ENVIRONMENTAL CONSEQUENCES

This "Environmental Consequences" chapter analyzes both beneficial and adverse impacts that would result from implementing any of the alternatives considered in this *White-tailed Deer Management Plan / Environmental Impact Statement.* This chapter also includes a summary of laws and policies relevant to each impact topic, definitions of impact thresholds (e.g., negligible, minor, moderate, and major), methods used to analyze impacts, and the analysis methods used for determining cumulative impacts. As required by the Council on Environmental Quality (CEQ) regulations implementing the *National Environmental Policy Act* (NEPA), a summary of the environmental consequences for each alternative is provided in table 12 which can be found in "Chapter 2: Alternatives." The resource topics presented in this chapter, and the organization of the topics, correspond to the resource discussions contained in "Chapter 3: Affected Environment."

SUMMARY OF LAWS AND POLICIES

Three overarching environmental protection laws and their implementing policies guide the actions of the National Park Service (NPS) in the management of the parks and their resources — the *Organic Act of 1916*, NEPA and its implementing regulations, and the *Omnibus Management Act*. For a complete discussion of these and other guiding authorities, refer to the section titled "Related Laws, Policies, Plans, and Constraints" in "Chapter 1: Purpose of and Need for Action." These guiding authorities are briefly described below.

The *Organic Act of 1916* (16 United States Code [USC] 1), as amended or supplemented, commits the NPS to making informed decisions that perpetuate the conservation and protection of park resources unimpaired for the benefit and enjoyment of future generations.

The *National Environmental Policy Act of 1969* is implemented through regulations of the CEQ (40 Code of Federal Regulations [CFR] Parts 1500–1508). The NPS has, in turn, adopted procedures to comply with these requirements, as found in Director's Order 12 (NPS 2001) and its accompanying handbook.

The *Omnibus Management Act* (16 USC 5901 et seq.) underscores the NEPA provisions in that both acts are fundamental to park management decisions. Both acts provide direction for connecting resource management decisions to the analysis of impacts and communicating the impacts of those decisions to the public, using appropriate technical and scientific information. Both acts also recognize that such data may not be readily available and they provide options for resource impact analysis should this be the case. Section 4.5 of Director's Order 12 adds to this guidance by stating, "when it is not possible to modify alternatives to eliminate an activity with unknown or uncertain potential impacts, and such information is essential to making a well-reasoned decision, the National Park Service will follow the provisions of the CEQ regulations (40 CFR 1502.22)." In summary, the Park Service must state in an environmental assessment or impact statement (1) whether such information is incomplete or unavailable; (2) the relevance of the incomplete or unavailable information to evaluating reasonably foreseeable significant adverse impacts on the human environment; (3) a summary of existing credible scientific adverse impacts that is relevant to evaluating the reasonably foreseeable significant adverse impacts; and (4) an evaluation of such impacts based on theoretical approaches or research methods generally accepted in the scientific community. Collectively, these guiding regulations provide a framework and process for evaluating the impacts of the alternatives considered in this draft EIS.

GENERAL METHODOLOGY FOR ESTABLISHING IMPACT THRESHOLDS AND MEASURING EFFECTS BY RESOURCE

The following elements were used in the general approach for establishing impact thresholds and measuring the effects of the alternatives on each resource category:

- general analysis methods as described in guiding regulations, including the context and duration of environmental effects
- basic assumptions used to formulate the specific methods used in this analysis
- thresholds used to define the level of impact resulting from each alternative
- methods used to evaluate the cumulative impacts of each alternative in combination with unrelated factors or actions affecting park resources
- methods and thresholds used to determine if impairment of specific resources would occur under any alternative

These elements are described in the following sections.

GENERAL ANALYSIS METHODS

The analysis of impacts follows CEQ guidelines and Director's Order 12 procedures (NPS 2001) and is based on the underlying goal of supporting forest regeneration and providing for long-term protection, conservation, and restoration of native species and cultural landscapes at Rock Creek Park. This analysis incorporates the best available scientific literature applicable to the region and setting, the species being evaluated, and the actions being considered in the alternatives.

As described in chapter 1, the NPS created an interdisciplinary science team to provide important input to the impact analysis. For each resource topic addressed in this chapter, the applicable analysis methods are discussed, including assumptions and impact intensity thresholds.

ASSUMPTIONS

Several guiding assumptions were made to provide context for this analysis. These assumptions are described below.

Analysis Period

Goals, objectives, and specific implementation actions needed to manage deer at Rock Creek Park are established for the next 15 years; therefore, the analysis period used for assessing impacts is up to 15 years. The impact analysis for each alternative is based on the principles of adaptive management, which would allow the NPS to change management actions as new information emerges from monitoring the results of management actions and ongoing research throughout the life of this plan.

Geographic Area Evaluated for Impacts (Area of Analysis)

The geographic study area (or area of analysis) for this plan includes Rock Creek Park in its entirety. The area of analysis may extend beyond the park's boundaries for some cumulative impact assessments. The specific area of analysis for each impact topic is defined at the beginning of each topic discussion.

Duration and Type of Impacts

The following assumptions are used for all impact topics (the terms "impact" and "effect" are used interchangeably throughout this document):

- *Short-term impacts* — Impacts would last from a few days up to three years following an action
- *Long-term impacts* — Impacts would last longer than three years up to the life of the plan (approximately 15 years)
- *Direct impacts* — Impacts would occur as a direct result of deer management actions

- *Indirect impacts* — Impacts would occur from deer management actions and would occur later in time or farther in distance from the action

Future Trends

Visitor use and demand are anticipated to remain relatively steady over the life of the plan, similar to what has been recorded for the past 10 years. The number of yearly visitors to Rock Creek Park has hovered at about 2 million visitors per year over the past 10 years, with a very slight upward trend since about 1996 (see figure 9 in chapter 3). There are no new facilities, access, or operations planned during the planning period that would affect visitation, and no substantial changes are envisioned in the population of the metropolitan area surrounding the park. In the absence of notable anticipated changes, it is expected that annual visitation over the life of the plan remain at about 2 million visitors per year, with slight variations from year to year.

Impact Thresholds

Determining impact thresholds is a key component in applying NPS *Management Policies* and Director's Order 12. These thresholds provide the reader with an idea of the intensity of a given impact on a specific topic. The impact threshold is determined primarily by comparing the effect to a relevant standard based on applicable or relevant/appropriate regulations or guidance, scientific literature and research, or best professional judgment. Because definitions of intensity vary by impact topic, intensity definitions are provided separately for each impact topic analyzed in this document. Intensity definitions are provided throughout the analysis for negligible, minor, moderate, and major impacts. In all cases, the impact thresholds are defined for adverse impacts. Beneficial impacts are addressed qualitatively.

CUMULATIVE IMPACTS ANALYSIS METHOD

The CEQ regulations to implement NEPA require the assessment of cumulative impacts in the decision-making process for federal projects. Cumulative impacts are defined as "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (federal or nonfederal) or person undertakes such other actions" (40 CFR 1508.7). As stated in the CEQ handbook, "Considering Cumulative Effects" (CEQ 1997), cumulative impacts need to be analyzed in terms of the specific resource, ecosystem, and human community being affected and should focus on effects that are truly meaningful. Cumulative impacts are considered for all alternatives, including alternative A.

Cumulative impacts were determined by combining the impacts of the alternative being considered with other past, present, and reasonably foreseeable future actions. Therefore, it was necessary to identify other ongoing or reasonably foreseeable future projects and plans at Rock Creek Park and, if applicable, the surrounding area. Table 24 summarizes these actions that could affect the various resources at the park, along with the plans and policies of both the park and surrounding jurisdictions, which were discussed in chapter 1. Additional explanation for most of these actions is provided in the narrative following the table.

The analysis of cumulative impacts was accomplished using four steps:

Step 1 — Identify Resources Affected

Fully identify resources affected by any of the alternatives. These include the resources addressed as impact topics in chapters 3 and 4 of the document.

Step 2 — Set Boundaries

Identify an appropriate spatial and temporal boundary for each resource. The temporal boundaries are noted at the top of table 24 and the spatial boundary for each resource topic is listed under each topic.

Step 3 — Identify Cumulative Action Scenario

Determine which past, present, and reasonably foreseeable future actions to include with each resource. These are listed in table 24 and described below.

Step 4 — Cumulative Impact Analysis

Summarize impacts of these other actions (x) plus impacts of the proposed action (y), to arrive at the total cumulative impact (z). This analysis is included for each resource in chapter 4.

TABLE 24. CUMULATIVE IMPACT SCENARIO

Impact Topic	Study Area	Past Actions	Current Actions	Future Actions (15 years)
Temporal boundaries for all resources are from the mid-1960s when deer were first sighted in Rock Creek Park to 15 years from the completion of the Draft White-tailed Deer Management Plan / Environmental Impact Statement (plan/EIS), unless otherwise noted.				
Vegetation	Rock Creek Park and adjacent land owners	Increasing deer population Adjacent property landscaping Park operations and maintenance (especially landscaping and exotic plant control) Boundary encroachment / urban development Pests and disease– gypsy moths (*Lymantria dispar*) and chestnut blight Vandalism (fire) Dumping Illegal camping Off-trail users/social trails Visitor uses Scientific research	Same as past actions plus: Pests and disease – dogwood anthracnose, gypsy moth management—monitoring	Same as current actions plus: Reconstruction of Rock Creek Park and Potomac Parkway Asian longhorned beetle, emerald ash borer
Soils and Water Quality	Rock Creek Park and Rock creek watershed	Urban development Impervious surface run-off Off-trail users / social trails Dumping Illegal camping Sewer overflows Park maintenance and operations Visitor uses Agricultural discharge in headwaters Flood events	Same as past actions plus: Headwater improvements	Same as current actions plus: Reconstruction of Rock Creek Park and Potomac Parkway Combined sewer overflow improvements (D.C. Water and Sewer Authority)
Wetlands and Floodplains	Rock Creek Park	Urban development Off-trail users / social trails Dumping Park maintenance and operations Visitor uses Flood events	Same as past actions	Same as current actions plus: Reconstruction of Rock Creek Park and Potomac Parkway

Impact Topic	Study Area	Past Actions	Current Actions	Future Actions (15 years)
Temporal boundaries for all resources are from the mid-1960s when deer were first sighted in Rock Creek Park to 15 years from the completion of the Draft White-tailed Deer Management Plan / Environmental Impact Statement (plan/EIS), unless otherwise noted.				
Wildlife and Wildlife Habitat (including deer)	Rock Creek Park and typical deer movement outside park	Increasing deer population Urban development Park management and operations Rabies, West Nile virus Illegal camping Poaching Dumping Traffic/Vehicle collisions Visitor uses Exotic plant control Off-trail users / social trails Nonnative wildlife / unrestrained pets Range expansion (large mammals) Fish passage Improvements Scientific research	Same as past action, plus epizootic hemorrhagic disease (deer), testing for Chronic wasting disease	Same as past actions plus: Possible rabies vaccine trials More development – Metropolitan Branch Trail Chronic wasting disease (deer) West Nile virus
Rare, Unique, Threatened or Endangered Species	Rock Creek Park	Exotic plant control Adjacent property landscaping Park landscaping Vandalism (fire) Dumping Illegal camping Traffic/Vehicle collisions Visitor uses Off-trail users / social trails Boundary encroachment Increasing deer population Gypsy moth management Nonnative wildlife / unrestrained pets Range expansion (large mammals) Fish passage Improvements Groundwater pollution Scientific research	Same as past actions plus: dogwood anthracnose, gypsy moth management—monitoring	Same as current actions plus: Hydrologic regime changes Asian longhorned beetle (*Anoplophora glabripennis*), West Nile virus

Impact Topic	Study Area	Past Actions	Current Actions	Future Actions (15 years)
Temporal boundaries for all resources are from the mid-1960s when deer were first sighted in Rock Creek Park to 15 years from the completion of the Draft White-tailed Deer Management Plan / Environmental Impact Statement (plan/EIS), unless otherwise noted.				
Cultural Landscapes	Rock Creek Park	Park development and maintenance Archeological survey Spread of exotic species Telecommunications facilities development Mountain/motor bikes on earthworks Vandalism (fire) Urbanization Chestnut blight and gypsy moths	Same as past actions	Same as current actions
Soundscapes	Rock Creek Park and adjacent landowners	Park maintenance and operations, including landscaping work Traffic Helicopter use Flight paths over park Emergency services Special and community events	Same as past actions	Same as past actions plus: increased traffic Reconstruction of Rock Creek Park and Potomac Parkway
Visitor Use and Experience	Rock Creek Park	Deer – increase in population Park management and operations including trails, interpretative programs Rabies, Lyme disease, West Nile virus Illegal camping Poaching Dumping Exotic plant control Traffic/Vehicle collisions Off-trail users / social trails Nonnative wildlife / unrestrained pets Urban development	Same as past actions plus: Shrinking green space surrounding park Parking	Same as present plus: Reconstruction of Rock Creek Park and Potomac Parkway Possible rabies vaccine trials Tree canopy trail Trail reconstruction/improvements
Visitor and Employee Health and Safety (including adjacent landowners)	Rock Creek Park and adjacent landowners	Vehicle collisions Urbanization Crime U.S. Park Police operations	Same as past actions	Same as past actions

Impact Topic	Study Area	Past Actions	Current Actions	Future Actions (15 years)
Temporal boundaries for all resources are from the mid-1960s when deer were first sighted in Rock Creek Park to 15 years from the completion of the Draft White-tailed Deer Management Plan / Environmental Impact Statement (plan/EIS), unless otherwise noted.				
Socioeconomics	Adjacent landowners	Landscaping impacts Exotic plants (from park) Increase in deer population Damage from other pests/animals	Same as past actions	Same as past actions
Park Management and Operations	Rock Creek Park	Park management, maintenance, and operations U.S. Park Police operations Budgetary constraints Traffic	Same as past actions plus: Archeological survey Changes in recreation	Same as current plus: Possibly new U.S. Park Police station

CUMULATIVE IMPACT SCENARIO

ROCK CREEK PARK PLANS, POLICIES, AND ACTIONS

Park Plans and Policies. The Rock Creek Park General Management Plan (NPS 2005a), Natural Resources Management Plan (NPS 1996a), Draft Long Range Interpretive Plan (NPS 2003), Draft Invasive Exotic Plant Management Plan (NPS 2004a), various cultural landscape reports, and the Fort Circle Park General Management Plan (NPS 2004b) are all park planning documents that include policies, goals, or desired conditions, that, when implemented, could contribute to the cumulative effects on the resources addressed by this plan. These plans are described in the chapter 1 under "Relationship to Other Planning Documents for Rock Creek Park."

Park Operations and Maintenance. Past, present, and future park operation and maintenance activities have the potential to impact numerous resource areas. Activities that would be considered include, but are not limited to:

- hazard tree removal
- exotic plant control
- routine maintenance along roads and picnic grounds
- trail maintenance
- various cultural and natural resource management actions
- interpretive and educational programs
- landscape maintenance (e.g., mowing and trimming)
- volunteer activities (stream and park cleanups)
- future telecommunication facilities

Vehicle Collisions. Starting in 1981, Rock Creek Park began collecting data on wildlife roadkill in Rock Creek Park. The first deer roadkill was recorded in 1989. Because heavy commuter and local use of park roadways, wildlife and deer/vehicle collisions are likely to continue within Rock Creek Park.

