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Deer Management Plan for the

Crum Woods

of

Swarthmore College

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Summary

The Crum Woods of Swarthmore College are significant not only for their large area but also for the high diversity and good health of the natural habitats that occur there. In recognition of the value of this unique resource, the College formed the Crum Woods Stewardship Committee in 2000.

In the spring of 2001, the Committee engaged Natural Lands Trust and Continental Conservation to prepare a *Conservation and Stewardship Plan for the Crum Woods*. The purpose of the plan would be to provide the Crum Woods Stewardship Committee with information and recommendations needed to address current management concerns within the Crum Woods and to guide future management to meet the pedagogical, ecological, and recreational needs of the Swarthmore College community.

The plan was completed in 2003 and concluded that overabundant deer were a major threat to the Crum Woods' biodiversity and ecosystem function. The challenge of overabundant deer and their consequential impacts on these ecosystems is, in large part, the result of human-caused extinction of large predators which controlled and limited both deer numbers and deer impacts through the millennium. Subsequently, the Crum Woods Stewardship Committee has established a goal of restoring the population-stabilizing effects of natural predators on deer in order to protect and restore the structure, diversity and function of Crum Woods in a safe, humane, socially responsible manner. In addition, the Committee wants to reduce the probability of users of Crum Woods contracting Lyme disease.

Natural Resource Consultants Inc. (NRC Inc.) was engaged by the Committee in 2006 to develop a deer management plan for Crum Woods based on these goals with instructions to evaluate all possible options. NRC Inc. recommendations include hiring a sharpshooter to humanely euthanize deer as the most appropriate and effective method to realize the goal of mimicking the population-stabilizing effects of natural predators on deer in order to protect and restore the structure, diversity and function of Crum Woods.

Problem

For hundreds of thousands of years, the white-tailed deer and its ancestor species shared habitats with a diverse array of predators. Predation controlled and limited both deer numbers and deer impacts on habitat through the millennium. The current overabundance of white-tailed deer throughout much of the country, and their consequent impacts on ecosystems are the result of human-caused extinction of large predators. There is broad agreement within the scientific community that forests throughout the northeast are in a seriously degraded ecological condition as a result of high deer densities (Latham et al. 2005). It is widely recognized that deer are a keystone species in wildlife communities (Waller and Alverson 1997) because they can directly affect habitat conditions (Anderson and Katz 1993, Augustine and deCalesta 2003, Horsely et al. 2003) and thus, indirectly affect other wildlife species (deCalesta 1994). An independent evaluation by a team of scientists on behalf of the Forest Certification Council found that deer had decimated the diversity and sustainability of flora and fauna on Pennsylvania's system of State Forest lands (Wager et al. 2004). Over time, high deer densities alter forest understories, reduce or eliminate native wildflowers and shrub species, and dramatically decrease the variety of tree species (Latham et al. 2005). Deer may also depress reproductive success of native plants while simultaneously facilitating the spread of exotic invasive species (Williams and Ward 2006). A study of Crum Woods by The Natural Lands Trust and Continental Conservation concluded that deer are currently overabundant on the tracts, and are negatively impacting forest biodiversity and ecosystem function (Latham et al. 2003).

Deer are described as overabundant when they limit the abundance or occurrence of another valued resource or interfere with some valued ecological process or human activity. How to deal with overabundant deer impacts is a "value" decision. The primary value identified by the Crum Woods Stewardship Committee is to protect and restore the structure, diversity and function of Crum Woods from an ecosystem management perspective. The challenge is to achieve that goal in a safe, humane, socially responsible manner.

Background

Crum Woods of Swarthmore College comprises two tracts totaling 220 acres. The Campus Woods are approximately 190 acres of mostly forested land straddling Crum Creek adjacent to the campus. The Martin Forest is an almost entirely forested tract of 30 acres about one mile north of campus in Springfield Township. In October 2000 Provost Jennie Keith formed The Crum Woods Stewardship Committee as an ad-hoc committee of faculty, students, and administrators. In December 2000 the committee established the following goal statement: "Our goal is to create a protection, restoration, and stewardship plan for Crum Woods. The planning effort will begin with an evaluation of biodiversity, teaching and recreational resources in the context of the College's educational mission and its commitment to social responsibility. The committee will develop the plan in collaboration with college faculty, staff, and students as well as stakeholders in surrounding communities, and will engage the services of professional experts."

In 2001, the committee selected Natural Lands Trust and Continental Conservation to conduct a detailed study of the Woods. The study was to provide the committee with information and recommendations needed to address current management concerns within Crum Woods and to guide future management to meet the educational, ecological, and recreational needs of the Swarthmore College community. The consultants' report entitled *Conservation and Stewardship Plan for Crum Woods of Swarthmore College* was completed in December 2003 Latham et al. 2003, (http://www.swarthmore.edu/NatSci/crumwoods/). The report contains much valuable scientific information on the past and current state of Swarthmore's properties in the Crum Creek valley. The report also offers recommendations for dealing with threats to forest and wildlife habitat integrity, recreational use, as well as institutional oversight and management infrastructure.

The report authors described the threat posed by overabundant deer within Crum Woods as "profound." "The current deer density is already high enough that tree seedlings are virtually absent from the forest floor." The report concludes: "The most pervasive, large-scale wildlife management issue in Crum Woods is the need to maintain healthy, sustainable plant communities by controlling overabundant populations of white-tailed deer" (Latham et al. 2003).

The report recommended developing a plan to mimic the population-stabilizing effects of natural predators on white-tailed deer, maintaining deer density at appropriate levels through lethal removal. A permanent, quantitative monitoring program to assess the extent of the deer population's effect on biodiversity and ecosystem function was also recommended.

A public presentation and discussion was held in May 2004, in which a constructive dialogue was begun between the college committee and the broader community of users of the woods. In December 2005 the College commissioned an aerial infrared deer count to be conducted of the habitat in and around Crum Woods. This showed a minimum deer density of 29 deer per square mile. In October 2006 the committee sponsored a community meeting on the challenge of overabundant deer in Crum Woods providing expert speakers on Lyme disease and forest ecology while soliciting further public input and discussion. In November 2006 the committee contracted with Natural Resource Consultants Inc., to develop a deer management plan for Crum Woods based on the committee's identified value of restored ecosystem function, and including a discussion of all the various management options available.

Deer Management Goals for Crum Woods

1. Maintain white-tailed deer as a valued component of the native fauna of Crum Woods while implementing a restoration plan for mimicking the population-stabilizing effects of natural predators on deer in order to protect and restore the structure, diversity and function of Crum Woods.

2. Manage deer in a safe, humane, socially responsible manner.

3. Establish a permanent, quantitative monitoring program to assess the extent of the deer population's effect on biodiversity and ecosystem function.

4. Reduce the probability of contracting Lyme disease by the community of users of Crum Woods.

Deer Management Objectives for Crum Woods

1. Reduce deer impacts to levels that allow forest understories to meet the quantitative standards for advanced forest regeneration in hardwood stands (Marquis et al. 1992).

2. Reduce deer impacts to a level that results in deer browsing intensity of less than 50% on preferred woody species using standardized browse sampling techniques.

3. Reduce deer impacts to levels that allow similar species richness, equability, structure, robustness and percent flowering within deer exclosures and adjacent control plots with a special focus on native wildflowers.

4. Reduce tick abundance by at least 75% through reducing overall deer densities and possible placement of 4-poster feeders.

5. Monitor deer presence and reproduction through staff observations supplemented by infrared ground cameras if necessary.

Aerial Infrared Deer Count at Swarthmore

Davis Aviation, Kent, Ohio, conducted an aerial infrared deer count for the Crum Woods and immediate surrounding areas on the night of December 27, 2005, between 2:24 a.m. and 3:40 a.m. The flight revealed a minimum of 50 deer on or in the vicinity of the property. This suggests a minimum deer density at the time of the survey of approximately 29 deer per square mile in the general area (Davis 2006).

Human nature tends to perceive these numbers as absolute measures of deer densities rather than minimum counts. The contractor suggests an accuracy of 90%. Other contractors have suggested accuracy of 85% to 100%. These assessments appear to be a combination of enthusiasm for the technology and good marketing. Where this technique has been evaluated under controlled conditions it has not been shown to perform as well as contractors suggest.

Thermal infrared sensing technology is not new to the field of wildlife management. In fact, researchers have been studying its application since the late 1960's (Cochran 1977). Forward Looking Infrared (FLIR) systems use a special camera mounted beneath an aircraft that can detect body heat emitted by deer, other mammals and birds. The aircraft flies a pre-determined grid until a specified tract is surveyed. Biologists then count observed deer to estimate deer density within the area.

The advanced technology associated with this technique would suggest that it is widely used as a deer management tool. However, the wide variation in detection rates (the percentage of deer observed compared to the number actually present during the survey) typically limits its application to small areas with high deer densities or where repeated flights within a year are possible (Diefenbach 2005). The most recent peer-reviewed research evaluating FLIR technology in a deciduous forest environment (Haroldson et al. 2003) reported that FLIR technology provided biased and variable population estimates. Nine aerial surveys using FLIR technology failed to detect 11-69% of the deer and, on average, detected 56% of deer on the study area (Haroldson et al. 2003). The researcher concluded, "Until the capabilities of thermal imaging are more fully understood and the sampling protocols refined, detection rates may be too variable to provide reliable counts of animal abundance."(Haroldson et al. 2003).

A literature review of FLIR technology, as applied to white-tailed deer, conducted by the Pennsylvania Game Commission in 2005 concluded that the technique provided inconsistent results (Mumma 2005). A study conducted by the Pennsylvania Cooperative Fish and Wildlife Unit in 2005 determined that a differences in the number of deer observed from one year to the next based on single FLIR surveys could be explained by inherent variability in the number of deer counted using this technique, unless the change was exceedingly large (Diefenbach 2005).

It is widely recognized that one of the primary variables that can affect the detection rate is tree canopy cover, because it can obstruct the camera's "view" of an animal's thermal image.

Surveys are typically done at night (e.g. Wiggers and Beckerman 1993, Haroldson et al. 2003) and during winter when deciduous trees are bare in order to minimize canopy interference (Graves et al. 1972, Wilde 2000, Potvin and Breton 2005). White-tailed deer, however, are adept at seeking out “micro-climates,” such as hemlock stands, rhododendron or mountain laurel thickets (all evergreens) where they can conserve energy or avoid detection and disturbance in the sheltering cover. Thermal infrared sensing can miss deer hidden in such cover because the vegetation shields the body heat emitted by the deer (Haroldson et al. 2003).

