Deer Management Plan –Binghamton University

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"I now suspect that just as a deer herd lives in mortal fear of its wolves, so does a mountain live in mortal fear of its deer. And perhaps with better cause, for while a buck pulled down by wolves can be replaced in two or three years, a range pulled down by too many deer may fail of replacement in as many decades." –Aldo Leopold

Summary

Deer overpopulation in the University's Nature Preserve over the past 40-50 years has had a devastating effect on forest ecology. Forest regeneration is virtually non-existent as deer eat all tree seedlings faster than they can be replaced. Wildflowers and native forest understory shrubs have disappeared, and the resulting reduction of food and habitat has adversely affected all other animals in the forest community. Low-nesting and ground-nesting birds, for example, have stopped reproducing in our forests. Because the deer have no natural predators in the Nature Preserve, and because hunting is not allowed, the deer population is currently five to ten times larger than research shows it should be. The goal is NOT to eliminate deer completely, but to reduce the population to a level at which the forest can begin to recover. We want deer to remain an integral component of a healthy, ecologically balanced environment in our natural areas.

After extensive research of all options for reducing the deer population presented to the Committee for the University Environment, the Committee agreed to recommend culling as an initial step for a deer management plan. The deer population and their effects on the forest will be monitored, options will be reviewed, and further actions will be taken when necessary.

I. Introduction

Aldo Leopold was the first person to write about the harmful effects of deer as he witnessed the damage caused to Wisconsin forests by growing populations throughout the early 20th century. Since then, the issue has become progressively worse, as dramatic increases in deer numbers have lead to overpopulations in many Midwestern and Western states as well as much of the Northeast. In New York alone, deer numbers have risen from around 20,000 in the early 1900s to a current population of over 1 million (Curtis and Sullivan 2001). This has happened principally due to the loss of their only natural predators, wolves and mountain lions, and the creation of much favorable brush habitat as a result of abandonment of agricultural land. The overpopulation of White-tailed Deer (*Odocoileus virginianus*) is now having drastic ecological consequences in many areas and has become perhaps the single greatest obstacle to the regeneration of native forest trees and plants. As we begin to understand more about the other threats affecting northeastern trees, it becomes critical that we take action to ensure the continued health and existence of our forests. In areas such as the Binghamton University campus, this involves addressing the problem of White-tailed Deer overpopulation by adopting a management plan to reduce and control population densities in the future.

Deer Management Goals for Binghamton University Natural Areas

1. Maintain white-tailed deer as a valued member of the native fauna of our natural areas by implementing a management program that mimics, as closely as possible, the population-stabilizing effects of natural predators on deer in order to restore the structure, diversity and function of BU Natural Areas.

> **Objectives: Reduce deer impacts that allow forest recovery and reintroduction of native understory. Maintain deer populations at levels that eliminate the effects of intense herbivory**

2. Manage deer in a safe and humane manner.

> **Objective: Manage deer at population levels which allow maintenance of the full ecological integrity of the natural habitats at BU, while maximizing public safety and minimizing the suffering of deer**

3. Continue a monitoring program to assess the extent of deer effects on biodiversity and ecosystem function.

II. Causes of Overpopulation

The White-tailed Deer populations that exist today are mostly the product of past hunting and land-use practices. In the early 1900s, the White-tailed Deer population of the entire nation was estimated at only 500,000 individuals. This was largely due to unregulated hunting, which threatened to remove the White-tailed Deer from much of its native range. Unregulated hunting was also responsible for removing the large predators such as the Gray Wolf (*Canis lupus*) and mountain lions (*Felis concolor*), which once helped to control deer populations. Though overhunting by man was responsible for great reductions in deer populations in the early part of the century, the subsequent laws and restrictions placed on deer hunting throughout the 1900s have allowed their numbers to rebound to unprecedented levels. Protected areas and hunting-free preserves have helped contribute to a deer population of over 20 million in the U.S. today.

Historical land-use practices have also helped deer populations to rise to the current numbers they have reached. Agricultural and forestry practices throughout the 20th century have created and improved suitable deer habitat and led to an increased availability of food (Cote 2004). Deer are able to thrive in the fragmented and edge habitats created by farming and logging, as well as urban and suburban areas with surrounding forest fragments (Levine 2009). The early successional systems and plant growth created by logging operations or the abandonment of farmland provides large amounts of high-quality food for deer (Cote 2004). Aside from these food sources, deer are able to take advantage of agricultural fields, orchards, roadsides, lawns, and gardens (Rawinski 2008).

Like almost all of the ecological problems we face today, the explosion of deer populations is a direct consequence of human actions. Together, the combination of reduced hunting pressure, lack of natural predators, increases in favorable habitat, and plentiful alternative sources of food has allowed deer populations to explode. In many northeastern forests, these populations are having a variety of broad ecological effects and will dramatically change the appearance and function of the forests of the future.