Traffic. Rock Creek Park contains a number of park roads that serve as local commuter routes. Beach Drive, which bisects the length of the park from the Maryland state line to the Rock Creek and Potomac Parkway, was designed as an internal park touring road to provide recreational access to the valley. Today, Beach Drive is a multiuse resource within the park that functions as a north-south commuter route during the week. On weekends and holidays, portions of Beach Drive are closed to vehicular traffic and used as a recreational area by pedestrians, bicyclists, and others participating in nonmotorized activities. Rock Creek and Potomac Parkway serves as a travel corridor that connects Beach Drive and Rock Creek Park with Potomac Park.

Visitor Uses

Visitor use itself can contribute to impacts to resources. Examples include active recreation uses, including golf, tennis, horseback riding, as well as trail use.

Horseback Riding. Rock Creek Park contains horse stables, as well as horseback trails throughout the park. Horseback riding has the potential to increase or introduce nonnative species through animal feed or animal wastes, as well as create trail erosion from heavy use.

Rock Creek Park Golf Course. The Rock Creek Park golf course is a 4,798-yard, par-65 public course noted for its hilly and challenging terrain. Park staff have noted that the golf course is an area of high deer density.

Multiuse Trail Rehabilitation. Rock Creek Park currently has plans to rehabilitate a section of multiuse trail from Peirce Mill to Potomac Park. This project will include some widening and realignment. An environmental assessment is currently being completed for this project.

Special and Community Events. Events and facilities in and around Rock Creek Park contribute to the soundscape experienced by visitors and wildlife. These include a tennis center and amphitheatre, which host numerous special events during the year, mainly during the summer months, which can add to the noise within the park. The amphitheater season extends May through September and shares parking with the tennis center. Special events include the Legg Mason tennis tournament and weekly summer events at Carter Barron. In addition to special events within the park, special events are held by park neighbors. Rock Creek Park is bordered by a number of public uses including schools, churches, embassies, and other similar institutions.

Telecommunications Facilities. There are currently two telecommunication towers permitted within Rock Creek Park in Reservation 339, one at the tennis center and one at the maintenance yard. The NPS has developed a telecommunications facilities management plan to assist the park in future decision making regarding potential wireless telecommunications facilities permit applications.

Dumping. Illegal dumping does occur within the park. This takes many forms including the dumping of landscaping waste, which increases the potential for introduction of nonnative species into the park. Dumping of other commercial waste and household waste has the potential to impact sensitive species if the dumping occurs in areas where that habitat is available. Dumping into park water bodies (i.e., illegal drain connections, draining of residential pools, spills) can also affect water quality within the park.

Vandalism. Rock Creek Park is the occasional subject of vandalism, including fire. Intentionally set fires have the potential to destroy large areas of vegetation if the events are frequent or large.

Illegal Camping. Illegal camping occurs throughout the park. Human disturbance in areas where illegal camping occurs includes displacement of wildlife, potential poaching, and vegetation removal.

Off-Trail Users and Social Trails. While there are many established trails, paths, and other use areas in Rock Creek Park, visitors often venture away from designated use areas into the undisturbed forested areas of the park to be nearer the creek or other feature. Some visitors create "shortcuts" between existing trails or to access the park from neighboring properties. If an area is accessed enough, an informal path may develop, becoming a social trail. Off-trail users in the park include geocaching clubs, running clubs, and dog walking. Off-trail users can trample vegetation, potentially during periods critical to the survival of the plants.

Nonnative Wildlife / Unrestrained Pets. In addition to native wildlife, Rock Creek Park is home to nonnative wildlife. Species include English sparrows (*Passer domesticus*), European starlings (*Sturnus vulgaris*), and feral dogs (*Canis lupus familiaris*) and cats (*Felis catus*). Nonnative species compete with native wildlife and/or present indirect competition through utilization of similar habitats. Unrestrained pets cause similar problems, contributing to the potential harassment of native park wildlife. For example, off-leash dogs can run through vernal pools disturbing sediments, which can cover amphibian eggs and interrupt breeding behavior.

Mountain/Motor Bikes on Earthworks. The Fort Circle Parks contain many earthworks and unauthorized recreational use of the earthworks as ramps for mountain and motorbikes negatively affects the resource by contributing to erosion.

Plant Pests and Disease. Several pests or disease can cause adverse impacts to vegetation throughout the park. Since the mid-1970s, the most prevalent pest concern at Rock Creek Park has been **gypsy moth**,

which the park controlled through spraying in 1989 and 1990 and now monitors. Currently, and in the future, additional concerns include **dogwood anthracnose**, **emerald ash borer (*Agrilus planipennis*)**, and the **Asian longhorned beetle**.

Deer and Wildlife Disease (Rabies, West Nile virus, Lyme disease, Chronic Wasting Disease, Epizootic Hemorrhagic Disease). Park habitat and wildlife are influenced by a number of wildlife diseases. In the 1980s, there was an outbreak of **rabies** in raccoons (*Procyon lotor*) living in the park. Rabies vaccine trials have been proposed in the future, but would require additional compliance by the park before implementation. **West Nile virus**, an established factor in avian mortality, has been identified in more than 100 bird species. Many long distance neotropical migrant species are not only affected by the disease, but contribute to the spread of the virus along migration routes. Migratory birds moving through the region may be infected by West Nile virus, and there are documented cases within the region and the park. **Lyme disease** is carried by ticks that are hosted by deer and other animals. **Epizootic hemorrhagic disease** (EHD) has been found at the National Zoo and other places near the park. A future concern related to deer health in Rock Creek Park includes the possibility of occurrence of Chronic Wasting Disease (CWD), as described more fully in the "Affected Environment" section of this plan/EIS.

Range Expansion (Large mammals). Coyote (*Canis latrans*) sightings continue to be reported to park staff, as recently as spring 2008. Coyotes have been seen in several areas of the park and in adjacent neighborhoods. A black bear (*Ursus americanus*) was seen in Rockville in June 2007, and in 2001 a black bear was struck by a vehicle on the Baltimore-Washington Parkway.

Fish Passage Improvements. As a part of the Woodrow Wilson Bridge project, man-made barriers to fish movement in Rock Creek Park were recently removed. The project, which began in December 2003, removed or bypassed several man-made barriers that had prevented herring and other migratory fish from returning to upriver spawning areas. In Rock Creek Park, six fish barriers were removed or modified, while two more were remedied in the adjacent National Zoological Park and a fish ladder was constructed at the Peirce Mill dam. Ongoing maintenance and monitoring at the fish ladder continue.

Flood Events. Rock Creek floods out of its banks once a year on average. About every five years the creek experiences a large flood event. The last major flood was in June 2006, which caused extensive damage in the park. The worst flood ever recorded in the park was caused by Hurricane Agnes in 1972 (Ferebee, pers. comm. 2008b).

Hydrologic Regime Changes. Hydrologic regime change is a potential future event; as the creek erodes and the channel deepens itself, the hydrologic regime could be altered.

Groundwater Pollution. Groundwater pollution has occurred in the past through point sources such as illegal dumping and may occur in the future. There have been leaking underground heating oil storage tanks in and adjacent to the park that have had some effect on groundwater. There are many potential sources of groundwater pollution within the urban development that surrounds the park, and it is possible that something could happen at any time to contaminate groundwater.

Parkwide Archeological Survey. Rock Creek Park has completed a parkwide archeological survey. This will provide information necessary to manage the park's historic resources effectively and develop information and material to interpret the history and prehistory of the park.

Scientific Research. Rock Creek Park frequently receives applications for research permits to conduct scientific studies in the park. Permits issued in the past include research on water quality, plant surveys, and wildlife. Requests for scientific research studies are processed as received. These requests are expected to continue into the future.

Reconstruction of Rock Creek and Potomac Parkway. Rock Creek Park will be reconstructing the Rock Creek and Potomac Parkway from P Street to Calvert Street and Beach Drive from the Parkway to

the Maryland/District of Columbia boundary line to eliminate unsafe driving conditions by reconstruction and rehabilitation. An Environmental Assessment was completed in 2006.

LOCAL/STATE PLANS, POLICIES, AND ACTIONS

Deer Management Plans and Programs of Neighboring Jurisdictions. Neighboring jurisdictions have implemented deer management plans and actions (Montgomery County) or have functions that address control of animals and disease prevention (District of Columbia). These are described in the chapter 1 under "Current Deer Management at Rock Creek Park and in Surrounding Jurisdictions."

Landscaping on Adjacent Properties and within the Park and the Spread of Invasive Exotic Plant Species. Many residential land uses are located along the boundary of Rock Creek Park. On some of these residential properties nonnative vegetation has been planted for landscaping and these exotic plants have spread into Rock Creek Park. Likewise, some of the Rock Creek Park administered units are designed landscapes that include exotic vegetation, which has the potential to expand from outside the designed unit into Rock Creek Park's natural landscapes. Exotic vegetation, when introduced in the park, can compete with native vegetation. Historical plant species that are part of the cultural landscape can be impacted and in some cases replaced by these exotic species as well.

Urban Development and Boundary Encroachment. Rock Creek Park is located in a highly-urbanized area that has undergone much development since the mid-1970s and will continue to develop in the foreseeable future. Some of this development has occurred along the boundaries of Rock Creek Park, and at times on small portions of Rock Creek Park land. For example, Tregaron Estates, a 20-acre wooded parcel adjacent to Reservations 365 and 635, has been proposed for subdivision development. Urbanization of the area has limited, and will continue to limit, the amount of green space and wildlife habitat available in the area, putting more pressure on Rock Creek Park's resources and displacing some wildlife. Bordering neighbors have complained about deer browse on landscape vegetation. Other concerns with urbanization include an increasing amount of impervious surfaces, which would lead to an increase in stormwater runoff.

D.C. Water and Sewer Authority (WASA) Combined Sewer Overflows Including Planned Improvements. Approximately one-third of the District of Columbia is served by combined sewers, including the parts of Rock Creek Park south of Piney Branch. When the capacity of a combined sewer is exceeded during storms, the excess flow, a mixture of sewage and stormwater runoff known as combined sewer overflow (CSO), is discharged into Rock Creek and other tributary waters, affecting water quality. The District of Columbia's National Pollutant Discharge Elimination System permit requires the preparation of a Long-Term Control Plan (LTCP) to control CSO discharges to the area waterways. In response to public comments, the final LTCP proposed significant reductions in CSO discharges. WASA is waiting for regulatory agency approval on the final LTCP. In addition, WASA's 10-year capital improvement program through fiscal year 2010 addresses wastewater treatment, CSO, stormwater, and sanitary sewer, as well as water service. WASA also has plans to improve some drainage conditions, including separating the combined sewer in Piney Branch to reduce the amount of raw sewage entering the Piney Branch Tributary, and mitigating the stormwater flow into Dumbarton Oaks Park by capturing the flow before it enters the park and piping it around the park. The flow would be discharged at a point below the park to reduce stormwater erosion.

Agricultural Activity in Rock Creek Headwaters. The headwaters of Rock Creek are located in Montgomery County, Maryland. Historically, discharges from agricultural activities in the creek headwaters have affected downstream waters. Currently, and in the reasonably foreseeable future, Montgomery County is implementing measures to reduce these impacts and improve water quality through use of buffers and other measures.

Flight Paths Over Park. These flights include helicopter use, including the presidential helicopter, military plane overflights, and the flight path for Ronald Reagan National Airport, a small portion of

which is located over Glover-Archbold Park and Reservation 404. According to the regional airports website (Metropolitan Washington Airports Authority 2008), there are about 775 flights in and out of the airport daily (based on July 2008 figures). Some of these extend over the Palisades neighborhood, which includes Glover-Archbold Park. According to the Chair of the Airport Noise Committee of the Palisades Neighborhood Association, depending on wind direction and velocity, the neighborhood is overflown by about 400 jet airplane arrivals or departures on weekdays and 300-350 on Saturdays and Sundays (Pavek, pers. comm. 2008).

U.S. Park Police. The current Rock Creek District 3 Station is in Rock Creek Park; park police patrol 1,800 acres of Rock Creek Park and adjacent parks, such as Meridian Hill, Glover-Archbold Park, Fort Totten (and other Fort Circle Parks), portions of the C&O Canal, and the newly acquired Capitol Crescent Trail located along a portion of the Potomac River. Depending on funding, a new station may be located outside the park or inside the park at an area known as H3 Park Police Horse Stables, where wood chipping activities currently occur. Also located within Rock Creek Park along the Rock Creek and Potomac Parkway is Edgewater Stables, where U.S. Park Police horses are kept.

Metropolitan Branch Trail. The District of Columbia is currently in the process of planning and implementing the Metropolitan Branch Trail, an 8-mile, multiuse trail that runs from Silver Spring, Maryland to Union Station in the District. The trail will provide a direct access route to seven of the Washington Area Metro Red Line stations and will connect to the Washington area's trail network at the Capital Crescent Trail and the East Coast Greenway. Part of the trail is proposed to cross NPS-owned land at Fort Totten.

IMPAIRMENT ANALYSIS METHOD

Chapter 1 describes the related federal acts and policies regarding the prohibition against impairing park resources and values in units of the national park system. According to NPS *Management Policies 2006,* an action constitutes an impairment when an impact "would harm the integrity of park resources or values, including the opportunities that otherwise would be present for the enjoyment of those resources or values" (NPS 2006, sec. 1.4.5). To determine impairment, the NPS must evaluate "the particular resources and values that would be affected; the severity, duration, and timing of the impact; the direct and indirect effects of the impact; and the cumulative effects of the impact in question and other impacts" (NPS 2006, sec. 1.4.5).

National park system units vary based on their enabling legislation, natural and cultural resources present, and park missions; likewise, the activities appropriate for each unit and for areas in each unit also vary. For example, an action appropriate in one unit could impair resources in another unit. Thus, this document analyzes the context, duration, and intensity of impacts of the alternatives, as well as the potential for resource impairment, as required by Director's Order 12 (NPS 2001). As stated in the *Management Policies 2006* (sec. 1.4.5), an impact on any park resource or value may constitute an impairment, but an impact would be more likely to constitute an impairment to the extent that it affects a resource or value whose conservation is

- necessary to fulfill specific purposes identified in the establishing legislation or proclamation of the park;
- key to the natural or cultural integrity of the park; or
- identified as a goal in the park's general management plan or other relevant NPS planning documents

The following process was used to determine whether the various deer management alternatives had the potential to impair park resources and values:

- *Step 1* — The enabling legislation and the park's General Management Plan (2005a) were reviewed to ascertain its purpose and significance, resource values, and resource management goals or desired conditions.
- *Step 2* — Resource management goals were identified.
- *Step 3* — Thresholds were established for each resource of concern to determine the context, intensity, and duration of impacts, as defined earlier in this chapter under "Impact Thresholds."
- *Step 4* — An analysis was conducted to determine if the magnitude of impact would constitute an "impairment," as defined by NPS *Management Policies 2006* (NPS 2006).

The impact analysis includes findings of impairment of park resources for each of the management alternatives. Visitor use, park operations and management, and socioeconomic environment are not considered resources per se, although they are dependent on the conservation of park resources. Impairment findings are not included as part of the impact analysis for these topics.

VEGETATION

GUIDING REGULATIONS AND POLICIES

The NPS *Organic Act of 1916* and the NPS *Management Policies 2006* (NPS 2006) direct parks to provide for the protection of park resources. The *Management Policies 2006* state that "the Service will not attempt to solely preserve individual species (except threatened or endangered species) or individual natural processes; rather, it will try to maintain all the components and processes of naturally evolving park ecosystems, including the natural abundance, diversity, and genetic and ecological ecosystems" (NPS 2006, sec. 4.1). The policies further state, "The Service will not intervene in natural biological or physical processes, except … to restore natural ecosystem functioning that has been disrupted by past or ongoing human activities, or when a park plan has identified the intervention as necessary to protect other park resources, human health and safety, or facilities" (NPS 2006, sec. 4.1).