Hemlock Farms Community Association, Pike County, Pennsylvania, faced with similar deer related challenges as Swarthmore College, encountered an example of the FLIR technology’s limitations in 2006. Vision Air Research, Inc. estimated 264 deer at Hemlock Farms in March, 2004, 141 in March 2005 and 149 in November 2005 after 89 deer had been removed by sharpshooters (personal communication Marian Keegan, Natural Resource Coordinator, Hemlock Farms Community Association). The sharpshoot within this residential community eventually removed 379 deer or more than 2 1/2 times the number of deer the aerial infrared survey reported was present. Following the sharpshoot removal a ground survey that sampled less than 50% of the community area counted an additional 128 deer, demonstrating that the property held at a minimum 507 deer or 72 deer-per-square-mile. The infrared aerial survey reported less than 1/3 of the deer present.

NRC Inc. recommends the use of infrared surveys only as a tool to determine an initial minimum estimate of deer densities. We do not recommend its continuation once a deer reduction program is initiated for three reasons. First, the goal of most deer management programs in residential landscapes such as Swarthmore is not a specified deer density or number, but rather reduced deer impacts. Therefore, we recommend effectiveness monitoring programs that focus on the abatement of those conflicts for which the deer reduction was initiated, not an arbitrary deer density. Secondly, in the diverse landscapes that make up urban/suburban environments, there is very little science-based data linking various deer density levels to the abatement of a range of deer conflicts, making deer density goals somewhat speculative and arbitrary. Finally, as deer numbers are reduced infrared surveys become increasingly unreliable. A detection rate of 50% when deer densities are at 80 deer/sq. mile provides a useful minimum population estimate.

When deer are reduced to 15 deer/sq. mile a 50% detection rate may create the illusion that deer have been reduced to low numbers initiating debate over whether the detection rate was 30% or 100%, with no constructive method of resolving the dispute. Effectiveness monitoring programs that focus on quantitative measures of those challenges for which a deer reduction was initiated are more meaningful, more reliable and less controversial.

It is possible to measure deer densities with statistical confidence. Such efforts are, however, costly and of questionable value given the committee's deer management goals. If a program involving deer removal is implemented at Crum Woods, it is exceedingly unlikely that the program will remove deer from Crum Woods entirely. Therefore, instead of monitoring deer numbers, a very difficult and expensive procedure, it is recommended that deer presence and reproduction be monitored. So long as deer and fawns are observed on the property the goal of maintaining a viable, reproducing population of deer will be confirmed. In the unlikely event that deer are not observed in the monitoring program the deer removal program should be reviewed and modified.

Landscape Analysis and Localized Deer Management

Along with human ecology, researchers and managers need to consider several approaches to examining suburban ecology (VanDruff et al. 1994) including the patch-dynamic approach. This perspective recognizes the urban/suburban landscape as a mosaic of biological and physical patches within a matrix of infrastructure and social institutions Nilon and Pais 1997, Zipperer et al. 2000). Swarthmore presents such a landscape.

In the context of deer management, landscapes are viewed on three spatial scales: deer home range size; contiguous available habitat; and conductivity with additional habitats in the broader landscape. Crum Woods of Swarthmore College comprises two tracts totaling 220 acres. The Campus Woods of approximately 190 acres straddles Crum Creek adjacent to the campus while the Martin Forest of 30 acres stands about a mile north of campus in Springfield Township.

Deer home ranges in urban habitats have been shown to be small, often less than 100 acres, compared to more rural landscapes (Cornicelli 1992, Henderson et al. 2000, Grund 1998, Kilpatrick and Spohr 2000, Kilpatrick and Stober 2002). Gaughan and Destefano 2005, found that suburban deer home ranges were one-tenth that of deer in rural landscapes. Neither of the two Crum Woods parcels likely represents a complete home range area for any individual deer. The Martin tract is too small while Campus Woods is a high use recreation/education area frequented by hikers with unleashed dogs. Both forests feature older stands with well-developed canopies and relatively sparse understories, offering little escape cover for deer to avoid humans or dogs. Consequently, deer use of Campus Woods during daylight hours is behaviorally restricted. Instead, deer use adjacent, less disturbed properties for diurnal cover and move into the campus woods at night.

The Campus Woods is surrounded by relatively small amounts of contiguous deer habitat except to the north across the Baltimore Pike where larger areas of habitat are available. Adjacent habitats are mostly by small parcels on residential lots, odd areas, such as along Route 476, and the Swarthmore Campus itself. This suggests that the deer that utilize Campus Woods have limited habitat beyond the area of management. The Martin Forest represents a small portion of the habitat north of the Baltimore Pike. Deer in this area may spend considerable time on adjacent properties and not be available to managers without the cooperation of neighboring landowners in a deer management program. No cooperative agreement currently exists.

Food at temporary bait sites has been used to manipulate the behavior and movement of white-tailed deer for research and management purposes for decades (Hawkins et al. 1967, Ishmael and Rongstad 1984, Drummond 1995, Rudolph et al. 2000). Deer with bait sites in their home range have been shown to use them while bait sites outside of deer home ranges will have no, or limited, effect on deer movement (Darrow 1993, Kilpatrick and Stober 2002). Deer with no bait sites within the core area of their home range have been shown to shift the core area closer to, or to include, the bait site (Kilpatrick and Stober 2002).

Using bait, managers of the deer population at Campus Woods, should be able to access a sufficient portion of the population to achieve the deer management goals for Crum Woods. The

Martin Forest is more challenging since it is smaller than a single deer's home range and represents a small portion of the available habitat in the surrounding landscape.

Human built environments create uninhabitable areas for deer as well as barriers to movement between habitat islands. At Crum Woods there is adequate conductivity within the landscape to allow deer dispersal and immigration between islands of habitat. Neither Campus Woods nor Martin Forest represent insular populations. The stream valleys and open space associated with them allow deer movement up and down the Crum Creek drainage and into the Ridley Creek drainage.

One of the more significant advances in deer ecology and management of the past two decades is the recognition that deer populations can be managed on a small spatial scale (Porter et al. 1991, McNulty et al. 1997, Oyer and Porter 2004). This approach to deer management utilizes the strong home range fidelity behavior of adult female deer (Van Deelen et al. 1998, Nelson and Mech 1999), the instinctive tendency of juvenile females to establish home ranges adjacent to their natal home range, social organizational patterns of female deer into genetically-related groups (Tierson et al. 1985, Nelson and Mech 1999) and the important role females play in deer population dynamics (Porter et al. 2004). Low female dispersal (0-20%) and strong home range fidelity (Aycrigg and Porter 1997, Lesage et al. 2000) allow for localized deer herd management to be effective at a small spatial scale, since social units of genetically-related female deer tend to remain in their respective home ranges. Studies have shown that creating local densities that are lower in comparison to those on the surrounding landscape is possible (Behrend et al. 1970, McNulty et al. 1997, Kilpatrick et al. 2001).

The result is that a given area like Crum Woods is occupied by a discrete, genetically related group of deer, whose removal can result in deer densities that are significantly lower than the surrounding landscape. Removals are most effective when the matrilineal groups are relatively undisturbed during removals; bait is used to shift individual deer core areas within their home range to removal sites, and where maintenance removals are conducted on an annual basis.

Deer Management Gradient

The Deer Management Gradient is a concept that attempts to explain the vulnerability of deer populations to traditional management activities. It views management through a combination of factors that affect the ability to manage deer across landscapes. Some of the most important factors are deer vulnerability, deer refugia, safety issues, community values and hunter values and goals. Foster et al. (1997) documented that deer vulnerability to harvest by hunters is influenced by land use patterns and human population density.

In landscapes that are dominated by extensive contiguous forests, deer vulnerability is low, as are the number of hunters per acre of huntable habitat. In these situations, managers are often challenged to kill sufficient antlerless deer to balance deer impacts with healthy habitats. In a recent 2-year study in Pennsylvania's Wildlife Manage Management Units 2G and 4B, both "big woods" areas, hunters harvested less than an average of 6 % and 22 % respectively of radio-collared female deer (Keenan et al. 2007). These deer were on public lands open to any recreational hunter in any season. In healthy deer populations, managers need to remove approximately 30 % of the female deer to stabilize the herd and 40 % to effect a population reduction. These data suggest that hunter mortality was insufficient to control deer populations. In addition, the study determined that hunter density was less than six hunters/square mile during the most intense hunting period--opening morning of the general firearms season--on both study areas (Keenan et al. 2007)..

Foster et al. (1997) found that the major factor influencing deer vulnerability to hunters was the relative proportion of forest cover. As forested landscapes become more fragmented and interspersed with agriculture, deer vulnerability increases because deer movements are more predictable, requiring less skill and effort on the part of hunters to be successful in harvesting an animal.

As rural lands transition into suburban and urban landscapes, with increasingly dense human development, the concept of deer "refugia" becomes an important factor. Deer have been shown to utilize refugia, or refuges, both formal and informal, to avoid hunting pressure and harvest (Nixon et al. 1991, Kammermeyer and Marchinton 1975). Kammermeyer and Marchinton

(1975) concluded that if deer can move freely between contiguous refuge and hunted areas, inadequate harvest and overpopulation may result. Harden et al. (2005) determined that as safety zone (legally defined as all areas within 150 yards of occupied buildings for firearms hunting, and 50 yards for archery hunting) areas expanded due to development, excluding more deer habitat from hunting, harvest efficiency decreased. They concluded that as human development increases deer management relying on traditional methods will become more difficult. To effectively serve communities, managers, now and in the future, will be required to identify likely areas of conflict in which nontraditional deer management options will prove more effective (Harden et al. 2005).

White-tailed deer adapt to habitat changes caused by human development (Conover 1995). They habituate to human presence (Hansen et al. 1997) and do well in and around suburban neighborhoods because there is little effective hunting, abundant food and cover, and few remaining predators. (DeStefano and DeGraaf 2003). Often, residents of suburban neighborhoods exhibit weak support for recreational hunting near their homes. Fragmentation of land ownership into smaller parcels and a lack of cooperation between the various levels of government that must work together in suburban areas can also pose challenges to effective deer management through traditional recreational hunting (Messmer et al. 1997b, Lauber and Knuth 2000). Some residents may oppose any lethal management options (Messmer et al. 1997a, Stout et al. 1997, Lauber and Knuth 2000). Consequently, deer vulnerability generally declines as the landscape becomes a mosaic of deer refugia that include backyards, high use recreation open space, safety zones and the numerous areas within such landscapes that provide cover for deer but where recreational hunting is not felt to be a compatible use. Deer in whatever huntable habitats do exist may recognize areas near human dwellings as refuges of “lower hunting pressure” and temporarily utilize these places to escape harvest (Harden et al. 2005).