III. Ecological Effects of Overpopulation

As keystone herbivores, deer have the ability to alter forest ecology by changing the course of forest vegetation development (Horsley 2004). In forests subject to sustained browsing pressure, deer can limit the regeneration of susceptible woody plants and eliminate populations of susceptible herbaceous plants (Rooney and Waller 2002). One of the most serious consequences of high levels of deer herbivory is the effect it has on regeneration under closed canopy systems (Tripler et al. 2005, Powers 2009). By consuming young, vulnerable seedlings and saplings, deer herbivory poses a direct threat to the regeneration of forest trees. When deer populations exist at high enough densities, they are capable of consuming young trees faster than they can be replaced. Compared to herbaceous plants, trees are relatively slow-growing and particularly sensitive to deer browsing, especially when repeated (Cote et al. 2004). Over time, the reduced success of young trees will affect forest canopy structure and composition (Rooney and Waller 2003). Under normal levels of deer herbivory, a gap created in the forest canopy will gradually be replaced by young understory trees. In forests with high levels of deer herbivory however, these young trees may be virtually absent, resulting in delayed or failed canopy closure. By reducing the rate at which canopy gaps are allowed to close, an increasing percentage of forest is in an open condition at any given time (Tripler et al. 2005). This causes soil moisture and humidity to decline, while at the same time, the temperature of the forest floor increases (Rooney and Waller 2002).

Herbaceous forest plants are subject to high levels of deer herbivory as well. Compared to trees, herbaceous plants are more susceptible to deer browsing in the sense that they never grow to a size large enough to offer them protection (Rooney and Waller 2003). Prolonged browsing pressure by deer can greatly reduce the abundance and diversity of native herbaceous plants. Over time, this selective browsing leads to altered plant communities dominated by less preferred or more browse-resilient species (Horsley et al. 2003). This is accompanied by a decline in spring ephemeral wildflowers: species like American Ginseng (*Panax quinquefolius*) are being threatened with extirpation (Thompson 2007). In mixed coniferous-deciduous forest stands for example, increased deer browsing often leads to an increase in the dominance of deer-resistant ferns, grasses, sedges, and rushes (Rooney and Waller 2003).

The increase in fern abundance, especially that of Hay-scented Fern (*Dennstaedtia punctilobbula*), in northeastern forests interferes with the regeneration of hardwood trees (George and Bazzaz 1999). Interference is caused primarily by the reduced light availability to the forest floor created by dense stands of ferns, which prevents the establishment of tree seedlings and thus the restoration of diversity and forest structure (Horsley et al. 2003). In addition to competition for light, ferns and herbaceous plants compete with tree seedlings for root space and potentially prevent seedling establishment through the production of allelopathic substances (chemicals poisonous to other species) (George and Bazzaz 1999). Thus, deer herbivory not only directly limits regeneration through browsing, but indirectly by promoting the establishment of ferns.

Many invasive species benefit from high levels of deer herbivory. Not only do deer serve as a mechanism for the dispersal of seeds of invasive and exotic species, but they also allow these species to exploit the niches left open by declining native species. In many cases, invasive species tend to be disproportionately resistant to deer herbivory when compared to native species (Rawinski 2008). Certain adaptations result in a competitive advantage for invasive species, such as the physical defenses seen in Japanese Barberry or the chemical defenses seen in Garlic Mustard. By avoiding unpalatable plants, deer help to increase populations of invasive species by consuming competing native plants. Once established, plant communities dominated by invasive species are often resistant to reinvasion by native species, meaning the ecological effects of high levels of deer herbivory may be exceedingly difficult to reverse.

Changes in forest structure caused by deer herbivory affect many other forest organisms. The most notable example is forest birds that rely on saplings and shrubs for nesting habitat. In North America, it has been shown that a loss of vertical structure can reduce the abundance and diversity of shrub-nesting birds and the densities of migrant birds (Rooney and Waller 2002). Ground-nesting birds can also be affected by exposure of their ground habitat from deer browsing. The loss of structural complexity in forests affects many species of birds indirectly as well. These open forests cause an increased vulnerability of birds to predators and a greater advantage to the Brown-headed Cowbird (*Molothrus ater*), a brood parasite that lays its eggs in the nests of other species for them to rear. This parasitism effectively reduces the reproductive success of birds that breed in northeastern forests.

IV. Further Reasons for Population Control

While a variety of problems continue to affect the health of northeastern forests, the issue of deer overpopulation is unique in the sense that it can be dealt with more easily than others. Though all forested ecosystems are important for the ecological services they provide, the Binghamton University Nature Preserve is of special interest for its importance as a teaching and research area, as well as the aesthetic and recreational value it provides to university students and the public. It provides essential habitat, and a sophisticated habitat management plan is implemented by those in charge to promote the highest level of diversity possible. To ensure that these efforts are not wasted, it is necessary to implement a deer management program to reduce populations to healthy ecological levels. More importantly, this overpopulation problem should be addressed before it causes irreversible damage to campus natural ecosystems, and to allow for the forest to begin healing.

Reducing car collisions

Besides threats to ecosystem health, deer pose a threat to human health and safety, and reducing overabundant deer populations would be beneficial for several reasons. Reduced deer populations would mean a reduction in deer-vehicle collisions (DVC). According to the Insurance Institute for Highway Safety (IIHS), there are an estimated 1.5 million DVC in the U.S. annually, amounting to over $1 billion in vehicle damage and resulting in about 150 occupant deaths (IIHS 2003). 50,000 of these collisions occur in New York State each year (Curtis and

Sullivan 2001). Reducing local deer densities through population control has been shown to directly reduce DVC (DeNicola and Williams 2008).