With regard to the restoration of natural systems, the NPS "will reestablish natural functions and processes in parks" and it "will seek to return such disturbed areas to the natural conditions and processes characteristic of the ecological zone in which the damaged resources are situated" (NPS 2006, sec. 4.1.5).

Rock Creek Park's General Management Plan (2005a) includes the following desired conditions that pertain to vegetation:

- native species populations that have been severely reduced ….are restored where feasible and sustainable
- invasive species are reduced in number and areas, or eliminated from natural areas of the park

ASSUMPTIONS, METHODOLOGY, AND INTENSITY THRESHOLDS

Maps showing vegetation cover within Rock Creek Park, communications with NPS staff, and past monitoring data were used to identify baseline conditions within the study area. Available information on the condition and composition of the vegetation in the park was compiled. The primary component of the forest that provides the best indicator of successful forest regeneration is the number of tree seedlings observed and their ability to reach heights above the average deer browsing height (60 inches or 150 centimeters). Thresholds identified for taking management action were based on recent research conducted in habitat similar to that at Rock Creek Park and are based on a certain number of seedlings per monitored plot to indicate the degree of regeneration, as described under "Thresholds for Taking Action" in chapter 2. Therefore, the intensity level for major impacts to woody vegetation was based on a similar threshold, assuming that 67% or more of the monitored plots should have 51 or more seedlings to maintain or achieve good forest regeneration at low (desired) deer densities. But, current deer densities are at high levels. This requires that 67% or more of the plots have 153 tree seedlings. The remainder of the impact thresholds were defined qualitatively, based on professional judgment and observations of vegetation cover.

IMPACT THRESHOLDS FOR WOODY AND HERBACEOUS VEGETATION

Negligible: A reduction in vegetation cover would occur, but the change would be so small that it would not be of any measurable or perceptible consequence. Observed seedling density would indicate that very good regeneration was occurring.

Minor: A reduction in vegetation cover would occur, but it would be small, localized, and of little consequence. Observed seedling density would represent that fair to good regeneration was occurring.

Moderate: Some reduction in vegetation cover would occur, and it would be measurable and of consequence to the resource, but localized. Observed seedling density would represent that poor regeneration was occurring.

Major: A noticeable reduction in vegetation cover would occur. The change would be measurable and would result in a possible permanent consequence to the resource. Observed seedling density would represent that little to no regeneration was occurring. Based on Stout's research, 67% or more of the monitored plots would have fewer than 51 seedlings at low deer densities per plot (appendix A).

AREA OF ANALYSIS

The area of analysis for assessing impacts on vegetation is all of Rock Creek Park. The area of analysis for cumulative impacts is the park and adjacent lands encompass typical deer movement outside the park boundary.

IMPACTS OF THE ALTERNATIVES

ALTERNATIVE A: NO-ACTION ALTERNATIVE (EXISTING MANAGEMENT CONTINUED)

Analysis

Park staff would continue monitoring the deer population and conducting activities to protect rare and unique plant species and landscaping, such as installation of small area protective caging and limited application of repellents.

WOODY VEGETATION. As described in chapter 3, the park has been monitoring woody vegetation growth within the park for over 17 years, with 27 long-term plots established in 1990. In 2000, paired plots (fenced plots paired with unfenced plots) were constructed. Monitoring results have shown that the mean tree seedling stocking rates or weighted measure declined substantially from 1991 through 2003, and all yearly action thresholds were below the 67% stocking rate recommended by Stout's research (appendix A). None of the plots that were measured in 2003 had at least 153 seedlings per plot, which is considered the minimum for successful forest regeneration under high deer densities. Preliminary data from the open long-term plots (2007) show that the stocking rate for 2007 was at 2.26 $\pm$ 0.32%, well below the recommended 67% stocking rate (Hatfield 2008). Under alternative A, it is expected that the deer population would continue at high densities (albeit with yearly fluctuations) and deer would continue to graze on plants to the extent that seedling densities would remain at or below these levels. Any periodic deer population declines would not be low enough or last long enough for forest regeneration to occur or vegetation to fully recover. Based on the most recent monitoring results and the expected high numbers of deer over the life of the plan, alternative A would have long-term, major adverse impacts on woody vegetation due to the amount of deer browsing and the associated reduction in numbers of stems per plot documented by monitoring.

The park has previously caged woody plant species to protect them from deer browsing, including some planted restoration areas and landscaped areas. These caged areas would continue to be maintained. New caging would be used on a limited basis for any newly identified rare species or for landscaping or plantings sensitive to deer browsing. This action would have long-term beneficial impacts on the plants or areas that were protected by prohibiting deer browsing. However, the impact on the majority of park vegetation that was not caged (as well as on vegetation outside the park boundary that is not caged and is

palatable to deer) would continue to be adverse, long term, and major because no measures would be taken to limit or control deer population size or growth under this alternative.

Under this alternative, repellents would continue to be used on a limited basis on landscape plantings. The effectiveness of repellents generally decreases as deer density increases and/or other food availability decreases. Therefore, this action would have short-term, beneficial impacts on plants treated with repellents, but as the deer numbers increased or the food availability in the park decreased, the effectiveness of repellents could be expected to decline. Similar to caging, the impact on the majority of the vegetation within the park that was not treated with repellents would continue to be adverse, long term, and major.

Monitoring vegetation plots and maintaining caged areas would result in very limited trampling of vegetation as staff traveled to and around any caged areas that are not located along trails. However, such impacts would be temporary, as these activities typically take only a few days per year, and the amount of vegetation affected by these actions would be minimal, as they would occur in only a few areas. Therefore, the impact of these activities would be short term, adverse, and negligible.

HERBACEOUS VEGETATION. Under alternative A, the impacts to herbaceous vegetation would be similar to those described for woody vegetation, because no action would be taken to control deer numbers. Based on observations and research conducted within the park, deer browsing has already caused noticeable changes to herbaceous vegetation, including a substantial reduction in plant cover in unfenced plots that can be directly attributed to deer browse (see discussion in Affected Environment - Vegetation). Vegetation outside the park boundary has also been adversely affected to varying degrees, depending on the species. Not controlling the growth of the deer population would result in adverse, long-term, major impacts on herbaceous vegetation, as deer browsing would be expected to cause noticeable changes to the abundance and diversity of herbaceous vegetation throughout the area of analysis.

Activities such as monitoring, caging construction and maintenance, or the application of repellents would not result in any measurable or perceptible change in herbaceous vegetation, resulting in adverse, short-term, negligible impacts. Vegetation within small caged areas would benefit from this level of protection over the long term, and repellent use would have a short-term benefit; however, such benefits would be limited to the small areas of the park.

Cumulative Impacts

Adverse impacts to vegetation within and surrounding the park have occurred and will continue to occur from several actions not related to park operations. Increasing urban development in the areas surrounding the park has resulted in encroachment into park lands and removal of vegetation in limited areas, and adjacent property landscaping has been and continues to be a source of exotic plants that can spread into the park and displace native vegetation, causing long-term minor localized adverse impacts. Acts of vandalism, dumping, illegal camping, and off-trail use, have all had minor localized adverse impacts on vegetation due to trampling and burying of vegetation, or spreading of noxious weed seeds, and will continue to do so in the future. Past fires have affected some areas, which have regrown, but with more nonnative species. Past actions within the park, such as construction of facilities and roads, have resulted in removal of vegetation and adversely affected forest resources to a minor extent in limited areas. Gypsy moths and chestnut blight have had a large, relatively widespread adverse impact in the past, but the park's efforts to control gypsy moths, and other plant diseases and pests, have reversed some of the adverse effects of pests and would continue to benefit forest resources and their ability to naturally regenerate in the future. The park's exotic plant management efforts would also benefit park vegetation in the long term. The future reconstruction of Rock Creek Parkway and continued park maintenance operations would have long-term minor adverse impacts on vegetation, limited to the areas affected. Nearly all off-trail visitor uses affect vegetation to some extent, but some activities like horseback riding, dog walking, and hiking can lead to more social trails and spread of exotic plants. Scientific research such

as vegetation monitoring benefits park vegetation by supplying information needed for management decisions, but even the use of area for monitoring plots limits natural growth in those areas. All of these activities, when combined with the major impacts of continued pressure on forest vegetation (woody and herbaceous) and the limited natural regeneration expected under alternative A because of continued deer browsing, would result in cumulative impacts that would be adverse, long term, and major, since deer would continue to restrict forest regeneration.

Conclusion

Under alternative A, the deer population would remain in excess of the recommended density for forest regeneration and would likely continue to gradually increase with annual fluctuations over the life of the plan, adversely impacting both woody and herbaceous vegetation. As long as the deer population remained in excess of recommended densities for forest regeneration, overall impacts would include decreased plant cover, increased exotic plants, and greatly reduced forest regeneration. Some benefits would be gained from management actions, such as maintaining small caged areas and applying repellents in selected areas; however, the benefits gained would not protect or affect the majority of the park. Although periodic declines in deer population would likely occur due to disease or lack of available food, population records indicate that past population declines have not dropped low enough or lasted long enough for forest regeneration to occur or vegetation to fully recover. The impacts of large numbers of deer browsing on a very large percentage of the park's woody and herbaceous vegetation and consequently limiting natural regeneration would be adverse, long term, and major. Past, present, and future actions, when combined with the continued pressure on forest regeneration expected under this alternative, would result in adverse, long-term, major cumulative impacts.

Current conditions in the park indicate severe adverse impacts on vegetation resources, based on the lack of regeneration found through monitoring. The park's enabling legislation states that the park is to provide for the "preservation from injury or spoliation of all timber, animals, or curiosities within said park, and their retention in their natural condition, as possible." The importance of vegetation is also recognized in the GMP goals for the park, including to "preserve and perpetuate for this and future generations the ecological resources of the Rock Creek valley within the park in as natural condition as possible…" Since alternative A would not reverse the expected long-term continued growth in the deer population, and damage to vegetation would likely continue, it is expected that impairment of vegetation resources would occur over the long term.

ALTERNATIVE B: COMBINED NON-LETHAL ACTIONS

Analysis

Under this alternative, a combination of several non-lethal actions would be implemented to protect forest resources and reduce deer numbers in the park. Actions include the use of large-scale exclosures and reproductive control of does, including both sterilization and reproductive control (assuming it is feasible).

WOODY VEGETATION. The repellents and small caged areas described under alternative A would continue to be used under alternative B. Large fenced exclosures would be constructed under alternative B to allow forest regeneration to occur within enclosed areas of the park that would not be accessible to deer. Approximately 14 exclosures of various configurations to fit the landscape, each encompassing from 7 to 25 acres, would be used throughout the park. The exclosures would eliminate deer presence within a total of 167 acres or about 5% of the park. Protecting these areas from deer browsing would allow native woody species to grow higher than heights reached by deer (60 inches or 150 centimeters) after about 10 years, at which time the exclosures would be moved, and another 5% of the park's vegetation would be enclosed. Although much of the most recent new growth (including seedlings) would be browsed once the surrounding exclosures are moved, many seedlings would be above the height reached by deer and

would not succumb to browsing. Therefore, this action would have a beneficial, long-term impact on up to about 10% of the woody vegetation in the park after 15 years (the life of the plan): 5% inside the existing exclosures at 15 years, and 5% in the original exclosures, which has grown above deer reach. Since 5% to 10% of the forested area would need to be fenced at any one time (Bowersox, pers. comm. 2005) to meet the park's regeneration goals, the actions under alternative B would meet this minimum by protecting 5% at any one time. However, the effect of no browsing protection on woody species in the remaining undeveloped areas of the park would be similar to alternative A. It is expected that monitoring over the life of the plan would continue to show that 67% or more of the long-term unfenced plots would have less than 51 seedlings per plot, resulting in an adverse, long-term, major impact.

Constructing, maintaining, and monitoring the 14 large exclosures would have some impact to the woody vegetation within the park due to the trampling of small tree seedlings and the incidental removal of existing woody vegetation. Even though fences would be located to avoid most trees, some trees would likely need to be removed during construction. Additionally, tree branches within 5 feet of either side of the fence would be removed to avoid branches hitting the fence in high winds or existing dead branches falling on the fence, thus minimizing future maintenance requirements. The area affected during construction would be about 10 acres (0.003%) of the park (45,540 total linear feet for all perimeters × 10-foot-wide cleared area = 455,400 square feet or 10.45 acres). Given the small size of the affected area in relation to the size of the park (about 3,000 acres), and the limited nature of the action, the impact of exclosure construction and maintenance would be adverse, long term, and negligible. Trampling during fence construction and removal of deer from within fenced areas, as well as during monitoring, would have adverse, short-term, negligible impacts, because construction and monitoring would average only a few days per year and affect only a few areas, resulting in very small changes to the herbaceous vegetation that would be very small.

Implementing reproductive control, as described in chapter 2, would have several impacts on vegetation. Sterilization would involve capturing does and taking them to a mobile field station set up to perform the surgical procedure. This would involve setting up a bait station where the deer would congregate to allow for easier trapping or darting, and carrying deer to the field station for the operation. Baited areas would be small, the bait would not remain long, and any uneaten bait would be removed after does had been collected. Construction of bait stations and transporting deer carcasses to the field station could temporarily disturb or trample some vegetation; however, the area of impact would be small, and the baiting and capture procedure would last approximately 45 days. Temporary holding pens may need to be constructed if more does are captured than can be treated in one day, and these would involve minor fence construction and trampling of any vegetation within the pen areas. Assuming reproductive control was used after year 5, impacts to vegetation would be similar, since this would also require setting up bait stations and trapping or darting deer. Impacts to vegetation in the areas around the bait piles and reproductive control operations would be adverse, short term (a few hours to a few days in any location), localized, and negligible.

The effect of reproductive control on the deer population and thus deer browsing could be beneficial. However, the time required for the population to be reduced could be several years; researchers disagree on the amount of time needed to reduce a population size using reproductive controls (Hobbs et al. 2000; Nielsen et al. 1997; Rudolph et al. 2000). The actual amount of time needed to observe a decrease would depend on a number of factors, such as the type of treatment, its effectiveness in stopping reproduction, the size of the population at the time of initial treatment, the actual mortality rate, and the percentage of the population that was treated. Other factors, such as untreated deer moving into the park and treated deer leaving the park, would also influence the time required to achieve reduced numbers. The benefit of this action would be in proportion to the population reduction, with the greatest benefit achieved when the population was lowered to the point where successful forest regeneration could occur. Hobbs et al. described a model where if 90% of the breeding does in the park were effectively treated annually, mortality would need to exceed the number of surviving offspring from the 10% of untreated does to

achieve a population reduction. An average mortality rate in urban/suburban deer populations is 10% (Hobbs et al. 2000). Based on these factors, it is expected that reproductive control could stop population growth, but the park would not be able to reach its initial deer density goal within the life of this management plan using current technology; therefore, forest regeneration would not be expected outside the large exclosures during the life of this plan. A longer time frame would be needed to see results from current reproductive control technology.

HERBACEOUS VEGETATION. Under alternative B, the impacts to herbaceous vegetation would be similar to those described for woody vegetation. The primary impact would result from not taking immediate action to control deer numbers. As described for alternative A, deer browsing has already caused noticeable changes to the herbaceous vegetation, based on observations and research conducted within the park. Providing no immediate reduction or control on the deer population would result in adverse, long-term, major impacts, because deer browsing would continue to cause noticeable changes to the abundance and diversity of herbaceous vegetation throughout the park. Exclosures would provide a beneficial, long-term impact on herbaceous vegetation in about 5% of the park at any one time; however, these benefits would be limited to the park areas that were treated. Reproductive controls would cause the deer population to decline slowly; however the regeneration of herbaceous vegetation outside exclosures is not expected to occur within the life of this plan under alternative B. Therefore, the impact of this action would remain adverse, long term, and major.