Acceptable hunting tackle also changes along the deer management gradient, from rifles to shotguns, archery equipment as safety issues are considered by local communities, the Game Commission and hunters themselves. The use of rifles is prohibited by the Game Commission within all Special Regulation Zones (designated suburban/urban areas that include Swarthmore) in Pennsylvania. Shotguns and muzzleloading firearms, however, may be used in those designated areas. In Philadelphia County, however, only bows and arrows are permitted for recreational hunting (Pennsylvania Game Commission 2006b).

As deer, hunters and non-hunters occupy more confined spaces, differences in values and goals regarding deer management become more apparent, requiring shifts in management techniques. Many hunters are committed to a deer management approach that focuses on managing deer for hunting recreation. Communities with an overabundant deer problem, however, are interested primarily in management techniques that are effective in reducing deer numbers, humane (Lauber and Knuth 2000), safe for residents, and pose the potential for minimal community disruption. Management of urban deer populations may involve lethal or nonlethal means of population control (DeNicola et al. 1997, Hansen and Berringer 1997). However, urban residents often prefer nonlethal tactics (Jones and Witham 1990, Warren 1995, Stout et al. 1997, Peterson et al. 2003).

But as deer impacts and deer/human conflicts increase, urban and suburban residents may shift their attitude from viewing deer as a local environmental resource, to one of perceiving deer as pests (Winston 1997).

Sociopolitical Observations

If human directed mortality is used, what happens to the deer that are killed?

All deer killed, whether harvested by hunters or under a deer control permit, must be processed for human consumption. In the case of recreational hunters, the meat may be eaten by the hunter and his family, given away to friends or donated to one of several programs that provide meat to charitable organizations. Deer taken under a deer control permit must be processed and provided to a suitable food bank, needy family or as otherwise determined by the PGC Executive Director. Deer processing costs are in the range of $45 to $75/deer. A community deer control program may not charge for the venison, but may ask the recipient of the meat to pay the processing fee. The statewide Hunters Sharing the Harvest Program pays the processing fees for some community deer control programs.

The American Heart Association recommends venison as a healthy alternative to beef. For those individuals who eat meat, “wild harvested” venison has the lowest ecological cost of any meat available. Where human directed deer mortality is used to mimic the population-stabilizing effects of natural predators on deer, there is a simultaneous positive ecological benefit to harvesting and consuming venison. Such harvest contributes to the protection and restoration of the structure, diversity and function of the forest ecosystem.

How do values and science impact deer management discussions and decisions?

Deer management is not driven by quantitative equations, studies, and science, but by human values.

The role of science in natural resource management is to flesh out the options, outline the probable results of decisions, and provide the tools for manipulating, monitoring, inventorying, and understanding the resource. Ultimately, however, the decision as to what to do with that resource, utilizing our scientific knowledge of it, is a product of personal and societal values—not science.

An excellent example of this is the current movement toward sustainable forestry. The idea that a forest should be managed for more than short-term timber production is not an idea of science. It is, instead, a reflection of values. Science can work to define what sustainable forestry is, how it can be achieved, and what the outcome of the alternative paths might be. But it is mute on whether an appropriate management goal involves balancing short-term, self-interest with the needs of future generations. So it is with deer.

Society has the resources and tools for regulating deer numbers, altering herd sex and age composition, estimating deer densities and measuring deer impacts on the forest environment. The question is, what is it we are trying to use science to achieve, based on what values and goals?

The public has been relatively clear about its values in the field of forestry. While people want and need forest products, recreational opportunities, and the ecological services that forests provide, they also want the diversity and sustainability of these systems protected. The upshot is that forest management on public lands has been evolving. The focus has shifted from simply growing trees for timber to recognizing that forests are complex interdependent systems. The result has been a slow but continuing shift from a management paradigm rooted in farming trees to one based on managing ecosystems, driven by public values and expectations.

Historically deer management is also rooted in a wildlife agriculture paradigm. In this value system, deer are viewed as a type of crop or livestock and the forest as the pasture to be managed to produce them (Shissler 1999). This historic approach to managing deer is built on the North American Wildlife model, which uses hunter license fees to fund wildlife conservation and management with a focus on hunter recreation, not ecosystem health (Alt et al. 2006). As deer populations repopulated landscapes where hunting has not typically occurred, and as residential communities have developed in more rural areas, more diverse deer management values, goals and perspectives have come into play.

The challenge for suburban communities grappling with deer management is to find methods that are acceptable to a broad range of public stakeholders, effective at decreasing deer numbers, and applicable at reasonable cost (Decker and Gavin 1987, Stout et al. 1993, Conover 1995, Swihart et al. 1995). The following are generalizations regarding some common perspectives of deer management stakeholders observed by NRC Inc. over the years. It should be noted that this is not an attempt to speak for these stakeholders or understate the diversity of opinions that exist within various groups. Instead, it is an attempt to provide a context for understanding discussions that influence deer management decisions in residential landscapes.

It is useful to know that studies of other communities have found that residents' attitudes toward management techniques are not necessarily fixed, and that communication can influence attitudes (Lauber and Knuth 2004). Suburban residents may have different concerns about management techniques than wildlife managers. Determining what those concerns are and distributing accurate, unbiased information about those concerns is most likely to influence public perceptions of deer management techniques (Lauber and Knuth 2004).

Community Member

The majority of the community's members favor non-lethal methods of removal for the residential landscapes in which they live, if they can be shown to be affordable and effective at resolving deer conflicts. When such is not the case, community members generally support human directed mortality, including hunting, provided it is safe, humane, affordable and effective at resolving deer conflicts.

Animal Rights Advocate

Animal rights advocates take the position that deer should not be harmed, and that deer/human conflicts have resulted from human actions for which deer should not be made to suffer. They note that non-lethal techniques and options are often presented in an optimistic perspective that goes beyond what the science will support.

Recreational Hunter

Many hunters believe sincerely that recreational hunting can reduce deer impacts within residential communities to levels that will address community concerns. They may see nontraditional approaches such as sharpshooting and fertility control as a threat to hunting and view its advocates as philosophically opposed to hunting in any form, anywhere. Some hunters view the killing of deer by professional animal control personnel as unethical, contradicting the concept of "fair chase." Often, these hunters are unable to distinguish between those landscape situations where hunting might play a constructive role and where it cannot.

Pennsylvania Game Commission

Created in 1895 as an independent state agency, the Game Commission is responsible for conserving and managing all wild birds and mammals in the Commonwealth, establishing hunting seasons and bag limits, enforcing hunting and trapping laws, and managing habitat on the 1.4 million acres of State Game Lands it has purchased over the years with hunting license dollars. The Game Commission does not receive any general state taxpayer dollars for its annual operating budget. The agency is funded by license sales revenues; the state's share of the federal

Pittman-Robertson program, which is an excise tax collected at the sale of sporting arms and ammunition; and monies from the sale or leasing of timber, oil, gas, coal and minerals extracted from State Game Lands (Pennsylvania Game Commission, 2007b).

The PGC has a unique relationship with recreational hunters who provide its funding. Like many hunters, PGC policies promote the concept that recreational hunting can solve most suburban deer challenges if hunters are simply provided access to the land. The benefits and effectiveness of recreational hunting in communities is often presented in an optimistic perspective that goes beyond what the existing science will support.

Conservation/Environmentalists

The vast majority of conservation/environmental organizations support valuing deer as an important part of our native fauna. They also support managing deer numbers so that deer impacts are in balance with the goals of biodiversity conservation and maintaining healthy habitats. Recreational hunting is strongly supported where it can be effective and is appropriate.

Sharpshooting Contractors

Many professional sharpshooting contractors have the same sincere confidence as recreational hunters that they can reduce deer impacts within residential communities to levels that will address community concerns. The success of sharpshoots, however, can vary widely depending on the program design and implementation. Nearly any sharpshoot contractor, regardless of their skill level and techniques, can kill a lot of deer in the initial years of a program. The challenge is continually removing deer without educating those that remain, rendering them less vulnerable. Poorly run sharpshoots reduce deer numbers initially but fall short of the sustained reduction required for ecological recovery.

Sharpshooting contractors, whether a government agency, nonprofit, or private for-profit organization, have as their primary goal, positive cash flow. Negotiated contracts with sharpshooters should always be for a minimum of four years with payments tied to the successful achievement of quantitative deer program goals. Payment should never be based solely on units of time expended or on a “per-deer-removed” basis.

Organized Suburban Hunting Groups

Recreational hunters can be particularly effective when operating as organizations that self-manage their membership, thereby offering landowners and communities the ability to customize hunting activities to their individual situations. Such programs allow the hunting organization to largely administer and monitor the management program.

Skilled, committed hunters can and do partner with landowners and communities in many situations to successfully manage deer. In those communities where land use patterns and residential density are compatible with hunting, recreational hunting can achieve community or landowner goals. Such programs and partnerships can be productive and positive. However, many of these organizations fail to distinguish between where they can and cannot be effective, believing that recreational hunting will work nearly everywhere. Effectiveness monitoring, a critical component of any successful program, is often nonexistent or focused only on the number of deer killed rather than quantitative measures of the conflicts for which the deer removal was initiated in the first place.

Deer Management Options

GOAL 1: Maintain white-tailed deer as a valued component of the native fauna of Crum Woods while implementing a restoration plan for mimicking the population-stabilizing effects of natural predators on deer in order to protect and restore the structure, diversity and function of Crum Woods.

GOAL 2: Manage deer in a safe, humane, socially responsible manner.

Managing overabundant deer has emerged as one of the most challenging issues in natural resource management this decade (Warren 1997). Warren (1997) very eloquently summarized the problem by stating: "… It is such a great management challenge because it is not simply a biological or ecological problem. Certainly, deer biology and ecology are important aspects to the problem; however, even more challenging are the social, political, legal, and economic aspects that are collectively referred to as human dimensions."

No Action - Not Recommended

No action could be considered as one deer management option. The result of inaction would be continued negative impacts by overabundant deer in Crum Woods as outlined in the report entitled: *Conservation and Stewardship Plan for Crum Woods of Swarthmore College*. These impacts are cumulative and would prevent the realization of the goal of protecting and restoring the structure, diversity and function of Crum Woods.

Mitigation Techniques - Not Recommended

Mitigation techniques such as fencing, repellents, feeding and establishing landscape planting resistant to deer browsing have value in addressing individual problem situations but not larger functioning landscapes on the scale of Crum Woods. It is neither practical nor effective to use deer repellants to protect forest ecosystems. Fencing, although costly, could be used to exclude deer but not without changing the character and function of the forest as part of an interacting landscape. Crum Woods is a living laboratory used for education, research and recreation. Isolating it from the surrounding community, stream valley and interconnected landscape is in conflict with its current use. In addition, fencing is not consistent with the goal of maintaining white-tailed deer as a valued component of Crum Woods' native fauna.