Disease

Reductions in deer populations could also mean a decrease in the incidence of Lyme disease in humans. Both humans and deer are capable of contracting Lyme disease when bitten by infected ticks. Deer are the primary hosts for adult black-legged ticks (= deer ticks, *Ixodes scapularis*), and infected deer serve as reservoirs for the disease. Previous to 2005, *I. scapularis* was unknown on Campus. Since then, the population of ticks has grown rapidly and an extensive new research project has documented their abundance, range, and rate of infection with the Lyme parasite on Campus. The Campus Health Services has seen a recent increase in the incidence of human cases of Lyme Disease. Decreases in deer populations have been correlated to decreases in tick populations, and may help to reduce the prevalence of the disease (Stafford et al. 2003). Furthermore, reducing populations would reduce economic costs of damages to agriculture and property caused by deer. High populations of deer increase the spread of disease among them. Recently, SARS-CoV-2 has been detected in deer in several states including New York (APHIS 2021).

Deer Health

Much of the opposition to deer control is due to failure to realize that population reduction is favorable for deer as well. Competition between deer in overpopulated areas leads to health problems such as decreased body weights, lower rates of winter survival, increased parasite loads, and increased levels of disease. Localized deer reduction programs have been shown to cause significant improvements in deer herd health and reductions in deer browsing (Kilpatrick et al. 2001, Stafford et al. 2003). A smaller deer population is thus beneficial for the environment, humans, and deer alike.

V. Binghamton University Campus – 40 + years of deer overabundance

Though deer densities are high in many northeastern forests, differences in forest management can result in uneven distributions of deer populations. Hunting bans on private and especially on public lands can cause population densities to exceed those of the surrounding areas (Cote 2004). Such is the case on the Binghamton campus in the Nature Preserve and natural areas. This phenomenon has been observed on other New York campuses such as Cornell and Vassar, which have responded by implementing active management plans to reduce deer densities and lessen their associated environmental impacts.

a. Influence of Deer Herbivory on BU Natural Areas and Campus

There is significant physical evidence in both the developed and undeveloped areas of the BU campus demonstrating the negative impacts of the deer population on vegetation. Deer lack upper incisors and so deer browsing is easily distinguished by the torn or jagged appearance of foliage. Throughout the core campus area, many of the plants used in landscaping and numerous lawns provide high quality food for deer. In the natural areas, most trees have been stripped of foliage within the height of a deer's reach (figure1 and figure 2). This has led to the formation of a distinct browse line found throughout much of the campus natural areas (Figure 1) and the forest understory is protected only on the slopes too steep to be easily traversed by deer. In the CIW Woods, larger amounts of vegetation in several experimental enclosures clearly shows the difference between areas protected from deer and those subjected to deer browsing. Almost all of the understory in the CIW Woods has either been destroyed or shows evidence of deer browsing. Species not usually preferred by deer, such as American Beech, show evidence of extensive browsing down to 6 inch sprouts. Invasive species such as multiflora rose (*Rosa multiflora*), and autumn olive (*Elaeagnus umbellate*) and Christmas fern (*Polystichum acrostichoides*) are being browsed by deer. Japanese stiltgrass (*Microstegium vimineum*) , white grass (*Leersia virginica*), white snakeroot (*Eupatorium rugosum*), and some fern species are swiftly becoming the dominant herbaceous plants in the understory of BU's forests. A recent study of seedlings in historically established plots showed zero seedlings of any species growing in any plot (Population Ecology course, Dr. John Titus, 2012). The only seedling-sized trees that were found were Beech sprouts that deer can't kill. However, Beech sprouts don't grow because deer eat them. Another recent study by the Conservation Biology class found no understory sapling under 5 years old and no canopy tree species under 20 years old.

Figure 1. Typical view of the forest floor in Binghamton University natural areas. High light levels, yet very little vegetation and the distinct browse line.

Figure 2. Another area near the wetlands with just Japanese Barberry in the understory. Recently, Japanese stiltgrass has taken over.

Twelve species of forest-floor wildflowers formerly found in the BUNP have not been documented in recent years, which is due in large part to deer herbivory:

Forest wildflowers that have disappeared from Campus
Wild ginger – Herbarium specimen 1977; last seen in Anderson Center Woods ca. 1997
Blunt-lobed hepatica – Herbarium specimens 1957, 1962, 1964
Canada violet -- Herbarium specimens 1961, 1966
Long-spurred violet – several groups disappeared between 1995 and 2000
Yellow forest violet -- Herbarium specimens 1961, 1964, 1968
Round-leaved yellow violet -- Herbarium specimens 1962, 1964
Barren strawberry – large clones all disappeared between 2000 and 2006
Dwarf ginseng -- Herbarium specimen 1962; last seen in Anderson Center Woods in 1980s
Yellow bead-lily – many clones in 1995, but all disappeared between 2000 and 2006
Perfoliate bellwort -- Herbarium specimen 1964
Yellow mandarin – last seen 1995
White trillium – last seen 1995

Forest wildflowers that have decreased by >50% from Campus between 1995 and 2006

Wood anemone
Red trillium- last seen 2006
Painted trillium- last seen 2006
False Solomon's seal

Several species of ground-nesting birds that once nested in the Binghamton University Nature Preserve, has not been documented in several decades:

Forest ground-nesting birds that have disappeared from Campus since 1975
Hermit thrush
Black-and-white warbler
Worm-eating warbler