Activities such as monitoring, fence construction and maintenance, and administering reproductive control agents would not result in any measurable or perceptible change in the herbaceous vegetation, resulting in adverse, short-term, negligible impacts.

Cumulative Impacts

The same past, present, and future actions described under alternative A would also occur under alternative B. Management actions identified in alternative B, where approximately 5% to 10% of the park's vegetation would be protected from browsing, combined with reproductive control, could reduce the deer density after more than 15 years of implementation and would provide some beneficial impacts over the long term, but not immediately. Large exclosures would give small patches of forest the opportunity to regenerate and reproductive control would eventually help reduce the size of the deer herd, resulting in beneficial impacts that would combine with the beneficial effects of research, exotic plant control, and disease and pest control. However, adverse effects from increased development and other cumulative adverse actions, in conjunction with continued deer browsing pressure on the majority of the woody and herbaceous vegetation and delayed reduction in the deer population, would not be offset by the beneficial effects of proposed actions. Therefore, cumulative impacts to vegetation under this alternative would be adverse, long term, and moderate to major.

Conclusion

Under alternative B, overall approximately 5% of the herbaceous vegetation and up to 10% of the woody vegetation in the park would benefit from constructing exclosures over the life of this plan. Remaining woody and herbaceous vegetation within the park would continue to be adversely affected by deer browsing over the long term until reproductive controls became effective and the population decreased. However, since the benefits of reproductive control would not be fully realized within the life of this plan, overall impacts to woody and herbaceous vegetation would be adverse, long term, and major as the young woody vegetation and herbaceous ground cover decreased in quantity and diversity in the majority of the park. Past, present, and future activities, when combined with the continued pressure on woody and herbaceous vegetation expected under this alternative, would result in long-term, moderate to major adverse cumulative impacts.

Alternative B would provide continued protection of certain areas of the park over the long term, would meet the minimum of protecting 5% to 10% of the park at any one time (Bowersox, pers. comm. 2005), and would introduce reproductive controls that could reduce deer numbers gradually over an extended period of time. Therefore, it is not expected that impairment of vegetation resources would occur under this alternative.

ALTERNATIVE C: COMBINED LETHAL ACTIONS

Analysis

Under alternative C, the deer herd would be reduced through sharpshooting and capture and euthanasia, when appropriate.

WOODY VEGETATION. The repellents and small caged areas described under alternative A would continue to be used under alternative C. No additional caging or repellent use would occur under this alternative. Immediately reducing the deer population would allow natural forest regeneration to occur.

Under this alternative, it is estimated that up to 193 deer (approximately 50% of the herd) would be removed during the first year of sharpshooting in the park. Roughly 50% of the population would be removed in subsequent years until the initial density goal (15 deer per square mile) was achieved, which would occur at the end of year 3 if the beginning deer population was at 2007 levels. It is expected with rapidly reduced deer browsing pressure (dropping from 82 deer per square mile to closer to 15 deer per square mile) would allow the number of tree and shrub seedlings to increase and survive to maturity, providing the necessary growth for natural forest regeneration. The closer the deer density got to 15 deer per square mile, the higher the chance of achieving successful forest regeneration (Bowersox et al. 2002; Horsley et al. 2003; Stout 1999; Marquis et al. 1992).

The conclusion is supported by the long-term unfenced vegetation plot data from the park. As described under alternative A, mean tree seedling stocking rates declined substantially from 1991 through 2003, and none of the plots that were measured in 2003 had at least 153 seedlings per plot at high deer densities. The most recent data from the 26 plots (2007) show that 0 plots had more than 153 seedlings (high deer densities) present, 3 plots had no seedlings present, and 21 plots had less than 10 seedlings each. Providing rapid deer herd reduction and control would result in beneficial long-term impacts on woody vegetation, because deer browsing would be substantially reduced, allowing the abundance and diversity of woody vegetation throughout the park to recover. It is expected that after approximately 10 years, monitoring would show that more than 67% of the plots would have more than 51 seedlings per plot (low deer density, action threshold). Therefore, existing adverse long-term impacts would be reduced from major to moderate and eventually minor levels, with impacts decreasing in intensity over time as regeneration progressed.

A number of other actions would occur as part of sharpshooting, as described in more detail in chapter 2, which would further affect vegetation in limited areas. These actions include setting up bait stations, occupying shooting areas, and dragging deer to locations for processing and transport. Baited areas would be small, the bait would not remain long, and any uneaten bait would be removed after annual sharpshooting efforts had been completed. Sharpshooting might take place from elevated positions, which would require portable tree stands to be temporarily hung in trees. Such portable stands do not damage the tree (no nails or screws) and would not have an adverse impact to woody vegetation. Removing deer carcasses from the kill site could require dragging over vegetation, which would temporarily trample some woody vegetation. All of these actions (bait stations, shooting stations, and dragging deer) would result in some trampling of woody vegetation; however, the area of impact would be small (less than 1% of park vegetation). The impact of trampling under this alternative would be adverse, short term, and negligible.

It is the park's intention to donate as much of the meat as possible to local charitable organizations. If this is done, there would be little waste to be buried or disposed of at an appropriate processing facility. If meat cannot be donated, carcasses may be disposed of in a burial pit that would be constructed in a developed area that has already been disturbed. Disposal pits would be approximately 8 feet wide, 8 feet long, and 5 feet deep. They would be dug prior to direct reduction activities and covered and fenced to prevent entry. Soil removed from the pits would remain onsite and would be covered to prevent erosion. Although these disposal sites could result in the removal of some vegetation, sites would be selected in areas outside historic districts, previously disturbed, and free of trees. Therefore, the impact on woody vegetation would be adverse, short term, and negligible.

Actions related to the capture and euthanasia of deer, which would generally be used in circumstances where sharpshooting would not be appropriate due to safety concerns (e.g., proximity of nearby residences or other occupied facilities), would be similar to those described for sharpshooting in that deer would be removed from the park through lethal means. The difference would be the way in which deer were captured and killed. This method would require physically capturing and handling deer before euthanizing them. Up to 10 deer annually might be taken under this method. Limited trampling would occur with the setting up of traps (rather than setting up bait stations), resulting in adverse, short-term, negligible impacts. Given that this method could be used at any time of the year, and that only up to 10 deer would likely be removed annually, the waste or carcasses would be buried onsite in a previously disturbed area. This would have no noticeable impact on woody vegetation in the park.

HERBACEOUS VEGETATION. Under alternative C, the impacts to herbaceous vegetation would be the same as what was described for woody vegetation. The primary impact within the park would be the result of immediate action taken to control deer numbers. It is expected with rapidly reduced deer browsing pressure, the changes previously observed in herbaceous vegetation would start to reverse, as was found in a number of exclosure studies conducted in the park. Immediately reducing and controlling the growth of the deer population would result in beneficial, long-term impacts on herbaceous vegetation, which could regenerate over time with decreased deer browsing.

Using bait stations, dragging deer carcasses, setting traps, shooting deer, burying waste and/or carcasses, monitoring, and maintaining fences, would not result in any measurable or perceptible change in herbaceous vegetation. These activities would result in adverse, short-term, negligible impacts.

Cumulative Impacts

The same past, present, and future activity impacts described under alternative A would also occur under alternative C. Quickly reducing the park's deer population would provide beneficial, long-term effects, with adverse impacts being reduced to negligible or minor levels over time. These effects, combined with other beneficial effects, would result in cumulative impacts that would be primarily beneficial. These beneficial impacts would somewhat offset the adverse effects from increased development and other cumulative adverse actions. Therefore, cumulative impacts to vegetation under this alternative would be mostly beneficial and long term.

Conclusion

Enhancing natural forest regeneration by quickly reducing deer browsing pressure under alternative C, and by maintaining a smaller deer population through direct reduction, would result in beneficial, long-term impacts because both woody and herbaceous vegetation throughout the park could thrive and recover where effects have been noted. Over time as natural forest regeneration occurred, adverse, long-term, major impacts that could be expected if the deer herd continued unchecked would be reduced to minor levels. Under alternative C, less than 1% of the park's woody or herbaceous vegetation would be affected by trampling at bait stations, shooting sites, trapping locations, or disposal sites. Therefore, adverse impacts of these actions would be short term and negligible. Past, present, and future activities,

when combined with the reduced pressure on woody and herbaceous vegetation and subsequent forest regeneration, would result in beneficial, long-term cumulative impacts. Vegetation resources would not be impaired under this alternative.

ALTERNATIVE D: COMBINED LETHAL AND NON-LETHAL ACTIONS

Analysis

Under alternative D, direct reduction as defined in alternative C would be implemented to reduce the size of the deer herd; once the goal of 15 to 20 deer per square mile was obtained and natural forest regeneration could occur, reproductive control and direct reduction (if needed) would be used to maintain the deer population at the reduced level.

WOODY VEGETATION. The repellents and small caged areas described under alternative A would continue to be used under alternative D, but no additional caging or repellent use would occur under this alternative. As described for alternative C, up to 193 deer (approximately one-half) would be removed during the first year of sharpshooting in the park. Roughly 50% of the population would be removed in subsequent years until the target density goal of 15 deer per square mile was achieved. It is expected with rapidly reduced deer browsing pressure (dropping from about 82 deer to about 15 deer per square mile) the number of tree and shrub seedlings would increase, and the number of seedlings surviving to sapling stage would also increase, providing the necessary growth for natural forest regeneration. The closer the deer density was to 15 to 20 deer per square mile, the higher the chance to achieve successful forest regeneration (Bowersox et al. 2002; Horsley et al. 2003; Stout 1999; Marquis et al. 1992).

Providing immediate reduction and control of the deer population would result in beneficial, long-term impacts on the woody vegetation, because deer browsing would be substantially reduced and the abundance and diversity of woody vegetation throughout the park could thrive and recover. As described for alternative C, it is expected that after approximately 10 years monitoring would show that more than 67% of the plots had more than 51 seedlings per plot (low deer density action threshold – see appendix A). As fair to good regeneration began to occur, the adverse impact level would be reduced from major to moderate and eventually minor.

As described for alternative C, a number of other actions would occur as part of implementing sharpshooting, such as setting up bait stations, occupying shooting areas, and dragging deer carcasses to locations for processing and transport. All of these actions would result in some trampling of woody vegetation; however, the area of impact would be small (less than 1% of vegetation), and the impact would be adverse, short term, and negligible given the small size of the affected area and the short duration of the impact. As forest regeneration increased, more woody stems might be affected by each action; however, the overall amount of vegetation affected would still be small, and the impact would be short term and negligible.

During the sharpshooting process, any waste and/or carcasses of removed deer that would need to be disposed of onsite could result in the removal of some woody vegetation. However, sites selected for disposal would be in previously disturbed areas and free of trees. Therefore, the impact on woody vegetation would be adverse, short term, and negligible.

The actions related to capture and euthanasia could result in trampling of vegetation because of setting up traps (rather than setting up bait stations), with adverse, short-term, negligible impacts. Given that this method could be used at any time of the year, and that only up to 10 deer would be removed by this method, the waste and/or carcasses would likely be buried onsite in a previously disturbed area where woody vegetation would not need to be removed or left to decompose naturally on the surface, so there would be no impact on the woody vegetation in the park.

Reproductive controls would be implemented after direct reduction efforts had initially reduced the population size to maintain the desired deer population level. However, the success of implementing

reproductive controls on a deer population that has undergone several years of direct reduction efforts would depend on technological advances, the sensitivity of deer to humans, methods used by the sharpshooters, changes in immigration with reduced deer density, and general deer movement behavior (Porter et al. 2004; Naugle et al. 2002). It should be expected that getting close enough to administer remote injections would become increasingly difficult after direct reduction efforts due to deer behavior changes in response to previous human interaction. If reproductive control could be successfully implemented, deer numbers could be kept low and impacts on vegetation would be adverse, long term, and minor.

Assuming a park deer population at a density of 15 deer per square mile when reproductive controls were initiated in year 4, there would be a maximum of 69 deer in the park (approximately 4.69 square miles). Assuming that 65% of the deer are does, there would be 45 does in the population. The majority of the does (90%, or 41 does) would need to be treated so that they could be identified for retreatment in successive years. It is estimated that up to 5 deer per day could be treated (taking about 8 days), given the increased effort to locate deer with lower deer numbers. The population would continue to be monitored for growth. If the deer population increased during the reproductive control application under this alternative or if reproductive control was not available, periodic direct reduction would be initiated to maintain the population density at the identified goal.

Some of the actions involved in implementing reproductive control (similar to implementing constructing fences and sharpshooting) could result in trampling of woody vegetation; however, these actions would last only a few hours to a few days in any location, and the adverse effect on vegetation would be negligible.

Assuming that reproductive controls could be used at a parkwide level to maintain the deer population size, impacts on woody vegetation would be beneficial and long term because a substantial reduction in deer browsing would allow the abundance and diversity of woody vegetation throughout the park to recover.

HERBACEOUS VEGETATION. The impacts to herbaceous vegetation under alternative D would be the same as those described for woody vegetation. The primary impact would be the result of actions taken to immediately reduce deer numbers, thus quickly reducing deer browsing pressure and allowing adverse effects on herbaceous vegetation to be gradually reversed, as found in a number of exclosure studies conducted in the park. Using direct reduction and/or reproductive controls to maintain the lowered deer population would allow herbaceous vegetation to continue regeneration through the life of the plan. Long-term impacts on herbaceous vegetation from reduced deer browsing would be beneficial.

Activities such as using bait stations, dragging deer carcasses, setting traps, shooting or treating deer, monitoring, or maintaining fences would not result in any measurable or perceptible change in herbaceous vegetation, so impacts would be adverse, short term, and negligible.

Cumulative Impacts

The same past, present, and future activity impacts described under alternative A would also occur under alternative D. Rapidly reducing the deer population would relieve browsing pressure on the majority of the park's vegetation, providing long-term beneficial impacts and reducing adverse impacts to minor levels. Some adverse impacts would affect woody and herbaceous vegetation as a result of trampling due to setting bait stations, occupying shooting locations, removing deer carcasses, and using traps. However, these impacts would be isolated, affecting less than 1% of the park, resulting in adverse, short-term, negligible impacts.

Rapid deer density reduction would give the forest the opportunity to thrive and regenerate, resulting in beneficial impacts that would combine with other beneficial effects, resulting in cumulative impacts that would be primarily beneficial. These beneficial impacts would somewhat offset the adverse effects from

increased development and other cumulative adverse actions. Therefore, cumulative impacts to vegetation under this alternative would be mostly beneficial and long term.

Conclusion

Enhancing natural forest regeneration by quickly reducing deer browsing pressure under alternative D, and by maintaining a smaller deer population through the use of reproductive control (and direct reduction if needed) would result in beneficial, long-term impacts because both woody and herbaceous vegetation could thrive and recover throughout the park. Over time as natural forest regeneration occurred, adverse, long-term, major impacts would be reduced to minor levels. Under alternative D, less than 1% of the park's woody or herbaceous vegetation would be affected by trampling at bait stations, shooting sites, trapping locations, or disposal sites. Therefore, adverse impacts of these actions would be short term and negligible. Past, present, and future activities, when combined with the reduced pressure on woody and herbaceous vegetation (forest regeneration) expected under this alternative, would result in beneficial, long-term cumulative impacts. Vegetation resources would not be impaired under this alternative.