Feeding is sometimes suggested as a method of mitigating deer impacts on vegetation. However, deer have no density limiting mechanisms independent of available nutrition. This allows deer populations, unrestricted by mortality, to increase to nearly unlimited densities so long as adequate nutrition is provided. Feeding deer without introducing some method of preventing population growth will only intensify the current challenges, not remove them.

Predator Restoration - Not Recommended

Predation has controlled and limited deer numbers and impacts through the millennium. The current overabundance of white-tailed deer and their pervasive effects on ecosystems is the result of human-caused extinction of large predators, including indigenous hunting cultures. Predator restoration is sometimes suggested as a way to restore this ecosystem process and re-establish a balance between deer and forested ecosystems. The restoration of large predators capable of limiting deer populations may have some merit in our most rural landscapes. In suburban settlings, such as Swarthmore, it does not.

Predators capable of limiting deer populations are also animals that see humans and our pets as potential prey. And while human fatalities from large predators such as cougars are rare, they do occur with sufficient frequency to present social resistance to their reintroduction. In addition, residential landscapes such as those surrounding Crum Woods do not offer the quality of habitat required to support predator densities sufficient to limit deer numbers and impacts.

If deer populations are to be reduced and maintained at densities low enough to maintain healthy forest ecosystems in residential landscapes, it will require human intervention to mimic the population-stabilizing effects of natural predators.

Trap and Transfer – Not Recommended

One method used within some communities has been the trapping and transfer of deer from problem areas to off site locations. Typically, the location of release is either a commercial cervid operation where deer are treated as livestock meat animals, or used for high fence recreational "hunting". In nearly all cases, trapping and moving deer simply changes the site at which mortality will occur. Seldom does it significantly prolong the lives of individual animals. In Texas for example, deer can be live trapped by a community and sent either directly to a slaughterhouse where they are killed and processed for meat or to a fenced hunting operation.

In most states, including Pennsylvania, live-trapping and relocating deer is not permitted because of high cost, disease and parasite risks, unavailability of suitable release sites, and concerns over stress to captured deer. Most relocated deer do not survive a year in their new locations (Conover 2002).

Contraception – Not Recommended

Communities around the country are exploring one form or another of reproductive control (Rutberg et al. 2004). These options include contraception through synthetic steroid hormones designed to prevent ovulation or conception by providing a daily dose of hormones similar to a birth control pill; immunocontraception vaccines, injected remotely with a dart gun, meant to develop antibodies that attach to the deer's own reproductive cells, blocking fertility and; contragestation, which terminates pregnancy by injecting the female with a drug that induces fetal abortion.

The small home range size and strong site fidelity of urban female deer suggest localized management using immunocontraception is theoretically possible in suburban communities, and immunocontraceptive vaccines offer significant promise for wildlife management (Turner and Kirkpatrick 1991, Kilpatrick et al 1997, Warren et al 1997 and Kirkpatrick et al. 2001). However, despite progress in the past two decades toward practical contraception tools, no fertility control agents have been approved by the Food and Drug Administration (FDA) or Environmental Protection Administration (EPA) for non-investigational use on wildlife populations in the United States. Several materials such as GonaConTM and Spay-VacTM show promise but may be used only in rigidly controlled research studies. These agents' use requires the capture and marking of each individual target animal before treatment. The regulation of GonaConTM has been moved from the FDA to EPA and may be approved for management use this year. The Game Commission must approve any contraception treatment program in Pennsylvania.

The specific application of any form of contraception at Crum Woods has several challenges:

- Contraception is experimental and has not been show to be an effective management tool for free ranging deer populations in situations like those at Crum Woods. Any use of contraception would need to be viewed as research and experimental, not as a management solution.

- Contraception, by design, requires time and non-directed mortality before a population reduction through attrition occurs. Under the best circumstances, a time lag of several years would be required for deer numbers and impacts to be reduced to the levels required to meet the deer management goals for Crum Woods.

- No experimental applications of these drugs have targeted the low deer densities required to achieve the goals of protecting and restoring the structure, diversity and function of forested ecosystems. Instead, their use has been focused on eliminating or reducing deer/human conflicts which typically can be realized at much higher deer densities. No field studies to date document that contraception is capable of reducing deer in a non-insular population to the densities required to meet the management goals at Crum Woods.

- If localized management of deer in suburban environments is to be successful, the geographic scale of movements will need to be limited, site fidelity high, and dispersal rates low (Porter et al. 2004). The geographic scale at which localized management can be effective is therefore determined by the movement behavior of females. Suburban deer appear to possess the necessary behavior attributes, but the dispersal rates can complicate management. It may not be possible for a program that requires low deer densities to overcome immigration from surrounding populations (Porter et al. 2004). This is particularly true for populations where deer removal is through attrition using fertility control, on the small scale of the Crum Woods, and where habitats are interconnected to properties both up and down Crum Creek.

- Contraception does not mimic the population-stabilizing effects of natural predators on deer from an ecosystem perspective. Instead it artificially reduces recruitment, altering both the behavior and interaction of individual animals and that of the deer herd.

The available published literature does not support the conclusion that any available contraceptives would be effective in realizing the deer management goals for Crum Woods. If proponents of these techniques disagree, it is suggested that they be given the opportunity by the Crum Woods Stewardship Committee to provide a detailed written proposal specific to Crum Woods, referencing the published literature and with a credible research partner as co-author.

Trap and Euthanize – Not Recommended

Trap and euthanize involves clover traps or drop nets. With clover traps a single deer is baited into a trap, where a telemetry signal notifies the trapper of a capture. The trapper then euthanizes the deer with a gunshot to the brain. With drop nets, multiple deer are lured under a net using bait. The net is then dropped over the group. Trappers, who are on site to activate the net, then euthanize the animals either with a gunshot to the brain or a bolt gun such as those used in slaughterhouses. Trap and euthanize using drop nets may not be viewed as humane because of the time interval between capture and euthanization. Clover traps are not recommended in high use recreation areas like Crum Woods due to the risk of vandalism. Neither technique is recommended as a single treatment approach due to the fact that deer eventually learn to avoid the traps, reducing program effectiveness.

Recreational Hunting - Not Recommended

In the absence of predators, recreational hunting has been the primary means of managing annual mortality rates in deer populations (Woolf and Roseberry 1998), which ultimately determines the number of deer in the population (McCullough 1987). Recreational hunting can, in many landscapes, be an effective mechanism for mimicking the population-stabilizing effects of natural predators on deer. Skilled, committed hunters can and do partner with landowners and communities in many situations to successfully manage deer (Kilpatrick et al. 2002). However, despite the good intentions, confidence and optimism of many hunters, there is no published data that supports the conclusion that recreational hunting can reduce deer impacts to the levels desired in situations similar to Swarthmore, particularly where the protection and restoration of ecosystem structure, diversity and function is a priority.

A review of urban/suburban deer programs, throughout the contiguous 48 states, has failed to produce a practical example, supported by quantitative, science-based data, in which recreational hunting reduced deer impacts to goal in a situation similar to that at Swarthmore. The failure of recreational hunting to be effective in these types of situations results from four primary constraints:

1. Recreational Threshold

“Recreational Threshold,” is defined as a deer density at which many hunters do not see enough deer to justify their continuing to hunt (Moyer and Shissler 2006). Hunters hunt for many reasons, but central to all motivation is recreational enjoyment. If the hunting experience fails to meet that expectation, hunters are likely to hunt somewhere else, hunt less or stop hunting. Pennsylvania hunters grew up and formed their expectations of hunting during decades of high deer densities, sometimes seeing scores of deer per day. Many hunters judge the success of their hunt more by how frequently they see deer than by what they eventually kill. Others take pride in providing healthy meat for their families, harvesting a large buck, refining their skills or simply spending time in the woods. Few hunters hunt to restore ecological balance and, understandably, few pursue deer solely to interrupt the enzootic cycle and transmission of Lyme disease.

One challenge to deer management programs that strive for low deer densities in order to restore or maintain ecological integrity is that, at some point, hunters are being asked to work against their own interests. As deer numbers are reduced, the effort required to harvest additional deer increases and approaches the recreational threshold. Finding a balance between a deer density that recreational hunters find satisfying and one sought by the community to meet its goals can be difficult.

In addition, hunting causes deer to be increasingly wary and nocturnal, reducing their visibility and vulnerability to hunters. One result may be that hunters who see few deer may be tempted, from their perspective, to declare the management program a success, even though deer numbers and impacts remain well above goal. Maintaining hunter effectiveness under such conditions is challenging, particularly given the widespread overabundance of deer in southeastern Pennsylvania, where a hunter can easily find another location where deer are dramatically more vulnerable and easy to observe.

2. Deer Vulnerability

Deer vulnerability is defined as the effort required to harvest a deer, independent of the hunter's skill level. In suburban landscapes deer are less vulnerable due to smaller home ranges, nocturnal behavior and abundant deer refugia where hunters cannot responsibly pursue them. These refugia include backyards, high use recreation open space, safety zones and the numerous areas within such landscapes that provide cover for deer but where recreational hunting is simply not a compatible use. Functional refugia set a constraint on the lower limit to which deer populations can be reduced and limit what traditional management can accomplish (McCullough 1984).

Deer successfully avoid hunters not by covering long distances, but by finding the least disturbed and most protective cover available and "hiding out." In landscape mosaics with abundant unhuntable ground, it becomes easy for deer to avoid hunters during daylight hours by remaining on properties within their home range where recreational hunting is not permitted or practical. This behavior of avoiding hunted areas until after dark reduces deer vulnerability to hunters while still allowing deer access to hunted habitats. This problem is compounded by the realities of recreational hunting itself. Those deer most easily removed by hunters tend to be those that are less cautious, while those that remain are further advantaged by learned behavior, allowing survivors to become more cautious, more nocturnal and less vulnerable. Finally, as deer are removed and their numbers decline there is more space for the remaining individuals to hide and elude hunters.

One suggestion sometimes offered as a cost effective approach in urban deer programs is to allow recreational hunters to take as many deer as possible, at no cost to the community, prior to initiating a sharpshoot or some other human directed removal method. However, managing hunters in situations like Crum Woods does involve costs in staff time and loss of recreation value as the woods are closed to other activities. In addition, unhunted suburban deer are very naïve to gunshots, and are reluctant to flee a bait site once shooting is initiated (DeNicola et al. In Press), increasing their vulnerability and the effectiveness of a sharpshoot. Conversely, recreational hunting may remove some deer but because of its inherent nature, which provides for “fair chase” opportunities for deer escape, “educates” survivors making their ultimate removal more difficult and expensive. In areas where sharpshoots are required to reach the community goals, recreational hunting, unfortunately, can increase costs and undermine the potential success of the program.