Forest ground-nesting birds that have decreased on Campus between 2001 and 2011 surveys
Veery (2→0 on lower Campus, 4→3 overall)
Ovenbird (5→2 on lower Campus, 20→10 overall)

Only other ground-nesting bird remaining
Dark-eyed junco (4→6)

b. Deer Counts:

Deer population in the CIW Woods suggests that this population exceeds the recommended density needed to prevent harmful effects to the environment. In the Deer Management Memorandum created by the Vassar Farm Oversight Committee, DEC Wildlife Biologist Kevin Clark suggested that a density below 30 deer/mile^2 allows for forest regeneration, and a density below 15 deer/mile^2 prevents negative impact to the environment. In another experiment designed by Horsley et al., a system of four enclosures were created and stocked with deer representing densities of 4, 8, 15, and 25 deer/km^2. Results indicated that the threshold of deer density for negative impacts on forest vegetation was >~8 deer/km^2 (Horsley et al. 2003). This is roughly equivalent to 20 deer/mile^2.

i. Aerial infra-red Count

The Binghamton University Campus and adjoining buffer areas were surveyed by use of an aerial infrared (IR) deer count flight on the night of March 29, 2013. The count was taken between 10:28pm and 11:41pm. The count was conducted by Davis Aviation and analyzed by Stockton Infrared Thermographic Services, Inc. The total number of deer was 260. The number of deer counted on university property was 135. Outside university property, but close to the boundary, were 125 individual deer. The number of deer directly using the campus natural areas is over 10 times the carrying capacity for healthy forest ecosystem. UPDATE: Aerial counts were conducted in 2015 (213 total 127 inside 86 outside) and 2018 (173 total 124 inside 49 outside).

ii. Deer censuses on foot

As the campus deer become more and more habituated to human presence, deer behavior allows for easier counting than would occur in habitat with hunting or predators. The impact of deer on our land is great enough that standard measurements of deer population actually overestimate deer numbers. Since deer tend to go into yards, the majority of campus deer migrate down from the upper elevations in the winter. Deer counts have been conducted by the Steward of Natural Areas every winter since 2006 using transects through each forested area amongst the buildings and lower elevation areas of the Nature Preserve. In the higher elevations of the Nature Preserve deer are more difficult to count as they are still shy of people and the terrain allows for more places to hide. In 2006, 45 deer were present. In 2008, the number of individual deer found on campus was 55 with the majority (40) found in and around CIW. In 2012, 59 deer were counted in the lower elevation with 43 in the campus natural areas and the remaining 16 in the lower elevations of the Nature Preserve. (Update: In 2014, 65 deer were counted.) The lower elevation counts amount to half the deer actually living on University land according to the FLIR. No matter what technique is used to count deer, from infrared imaging to visual count to capture, there will always be a percentage of the population which evades census (Haroldson et al. 2003.) Given that ~60 can be directly observed and there are most certainly more, previous estimates of 80 deer were quite conservative. Management efforts will concentrate on the most densely populated areas.

iii. CIW Deer Counts in 2011:

Though the distribution of deer populations varies temporally throughout the year as shifts in resource availability occur, an index of the campus deer population was taken in early 2011. A series of counts were performed in a 33 acre area known as the CIW Woods. The CIW Woods was chosen as a study site for its size and clear boundaries of campus roads. During the winter months, deer congregate in areas known as deer yards and tend to select areas with greater densities of evergreen trees that provide shelter from snow and wind. Deer select the CIW Woods for this reason, though there are numerous other suitable sites for deer yards in other campus natural areas.

Deer counts were performed visually and on foot. Campus deer tend to be relatively accustomed to the presence of humans, and deer can be followed with relatively little disturbance. Even when disturbed, campus deer tend to flee only very short distances. This allows deer to be driven in a certain direction with relative ease, and deer were followed until they congregated into larger herds. To avoid double counting, the results represent the maximum number of deer in field of view at one time. Using this method, the possibility of over-counting is avoided, and the maximum number of deer recorded in each entry represents the minimum number of deer present on the Binghamton campus at a given time. Some entries were omitted because deer fled the boundaries of the study site before they could be counted, and so data has been limited to reliable entries.

Date:	Number of Deer:
March 15	16
March 24	31
March 27	26
April 6	22
April 8	23
April 13	11

Table 1. Numerous counts showing large numbers of deer in the CIW Woods.

On the 33-acre study site, the presence of an average of 21-22 deer represents a population density of 420 deer/mile^2. Observations suggest that the CIW Woods has the highest population density of deer on campus, but other areas clearly show similar levels of damage caused by deer. Together, the combined area of the Binghamton campus is 872 acres. Of this, over 600 acres are undeveloped and in a natural state, including the 182 acre BUNP. The remaining acreage is developed, creating a mixture of suitable habitats protected from hunting for deer to exploit. A recent pellet count study conducted in February 2012, estimated deer from 113 to 1650 deer/mile^2, estimates far greater than the actual number of deer observed on campus. This demonstrates the intensity of use of the forest by deer is worse than the actual number of deer.