SOILS AND WATER QUALITY

GUIDING REGULATIONS AND POLICIES

The *Clean Water Act* (33 USC 1251 et seq.) protects and restores the quality of natural waters through the establishment of nationally recommended water quality standards. Under the oversight of the U.S. Environmental Protection Agency (EPA), states administer provisions of the *Clean Water Act* by establishing water quality standards and managing water quality. According to EPA regulations, water quality standards must (1) designate uses of the water; (2) set minimum narrative or numeric criteria sufficient to protect the uses; and (3) prevent degradation of water quality through antidegradation provisions.

As described in chapter 3, in administering the *Clean Water Act*, the District of Columbia has identified Rock Creek and its tributaries for all five beneficial use classes and also as "Special waters of the District of Columbia." It is intended that the water quality of such designated waters be maintained and not allowed to degrade.

In supporting federal and state regulations the NPS *Management Policies 2006* state that the NPS will "take all necessary actions to maintain or restore the quality of surface waters and groundwaters within the parks consistent with the *Clean Water Act* and all other applicable federal, state, and local laws and regulations" (NPS 2006, sec. 4.6.3). The policies also instruct park units to prevent, to the extent possible, the unnatural erosion, physical removal, or contamination of the soil, or its contamination of other resources (NPS 2006, sec. 4.8.2.4).

Rock Creek Park's General Management Plan (2005a) includes the following desired condition that pertains to water quality: surface waters and groundwater are protected or restored such that water quality as a minimum meets all applicable District of Columbia water quality standards.

ASSUMPTIONS, METHODOLOGY, AND INTENSITY THRESHOLDS

Impact intensities for soils and water quality were derived from the available soils information and park staff observations of the effects on soils from loss of vegetation and from water quality observations by park staff. The only aspect of water quality that is being assessed is turbidity, which is primarily affected by sedimentation related to lack of ground cover, assuming that removal of vegetation could result in increased soil erosion, nonpoint runoff, and stream flows. The thresholds for the intensity of an impact are defined as follows.

Negligible: Impacts to soils and water quality would not be detectable or measurable. Water quality would be within historical conditions.

Minor: Soil impacts would be detectable and occur within a small area. Resulting changes in soil erosion rates would cause only detectable and localized impacts to water quality that are within historical or baseline water quality conditions and flows.

Moderate: Impacts to soils would be readily apparent and result in impacts to soil character over a relatively wide area. Resulting changes in soil erosion rates could cause occasional and temporary alterations to historical or baseline water conditions during some storm events.

Major: Impacts to soils would be readily apparent and widespread. Resulting changes in soil erosion rates would cause frequent alterations in the historical or baseline water quality conditions over a large area.

AREA OF ANALYSIS

The area of analysis for assessment of impacts of the various alternatives is the park. For cumulative impacts, the area of analysis is the Rock Creek watershed, which includes the main steam and tributaries in the park and their respective drainage basins.

IMPACTS OF THE ALTERNATIVES

ALTERNATIVE A: NO-ACTION ALTERNATIVE (EXISTING MANAGEMENT CONTINUED)

Analysis

Since no measures would be implemented to actively reduce the size of the deer population under alternative A, loss of vegetative cover would continue to increase as a result of the expected continued high numbers of deer and associated deer browsing. Park staff would continue activities to protect native plants, such as creating small caged areas; however, such small exclosures would do little to protect against soil erosion and may cause deer to browse elsewhere, reducing cover in small areas and exposing soils to erosion. Installation and maintenance of small caged areas would result in negligible adverse impacts to soils. Although the loss of vegetative ground cover park-wide from deer browsing is not currently documented as a problem relating to soils and water quality, it is expected that the deer population would increase or remain at high levels under alternative A over the life of the plan, albeit with periodic decreases that could occur due to variables, such as herd health or weather conditions in any particular year. The expected loss of vegetative ground cover from increased deer browsing over time could eventually result in increased sedimentation and high turbidity if exposed soils are washed away and into surrounding water bodies by heavy rainfall. This would especially affect the smaller tributaries and around seeps and springs, which have less volume of water to dilute the additional sediment load. Therefore, alternative A would result in adverse, long-term, negligible to minor impacts on the soils and water quality of the park.

Cumulative Impacts

Cumulative impacts on soil and water quality would arise not only from activities within the park, but would also be heavily influenced by past, present, and future actions in the areas adjacent to the park. In particular, adverse effects have occurred and continue to occur from the increase in urban development surrounding the park and in upstream areas. As a result, impervious surface runoff and nonpoint pollution that causes siltation and high levels of turbidity and other pollutants in Rock Creek and its tributaries has increased. This has resulted in short- and long-term minor to moderate adverse impacts. The smaller tributaries are especially susceptible to short-term episodes of high siltation and higher impacts because of their lower size and flows. Sewer overflows and leaks have periodically caused short-term minor to moderate adverse impacts on water quality. The District's LTCP to control CSO discharges to the area waterways proposes significant reductions in CSO discharges, as does WASA's 10-year capital improvement program through fiscal year 2010. WASA also has plans to improve some drainage conditions, including separating the combined sewer in Piney Branch to reduce the amount of raw sewage entering the Piney Branch Tributary and mitigating the stormwater flow into Dumbarton Oaks Park by capturing the flow before it enters the park and piping it around the park. The flow would be discharged at a point below the park to reduce stormwater erosion. All these actions would have long-term beneficial impacts on water quality and soil erosion.

Historically, discharges from agricultural activities in the creek headwaters have also affected downstream waters, causing long-term minor to moderate adverse impacts including effects of siltation. Currently, and in the reasonably foreseeable future, Montgomery County is implementing measures to reduce these impacts and improve water quality through use of buffers and other measures, resulting in long-term beneficial impacts on water quality.

Other actions within the park have contributed to soil erosion and stream sedimentation. Off-trail uses, illegal camping, various visitor uses, and park operations and maintenance activities can result in small areas of disturbed soils, causing localized negligible to minor soil erosion and associated adverse impacts on soils and water quality of nearby waters. Dumping can affect water quality, with the impact depending on the type and amount of material dumped, but mostly short-term negligible impacts. Future actions that could cause adverse impacts include utility development and construction of the parkway, which could have adverse, short- and long-term, negligible to minor adverse impacts on soils and water quality.

All of these activities, when combined with the negligible to minor impacts from continued deer browsing and trampling expected under alternative A, would result in cumulative impacts that would be adverse, long term, and minor.

Conclusion

Adverse, long-term, negligible to minor impacts on soils and water quality could result from soil erosion and sedimentation due to loss of vegetation from increased deer browsing, assuming continued high numbers of deer and possible growth in the population over the life of the plan. Past, present, and future activities both inside and outside the park, when combined with the continued pressure on forest resources expected under this alternative, would result in adverse, long-term, minor impacts on soil and water quality. There would be no impairment of park soils or water resources under alternative A.

ALTERNATIVE B: COMBINED NON-LETHAL ACTIONS

Analysis

Several non-lethal actions under alternative B would be implemented in combination to protect forest resources and reduce the park's deer population. Actions include the use of large-scale exclosures and reproductive control of does.

Under alternative B, approximately 14 exclosures, each encompassing 7 to 25 acres, would be used throughout the park to exclude deer from those areas for at least 10 years. This would allow reforestation within the exclosures, so they would be relocated after 10 years to a new area. The use of large exclosures could have both beneficial and adverse impacts on park soils and water quality. Revegetation within the exclosures would help minimize the potential for soil erosion in approximately 5% of the park at any one time. However, exclosures alone would not decrease overall deer browsing pressure within the park, and the benefits of the exclosures might initially be offset by adverse impacts in other areas or result in a change in browsing patterns. The exclosures would be spaced so as to prevent the funneling of deer into certain areas, and they would be relocated periodically. However, deer displaced from the exclosures might still concentrate in other areas of the park. This could have adverse impacts in those areas by further increasing the loss of vegetative ground cover, resulting in increased soil erosion and sedimentation into park streams. Adverse impacts would be long term and minor, gradually shifting to beneficial as more and more of the forest regenerated due to protection afforded by the exclosures.

Continued use of small cages and repellents would probably have little impact mitigating soil erosion and may cause deer to concentrate browsing elsewhere, resulting in increased loss of vegetation in those areas, which could in turn result in localized increased soil erosion and adverse impacts to water quality at negligible levels.

Impacts of reproductive controls would be limited. Short- to long-term negligible to minor adverse impacts could occur from use of temporary holding pens that may need to be constructed if more does are captured than can be treated in one day. Use of these would involve trampling of any vegetation within the pen areas, which could expose soils to erosion. The use of reproductive control could reduce the deer population to a limited extent if it was successfully implemented. Even if all does targeted were treated, reproductive control would take several years to take effect, with a best case scenario of a 5% reduction in population over several years after 90% of the does were treated. However, any reduction in the deer population would help decrease the loss of vegetation due to deer browsing, reduce soil erosion, and would be beneficial in the long term to water quality.

Cumulative Impacts

The cumulative impacts under alternative B would be similar to those under alternative A, because the same past, present, and future activities are expected under both alternatives. The beneficial long-term impacts on soil and water quality of alternative B would slightly offset some of the adverse cumulative impacts; however, the majority of the watersheds for the park's creeks lie outside the park, where impacts might or might not be mitigated. Therefore, actions under alternative B would offset only a very small part of the overall cumulative impacts, which would continue to be adverse, long term, and minor.

Conclusion

Adverse, long-term, minor impacts to soils and water quality could occur if deer displaced by the fenced exclosures concentrated in other areas of the park, resulting in increased loss of vegetation in those areas and a potential increase in soil erosion. These impacts would gradually shift to beneficial in the long term as reforestation occurred in the large exclosures, potentially reducing soil erosion. Beneficial long-term impacts would also result from decreased vegetation loss and associated erosion and sedimentation from exposed soils, as reproductive control of the deer population would gradually reduce deer numbers over time. Cumulative impacts would be adverse, long term, and minor due to the large portion of the creeks' watersheds that are outside the park boundary, and beneficial long-term impacts occurring inside the park would offset cumulative impacts only slightly. There would be no impairment of park soils or water resources under alternative B.

Alternative C: Combined Lethal Actions

Analysis

Sharpshooting and capture and euthanasia, where appropriate, would be used to immediately reduce the number of deer within the park and to maintain sustainable deer population of 15 to 20 deer per square mile after the third year of implementation. A smaller deer herd would allow reforestation to occur throughout the park and for woody and herbaceous vegetative cover to recover, because deer browsing pressure would be decreased. Regrowth of vegetative ground cover would reduce the potential for soil erosion and sedimentation of park streams, resulting in beneficial, long-term impacts on soils and water quality.

Continued use of small cages and minimal use of repellent would probably have little impact mitigating soil erosion and may cause deer to concentrate browsing elsewhere, resulting in increased loss of vegetation in those areas, a negligible adverse effect.

Cumulative Impacts

The cumulative impacts from alternative C would be similar to those for alternatives A and B, but with a slightly greater beneficial effect from the immediate reduction of deer numbers and the maintenance of a smaller sustainable deer population (15 to 20 deer per square mile) after the fourth year of implementation. However, as with alternative B, the beneficial impacts of this alternative would only

slightly offset some of the cumulative adverse impacts, since the majority of the watersheds affected lie outside the park where impacts may or may not be mitigated. Therefore, the combined actions of alternative C with other past, present, and future activities would result in adverse, long-term minor impacts.

Conclusion

Beneficial, long-term impacts on soils and water quality would result from immediately reducing the number of deer in the park and maintaining a sustainable population of 15 to 20 deer per square mile after the third year of implementation. Vegetative ground cover would be able to reestablish itself, helping reduce soil erosion and sediment loading in the park's creeks. Cumulative impacts would be adverse, long term, and minor due to the large portion of the creeks' watersheds occurring outside the park boundary; the beneficial, long-term impacts of alternative C would offset cumulative impacts only slightly. There would be no impairment of park soils or water resources under alternative C.

ALTERNATIVE D: COMBINED LETHAL AND NON-LETHAL ACTIONS

Analysis

Under alternative D, direct reduction would be used to initially reduce the number of deer within the park and reproductive control of does (and direct reduction if needed) would then be used to maintain a sustainable population of approximately 15 to 20 deer per square mile after the third year of implementation. The reduction and long-term maintenance of a small herd would allow vegetative ground cover to reestablish itself throughout the park and potentially reduce soil erosion, providing beneficial, long-term impacts on the soils and water quality of the park.

Continued use of small cages and repellents would probably have little impact mitigating soil erosion and may cause deer to concentrate browsing elsewhere, resulting in increased loss of vegetation in those areas, a negligible adverse effect. Therefore, overall impacts under alternative D would be beneficial and long term.

Cumulative Impacts

Cumulative impacts to soils and water quality under alternative D would be very similar to those described for alternative C, with the beneficial, long-term effects on soils and water quality resulting from the relatively rapid reduction of deer numbers and the long-term maintenance of a smaller deer herd over the life of the plan. However, as with alternative C, these beneficial effects would only slightly offset the other adverse cumulative impacts occurring outside the park boundary, where the majority of the park watersheds occur. Adverse activities on adjacent lands might or might not be mitigated. Overall the cumulative impacts would be adverse, long term, and minor.

Conclusion

Impacts on soil and water quality would be beneficial and long term as a result of immediately reducing the number of deer in the park and maintaining a population of 15 to 20 deer per square mile after the third year of implementation. Vegetative ground cover would be able to reestablish itself, helping mitigate any soil erosion and sediment loading into the park's creeks. Cumulative impacts would be adverse, long term, and minor due to the large portion of the creeks' watersheds that occur outside the park boundary, where adverse actions might or might not be mitigated; the beneficial, long-term impacts of the alternative D actions in the park would only slightly offset cumulative impacts outside the park. There would be no impairment of park soils or water resources under alternative D.

WETLANDS AND FLOODPLAINS

GUIDING REGULATIONS AND POLICIES

As described in chapter 1, two federal executive orders (EO), EO 11990 (Protection of Wetlands) and EO 11988 (Floodplain Management) direct federal agencies to avoid adverse impacts to floodplains and wetlands. Director's Order 77-1 establishes policies, requirements, and standards for implementing EO 11990, while Director's Order 77-2 applies to all NPS proposed actions that could adversely affect the natural resources and functions of floodplains. This order states that when it is not practicable to locate or relocate development or inappropriate human activities to a site outside and not affecting the floodplain, the NPS will prepare and approve a Statement of Findings (SOF), in accordance with procedures described in Procedural Manual 77-2: Floodplain Management, and take all reasonable actions to minimize the impact to the natural resources of floodplains. Similarly, if adverse impacts to wetlands would occur from a proposed project, a SOF is prepared, unless the actions are accepted for various reasons provided in Procedural Manual 77-1, section 4.2(A). As described more fully below in the analysis, the actions proposed to mange the deer population would not adversely impact wetlands or floodplains, and no SOF were required for this project.

NPS *Management Policies 2006* specifically address wetlands and floodplains in sections 4.6.4 and 4.6.5, respectively. The policies provide protective provisions for wetlands and floodplains that reiterate the language in the DOs discussed above (NPS 2006).

ASSUMPTIONS, METHODOLOGY, AND IMPACT THRESHOLDS

National Wetland Inventory (NWI) wetland maps and Federal Emergency Management Agency (FEMA) floodplain maps and communications with NPS staff were used to identify baseline conditions for the analysis.

The thresholds for the intensity of an impact on wetlands and floodplains are defined as follows:

Negligible: The structure and function of wetlands or floodplains would not be affected; effects would either be nondetectable, or, if detected, would be considered slight and localized. No measurable or perceptible effects on size, integrity, or connectivity of wetlands would occur.

Minor: Effects on the structure or function of wetlands or floodplains would be measurable, although the effects would likely be small and localized. A small effect on size, integrity, or connectivity of wetlands would occur; however, the overall viability would not be affected. If left alone, an adversely affected wetland would recover and the impact would be reversed. No mitigation measures associated.