3. Tackle

Many urban deer management programs implement archery hunts with the goal of resolving deer overabundance challenges. Archery hunters are among our most skilled hunters, many of whom have chosen archery equipment specifically to increase the challenge of harvesting deer. The commitment of these hunters and their organizations has contributed to the public’s general philosophical support of hunting. However, there is no quantitative data that demonstrates that archery hunting alone can successfully reduce deer impacts to levels compatible with healthy forest ecosystems or with the goals of densely populated residential communities or heavily used suburban open space.

Archery equipment, by design, is less efficient than other forms of hunting tackle. Deer at 50 yards are beyond the responsible reach of a bow but not a rifle. To consistently kill deer, the archery hunter must be closer to the animal and far more concerned about scent, movement and camouflage than a rifle hunter. Furthermore, while the firearm hunter can shoot with a minimum amount of movement, the archer must draw the bow in the near presence of the animal, and hold the draw until taking a shot. Crossbows reduce movement but do not increase range and have the limitation of one shot. A skilled rifle hunter can remove entire groups of deer, particularly if the rifle is suppressed (modified to minimize noise), while an archery hunter cannot. As a result, not only are individual deer less vulnerable to a hunter using archery equipment than other forms of tackle, local deer populations are also more likely to learn to avoid archery hunters because of the inherent limitations of reduced range, increased movement and inability to remove entire groups of deer.

Rifles are more efficient at removing deer but are not legal tackle for recreational hunters in Wildlife Management Unit 5D, in which Crum Woods is located. The Pennsylvania Game Commission prohibits rifles for recreational hunting in special regulation areas like WMU 5D, where land use is dominated by development, because of safety concerns. However, rifles may be used under a deer control permit issued by the commission.

Muzzleloading rifles of .44 caliber or larger and shotguns are permitted as legal tackle for recreational hunting in Wildlife Management Unit 5D by the Pennsylvania Game Commission. However, hunter activity and access are restricted by safety zone laws. Recreational firearm hunters may not shoot at, take, chase or disturb wildlife within 150 yards of any occupied residence, camp, industrial or commercial building, farm house or farm building, or school or playground without the permission of the occupants. It is unlawful to shoot into a safety zone, even if the hunter is outside of the zone. Driving game, even without a firearm or bow, within a safety zone without permission of the occupant is unlawful. The safety zone around an occupied building equals approximately 16 acres. It is obvious that in a densely developed region such as that surrounding Swarthmore, safety zones will exclude much of the landscape from recreational hunting.

The majority of Crum Woods falls within safety zones and is unhuntable without safety zone wavers by dozens of adjacent residences. However, safety zones do not apply to deer removals under a deer control permit.

4. Compatible Use

As stated previously, in the absence of predators, recreational hunting has been the primary means of managing annual mortality rates in deer populations (Woolf and Roseberry 1998), which ultimately determines the number of deer in the population (McCullough 1987). Historically, deer populations have been seen as a natural resource to be managed for hunter recreation. In residential landscapes, however, residents typically view deer not as a recreational resource but as an animal control problem.

Community goals are often simply the reduction of deer/human conflicts using methods that are safe, humane, unobtrusive, effective and fiscally responsible.

Recreational hunting may, under regulations designed for the realities of modern, urbanized environments, play a role in reducing deer in some communities. However, for many suburbanites, hunting is not a familiar or comfortable concept. Nor is the use of firearms and archery equipment within their community and around their homes an activity that is easily embraced. People whose "social values" lead them to reject hunting in their neighborhoods do not necessarily oppose the concept of hunting in a broader, philosophical way (Moyer and Shissler 2006). Instead, they may simply see hunting as an incompatible use within the context of their immediate living environment. Residential open space like Crum Woods, laced with trails and serving daily as the backyard for hundreds of college students and their neighbors is, arguably, not a place compatible with recreational hunting.

Recreational hunting is often presented as the most cost efficient method of deer management. However, given the dearth of evidence regarding its effectiveness in achieving community goals in situations like Crum Woods, it is difficult to argue for its cost effectiveness.

The use of baiting to lure deer to areas where they may be safely and legally removed by hunters was legalized for Wildlife Management Unit 5D in October 2006 (PGC 2007d). Managers hope this tool will allow hunters to be more effective at controlling deer populations in residential landscapes by increasing deer vulnerability, lowering the recreational threshold for hunters and increasing acceptance of recreational hunting within communities. Baiting can be a useful tool to increase hunter effectiveness in some landscape situations. Baiting deer during regulated hunting seasons is permitted in 26 of 48 U.S. states (Durkin 2000) including most of Pennsylvania's neighbors such as Ohio, Maryland, New Jersey, Delaware, and West Virginia. Hunting over bait increases deer harvest rates, reduces mean shot distances and reduces hunter effort per kill (Synatzke 1981).

> Regulated baiting can increase deer vulnerability if done properly. It will move the core area (area of highest use within a deer's home range and where it spends 50 % or more of its time) of the deer that use Crum Woods as part of their home range, closer to bait sites (Darrow 1993, Kilpatrick and Stober 2002), thus allowing for their more efficient and safe removal. Baiting also may be used to shift deer activity away from residential areas to enhance shooting safety (Kilpatrick and Stober 2002). Deer home ranges are relatively small in urban landscapes (Cornicelli 1992, Grund 1998, Kilpatrick and Spohr 2000), often averaging 100 acres or less.
>
> However, even though baiting has been legal for use in situations similar to Crum Woods in many states for decades, there remains no quantitative, science-based evidence that recreational hunting, even with bait, can successfully achieve the deer management goals established for Crum Woods.

Recreational hunting, using skilled, committed hunters can be an effective method for meeting community deer management goals in some suburban landscape situations but not in others. The challenge for urban deer managers is to have the knowledge, experience and impartiality to be able to recognize where recreational hunting will and will not work. There is little reason to believe that Crum Woods is a location where recreational hunting would be effective in realizing the college's deer management goals.

Sharpshoot Utilizing Bait and Nocturnal Removals – Recommended

Sharpshooting in suburban landscapes has been show to be an effective localized tool for reducing deer populations by removing up to 90 % of deer within a single year (DeNicola et al. In Press). Sharpshooting involves the use of a suppressed, small caliber rifle by trained personnel to remove deer at multiple pre-approved and prepared bait sites at night or during the daylight. Deer are humanly euthanized (i.e., killed with a shot to the center of the brain) from a vehicle or from a tree stand (DeNicola et al. In Press, DeNicola et al. 1997). Human safety is ensured by shooting only where a known earthen backstop occurs beneath the shooter's relative elevation (e.g. tree stand) and shooters have a clear field of vision. Deer are not removed in brush, at random locations or while moving. Deer are shot on a first opportunity basis with antlerless deer being given priority. Unhunted suburban deer are very naïve to gunshots, and are reluctant to flee a bait site once shooting is initiated (DeNicola et al. In Press). To prevent "educating" deer and to maintain their naïve behavior, it is critically important to only take shooting opportunities where all female deer present at a bait station can be removed at that time.

Properly designed sharpshoots can be very efficient and result in safe, humane, socially responsible and effective deer management programs. One shooter may remove dozens of deer in one night. As with any type of animal control, the success of a sharpshoot depends on the quality of the program design and field personnel compliance. Costs for contracted deer removals vary from $100 to $350 per deer, when using off site contractors. Costs can be reduced, however, by training local personnel to do the removal.

The college will need to work with the municipal authority in which the removal area is located to apply for and obtain a deer control permit from the Pennsylvania Game Commission. In the case of Campus Woods this will be Swarthmore Borough while for Martin Woods it will be Springfield Township. The application will require the applicant to substantiate the background and scope of the deer problem and include alternative approaches to the problem and propose what action is recommended under the permit. A complete map showing the boundaries of the area being considered and indicating the land use, cover types, huntable areas, damage and deer concentration areas, safety zones and proposed control areas within the municipal boundary will need to be provided. In addition, a deer management plan will need to be submitted which provides deer density estimates and requesting the number of animals to be removed.

Deer could be removed safely, efficiently and unobtrusively anytime during the winter using nocturnal removals. However, it may be desirable to target removals during those periods when recreational and educational use of the woods are at their lowest points, which would be during the Christmas break when students are not on campus. During this period deer could be removed day or night. One challenge to such a specific removal period is that it offers a convenient window during which objectors could attempt vandalism or arouse public protest. Conversely, sharpshoots that are allowed to occur over a span of months are more difficult to disrupt. Those that have short and specific removal periods can effectively be vandalized. In addition, the permitted removal period is February 1 to September 30, unless otherwise authorized by the PGC Director. A permit application to target the winter break would require a specific request in the application to begin the removal in mid-December.

NRC Inc. recommends requesting in the permit application a removal period beginning December 15 so the removal maybe initiated during the winter break. However, we do not recommend the college limit itself to conducting the removal to only that time period. It is advisable to keep the removal period open and flexible.

On private property there is no requirement to provide public notice as to your deer management activities, although your deer permit application will be a public document available for public review from the PGC. Additionally, we recommend that you notify the community of your intentions and contact the immediate property owners directly. We suggest, however, that you not specify removal periods or locations beyond a description of Campus Woods and Martin Forest.

Three weeks are required for deer to pattern well on bait sites. We suggest baiting begin three weeks prior to the earliest possible removal period. Baiting material should be bagged shell corn. Corn can be transported to or near the bait sites by small all-terrain vehicles. The amount of bait placed at each site should be regulated by observation of use. We recommend placing sufficient corn to see most of the material gone by the next visit. This will entail some trial-and-error but the general pattern will be to begin with about three gallons of shell corn until the bait site is discovered by deer, then increase the amount to keep bait available. Different bait sites will have varying amounts of bait removed and should be treated accordingly. Bait should not be dumped out but spread as if you were feeding chickens, so the grain is not piled but scattered over an area several yards in diameter. Bait site visits should begin at an interval of once every three days until sites are well used by deer, then every other day. Baiting should occur in the evenings and be as inconspicuous as possible. Baiting should be discontinued for periods when snow is on the ground. Five bait sites are recommended for Campus Woods and three for Martin Forest.