VI. Possible Methods of Lessening Impact of Deer on our Forests

Unfortunately, we can no longer rely on natural methods to reduce the impact of deer on forest ecosystems, as large predators have been extirpated from the Northeast. These predators require large territories, and the same habitat fragmentation that has benefitted deer populations has removed the possibility of their reintroduction. Though general hunting is often accepted as the traditional means of deer population control, it doesn't always effectively control deer populations and is often prohibited. Controlled hunting and special hunting periods would be needed.

In these situations, other forms of control must be used, and a variety of methods have been created to reduce and maintain deer populations at desired densities. Many non-lethal methods of control have proven to be ineffective, and many of the more successful lethal methods remain highly controversial. Any effective population control-effort must contain active forms of control aimed at physically reducing the number of deer, followed by the long-term maintenance after the deer density has been lowered to the desired level (DeNicola et al. 2000). Methods of deer population control are evaluated according to effectiveness, amount of suffering of the deer, and cost (including money, time, and effort).

a. Fencing

Fencing the whole campus is impractical, doesn't meet ecological goals, and would cause deer to suffer. Can be effective for smaller sensitive areas or combined with other methods.

Fencing off a square mile of land with a highly uneven border and differing elevations is highly impractical at the least both in cost and logistics. Do we want to open a gate to enter our natural areas? Fencing doesn't allow for the natural movement of many animals including the deer and doesn't follow the management goal of including deer in a healthier forest ecosystem. A major problem is what to do with the deer inside the fenced in area. Do we try to remove them (see below) or leave them to starve and die inside the fenced in area? Our deer depend on walking around campus and surrounding neighborhoods to compensate for their own depletion of food in the forest. Deer trapped inside the fencing will surely starve to death which is cruel and wasteful.

b. Capture and Translocation

If the goal is not to kill deer or not cause suffering, relocation doesn't work.

Lethal methods of population control are often met with resistance, and so non-lethal control methods such as relocation are frequently attempted. Relocation involves the trapping and transport of deer, and has proven to be expensive and labor intensive with low rates of survival. An important requirement of relocation programs are suitable release sites capable of accommodating new deer. In areas already afflicted with deer overpopulation, these sites are usually rare or absent. Prior to capture, deer in overpopulated areas are typically in poor physical health due to competition with other deer. During capture and transport, exhaustion and high levels of stress often leads to a disease known as capture myopathy, causing delayed mortality in released deer (DeNicola et al. 2000.) Death from capture myopathy can occur up to 26 days after capture (Beringer et al. 2002). Mortality rates of 45 to 95% have been documented and reviewed by the Michigan Department of Natural Resources (2000). The capture and transport of deer also requires the use of expensive tranquilizers, most of which are controlled substances requiring special licenses from the U.S. Drug Enforcement Agency (DeNicola et al. 2000) Each deer costs several hundred dollars to relocate, with estimates ranging anywhere from $400 to $2,931 (DeNicola et al. 2000) This is a substantial amount considering the limited effectiveness of relocation and the low rate of survival in released deer. Relocation does nothing to prevent the immigration of new deer, and relocated deer may cause problems in the release area similar to those of the capture site.

At the present time, the Environmental Conservation Law §11-0505 (3) prohibits the trapping of deer except under special permit issued by the DEC for scientific purposes. A DEC permit is required to capture and relocate deer. Current laws and concerns about disease preclude such permits being issued.

c. Fertility Control

Ineffective in reducing deer numbers sufficiently to affect ecological restoration.

There are two major methods of fertility control, surgical sterilization and contraceptives.

Similar to other methods of non-lethal control, sterilization is both expensive and labor intensive, requiring a surgical operation performed by a licensed veterinarian. Many of the problems associated with sterilization involve the trapping of deer. Trapping of the deer increases likelihood of suffering and mortality. Sterilization requires the capture of fertile female deer, so the capture of males or previously sterilized females results in wasted capture effort (Merrill et al. 2006). Secondly, trapping affects the likelihood of recaptures in one of two ways. Previously captured females may avoid traps due to the associated stress of capture, resulting in a decreased number of recaptures. On the contrary, previously captured females may be attracted to traps due to the presence of bait, ultimately resulting in an increased number of recaptures, leading to an inadequate number of sterilized deer. (Merrill et al. 2006).

Despite optimistic reports by proponents of fertility control, most research suggests that contraceptive methods are effective only in populations with limited immigration (islands, enclosed herds), and even then only after many years. Fire Island National Seashore has shown varied results: the most dramatic is one study area that showed a decline of deer by 60% over 10 years. (Naugle et al. 2002, Underwood 2005.) After a 60% reduction in one study area, the deer population is still greater than what BU is starting with. This is not consistent with our goals of reducing impact of deer herbivory on Binghamton University forests. Adding another ten years of intense feeding pressure to over 40 years of deer impacts puts forest recovery in jeopardy. In order for a population to decrease, it requires negative growth, meaning that the mortality rate must exceed the birth rate. Over time, fertility control programs may be able to achieve small reductions by reducing the number of fertile females, but this does not account for immigration in open populations. At Binghamton University, deer are easily able to migrate between the natural areas of campus and adjacent suburban areas, making the use of sterilization questionable. In populations with substantial rates of immigration, it is doubtful that fertility control will be able to reduce the population size, regardless of management effort (Merrill et al. 2006). Fertility control may be a useful tool in population maintenance, however, and may be more successful and cost effective following an initial major reduction in population numbers (Rooney 2010).

d. Controlled Hunting

More effective in maintaining balanced deer numbers after an initial reduction. Given that culling may not be an option, hunting is the "next best" strategy.