Moderate: Effects on the structure or function of wetlands or floodplains would be measurable, but would be relatively localized. The impact would be sufficient to cause a measurable effect on either the size, integrity, connectivity of wetlands or would result in a permanent loss or gain in wetland acreage, but not to large areas. Mitigation could be required and if implemented, would likely be successful.

Major: Effects on the structure or function of wetlands or floodplains would be readily measurable, would have substantial consequences, and would be observable over a relatively large area. The character of the floodplain would be changed so that the functions typically provided by the floodplain would be substantially changed. The impact would result in a measurable effect on wetland size, integrity, and connectivity or a permanent loss or gain of large wetland areas. The character of the wetland would be changed so that the functions typically provided by the wetland would be substantially altered. Mitigation would be required and its success could not be assured.

IMPACTS OF THE ALTERNATIVES

ALTERNATIVE A: NO-ACTION ALTERNATIVE (EXISTING MANAGEMENT CONTINUED)

Analysis

Loss of vegetative cover under alternative A would continue to increase as a result of the expected continued high numbers of deer and associated deer browsing, since no measures would be implemented to actively reduce the size of the deer population. Since the deer population would increase or remain at high levels under alternative A over the life of the plan, continued loss of vegetative ground cover and a change in the floodplain forest composition and structure would be expected from increased deer browsing over time in these wetland areas. In forested wetlands, there are some species that are browsed by deer (e.g., young tulip poplar [*Liriodendron tulipifera*] and most herbaceous plants), but other common species (e.g., sycamore]*Platanus occidentalis*]) are not as palatable as some of the upland species (e.g., white oak (*Quercus alba*) and beech (*Fagus grandifolia*); USFS 2008). Based on the past impacts and the expected high numbers of deer over the life of the plan, alternative A would have long-term, moderate adverse impacts on wetland woody and herbaceous vegetation due to the amount of deer browsing.

Small wet areas (springs and seeps and vernal pools) could also be adversely affected by high deer density, if deer trample these areas while passing through or seeking water sources, causing siltation and erosion in these areas, or if the more intense browsing reduces pool vegetation cover or opens up the canopy, which could allow these pools to dry up faster. Impacts would likely be very localized and minor to moderately adverse, depending on the amount of deer present in specific areas.

The park has previously caged woody plant species to protect them from deer browsing, including several in riparian areas that may be small wetlands. These caged areas would continue to be maintained, and construction and maintenance of these caged areas would have negligible adverse impacts in the area of construction. New caging would be used on a limited basis for any newly identified rare species or plantings sensitive to deer browsing. This action would have long-term beneficial impacts on the plants or areas in wetlands that were caged by prohibiting deer browsing. However, the impact on the remainder of park vegetation that was not caged would continue to be adverse, long term, and moderate to major because no measures would be taken to limit or control deer population size or growth under this alternative.

No occupancy, modification, or development of floodplains is expected under alternative A, other than the small caging described above. The removal of ground vegetation through deer browsing could have the potential to increase stormwater runoff and flood events, but this would likely have a negligible to minor adverse impact on overall floodplain functioning.

Cumulative Impacts

Cumulative impacts on wetlands and floodplains would occur from many of the same actions both inside and outside the park that would affect water quality and vegetation, as previously described. Upstream and surrounding urban development has increased impervious surface runoff that can cause periodic washouts and/or siltation of smaller wetland areas in tributaries and increase flooding, and this is expected to continue into the future. Rock Creek has experienced a large flood event about every five years, and the last major flood (June 2006) caused extensive damage in the park, so impacts to floodplain function have been periodic, but continuing over the long term, moderate and adverse. Most wetland vegetation that naturally occurred along Rock Creek has been eliminated and replaced with seeded and transplanted species as the land was developed, resulting in long-term, minor to moderate adverse impacts. The number of vernal pools in the park today has been reduced from the pre-urbanization era because of past draining or filling activities, stream bed scouring from increased runoff that has resulted from development in the watershed upstream from the park, and lowered water tables from incising of the stream channel or urban groundwater use, resulting in long-term moderate adverse effects on these sensitive areas.

Other actions within the park have contributed to lesser impacts on wetlands and floodplains, including off-trail uses and various visitor uses, such as horseback riding that can disturb floodplain and wetland soils and vegetation. Dogs that are allowed to run free disrupt wetland ground cover and soils and help spread noxious weeds in the floodplain. Dumping in these locations can affect water quality and the ecological integrity of wetland areas and introduce foreign materials into the system, which could be carried away during flooding. Impacts would depend on the type and amount of material dumped, but mostly short-term localized negligible impacts would be expected. Park operations and maintenance activities can result in small areas of disturbed soils or vegetation, causing localized negligible to minor adverse impacts on wetlands. Structures have been located in the 100-year floodplain, although with little impact on floodplain functioning. Future actions that could cause adverse impacts to floodplains include reconstruction of the parkway, which could have short- and long-term, negligible to minor adverse impacts due to the increase in imperious surface and amount of runoff.

All of these activities, when combined with the moderate impacts to wetlands and negligible to minor to floodplains from continued deer browsing and trampling expected under alternative A, would result in cumulative impacts to wetlands and floodplains that would be adverse, long term, and moderate.

Conclusion

Adverse, long-term, moderate impacts on wetlands and floodplains could result from soil erosion and sedimentation due to loss of vegetation from increased deer browsing, disturbance to small wetland areas and vernal pools from deer trampling and vegetation loss, and changes in species composition, assuming continued high numbers of deer and possible growth in the population over the life of the plan. Past, present, and future activities both inside and outside the park, when combined with the continued pressure on forest resources expected under this alternative, would result in adverse, long-term, moderate impacts on wetlands and floodplains. Because the effects of this alternative would not physically affect the floodplain and the floodplain plant community would continue to exist, although with an altered species composition, there would be no impairment of park wetlands or floodplains under alternative A.

ALTERNATIVE B: COMBINED NON-LETHAL ACTIONS

Analysis

Several non-lethal actions under alternative B would be implemented in combination to protect forest resources and reduce the park's deer population. Actions include the use of large-scale exclosures and reproductive control of does.

Under alternative B, approximately 14 exclosures would be used to exclude deer from certain areas in order to allow reforestation to occur. Each exclosure would encompass 7 to 25 acres and would be located throughout the park for at least 10 years, after which time the exclosures would be relocated. Several of these are proposed to be located specifically to protect the forested wetland areas and the associated 100-year floodplains located in the northern portion of the park (see figure 6). The use of large exclosures could have both beneficial and adverse impacts on park wetlands and floodplains. If positioned to enclose wetlands, there would be no direct impacts to wetlands from the construction of the fencing, and revegetation within the exclosures would help minimize the potential for soil erosion and increase vegetation cover in approximately 5% of the park at any one time. However, exclosures alone would not decrease overall deer browsing pressure within the park and the benefits of the exclosures in one location might initially be offset by adverse impacts in other wetland areas. Also, when the exclosures are moved, all herbaceous wetland vegetation would be subject to deer browsing again. Adverse impacts from the use of the exclosures would be long term and negligible to minor, and the protection of these forested wetland areas would have long-term beneficial impacts as more and more of the woody vegetation is regenerated due to protection afforded by the exclosures.

As described under the "Vegetation" topic, the use of reproductive control could reduce the deer population to a limited extent if it was successfully implemented. However, even if all does targeted were treated, reproductive control would take several years to take effect, with a best case scenario of a 5% reduction in population over several years after 90% of the does were treated (Hobbs et al. 2000). Therefore, adverse impacts to wetland vegetation structure and species composition and to smaller wetlands that are not protected by exclosures would continue to occur over the long term, with intensity depending on site-specific conditions. However, any reduction in the deer population would help decrease the loss of vegetation due to deer browsing and would be beneficial in the long term.

No modification or development of floodplains is expected under alternative B, but the exclosures would be constructed within the 100-year floodplain at several locations where the areas to be protected are forested wetlands or lie in riparian areas. The permanent placement of posts and fencing would present a potential for affecting flood characteristics in local areas if flood debris would catch on these and obstruct the natural flow of water during flood events. This would likely have a negligible adverse impact on overall floodplain functioning, but could result in short-term, minor adverse impacts on flooding during storm events.

Cumulative Impacts

Management actions identified in alternative B, where a few forested wetlands would be protected from browsing, combined with reproductive control, could reduce the deer density after more than 15 years of implementation, would provide some beneficial impacts over the long term, but not immediately. Large exclosures would give certain areas of forested wetlands the opportunity to regenerate, and the exclosures would also keep out trespassing dogs, a long-term benefit. However, adverse effects from increased development and other past cumulative adverse actions, in conjunction with continued deer browsing pressure and possible trampling effects on the other wetlands areas, would not be offset by the beneficial effects of proposed actions. Therefore, cumulative impacts to wetlands under this alternative would be adverse, long term, and moderate.

Conclusion

Use of exclosures to protect many of the park's forested wetlands would gradually result in beneficial long-term impacts to wetlands and many vernal pools located in fenced areas, as reforestation occurred in the large exclosures, although continued long-term minor to moderate adverse impacts would be expected in areas that are not fenced and in smaller wetland areas and seeps. Beneficial long-term impacts would also result from decreased vegetation loss as reproductive control of the deer population would gradually reduce deer numbers over time. Construction of exclosures within the 100-year floodplain would likely

have a negligible adverse impact on overall floodplain functioning, but could result in short-term, minor adverse impacts on the floodplain. Past, present, and future activities both inside and outside the park, when combined with the effects expected under this alternative, would result in adverse, long-term, moderate impacts on wetlands and floodplains. There would be no impairment of park wetlands or floodplains under alternative B.

ALTERNATIVE C: COMBINED LETHAL ACTIONS

Analysis

Sharpshooting and capture and euthanasia, where appropriate, would be used to immediately reduce the number of deer within the park and to maintain sustainable deer population of 15 to 20 deer per square mile after the third year of implementation. A smaller deer herd would allow reforestation to occur throughout the park and for woody and herbaceous vegetative cover to recover, including within wetland areas, and would limit the damage from deer trampling in smaller wetland areas, resulting in beneficial, long-term impacts on wetlands.

No occupancy, modification, or development of floodplains is expected under alternative C, other than possibly some of the small caging around specific landscape or rare plants if these were located within wetlands or floodplains. The removal of ground vegetation through deer browsing would be greatly reduced, with long-term, beneficial effects on overall floodplain functioning.

Cumulative Impacts

The cumulative impacts from alternative C would be similar to those for alternatives A and B, but with a slightly greater beneficial effect from the immediate reduction of deer numbers and the maintenance of a smaller sustainable deer population (15 to 20 deer per square mile) after the third year of implementation. However, as with alternative B, the beneficial impacts of this alternative would only slightly offset some of the cumulative adverse impacts, since the majority of the impacts to wetlands and flooding have occurred from past actions and upstream development. Therefore, the combined actions of alternative C with other past, present, and future activities would result in long-term, minor to moderate adverse impacts.

Conclusion

Beneficial, long-term impacts on wetlands and floodplains would result from immediately reducing the number of deer in the park and maintaining a sustainable population of 15 to 20 deer per square mile after the third year of implementation. Vegetative ground cover would be able to reestablish itself, reducing flooding velocities and adding to the ecological value of wetland areas. Cumulative impacts would be adverse, long term, and minor to moderate due mainly to past actions, and the beneficial, long-term impacts of alternative C would offset cumulative impacts only slightly. There would be no impairment of park wetlands or floodplains under alternative C.

ALTERNATIVE D: COMBINED LETHAL AND NON-LETHAL ACTIONS

Analysis

Under alternative D, direct reduction would be used to initially reduce the number of deer within the park, and reproductive control of does (and direct reduction, if needed) would then be used to maintain a sustainable population of approximately 15 to 20 deer per square mile after the third year of implementation. The reduction and long-term maintenance of a small herd (either through sharpshooting or reproductive control) would allow vegetative ground cover to reestablish itself in wetland areas, as well as in other areas of the park, and would limit the damage from deer trampling in smaller wetland areas, resulting in beneficial, long-term impacts on wetlands.

Similar to alternative C, no occupancy, modification, or development of floodplains is expected under alternative D, other than possibly some of the small caging around specific landscape or rare plants if these were located within wetlands or floodplains. The removal of ground vegetation through deer browsing would be greatly reduced, with long-term, beneficial effects on overall floodplain functioning.

Cumulative Impacts

Cumulative impacts to wetlands and floodplains under alternative D would be very similar to those described for alternative C, with the beneficial, long-term effects on soils and water quality resulting from the relatively rapid reduction of deer numbers and the long-term maintenance of a smaller deer herd over the life of the plan. However, as with alternative C, these beneficial effects would only slightly offset the other adverse cumulative impacts from other past actions and overall cumulative impacts would be adverse, long term, and minor to moderate.

Conclusion

Beneficial, long-term impacts on wetlands and floodplains would result from immediately reducing the number of deer in the park and maintaining a sustainable population of 15 to 20 deer per square mile after the third year of implementation. Vegetative ground cover would be able to reestablish itself, helping reduce flooding velocities and adding to the ecological value of wetland areas. Cumulative impacts would be adverse, long term, and minor to moderate due mainly to past actions, and the beneficial, long-term impacts of alternative D would offset cumulative impacts only slightly. There would be no impairment of park wetlands or floodplains under alternative D.

WILDLIFE AND WILDLIFE HABITAT

GUIDING REGULATIONS AND POLICIES

The NPS *Organic Act of 1916*, NPS *Management Policies 2006* (NPS 2006), and NPS *Reference Manual 77: Natural Resource Management* (NPS 1991) direct NPS managers to provide for the protection of park resources. The *Organic Act* requires that wildlife be conserved unimpaired for future generations, which has been interpreted to mean that native animal life are to be protected and perpetuated as part of a park unit's natural ecosystem. Parks rely on natural processes to control populations of native species to the greatest extent possible; otherwise, they are protected from harvest, harassment, or harm by human activities. The NPS *Management Policies 2006* make restoration of native species a high priority. Management goals for wildlife include maintaining components and processes of naturally evolving park ecosystems, including natural abundance, diversity, and ecological integrity of plants and animals (NPS 2006, sec. 4.1). Policies in the NPS *Natural Resource Management Guideline* state, "the National Park Service will seek to perpetuate the native animal life as part of the natural ecosystem of parks" and that "native animal populations will be protected against . . . destruction . . . or harm through human actions."

Rock Creek Park's General Management Plan (2005a) includes the following desired conditions that pertain to wildlife:

- native plant and animal species function in as natural condition as possible, except where special management considerations are allowable under policy
- native species populations that have been severely reduced or extirpated are restored where feasible and sustainable
- invasive species are reduced in numbers and area or eliminated from natural areas of the park

ASSUMPTIONS, METHODOLOGY, AND INTENSITY THRESHOLDS

The evaluation of wildlife (including deer) was based on a qualitative assessment of how expected changes to park vegetation (as a result of increased or decreased deer browsing pressure), or management actions themselves, would affect both the deer population and other park wildlife or wildlife habitat. The park's wildlife species are directly affected by the natural abundance, biodiversity, and the ecological integrity of the vegetation that comprises their habitat. For purposes of this plan/EIS, impacts to deer were assessed separately from impacts to other wildlife species, but using the same basic methodology and impact thresholds.

Available information on known wildlife, including unique or important wildlife or wildlife habitat, was compiled and analyzed in relation to the management actions. The thresholds for the intensity of an impact were defined as follows:

Negligible: There would be no observable or measurable impacts to native species, their habitats, or the natural processes sustaining them.