The sex and age structures of non-hunted suburban deer populations are fairly uniform and predictable, consisting of 60 % females and 40 % males with ~40 % yearling/adult females, ~20 % yearling/adult males and ~40 % fawns (DeNicola et al. In Press). Adult female/male sex ratio of 2:1 is typical of unhunted suburban populations (DeNicola et al. In Press). This ratio is significantly less skewed toward females than that typically found in hunted populations (3:1 to 6:1; Mattfeld 1984,Van Deelen et al. 1997, Vercauteren and Hygnstrom 2000) because hunters prefer to shoot bucks. Males are more prone to dispersal than females (Holzenbein and Marchinton 1992), and are subject to increased rates of mortality (Nixon et al. 1994). There also may be disproportionately high male mortality rates related to the breeding season in urban landscapes because of deer/vehicle collisions and the potential for injury while competing for females (Gavin et al. 1984) within a relatively large population proportion of males.

The Deer Control Permit application process will require the college to identify the number of deer you wish to remove. Current deer densities in the area of Crum Woods are likely 50 to 70 deer/square mile. There is no significant organized hunting activity on properties bordering Crum Woods that we are aware of. Pennsylvania Game Commission records show that for the 2005-2006 hunting season no deer harvest report cards were submitted for Swarthmore and only 4 antlerless deer were reported for all of Springfield Township (personal communication Brett Wallingford, Wildlife Biologist, Pennsylvania Game Commission). We suggest a request for 100 permits for the initial removal year. This will eliminate the availability of permits as an obstacle to a maximum reduction the initial year.

A contractor should be hired to either conduct the deer removal or train local personnel in removal methods. If a contactor is hired to conduct the removal, the contract should be for a minimum of four years with payments tied to the successful achievement of quantitative deer program goals, not simply hourly or “per deer removed” payments. If staff or local partners are used, the proper equipment and permits would need to be purchased by the college or the individuals involved.

Integrated Program – Not Recommended

Some communities, depending on their circumstances, combine deer management techniques successfully. Sharpshooting reductions, for example, may be followed by trap-and-euthanize programs using local staff to maintain the population at low levels. Controlled hunts using recreational hunters may be used in larger open space areas, while sharpshoots are employed in areas where hunting is deemed to be inappropriate. Every situation is unique and communities are well advised to design their program based on their circumstances, resources, values and goals.

Integrated programs that use multiple tools at appropriate locations are often the most effective. At Crum Woods some would argue that an integrated program that included limited archery hunting would "help" reduce deer numbers prior to sharpshooting, thereby reducing costs and increasing effectiveness. However, Crum Woods does not lend itself to recreational hunting from a compatible use perspective. Hunting prior to a sharpshoot would increase deer wariness and consequently increase the amount of effort (and expense) required by sharpshooters.

GOAL 3: Establish a permanent, quantitative monitoring program to assess the extent of the deer population's effect on biodiversity and ecosystem function.

Measurable indicators are the basic to the success of any program to maintain or recover forest structure, diversity, and ecological processes. Vegetation assessments can utilize both or either of two methods: (1) comparing the overall influence of deer browsing on existing vegetation to an established index, such as SILVA for advanced forest regeneration (Marquis et al. 1992) or a browse survey as used the Pennsylvania Department of Conservation and Natural Resource (DCNR) (Benner 2006); (2) quantitative sampling that includes measuring, cataloging and comparing vegetation within fixed plots, using deer exclosures as controls. DCNR is currently funding a Rapid Habitat Assessment Study by the Pennsylvania Cooperative Fish and Wildlife Research Unit, designed to identify a suite of possible indicators of forest recovery from deer overbrowsing (Benner 2006). The results from this study are not yet available but should be monitored for potential value at Crum Woods.

NRC Inc. recommends building four exclosures in Campus Woods and two in Martin Forest measuring 10 meters by 10 meters. Exclosure fences should be made of 8' high-tensile, woven, wire designed for wildlife with 6" vertical wires and supported by wooden posts. Exclosure locations should be chosen based on practical issues such as topography, access, lack of previous disturbance, etc., but also on being representative of the most sensitive forest types on the property. A corresponding unfenced control plot for each exclosure will also need to be identified and permanently marked. Sites should be subject to minimal disturbance when erecting the fences. General data recorded for each plot should include slope, aspect, topographic position, percent canopy cover and visible indications of natural disturbance history. Data collection in the fenced and paired unfenced plots should be as follows:

1. 4 m radius circular plot centered in each exclosure and paired control plot measuring:

   -trees (trees defined as >12 cm dbh) species and dbh of each tree.
   -shrubs (shrubs defined as <12 cm dbh and > 1 m tall) for each species, percent cover and height of tallest individual.

2. Ten 1 m sq. plots

   -for each herbaceous species record percent cover
   -height of tallest individual, ground surface percent cover of bare soil, leaf litter, rock, tree base, dead down woody material.

3. Cover board (record number of squares covered by vegetation) on assigned grid at 10 random intersections but recorded and using the same grid points year to year.

4. Total plot species list

Woody and herbaceous vegetative data should be collected in June. The herbaceous survey should include a "random walk" in March, June and August that identifies species that may be rare on the property. When species are found they should have an estimate of number, percent flowering, amount of ground coverage in square meters and height of the tallest plant and location record. Random walks should include a review of plot locations. Vegetation data should be compiled and submitted each September.

SILVA and DCNR data collection should follow outlined protocols. Consultation between college staff and Continental Conservation is recommended in developing, collecting and analyzing vegetation data.

Historic Background of Lyme disease

Background

The “deer tick,” *Ixodes scapularis*, is the principal vector for Lyme disease bacteria, *Borrelia burgdorferi*. White-tailed deer, *Odocoileus virginianus*, are the principal host for the adult blacklegged tick and a key to its abundance, (Barbour and Fish 1993) resulting in the commonly used name, “deer tick.”

The blacklegged tick is believed to be a native arthropod that declined in the 19th century due to a dramatic reduction in deer numbers as the result of the unrestricted hunting and landscape level conversion of eastern forests to open agricultural habitats (Ginsberg 1993, Stafford 2004).

In pre-European Pennsylvania, and throughout much of the northeast, the land was primarily forested, broken only by rivers and lakes and clearings associated with Indian villages (Cummings 1810, Dudley 1886, Maxwell 1910, Day 1953). As European settlers claimed the land, trees were cut down to make room for farms and towns. Wood not needed for fuel or building material was often burned in the process of clearing land (Latham et al. 2005). By

1907, Penn's Woods, which once covered 95 % of the state's land area, was reduced to less than 30 % (deCoster 1995), creating an open sunny habitat inhospitable to the blacklegged tick. Simultaneously, deer populations were crashing as a result of over exploitation through unregulated hunting and habitat destruction (Rhoads 1903, Severinghaus and Brown 1956, Kosack 1995, Latham et al. 2005). Deer were rare throughout the eastern United States by 1900, but they were scarce in Pennsylvania by 1895 when the Pennsylvania Game Commission was formed, in part to restore deer numbers (Kosack 1995).

Deer were largely extirpated from southeastern Pennsylvania by the 1860's with no legal reported hunting kills until 1923 (Pennsylvania Game Commission 1995a). Deer densities remained low until the 1970's when populations began to grow, increasing dramatically in the 1980's and 90's.

Today, Pennsylvania has regained much of its former forest cover, but with a much higher deer density than the original 7-10 deer/square mile found in the pre-European landscape (McCabe and McCabe 1984).

The history of the Swarthmore area reflects that of the larger landscape. Beginning in the late 1600's the forest was cleared for agriculture from nearly all but steeply sloping land (Latham et al. 2003). By the late 1800's deer had become quite rare throughout the southeast (Frye 2006). No legally harvested deer were reported within Delaware County until the late 1930's. In the early '40's hunter harvest averaged less than seven deer/year in Delaware County, while by the early 1970's the buck kill alone had increased to an average of 71 and over 500 by the early 1990's (Pennsylvania Game Commission 1995, Frye 2006). Today, despite the extensive development and loss of habitat, hunters take over 5,000 deer each year in Wildlife Management Unit 5D (Pennsylvania Game Commission 2007d), which includes Swarthmore, much of Delaware County, Philadelphia and suburbs.

Road kills followed a similar pattern. Prior to the 1960's no deer/vehicle collision data was recorded since it was not perceived as a problem. Between the early 1960's and the early 1990's deer vehicle collisions increased by nearly 2000 % (Pennsylvania Game Commission 1995b).

Lyme disease and blacklegged ticks were unknown in Pennsylvania in the 1940's. Today Pennsylvania is second only to New York in new cases of Lyme disease.

It is believed that blacklegged ticks probably survived during the 19th and early 20th century on islands off the New England coast where they were documented in the 1920's. With the regrowth of forests and the explosion of deer numbers, the blacklegged tick re-established its populations on the mainland (Stafford 2004). Lyme disease was first recognized in 1975 in Lyme, Connecticut and has spread south.

The geographic spread of Lyme disease and its rising number of cases is closely correlated with the distribution and abundance of the blacklegged tick, *Ixodes scapularis,* infected with the Lyme disease agent, *Borrelia burgdorferi* (Mather et al. 1996, Stafford et al. 1998). Increases in tick populations has been linked to changing landscape patterns and expanding populations of white-tailed deer, which is the primary host for the adult *I. scapularis* (Barbour and Fish 1993). The abundance and distribution of blacklegged ticks has been directly related to deer densities (Wilson, et al. 1990, Barbour and Fish 1993). Epidemic Lyme disease in the northeastern United States occurs only in areas where populations of white-tailed deer are dense (Spielman et al. 1985, Lastavica et al. 1989). Adult ticks will utilize other host animals but prefer white-tailed deer (Barbour and Fish 1993). It is estimated that over 90 % of adult ticks feed on deer (Stafford 2004). Therefore, deer are key to the reproductive success of the blacklegged tick and the spread of Lyme disease (Barbour and Fish 1993, Stafford 2004).

Lyme disease Management Options

GOAL 4: Reduce the probability of contracting Lyme disease by the community of users of Crum Woods.

Area-wide Applications of Aracricides – Not Recommended

Wide applications of aracricides for controlling ticks (Curran et al. 1993 Allen and Patrican. 1995), vegetation management and landscape modifications to reduce the quality of habitat for ticks (White 1993, Schulze et al. 1995) are in conflict with the Crum Woods's management values and goals and are not recommended.

Use of Rodent Bait Boxes with Fipronil – Not Recommended

The white-footed mouse, *Perimiscus leucopus*, is typically the most abundant and efficient reservoir animal for the bacteria, *Borrelia burgdorferi,* which causes Lyme disease. One approach to reducing Lyme disease has been to target rodents like white-footed mice with a controlled application of aracricide. This technique utilizes a box that restricts animal access based on the size of the opening and uses bait to lure rodents inside. To access the bait, mice and/or chipmunks must pass over a wick treated with 0.70 % fipronil, an effective aracricide that with one dose will kill existing ticks and protect the rodent from new ticks for 40 days. The box, once baited and charged with fipronil, will generally not need maintenance for 90 days. For greatest effect, boxes should be maintained from April through October.