Though many identify hunting as the traditional means of controlling deer populations, the number of hunters in the U.S. has been decreasing since the 1970s (Brown et al. 2000) More importantly, there has also been an increase in lands where hunting is prohibited (Brown et al. 2000). This includes residential areas and areas like the Binghamton University campus. In these situations, controlled hunting can possibly be used to reduce deer populations. This requires hunters to obtain a special license to hunt within protected or residential areas and out of season. This is often accompanied by a skill test to ensure a hunter is proficient. Though the hunting technique used is dependent on the area, archery hunting is often the most practical method in populated areas. Compared to the use of firearms, archery hunting is less disruptive and the limited range of arrows makes it a safer option. Controlled hunting programs have the potential to be very cost effective depending on the hunters used. Groups of professional archery hunters do exist, however local volunteers can be used to reduce costs. Limitations of controlled archery hunting include possible lower rates of success compared to firearms hunting, meaning a longer time to reach target populations and increasing the likelihood of injured deer in residential areas. Specific to Binghamton University, the number of areas on campus at a legal distance from dwellings (500 ft. NYS, 1000ft. Vestal) is limited. Also, a controlled hunt with a significant reduction in deer numbers would necessitate closing most of the Campus Natural Areas and Nature Preserve for a substantial period (several weeks or more), preventing access by University students, staff, and the neighboring community. Controlled hunting programs have proven safe (Doer et al. 2001), but the nature of access to university property would necessitate a special out of season permit to hunt in the safest time period of winter break when students are away and the least number of people are likely to be in the natural areas.

e. Drive to adjacent privately owned legal hunting properties

Requires a large number of "drivers", but may be effective if the deer move.

In the Binghamton University Nature Preserve, it may be possible to do a drive. A drive involves a number of people attempting to move (drive) deer in the direction of waiting hunters. All involved must have hunting licenses whether or not they are handling firearms/bows. The goal of the drivers is to move the deer calmly, so that the deer are moving far ahead of the drivers to allow hunters to make safe shots. Deer drives are rarely published as a control method, but have been used to count deer before intensive traditional hunting (Berhend et al. 1970.) It's possible to do a drive during established hunting seasons, but would likely be safer and more effective with a special season similar to controlled hunting above.

f. Culling with Sharpshooters

Safe and effective when repeated or combined with other options, but elicits negative publicity.

Many communities and institutions have used trained personnel to remove deer through sharpshooting. Sharpshooting is perhaps the most effective yet most controversial means of lethal deer control. A number of cautions can be taken to ensure that sharpshooting is effective, safe, and humane. DeNicola et al. suggests the following measures be taken: (1) baits should be used to attract deer to predetermined removal areas, (2) deer should be shot from portable tree stands, blinds, or a vehicle during the day or night, (3) deer should be shot through the head or neck whenever possible to ensure quick and humane death, (4) deer should be processed in a closed and sheltered facility, and (5) meat should be donated to food banks to be distributed to hungry people in the community (DeNicola et al. 2000). In addition to these measures, the use of firearms equipped with noise suppressors and the careful selection of shooting times can limit disruption and make these programs largely unnoticeable. A cull along these lines would take only a few days. Compared to other methods of deer control, sharpshooting has the potential to be most cost effective. White Buffalo, Inc. is the premier non-profit wildlife management and research organization using sharpshooting as a means of control and estimates the cost per deer to range from $150 to $400 (White Buffalo, Inc.)

Public reaction is an important consideration when choosing a management method.
Though non-lethal methods of control are often preferred by animal rights advocates, these methods are less effective and take a longer period of time for any reduction in population to occur, thus allowing the negative effects of deer overpopulation to persist. The results of lethal forms of deer control are seen almost immediately, and methods like sharpshooting have added benefits. White Buffalo, Inc. has removed 9,000 deer to date and these programs have donated over 200,000 pounds of venison have been donated to food shelters for distribution (White Buffalo, Inc.)

VII. Current Management Programs of other institutions

There are nearly 30 deer reduction programs in NYS according to NYups.com and many in practically every state. Airports, parks, municipalities, and many other areas of NYS have the needed to reduce deer populations. There are many more examples than what are described in *this document.*

Westchester County, NY
Bow hunting programs in county parks. Different parks have different times and restrictions. Parks remain open during the season.

Suffolk County, NY
Suburban bow hunting program.

Albany, NY
Albany Pine Bush Preserve allows hunting in different areas during specific times of the year.

Town of Dewitt, NY
Implemented a hunting program in 2017.