Minor: Impacts on native species, their habitats, or the natural processes sustaining them may not be detectable, and changes to population numbers, population structure, or other demographic factors would not occur. Occasional responses to disturbance by some individuals could be expected, but without interference to factors affecting population levels. Sufficient habitat would remain functional to maintain viability of all species. Impacts would be outside critical reproduction periods for sensitive native species.

Moderate: Impacts on native species, their habitats, or the natural processes sustaining them would be detectable, and changes to population numbers, population structure, or other demographic factors would occur, but species would remain stable and viable. Frequent responses to disturbance by some individuals could be expected, with some negative impacts to factors affecting population levels. Sufficient habitat would remain functional to maintain the viability of all native species. Some impacts might occur during critical periods of reproduction or in key habitat.

Major: Impacts on native species, their habitats, or the natural processes sustaining them would be detectable and extensive. Population numbers, population structure, or other demographic factors might experience large declines. Frequent responses to disturbance by some individuals would be expected, with negative impacts to factors resulting in a decrease in population levels. Loss of habitat might affect the viability of at least some species.

AREA OF ANALYSIS

The area of analysis for assessment of impacts is Rock Creek Park. The area of analysis for cumulative impacts is the park and the areas that encompass typical deer and wildlife movement outside the park boundary.

IMPACTS OF THE ALTERNATIVES ON THE WHITE-TAILED DEER (*ODOCOILEUS VIRGINIANUS*) POPULATION

ALTERNATIVE A: NO-ACTION ALTERNATIVE (EXISTING MANAGEMENT CONTINUED)

Analysis

Under this alternative, park staff would continue monitoring the deer population and use some controls to protect important resources, none of which would reduce the size of the deer population in the park. The actions under this alternative would be very limited and would reflect what is occurring today. With no control on the deer population, the population would continue to vary depending on conditions; however, the general trend toward increased numbers would continue. In addition, the park would continue to conduct activities to protect sensitive plant species. As additional rare understory plant species are found within the park, they would be protected with additional caging, which would further limit potential food sources for park deer, but at a very small scale, a negligible adverse effect.

Under alternative A, the deer population in Rock Creek Park would continue to degrade the ground/shrub habitat that is important to deer. As detailed in the previous “Vegetation” section, the deer population would remain in excess of the recommended density for forest regeneration and may increase over time. This would adversely impact the abundance and diversity of native vegetation, including woody and herbaceous plants that provide forage and habitat for deer. High density deer populations that have reached or exceeded the ability of the natural environment to support them are at increased risk for disease and substantial losses due to malnutrition and parasitism, particularly during harsh winters. High deer density populations would also increase the potential for the spread of CWD, if the disease should occur near the park in the future.

Starvation and poor reproduction demonstrated by deer in overpopulated herds is not evidence that the herd is regulating itself. Starvation and disease are not acute mortality factors, such as predation, but

rather provide only chronic control over a population (Eve 1981, as cited in Warren 1991). Under these conditions, deer herds can remain at high levels for many years until starvation, disease, or severe winter weather cause a reduction in population size typically lasting two to five years. By this time, adverse ecological effects can already have occurred. Such reductions in the deer herd, as a result of natural die-offs, probably would not allow recovery of the natural community (Warren 1991).

It is expected that unchecked growth of the deer population under alternative A would continue to result in the degradation of habitat and loss of food sources. There would also be increased loss of deer through vehicle collisions, which would have adverse impacts on individual deer, but could keep deer numbers lower. The limitation on available forage and the high density would make individuals susceptible to starvation and to the spread of diseases such as EHD, which has been reported in locations near the park. Impacts could be severe, but the intensity of effects would depend on the level of stress incurred, and this would be related to how much forage the deer would find outside the park. Therefore, although impacts could be more severe, given the current condition of deer herd condition and the likelihood that deer would continue to seek food on neighboring properties, it is expected that alternative A would have long-term, moderate adverse impacts on the deer population.

Cumulative Impacts

Impacts on deer from vehicle collisions and poaching, as well as disturbances from traffic, visitor use (including off-trail users and social trails), illegal camping, and the presence of unrestrained pets would all continue to have long-term, minor adverse impacts by displacing deer and potentially causing some mortality. Although wildlife diseases do not appear to be affecting deer at this time, the potential for these diseases, especially those like CWD and EHD that could affect deer populations, could also contribute to long-term adverse impacts on deer. The return of coyotes to the area could have limited beneficial effects on deer, as they are not expected to influence the population size to such an extent that it would reduce the effects of deer browse on habitat provided in the park. Deer management plans and programs of local, state, and other federal agencies also contribute to long-term, beneficial effects by helping maintain deer densities at lower levels; however, the effects of these programs are limited as evidenced by the continued growth of the deer population at Rock Creek Park. In fact, these programs may actually cause deer to move into the park where there is less pressure, thereby contributing to park deer population growth and associated effects of browsing on the degradation of deer habitat.

Actions resulting in cumulative impacts to deer habitat would be similar to those described for vegetation, since vegetation comprises the habitat that affects deer to a great extent. Urban development in the areas surrounding the park that result in encroachment into park lands and removal of vegetation that provides deer habitat in limited areas have caused, and will continue to cause, long-term minor localized adverse impacts. Acts of vandalism, dumping, illegal camping, and off-trail use have all had minor localized adverse impacts on deer habitat due to trampling and burying of vegetation, or spreading of noxious weed seeds, and will continue to do so in the future. Past fires have affected some areas, which have regrown but with more nonnative species. Past actions within the park, such as construction of facilities and roads, have resulted in removal of vegetation and adversely affected forest resources that support deer to a minor extent in limited areas. Gypsy moths have been a threat, but the park's efforts to control gypsy moths have minimized their impact to deer habitat. The park's exotic plant management efforts would also benefit deer habitat in the long term by removing plants that compete with native species. Continued park maintenance operations would have long-term minor adverse impacts on edge habitat for deer, limited to the areas affected. Any off-trail visitor uses affect deer habitat to some extent, but particular activities like horseback riding, dog walking, and hiking can lead to more social trails and spread of exotic weed seeds. Scientific research benefits park vegetation and deer habitats by supplying information needed for management decisions, but even the use of an area for research plots limits natural growth in those areas. All of these activities, when combined with the moderate adverse impacts to the deer population from the continued pressure on woody and herbaceous vegetation that makes up the deer habitat and the limited

natural regeneration expected under alternative A, because of continued deer browsing, would result in cumulative impacts that would be adverse, long term, and moderate.

Conclusion

Under alternative A, there would be no control on the growth of the deer population, which would result in long-term, moderate adverse impacts on the deer population. These impacts would continue due to excessive deer browsing that would degrade habitat and limit food sources. Past, present, and future activities, when combined with the continued pressure on vegetative resources and deer habitat expected under this alternative, would result in adverse, long-term, moderate cumulative impacts. Although impacts to deer under alternative A could be severe, they would not approach the level of impairment over the long term.

ALTERNATIVE B: COMBINED NON-LETHAL ACTIONS

Analysis

Under this alternative, several non-lethal actions would be implemented in combination to protect deer habitat and reduce deer numbers in the park. Actions include the use of large, fenced exclosures and reproductive control of does. Small caged areas and repellents would be implemented with negligible adverse impacts on deer food sources, as described under alternative A.

Use of large-scale exclosures and repellents would protect some deer habitat, but would exclude deer from potential food sources in approximately 5% to 10% of the park at any given time. Areas outside the exclosures would be affected by heavy deer browsing, which would have similar effects to those discussed under alternative A, including the degradation of habitat and loss of food sources. As a result, there would be long-term, moderate to major, adverse impacts on deer habitat and associated adverse impacts on the deer population.

If successfully implemented, surgical sterilization, supplemented by the use of reproductive controls when feasible (see chapter 2), would help reduce the impact on deer by gradually decreasing their numbers and allowing habitat to improve over time. Researchers disagree on the amount of time needed to reduce a population size using reproductive controls (Hobbs et al. 2000; Nielsen et al. 1997; Rudolph et al. 2000); however, the time required to see results could be several years. A number of factors may influence the efficacy and reduction period of this method, including the amount of immigration/emigration of deer to/from the park, availability of veterinarian and surgical facilities (at zoo or mobile field unit), mortality and recruitment rates, the size of the population at the time of initial treatment, and the percentage of the population treated. Other factors, such as untreated deer moving into the park and treated deer leaving the park, would also affect the time required to reduce herd numbers. The benefit of this action would be proportional to the amount of population reduction that it provided; therefore, a benefit could not actually be established until an improvement in vegetation and deer habitat was observed. Hobbs et al. (2000) described a model where if 90% of the breeding does in the park were effectively treated annually, mortality would need to exceed the number of surviving offspring from the 10% of untreated does in order to achieve a population reduction. An average mortality rate in urban/suburban deer populations is 10% (Hobbs et al. 2000). Based on these factors, it is expected that reproductive controls could stop population growth, but the park would not be able to reach its initial deer density goal within the life of this management plan using current technology. Therefore, impacts to deer habitat and deer would not be offset by this alternative and would continue to be adverse, long term, and moderate from degradation and the loss of food sources. Also, continued high deer densities could increase the potential for the spread of CWD, if it were detected near the park in the future.

Specific effects of surgical sterilization on breeding and social behavior (extended rut) that result from the associated loss of reproductive hormones are not well documented. But deer would be expected to react in a similar way to deer that have been treated with reproductive control agents (see the “Reproductive

Control" section of chapter 2 and appendix C). The intensity of long-term effects of implementing reproductive control on a free ranging deer herd is difficult to predict given the many variables. The effect on individual deer may be considered a major adverse impact, due to handling stress and the possible physiological or behavioral changes due to the use of sterilization and reproductive control agents. However, it is expected that the long-term adverse affect on the population would be minor to moderate, as the adverse impacts over time would be offset by the beneficial effect of population reduction.

Cumulative Impacts

The same past, present, and future activity impacts described under alternative A would also occur under alternative B. Management actions identified in alternative B, where approximately 5% to 10% of the park's vegetation would be protected from browsing, plus reproductive control would provide beneficial effects over the long term, but not immediately. Large exclosures would give small patches of deer habitat the opportunity to recover, and reproductive control could eventually help reduce the size of the deer herd, resulting in beneficial impacts that would combine with the beneficial effects of the return of coyotes, other deer management programs, control of gypsy moths and other plant diseases and pests, exotic plant management, and scientific research. However, adverse effects from continued development and other cumulative adverse actions described for alternative A, in conjunction with continued pressure on vegetation resources that make up deer habitat and potential effects of reproductive control, would not be offset by the beneficial effects of the proposed actions. Therefore, cumulative impacts to deer and deer habitat under this alternative would be adverse, long term, and moderate.

Conclusion

Under alternative B, approximately 5% to 10% of the deer habitat in the park would benefit from construction exclosures over the life of this plan. Remaining habitat would continue to be adversely affected by deer browsing over the long term until reproductive controls became effective and the population decreased. However, because the benefits of reproductive control would not be fully realized within the life of this plan, overall impacts to deer habitat, and in turn deer, would be adverse, long term, and moderate as a result of habitat degradation and loss of food sources. There could also be long-term, major adverse impacts to individual deer from the physiological, biological, and behavioral effects associated with the use of reproductive control; however, long-term impacts to the population would be minor to moderate because the adverse effects would be offset over time by the benefits of population reduction. Past, present, and future activities, when combined with continued pressure on vegetative resources and deer habitat expected under this alternative, would result in long-term, moderate adverse cumulative impacts. Because alternative B would provide for reproductive control of the deer herd and a potential for gradual reduction in deer herd numbers over an extended period of time, it is not expected that impairment of the white-tailed deer herd in Rock Creek Park would occur under this alternative.

ALTERNATIVE C: COMBINED LETHAL ACTIONS

Analysis

Sharpshooting would be used under this alternative, along with capture and euthanasia where appropriate, to reduce the deer herd size. The intent would be to rapidly reduce deer density within the park to allow for the herbaceous vegetation and tree seedlings to recover from browsing pressure. Small caged areas and repellents would be implemented with negligible adverse effects on the deer population, as described under alternative A.

Reducing deer density levels and maintaining these levels would allow vegetation to recover, providing better foraging habitat for deer in the park in the long term. Adverse impacts would still range from minor to moderate during the short term while habitat recovered. But, with increased vegetation and improved foraging habitat, this alternative would have beneficial, long-term effects, and the current adverse impacts

to deer and their habitat would be reduced to negligible or minor over the long term as the deer density goal is achieved.

This alternative would result in an impact to the deer population size, reducing the population from approximately 82 deer per square mile to approximately 15 to 20 deer per square mile. Research indicates that when habitat is stressed it cannot support healthy deer over the long term (Eve 1981, as cited in Warren 1991). When deer density is high, signs of nutritional stress, such as low body and internal organ mass, low fecal nitrogen levels, and high prevalence of parasitic infections, typically occur. When deer density is reduced to the nutritional carrying capacity, all of these indicators show improved condition (Sams et al. 1998). Also, a reduced deer density would help limit the spread of CWD, if this disease should be detected near the park in the future. As described in chapter 2, 15 to 20 deer per square mile is more closely aligned with levels that are in balance with other components of the ecosystem, namely a regenerating forest system. Therefore, reducing the population to this level would have a beneficial effect on the long-term viability of the deer population within the park by minimizing the potential for nutritional stress and disease, and improving habitat.

Cumulative Impacts

The same past, present, and future activity impacts described under alternative A would also occur under alternative C. Relieving deer browsing pressure through rapid reduction in the deer population under alternative C would allow the majority of the park's habitat to regenerate, resulting in beneficial effects and reducing adverse impacts over the long term to negligible or minor levels. These effects, combined with other beneficial effects, would result in cumulative impacts that would be primarily beneficial. These beneficial effects would somewhat offset the adverse impacts from increased development and other cumulative adverse actions. Therefore, cumulative impacts to deer and deer habitat under this alternative would be mostly beneficial and long term.

Conclusion

The relatively rapid reduction of the deer herd and the resultant regeneration of forage under alternative C would result in beneficial effects on deer herd health and would reduce adverse impacts to negligible or minor levels over the long term as the deer density goal was achieved. Adverse impacts would still range from minor to moderate while habitat recovered. Past, present, and future activities, when combined with the reduced browsing pressure expected under this alternative, would result in long-term, beneficial, cumulative impacts on deer herd health. There would be no impairment of the white-tailed deer population in the park under alternative C.

ALTERNATIVE D: COMBINED LETHAL AND NON-LETHAL ACTIONS

Analysis

Under alternative D, the size of the deer herd would be directly reduced through sharpshooting and capture and euthanasia, and reproductive control or direct reduction (if needed) would be used to maintain the population at the desired level. Small caged areas and repellents would be implemented, as under alternative A.

As with alternative C, the intent of this alternative would be to rapidly reduce the deer density within the park to allow for the native vegetation to recover from deer browsing pressure. Adverse impacts would still range in the minor to moderate level during the short term while habitat recovered; however, as vegetation regenerated, better foraging habitat would be provided for the deer in the park.

Reproductive control (or direct reduction, if needed) would be used to maintain deer at a density that would further encourage forest regeneration and improvement of habitat for deer. As described for alternative B, a number of factors may influence the efficacy of this method, including the amount of

immigration/emigration of deer to/from the park, availability of veterinarian and surgical facilities (at zoo or mobile field unit), mortality and recruitment rates, the size of the population at the time of initial treatment, percentage of the population treated, as well as other factors, such as untreated deer moving into the park and treated deer leaving the park. Considering these factors, it is expected that reproductive controls could stop further population growth, allowing the park to maintain the deer density goal for the life of this management plan. With increased vegetation and improved foraging habitat, this alternative would have long-term beneficial effects on deer and deer habitat, and the current adverse impacts to deer and their habitat would be reduced to negligible or minor over the long term as the deer density goal was achieved.