Field trials have shown a high acceptance of the boxes by mice and a dramatic reduction in the total number of ticks in the areas treated after only one year. The technique also showed positive results in decreasing the abundance of ticks infected with *Borrelia burgdorferi* (Dolan et al. 2004).

Disadvantages of the technique include the intensity of treatment, an average of 10 bait boxes per 1/2 to one acre of habitat, and high cost. Compounding these challenges is the withdrawal in 2006, of the modified commercial bait boxes registered by the Environmental Protection Agency in 2003. Bayer Environmental Science, the manufacture of Maxforce Tick Management System, explains the decision as based on challenges with squirrels chewing open the boxes to access the bait resulting in the potential exposure of non-target wildlife and children to the fipronil inside. EPA has required that Bayer Environmental Science develop a shield to prevent uncontrolled access and the re-registering of the product. The manufacturer would not provide an estimate of when the product would again be available, but was not encouraging. They do recommend, as a replacement, area-wide spray applications of aracricides.

Considering the withdrawal by the Environmental Protection Agency of the Maxforce Tick Management System, it seems imprudent to use bait boxes with fipronil unless an EPA registered product becomes available.

Use of 4-Poster Feeder – Not Recommended at this time

The use of 4-poster feeders to treat deer with topical aracricides was developed in Texas (Pound et al 2000). Computer models indicate that if 90 % of a local deer population could be treated by 4-posters, achieving 95 % control of *I. scapularis* on treated animals, local tick populations could be reduced dramatically over several years (Stafford 2004). The 4-poster feeders rely on a central bin containing clean, whole corn as bait to lure deer to place their heads in such a way as to contact pesticide-impregnated applicator rollers that apply aracricide to their ears, head, neck and shoulders. In restricted populations, 4-poster technology has resulted in the control of 92 to 98 % of free-living ticks (lone star ticks, *Amblyomma americanum)* in the area around the devices after three years of use (Pound et al. 2000, American Lyme Disease Foundation 2006). The use of 10 % permethrin resulted in a 91-100 % reduction of larval, nymphal, and adult questing ticks in sampled plots (Stafford 2004) under controlled conditions. In a Maryland study at three locations with free ranging deer populations, Carroll et al. (2002) reduced *I. scapularis* nymphs by 69, 75.8 and 80 %.

One challenge at Crum Woods may be that while 4-poster use is generally high, utilization by deer is extremely low when other attractive food resources are available (Stafford 2004). Attractive food resources could be intentional recreational feeding of deer, incidental feeding at bird feeding stations, or naturally occurring mast such as acorns or beechnuts. Forests with significant oak composition can produce hundreds of pounds of high quality acorns per acre. Deer prefer acorns over corn. In years of significant acorn crops, corn consumption is likely to decline independent of deer numbers. The major environmental factor that interferes with feeder use by deer, thus temporarily reducing efficacy, is the occurrence of heavy acorn crops (personal communication J. Mathews Pound).

A negative result of 4-posters and the corn they use to attract deer would be a potential increase in the use of Crum Woods by deer. Food at temporary bait sites has been used to manipulate the behavior and movement of white-tailed deer for research and management purposes for decades (Hawkins et al. 1967, Ishmael and Rongstad 1984, Drummond 1995, Rudolph al. 2000). Deer with bait sites in their home range have been shown to use them while bait sites outside of deer home ranges will have no, or limited, effects on deer movement (Darrow 1993, Kilpatrick and Stober 2002). Deer with no bait sites within the core area of their home range have been shown to shift the core area closer to, or including, the bait site (Kilpatrick and Stober 2002). Deer with bait sites in their core areas maintain their original core area (Kilpatrick and Stober 2002). Therefore, deer that use Crum Woods as part of their home range may shift their core areas onto the property spending more time there and cause an increase in deer impacts on vegetation.

An important issue regarding 4-poster effectiveness is feeder maintenance. Failure to properly maintain 4-posters can be an obstacle to an effective program. One serious challenge is habitat type and the presence of squirrels. When possible, 4-posters should be placed in clearings where they are not available to squirrels. Where squirrels do have access they will feed on the shell corn but focus primarily on the seed embryo leaving much of the endosperm behind. The result is exposed, partially eaten kernels which quickly mold clogging the corn flow within the 4-poster and resulting in moldy corn being available to deer and deer avoidance of the bait. In areas where feeders are exposed to squirrels it is recommended that feeders be checked and cleaned daily (Personal Communication Andy Szulinski, C.R. Daniels, Inc. Ellicott City, Maryland).

The use of 4-posters is labor intensive and requires multiple years to show efficacy. The estimated cost of a 4-poster program the initial year when purchasing feeders is approximately $22/acre. In subsequent years the cost is approximately $11/acre/yr. At sites like Swarthmore, where squirrels will be problematic, cost will be higher due to increased labor for maintenance.

Properly maintained and positioned 4-poster feeders may, in and of themselves, reduce tick numbers to levels acceptable to the community. However, because of the exposed class 4 pesticide on the application rollers, 4-poster technology may not be appropriate to open spaces with extensive trails and public access. Feeders must be posted with warning signs.

Deer Reduction – Recommended

The exclusion, elimination, or reduction of deer has been shown to substantially reduce tick abundance (Wilson et al. 1988, Daniels et al. 1993, Stafford 1993, Stafford et al. 2003). However, to interrupt the transmission of Lyme disease with deer reductions alone, deer densities may need to be reduced to densities similar to pre-European development, perhaps eight deer per square mile (Stafford 2004). Kilpatrick and LaBonte (2003) reported that incidence of Lyme disease decreased by 83 % in a residential community following a 92 % reduction in deer.

Field experiments have shown that it is possible to manage deer on a small spatial scale through antlerless deer removals. It is particularly promising in urban/suburban landscapes such as Swarthmore, where deer home ranges have been shown to be small, often less than 100 acres, (Cornicelli 1992, Grund 1998, Kilpatrick and Spohr 2000, Kilpatrick and Stober 2002) and where deer populations are more isolated from one another by human built environments.

Given the primary deer management goal of reducing deer impacts to levels that protect and restore the structure, diversity and function of Crum Woods, deer densities may well be reduced to levels that interrupt the enzootic cycle and transmission of Lyme disease. It is suggested that the incidence of Lyme disease and baseline tick abundance be estimated and monitored. If tick populations and or incidence of Lyme disease remain above acceptable levels, the use of 4-posters may be considered.

Monitor trends in the abundance of ticks on the property using standardize tick drags.

Managing Lyme disease means managing tick bites which means reducing tick numbers. Therefore to judge the success of the Lyme disease management, program managers must have good data on trends in relative tick abundance. Estimates of absolute tick density are unnecessary. Two techniques are recommended, tick drags and tick flagging. Both are manpower-intensive and tedious but invaluable in tracking population change and program effectiveness.

It should be recognized that tick abundance can vary dramatically from one year to the next (Daniels et al. 2000), even in the absence of any tick control program. The reasons for these changes are unknown. Daniels et al. (2000) showed a fourfold range in nymph population size over a 5-year study. Nymphs prefer woodland habitats. It has been suggested that local environmental conditions over relatively small areas have a role in shaping the distribution of tick abundance year to year (Daniels et al. 2000). McEnroe (1985) recorded an exceedingly high density of adult ticks along roadside drag courses, indicating the impact that landscape features may play in the distribution of ticks. Tick infestations tend to occur in clumps with many drags producing few or no ticks while others have high tick counts. Immigration and emigration of host-seeking ticks is negligible in all life stages (Daniels and Fish 1990, Falco and Fish 1992, Curran et al. 1993), so differences in local abundance on a property cannot be explained by tick movement.

Tick drag sampling efficiency, that is the number of ticks picked up by a single drag, compared to the actual number of ticks present, is low. Daniels et al. (2000) reported a drag efficiency average of 8.6 % for larvae, 6.7 % for nymphs and 3.6 % for adults. Tick dragging involves pulling a 1-meter square panel of flannel, muslin or corduroy fabric along the ground and over vegetation (Falco and Fish 1992) for a given distance and then removing ticks using an adhesive tape lint roller, placing the tapes in a plastic bag, which is then sealed and marked with the date and plot number (Daniels et al. 2000). Ticks are later identified and counted by species and life stage using magnification. The result is a relative tick abundance estimate for that sample and site, by tick stage, based on the number collected per square meter dragged (Fish 1993).

Tick abundance for all stages increases to a peak and then decreases over several weeks during the season in which a particular stage is active (Daniels et al. 1989, Fish 1993). Larval abundance tends to decline rapidly after reaching its peak (Daniels and Fish 1990). At Swarthmore, nymph sampling should occur from June 15 through August 31. Nymphs normally have only one peak abundance period per year. Larval abundance at Swarthmore should show a peak in July and August and a smaller second peak in May. Sampling is recommended during July through the end of August.

In the initial years of the Lyme disease management program, tick surveillance should be rigorous in order to provide effectiveness monitoring that can be used to track program success. If the program demonstrates effectiveness, tick monitoring efforts can be reduced as determined by the college. One option for low-density tick monitoring would be to conduct tick drags on a “number-of-ticks-per-time-of-effort” basis as a standard measure of relative tick abundance.

It is recommended that a field data sheet for tick drags be developed with a campus map on the back and all tick drag transects marked and numbered. The data sheet should have a field for recording the observer name, date, transect number, transect length in meters, time of day, temperature, humidity, cloud condition, general level of soil moisture (e.g. dry, normal, above normal), number of nymphs, larva, and adults by species and the resulting calculated tick density for nymphs, larva, and adults. Approximately 20 10-meter sample transects should be established throughout the property focusing on high quality tick habitats like forest understories and where forests open into fields. Transects should be permanently marked in the field to facilitate their location and identification from year to year. Drag equipment as described by Carroll and Schmidtmann (1992) using PVC pipe and flannel-sided rubberized laminate cloth is suggested. Personal precautions in dress and tick management should be taken before and after conducting tick drags and flagging. However, surveyors should not avoid tick areas in order to avoid walking where ticks may be. Conduct tick drags weekly between June 15 and August 31 sampling each transect twice during each 4-week period, doing each at two different times of the day. Ideally, one late morning after the dew has dried and also during the late afternoon as temperatures cool. Do not sample if the leaf litter or grass is wet.

Monitor trends in the number of cases of Lyme disease in humans within the community.