Cornell University
Cornell University in Ithaca, New York implemented a management program incorporating multiple methods to reduce deer populations on campus and surrounding suburban areas, agricultural lands, and woodlots. The following information has been obtained from the 2007-2010 Progress Report prepared by Curtis and Boulanger assessing Cornell's deer management program. Sterilization is used near campus where hunting cannot be used as a management tool, and hunting is used in surrounding areas where state regulations do not prohibit the discharge of firearms. The hope is to reduce deer populations in the hunting zone, to prevent immigration that interferes with sterilization efforts in the sterilization zone. Seventy-seven deer have been sterilized since October 2007 at a cost of $1075 per deer. The surgical costs were $550 per deer, and labor costs for capture and marking amounted to an additional $525 per deer. This was practical for Cornell because surgical costs were donated to the program by the College of Veterinary Medicine, but the costs of sterilization may be too high for other institutions. The controlled hunting efforts required DEC Deer Management Assistance Program permits, allowing hunters to take only antlerless deer to reduce the reproductive potential of the deer herd. Beginning in 2008, the controlled hunting program harvested 69 deer during the 2008 season and 112 deer during the 2009 season with the increase in harvest due to additional lands added to the management area. These combined efforts have begun to show moderate success, and the population density has been lowered from 52 deer/mile^2 in 2009 to 46 deer/mile^2 in 2010. Currently, Cornell is using intense deer hunting on several properties to manage the deer at lower levels.

Vassar College
Vassar College in Poughkeepsie, New York has also recognized the need to reduce the deer herd on its 530 acre Farm and Ecological Preserve. Research at Vassar has shown that overpopulated deer are preventing forest regeneration. Flyovers using infrared photography revealed 100 deer in the management area, translating to a population density of around 125 deer/mile^2. The goal set forth in the Vassar Management plan was to reduce deer population density to 20 deer/mile ^{2}, meaning a population of 15 deer on the Farm and Ecological Preserve areas. Vassar acquired a Nuisance Deer Permit from the NYSDEC and contracted the non-profit organization White Buffalo, Inc. to remove deer using a sharpshooting program (Henry 2010). A total of 64 deer

were removed from the management area in January 2010 in two nights of sharpshooting. Now that the deer population has been reduced, the Vassar management plan hopes to maintain the population using controlled hunting. In January, 2022 Vassar have reduced deer to 36 deer/mile ^{2} and are conducted a cull implemented by the U. S. Department of Agriculture. By reducing the deer populations to ecologically healthy levels, Vassar College is protecting ecosystem health and the future use of the Farm and Ecological Preserve for education and research.

VIII. Recommendations for Binghamton University

Binghamton University should follow suit and adopt an active management program with the goal of reducing and maintaining deer populations at densities low enough to prevent negative impacts to the campus environment. This management plan recommends a combination of methods: fencing areas where feasible or with higher priority vegetation and culling by sharpshooters with the goal of reducing deer numbers to below the threshold at which the forest may begin recovery (below 13 deer/ mile^2). The true indicator of population management success will be the recovery of forest understory, the presence of new tree seedlings, and wildflowers.

Though management programs involving lethal control are controversial, they are justified because they are the most successful method to accomplish these goals. Sharpshooting programs like that of Vassar College have received a certain amount of publicity, but programs like these are valuable because of the immediate results. More importantly, these programs can be safely implemented on a college campus. The constant presence of people on the Binghamton campus and in campus natural areas creates a need to limit the actual time spent removing deer.

Sharpshooting efforts can limit the number of harvests and can be carried out at night to limit disturbance. For this reason, sharpshooting is a more practical alternative to controlled hunting, which requires a longer hunting period and may not initially achieve the same results. However, given that culling had been blocked, controlled hunting was the closest alternative. Controlled hunting programs with archery have been implemented in many municipalities and have proven safe.

Any control efforts should occur during break periods throughout the year when students are absent from campus with the winter break period being the most critical. During winter break from December to January, visibility is high and there are a minimum number of visitors in the Nature Preserve, improving the safety of the program. Also at this time, deer are concentrated in deer yards, allowing for easy and efficient removal. After an initial population reduction, population densities should be monitored and could be maintained accordingly using a similar harvest program during the winter break period every 3 to 10 years. As with other programs, a portion or all meat harvested can be donated to local food shelters for distribution (depending on desire of the food shelter or CHOW), and so a local reduction of the deer population would not only greatly benefit Binghamton University but the surrounding community as well.

IX. Ethical Considerations

The topic of deer management has long been a cause for disagreement between conservationists and animal rights advocates. In general, conservationists recognize the need for population control to preserve ecosystem health, while animal rights advocates are strongly opposed to any form of management involving lethal control. When discussing the ethics involved in deer management, it should not go unnoticed that human activities are responsible for the increase in deer populations that have led to current overpopulations. These activities have altered nature's course, and allowing nature to follow this altered course has led to the current overpopulation problem. Natural methods of population control have been removed and at the same time land use practices have created vast amounts of high quality food and favorable habitat for deer. We are responsible for the extirpation of natural predators from the Northeast and so we should be responsible for assuming the role of predators in northeastern ecosystems. This entails ensuring sufficient deer mortality which is essential in promoting herd and ecosystem health.

Still, there will always be those who believe that it is morally wrong to kill a deer in any situation. It is also morally wrong to allow deer overpopulations kill an entire forest. The ecosystem as a whole is far more important than individual deer, and the continued existence of other species may be dependent on reducing deer populations. Deer will continue to thrive even when management efforts are needed, and deer harvested in these programs can be donated to feed the hungry, meaning that nothing is wasted. Finally, we can draw upon the words of Aldo Leopold. "A thing is right when it tends to preserve the integrity, stability and beauty of the biotic community. It is wrong when it tends otherwise." This is the goal of deer management programs, and we should be fully committed to this sort of ethic. Despite the stigmas associated with management programs involving lethal control, they ultimately result in more good than harm.

