem components, demonstrate the benefits of sound conservation measures, and help establish the Audubon Center as a model of science-based land management.

## 12. Summary of the Management Plan

- The population of white-tailed deer at the Audubon Center will be managed through bowhunting, in compliance with all state regulations.
- Our goal is to reduce the Center's deer population to 5 to 7 deer; we estimate a minimum of 40 deer need to be removed within the initial two-year reduction stage.
- The deer population will be maintained at sustainable levels by periodic hunting after the initial reduction phase.
- The Greenwich Sportsmen and Landowner's Association (GSLA) will perform the reduction phase hunt on Audubon property, in partnership with the Center Manager.
- The hunting program will be conducted three mornings per week, from dawn to 9:30 am, over a two month period (from October to December, in 2003).
- Hunting will occur from tree stands placed away from all hiking trails.
- The Center Manager will be informed by GSLA regarding which members are hunting on each day, their locations, when they have left the property, and what results they had.
- Public access to the Center grounds will be closed during hunting hours.
- Hunter access, parking and deer removal will not be permitted through the Center's main gate.
- All harvested deer will be butchered at a licensed facility and the venison donated to the Food Bank of Lower Fairfield County.
- Audubon Greenwich will assist GSLA in funding the $40 per deer cost of butchering.
- The Center Manager will communicate the management plan to local Audubon members, neighbors, and the community in advance of the harvest.
- The management plan and hunting protocol will be monitored and reviewed daily, monthly, and annually, and adjustments made as necessary for safety and effectiveness.
- Once reduction targets are achieved, vegetation will be monitored in sample plots on the sanctuary grounds to determine deer browsing pressure on the forest ecosystem.
- The Center Manager will report to the Audubon Greenwich board, at the end of each hunting season, on the success of the management plan and any modifications needed for the following season.

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