A primary goal regarding Lyme disease at Swarthmore is to reduce the incidence of the disease within the community of people who use the woods. Therefore the best indicator of program success would be a downward trend in the cases of Lyme disease. To accomplish this, an annual survey of Lyme disease cases within the college population is recommended.

One challenge of monitoring Lyme disease within a mobile and transitory community is differentiating between cases that result from ticks picked up in the Crum Woods verses those encountered off campus. Trend data can also be confounded by changes in personal behavior as attitudes towards the threat of the disease change. This might mean increased outdoor activity with less personal protection as individuals perceive the problem as having been addressed or a decrease in exposure resulting from increased awareness and individuals becoming more cautious. To address these issues it is suggested that any survey process include follow-up questions, in positive cases, about the individual's outdoor activities on and off campus and be reviewed in the context of other monitoring information such as tick abundance.

Deer Presence and Reproduction Monitored.

The use of remotely placed digital cameras for studying, surveying and observing wildlife has become a common practice. Today there are dozens of manufactured units designed for this purpose on the market. They are relatively inexpensive and easy to mount and maintain. These cameras will provide images of those animals utilizing bait sites and, if desired, provide a record that can be presented to the community. It is possible to estimate deer populations using these cameras (Jacobson et al. 1997, Koerth et al. 1997). However, their purpose at Swarthmore will be to simply monitor the minimum presence of deer, fawns (reproduction) and pattern of deer use of bait sites if desired.

Should monitoring be desired, NRC Inc. recommends the Cuddleback Digital Scouting Camera with the Compact Flash memory cards, which cost approximately $400 per unit.

Other less expensive models are available. Units that use film or flashes are not recommended. Cameras should be downloaded onto a memory card once every week. Each photo will have recorded on it the date, camera location, and time and should be archived.

Compliance Monitoring

Compliance monitoring is simply a formalized process of documenting that the treatments agreed to within a management/monitoring program are being applied as designed and the data properly recorded. It is suggested that once a course of action is decided upon, the Crum Woods Stewardship Committee identify a compliance monitoring coordinator. This individual should develop compliance monitoring protocol and forms for each aspect of the management program that is adopted and annually reviewed monitoring and deer removal activities for completeness and conformity to the agreed design. Data sheets should be checked for completeness and field checks of techniques made. The compliance monitoring coordinator would be responsible for preparing an annual report.

Monitoring compliance for a deer removal program will depend on whether the removal is done by trained staff, a contractor or by a local partner. Compliance monitoring should include data sheets for baiting and removal activity. Baiting data sheets should record site, date, bait volume placed out per treatment, amount remaining, deer use, deer observed etc. Removal data sheets should record every removal attempt, whether successful or not, by date and time, weather conditions, location, deer observed, deer group size, deer passed, the number of deer within a group when a removal occurs, when one is passed, description of any deer that escape, deer use of baited sites, deer behavior when approaching a baited site, deer behavior within the group during shooting, shooters position (which pre-established shooting site) tackle, shots taken, deer killed by age, sex, site, body weight, PGC tag number, etc.

If tick drags are implemented for tracking relative tick abundance, the compliance monitoring coordinator should make sure those conducting the drags are familiar with and using the proper sampling protocols, are on the desired transects at the appropriate times and accurately and completely fill out data sheets. Similar approaches should be taken to monitoring forest regeneration, browse utilization, fenced plots, ornamental and plant specimen deer damage, 4-poster program, etc.

Effectiveness Monitoring

Effectiveness monitoring uses a group of indicators to quantitatively measure whether your management program is successfully accomplishing the goals and objectives it was designed to accomplish. The focus of effectiveness monitoring within Swarthmore will be primarily the vegetation trend data from the paired exclosure and control plots, SILVA advanced regeneration plots, DCNR browse utilization transects, measurements of relative tick abundance and the number of cases of Lyme disease on campus. Compliance monitoring will track how well treatments are being applied and allow for adjustment. Effectiveness monitoring will track whether the overall deer management program is resulting in the abatement of the problems for which it was implemented. If community goals are achieved, some treatments maybe modified, gradually reduced or dropped to maximize cost effectiveness both in dollars and effort without compromising the success of the program.

Regulation Review

Recreational Hunting Seasons and Bag Limits

Recreational hunters in Wildlife Management Unit 5D may hunt with muzzleloading long guns .44-caliber or larger, bows and arrows, manual or autoloading shotguns .410 or larger using slugs, or 20-gauge or larger using buckshot. Crossbows with a draw weight of at least 125 pounds, but not more than 200 pounds, may be used during the regular firearms deer seasons, including the antlerless deer season Dec. 10-22 and Dec. 26-Jan. 26 (Pennsylvania Game Commission, 2006b and Pennsylvania Game Commission 2007a). Recreation hunting seasons and bag limits for deer in WMU 5D are;

DEER, ARCHERY (Antlered and Antlerless) Sept. 15-28, and Nov. 12-24. One antlered deer per hunting license year. One antlerless deer with each required antlerless license.

DEER, ARCHERY (Antlered and Antlerless) Sept. 29-Nov. 10 and Dec. 26-Jan. 12. One antlered deer per hunting license year. One antlerless deer with each required antlerless license.

DEER (Antlered and Antlerless) (Statewide) Nov. 26-Dec. 8. One antlered deer per hunting license year. One antlerless deer with each required antlerless license.

ANTLERLESS DEER (Statewide): Oct. 18-20. Junior and Senior License Holders, Disabled Person Permit (to use a vehicle) Holders, and Pennsylvania residents serving on active duty in the U.S. Armed Services or in the U.S. Coast Guard only, with required antlerless license. Also eligible to hunt are persons who have reached or will reach their 65th birthday in the year of the application for an antlerless license and hold a valid general license, or qualify for license and fee exemptions under section 2706. One antlerless deer with each required antlerless license.

DEER, ANTLERLESS MUZZLELOADER (Statewide): Oct. 13-20. An antlerless deer with each required antlerless license.

DEER, ANTLERED OR ANTLERLESS FLINTLOCK (Statewide): Dec. 26-Jan. 12. One antlered per hunting license year, or one antlerless deer and an additional antlerless deer with each required antlerless license.

DEER, ANTLERLESS (WMUs 5C and 5D): Dec. 10-22 and Dec. 26-Jan. 26. An antlerless deer with each required antlerless license (Pennsylvania Game Commission 2007a).

Baiting For Recreational Hunting

Hunters are permitted to use bait only on private lands. Bait may be placed or distributed two weeks prior to the opening of the year's initial deer season and baiting may continue until the deer seasons conclude. Bait accumulation in any one location will not be permitted to exceed five gallons at any given time (Pennsylvania Game Commission 2006a).

Deer Control Permit

A deer control permit from the Pennsylvania Game Commission would allow deer to be removed safely, humanely, efficiently and discreetly from Crum Woods. Under current law, the municipalities within which the Swarthmore properties are located would need to apply for the Deer Control Permit (Borough of Swarthmore and Springfield Township). Current regulations are as follows:

§ 147.322. Application for deer control permit.

(a) An application for a deer control permit shall be completed in conjunction with the Commission and submitted by an authorized officer or employee of the political subdivision in the form required by the Director and contains the information requested by the Director.

(b) An application for a deer control permit shall contain the following information:

(1) A complete map showing the boundaries of the property being considered and indicating land use, cover types, huntable areas, damage and deer concentration areas, safety zones and proposed control areas within the municipal boundary.

(2) A deer management plan shall be submitted with each application which provides deer density estimates and requesting the number of animals to be removed.

(3) Each application shall substantiate the background and scope of the deer problem, include alternative approaches to the problem, and propose actions to be taken under the permit.

Source

The provisions of this § 147.322 adopted July 29, 1994, effective July 30, 1994, 24 Pa.B. 3716.

§ 147.323. Permit.

An application shall show the name, address, date of birth and telephone number for each permittee and subpermittee.

Source

The provisions of this § 147.323 adopted July 29, 1994, effective July 30, 1994, 24 Pa.B. 3716.

§ 147.324. Privileges authorized under the permit.

Deer may be taken:

(1) Outside the established hunting seasons as set by the Commission in § 139.4 (relating to seasons and bag limits for the license year).

(2) Regardless of age or sex.

(3) From February 1 to September 30, unless otherwise authorized by the Director and listed on the permit.

(4) At any hour, day or night, and with or without an artificial light.

(5) With any lawful firearm for big game as described in section 2322(a) of the act (relating to prohibited devices and methods).

(6) Only in areas designated by the political subdivision.

Source

The provisions of this § 147.324 adopted July 29, 1994, effective July 30, 1994, 24 Pa.B. 3716.

§ 147.325. Special conditions of permit.

(a) Special conditions specific to the applicant's area will be listed on the permit.

(b) Permits shall list the applicant's name, authorized officers or employees of the political subdivision responsible for the activities conducted under this permit, and list not more than five subpermittees who shall be licensed hunters or law enforcement officers, or both.

(c) A copy of the permit shall be carried by the permittee and subpermittees when engaged in activities granted by the permit. The permit shall be shown to any officer of the Commission or person empowered to enforce the act or this part.

Source

The provisions of this § 147.325 adopted July 29, 1994, effective July 30, 1994, 24 Pa.B. 3716.

§ 147.326. Carcass handling.

(a) Each deer harvested shall have the entrails removed at a suitable location away from where the animal was taken.

(b) Each deer shall be tagged or marked with a tag supplied by the Commission.

(c) Due care shall be taken with each carcass to preserve the meat for human consumption.

(d) Deer suitable for human consumption shall be utilized through a food bank or needy family or as otherwise determined by the Director.

(e) Antlers from deer taken under the authority of this permit shall be submitted to the Commission for disposal by the Director.

Source

The provisions of this § 147.326 adopted July 29, 1994, effective July 30, 1994, 24 Pa.B. 3716.

§ 147.327. Reports.

(a) Deer taken under the authority of this permit shall be reported to the Director on forms supplied by the Commission.

(b) Reports shall be submitted on a monthly basis when deer are taken.

Source

The provisions of this § 147.327 adopted July 29, 1994, effective July 30, 1994, 24 Pa.B. 3716.

§ 147.328. Permit renewal.

(a) Permits will be issued on a fiscal basis of July 1 to June 30 next following.

(b) Permit renewal will be subject to the review of progress toward deer management plan objectives.

Source

The provisions of this § 147.328 adopted July 29, 1994, effective July 30, 1994, 24 Pa.B. 3716.

§ 147.329. Violations.

The Director may revoke a permit for a violation of this subchapter, conditions of a permit, or for failure to submit reports, as required, upon written notice to the permittee.

Source

The provisions of this § 147.329 adopted July 29, 1994, effective July 30, 1994, 24 Pa.B. 3716.

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