X. Past Actions

a. Exclosures

Eight deer exclosures have been created over the years. In 2007, a student built 3 exclosures, two of which were placed in areas where classes could easily access them as a demonstration. Two more exclosures were created in 2011 for the purpose of planting native wildflower species, such as trilliums. A gap habitat demonstration fence was completed in 2012. Finally, two larger exclosures were created in 2015 for research purposes. Only the gap fence has had dramatic results, with the light exposure from creating a gap in the canopy. Most of the exclosures contain species and/or tree seedlings that do not survive outside the fenced in areas such as hemlock, sassafras, and deer berry. This shows hope that native plants can recover if relieved from the herbivory pressure. All of these exclosures combined make up 1% of our natural areas.

A new set of larger exclosures has been constructed in March 2022 through the Regenerate New York Forestry Cost Share Grant Program. Infected and dying ash trees have been cut in order to allow sunlight to reach the forest floor and spur plant growth. The three exclosures surround approximately 17 acres (3% of the area of our natural areas.)

b. Controlled Bow Hunt

A controlled bow hunt program was tried for three seasons from 2018 to 2020. Unfortunately, the numbers of deer taken were too low: 4, 10, and 6 respectively. There were many limitations to the hunt in the small number of days available, a 1000ft rule of Vestal, NY which shrunk the available land area, and the fact that the deer could walk into the surrounding neighborhoods and on to campus where they were safe from hunting. In order to make the hunt as safe as possible, the hunt was conducted in late bow season after students had left campus and the natural areas were closed and monitored by police. This program proved unsuccessful in deer population reduction and proved expensive for a small outcome.

XI. Future Actions

The deer management plan is an adaptive management plan. Future actions depend on a number of factors from the deer population recovery rate to agreement among decision makers. One the most important indicators of future action will be the recovery of the forest ecosystem.

The deer that we are targeting are very much habituated to human presence and have very little fear. It is only within the last ten years that deer have penetrated the inner campus natural areas, in essence taking 30+ years to habituate. Recovery rate of the deer will depend on the behavior of those that are left as well as the behavior of immigrating deer. Personal communication between the authors and various land managers and deer biologists suggest a period of 3 to 10 years before deer reach levels of impact that they have now. Experiments in deer removal have shown that deer will take 5 years to move into the vacancies and may give 10 to 15 years of reduced browse impact (Porter et al. 1991, Oyer and Porter 2004). However, deer populations left too high will fill in vacancies within 1-2 years (Miller et al. 2010). Observations of deer in the southernmost borders of the Nature Preserve, the higher elevations, show they are less habituated to humans.

XII. Monitoring

Deer immigration and the reproduction of the deer that are left on campus will be monitored by counts on the property. Drones with cameras have been and will be used to count deer.

Forest ecosystem health is the major goal of BU deer management. More than actual numbers of deer, forest recovery will determine future actions. We reduce deer numbers until forest understory of canopy tree seedlings, saplings, understory shrubs, and forest wildflowers reappear. Once we have forest recovery, we need to maintain deer population at the level that has allows the forest to remain a healthy forest ecosystem. The recovery of the forest ecosystem will be monitored in several ways. Vegetation surveys in established quadrats, vegetation surveys in additional transects, and comparisons with established deer exclusion fences (as well as any added fenced areas) will all indicate forest recovery success or failure.

The deer population will have to be reduced before the deer repopulate to the levels it is at the present time, but this will require fewer actual deer to be taken each period of reduction. In order to maintain the deer population at a balanced level, one of two actions may be taken. 1. A repeated culling which would be the safest way to reduce the deer population every three years (or more depending on population recovery). 2. A program of controlled hunting/drives which would likely need to be used annually in order to maintain balanced deer population. In order to protect certain areas, fencing may be used.

XII. Conclusion

Northeastern forests are being affected but a multitude of stressors, and the added stress of overpopulations of White-tailed Deer places the health of these forests in serious danger. There is no question that deer herbivory is capable of having a negative impact on forest ecosystems. Deer are capable of causing severe, long term impacts that are difficult to reverse, and populations should be controlled before any such impacts become apparent (Cote et al. 2004).

At Binghamton University, these impacts are already severe, and it is crucial that immediate action be taken to prevent further damage to the ecosystem and begin the healing process. In the natural areas of the Binghamton campus, deer browsing is preventing tree regeneration, and little tree reproduction has occurred here in the past 50 years. Native herbaceous vegetation has been virtually eliminated and is being replaced with an increasing amount of invasive species. These changes in forest structure and composition have a variety of effects on the broader ecosystem, and other campus wildlife will be affected as well. As long as the campus deer population is allowed to exist at such high numbers, the health of campus forests will continue to decline.

Though deer management programs are essential to preserve forest health, they remain highly controversial. As previous experience has shown, any deer management program involving lethal control will be met with intense public resistance at first. This is especially true in a university setting and any form of management at Binghamton will be almost certainly be protested by university students and the public. Regardless, Binghamton University has both the ability and ethical responsibility as a steward of its lands to prevent further harm caused by its overpopulation of White-tailed Deer. This involves an active management plan aimed at reducing the deer population to a density low enough to prevent damage to the Binghamton campus, nature preserve, and natural areas. If Binghamton University fails to address this problem, much of the natural, educational, and recreational value of the Binghamton University campus will be lost.

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