As described for alternative B, surgical sterilization and the associated loss of reproductive hormones is expected to affect deer in a similar way to those that have been treated with reproductive control agents (see the "Reproductive Control" section of chapter 2 and appendix C). As a result, there could be long-term, major, adverse impacts to individual deer due to handling stress and the possible physiological or behavioral changes due to the use of sterilization and possibly reproductive controls. However, it is expected that the long-term, adverse affect on the population would be minor to moderate, as the impacts over time would be offset by the beneficial effect of population reduction.

This alternative would result in an impact to the deer population size, reducing the population from approximately 82 deer per square mile to approximately 15 to 20 deer per square mile. As described for alternative C, this would minimize the potential for the spread of CWD and for nutritional stress and result in a deer density more closely aligned with levels that are in balance with other components of the ecosystem, namely a regenerating forest system. Therefore, reducing the population to this level would have a beneficial effect on the long-term viability of the deer population within the park.

The impacts of each method (sharpshooting, euthanasia, or reproductive control) on deer and deer habitat would be essentially the same, as long as habitat was improved by reducing deer browsing pressure. Potential differences in impacts would relate to the time required for implementation and the resulting deer population size.

Cumulative Impacts

The same past, present, and future activity impacts described under alternative A would also occur under alternative D. Rapidly reducing deer density levels and maintaining these levels under alternative D would relieve browsing pressure and provide better foraging habitat for deer in the park population. Achieving the deer density goal would result in long-term beneficial impacts and reduce adverse impact to negligible to minor levels.

Rapid deer density reduction would allow the forest to regenerate, resulting in beneficial impacts to deer habitat that would combine with other beneficial effects resulting in cumulative impacts that would be primarily beneficial. These beneficial impacts would offset the adverse effects from increased development and other cumulative adverse actions. Therefore, cumulative impacts to deer and their habitat under this alternative would be mostly beneficial and long term.

Conclusion

Enhancing natural forest regeneration by quickly reducing deer browsing pressure under alternative D, and by maintaining a smaller deer population through the use of reproductive control (and direct reduction if needed), would result in beneficial, long-term impacts to deer and deer habitat by allowing vegetation to recover and improving foraging habitat. Over time as natural forest regeneration occurred, adverse, long-term, major impacts would be reduced to negligible to minor levels. Past, present, and future activities, when combined with the reduced pressure on woody and herbaceous vegetation (forest regeneration) expected under this alternative, would result in beneficial, long-term cumulative impacts. White-tailed deer would not be impaired under this alternative.

IMPACTS OF THE ALTERNATIVES ON OTHER WILDLIFE

ALTERNATIVE A: NO-ACTION ALTERNATIVE (EXISTING MANAGEMENT CONTINUED)

Analysis

Under this alternative park staff would continue monitoring the deer population and conduct activities to protect native plants, such as creating small caged areas and applying limited amounts of repellents in landscaped areas. Maintaining small caged areas or applying repellents to protect individual or groups of plants from deer browsing could restrict other wildlife from using these plants. However, these actions would have little effect on other wildlife because of their small scale and their impact would not be measurable. Therefore, the impact of small caged areas and repellent use under this alternative would be adverse, short term, and negligible.

The vegetation/habitat conditions described in chapter 3, for both vegetation and other wildlife and wildlife habitat indicates that deer have already affected the vegetation, and thus habitat, for other wildlife species within the park. The herbaceous and woody seedling layers of the forest have been browsed by deer, and monitoring results indicate a substantial decline in seedlings in paired unfenced plots compared to fenced plots. McShea and Rappole (2000) found that avian species composition changes as the understory recovers from a period of extended deer browsing. Flowerdew and Ellwood (2001) suggested that deer have indirectly decreased bank vole (*Myodes glareolus*) populations by removing the bramble blackberry (*Rubus fruticosus*) that provides most of their hiding cover (S. Bates, pers. comm. 2008c).

Species that use deer as a food source, such as coyotes that now are known to occur in the park, could benefit from high deer density or open understory conditions. Other animals may also feed on deer carcasses, like crows (*Corvus* sp.), raccoons, and vultures. Small predators, such as foxes, hawks, skunks, and raccoons, would also benefit from a more open understory because prey would be easier to find. However, if the habitat of the prey species deteriorated to the point where prey (mice, rabbits, and ground-nesting birds) could no longer maintain viable populations within the park, then predator species would also decline).

Heavy deer browsing also degrades habitat and results in lack of cover for small mammals, as well as snakes, frogs, and small ground-nesting or feeding birds, making them increasingly vulnerable to predation from hawks, owls, foxes, skunks, raccoons, and coyotes. As previously described, breeding bird surveys are conducted in Rock Creek Park and have documented that many of the breeding birds found within Rock Creek Park nest on or near the ground. These include ground nesting birds, such as ovenbirds (*Seiurus aurocapilla*), black-and-white warblers (*Mniotilta varia*), worm-eating warblers (*Helmitheros vermivorus*); shrub nesting birds, such as northern cardinal (*Cardinalis cardinalis*), wood thrush (*Hylocichla mustelina*), American robin (*Turdus migratorius*), and American goldfinch (*Carduelis tristis*); as well as birds that nest both on the ground and in shrubs, such as song sparrows (*Melospiza melodia*), rufous-sided towhee (*Pipilo erythrophthalmus*), and common yellowthroat (*Geothlypis trichas*).

Species that depend primarily on other habitats are less affected by high deer numbers. Some frogs, snakes, salamanders, and turtles live close to water during much of their lives and are therefore less affected by deer. Similarly, heavy deer browsing would not directly change fish habitat. However, any amphibians that use vernal pools for breeding areas could be adversely impacted if deer overbrowsing impacted the pools through either siltation or reduction of vegetation that shades the pools. Other species (e.g., turtles and toads) are dependent on vegetation, fruits, and insects found within the understory of the forest, and their habitat is affected by high deer numbers. Therefore, animals such as turtles, rabbits, mice, and ground-nesting birds, which require ground vegetation to maintain viable populations within the park, would be adversely affected by high deer densities (greater than 20 deer per square mile) because

available food and cover would be greatly reduced by browsing. As browsing impacts increased, more and more wildlife species would be adversely affected by these changes.

Therefore, the impact of alternative A to other wildlife would be adverse, long term, and would range from negligible to major, depending on the species and its reliance on habitat that is adversely impacted by deer browse. Species that depend on ground cover, young tree seedlings, or understory shrubs for food, cover, or nesting habitat (such as ovenbirds, cardinals, goldfinches, and others described in the analysis above) could be severely reduced or possibly eliminated from the park over time, resulting in potentially major adverse effects. However, impacts on species that depend primarily on other habitats such as wetland-dwelling amphibians and reptiles, or middle or upper canopy dwellers such as owls and woodpeckers, would be negligible.

Cumulative Impacts

Actions resulting in cumulative impacts to wildlife would be similar to those described for the deer population. These include vehicle collisions and poaching, disturbances from traffic, visitor use (including off-trail users and social trails), illegal camping, and the presence of unrestrained pets. These actions would all continue to have long-term, minor adverse impacts by displacing wildlife and potentially causing some mortality. Cell towers may result in bird collisions. The return of coyotes to the area has a beneficial effect on wildlife by helping to reestablish predator-prey relationships. Deer management plans and programs of local, state, and other federal agencies have limited contributions to long-term beneficial effects on wildlife and wildlife habitat by helping maintain a more balanced ecosystem. Past improvements to fish passages in the park also contribute beneficial effects on aquatic habitats and fish.

Actions resulting in cumulative impacts to wildlife habitat would also be similar to those described for deer. This includes urban development that has and would continue to cause long-term minor localized adverse impacts from the loss of habitat; acts of vandalism, and dumping, which have had and would continue to cause minor localized adverse impacts from trampling and burying of vegetation, or spreading of noxious weed seeds; past fires that have affected some areas, which have regrown but with more nonnative species; and past actions within the park, such as construction of facilities and roads that have resulted in removal of habitat. The park's exotic plant management efforts would also benefit wildlife habitat in the long term by removing plants that compete with native species. The future reconstruction of Rock Creek Parkway and continued park maintenance operations would have long-term minor adverse impacts on edge habitat for wildlife, limited to the areas affected. Any off-trail visitor uses affect wildlife habitat to some extent, but particular activities like horseback riding, dog walking, and hiking can lead to more social trails and spread of exotic weed seeds. Scientific research benefits park vegetation and wildlife habitats by supplying information needed for management decisions, but even the use of an area for research plots limits natural growth in those areas. All of these activities, when combined with the negligible to major impacts of continued pressure on woody and herbaceous vegetation that makes up the wildlife habitat and the limited natural regeneration expected under alternative A because of continued deer browsing, would result in cumulative impacts that would be adverse, long term, and minor to major depending on the species.

Conclusion

Under alternative A, habitat for wildlife species other than white-tailed deer would continue to be adversely affected by a large deer population and related browsing, resulting in decreased plant diversity, increased invasive exotic plants, and reduced forest regeneration (as long as the deer population remained high or increased). A few predator species would benefit from a large deer population and an open understory, enabling them to better see and catch prey. However, the impacts of large numbers of deer browsing on vegetation would adversely affect a large percentage of habitats for other wildlife (e.g., ground-nesting birds, frogs, snakes, and turtles), resulting in adverse, long-term, and potentially

negligible to major impacts, depending on the species. Past, present, and future activities, when combined with the continued pressure on forest regeneration expected under this alternative, would result in both adverse and beneficial impacts, with adverse, long-term, major cumulative impacts.

As explained in the conclusion for "Vegetation" above, impairment is tied to the park's purpose and significance, and the enabling legislation calls for the protection of animals within the park. Alternative A would not reverse the expected long-term continued growth in the deer population, and wildlife habitat would likely continue to be degraded. Although not all wildlife species would be affected to the same extent, impairment of those wildlife species that depend on the presence of ground cover and understory vegetation that are heavily browsed by deer could occur under this alternative over the long term.

ALTERNATIVE B: COMBINED NON-LETHAL ACTIONS

Analysis

Under this alternative, several non-lethal actions would be implemented in combination to protect wildlife habitat and reduce deer numbers in the park. Actions include the use of large, fenced exclosures and reproductive control of does. Small caged areas and repellents would be implemented, as under alternative A.

Large, fenced exclosures would be constructed to allow forest regeneration within localized areas of the park. Human presence associated with the installation of fenced exclosures could adversely affect wildlife while the actions were being carried out. However, such small areas of the park would be affected for a short period that the adverse impact would be short term and negligible.

As explained previously in this chapter under "Vegetation," approximately 5% of the park would be protected from deer browsing in this manner at a given time, and about 5% to 10% of the woody vegetation would be protected over the life of the plan. The size of the openings in the fence (4 inches square) would allow small birds and mammals (e.g., songbirds, rabbits, and squirrels) to pass in and out of these exclosures. The added fence posts and fence would also provide perches for some birds, such as hawks. The fence could be an obstacle to other wildlife (e.g., birds or small mammals such as foxes running into the fence). This action would make more ground/shrub layer habitat available to other wildlife than alternative A over the long term. However, because only 5% of the park would be fenced off from browsing deer at any one time, and because deer density outside the protected areas would continue to remain high for many years (see following discussion), the beneficial impact to other wildlife would be limited.

Implementation of sterilization would have short-term, negligible adverse effects on other wildlife in the vicinity of the operations from the temporary noise and human presence, as well as the construction of bait stations and temporary holding pens, if needed. The use of reproductive controls could help reduce the impact on other wildlife by reducing effects of deer browsing on wildlife habitat. However, the time required to see these results could be several years; researchers disagree on the amount of time needed to reduce a population size using reproductive controls (Hobbs et al. 2000; Nielsen et al. 1997; Rudolph et al. 2000). The actual amount of time needed to observe a decrease would depend on a number of factors, such as the type of treatment used, its effectiveness in stopping reproduction, the size of the population at the time of initial treatment, the actual mortality rate, and the percentage of the population treated. Other factors, such as untreated deer moving into the park and treated deer leaving the park, would also affect the time required to reduce herd numbers. The benefit of this action would be proportional to the amount of population reduction that it achieved, and a corresponding improvement to understory habitat.

Hobbs et al. (2000) described a model where if 90% of the breeding does in the park were effectively treated annually, mortality would need to exceed the number of surviving offspring from the 10% of untreated does in order to achieve a population reduction. An average mortality rate in urban/suburban

deer populations is 10% (Hobbs et al. 2000). Based on these factors, it is expected that reproductive controls could stop population growth, but it would not be possible to achieve the density goals for the park during the life of this management plan.

Similar to alternative A, a continued high deer density and the associated browsing throughout the majority of the park would reduce the availability of food for species that depend on ground/shrub layer vegetation for survival. These species, including ground and/or shrub-nesting birds (e.g., ovenbirds, black-and-white warblers, northern cardinal, wood thrush, song sparrows, and rufous-sided towhee), turtles, toads, rabbits, and mice would decline over time, with potential adverse, long-term, major impacts. Other species that have a more diverse diet (e.g., raccoons) or that spend more time in other habitat (e.g., salamanders and snakes) or the upper canopy (e.g., barred owls [*Strix varia*] and woodpeckers) versus the ground/shrub layer, would be less affected by high or increased deer density. As with alternative A, species that use deer or their carcasses as a food source, such as coyotes, turtles, crows, and chickadees (*Parus* spp.), could benefit from the high deer densities. Small predators, such as foxes, hawks, skunks, and raccoons, would also benefit from a more open understory because prey would be easier to find. However, if the habitat of the prey species deteriorated to the point where prey (e.g., mice, rabbits, and ground-nesting birds) could no longer maintain viable populations within the park, then predator species would also decline. As a result, the overall impact to wildlife throughout the park would continue to be adverse, long term, and negligible to potentially major, depending on the species.

Cumulative Impacts

The same cumulative actions described under alternative A would also occur under alternative B. Under alternative B, protecting approximately 5 to 10% of the park's vegetation from deer browsing through use of exclosures, and using reproductive control that could reduce deer density and related browsing impacts after more than 15 years of implementation, would gradually reduce impacts to wildlife habitat. Combined with the effects of exotic plant control, research, and disease and pest control, this would provide some beneficial, long-term impacts. However, these beneficial effects would not be large enough to offset the adverse effects from increased development and other cumulative adverse actions, in conjunction with the continued deer browsing pressure on the majority of the woody and herbaceous vegetation that provides habitat for wildlife in the park. Therefore, overall cumulative impacts to wildlife habitat, and thus to other wildlife species, under this alternative would be adverse, long term, and moderate to major.

Conclusion

Under alternative B, approximately 5% of the herbaceous vegetation and up to 10% of the woody vegetation in the park would benefit from the construction of large, fenced exclosures over the life of the plan. The remaining habitat, however, would continue to be subject to a high degree of deer browsing, adversely impacting both ground and shrub layer habitat for many other species of wildlife until reproductive controls took effect and reduced the deer population (more than 15 years). A few species would tend to benefit from a large deer population and an open understory, enabling them to better see and catch prey. Overall, impacts to other wildlife would be adverse, long term, and negligible to potentially major, depending on the species. Past, present, and future activities, when combined with the continued pressure on wildlife habitat expected under this alternative, would result in both adverse and beneficial impacts, with overall adverse, long term, moderate to major cumulative impacts on other wildlife. Since alternative B would provide continued protection of certain areas of the park over the long term and would introduce reproductive controls that could reduce deer numbers over an extended period of time, it is not expected that impairment of other wildlife species or habitat would occur under this alternative.

ALTERNATIVE C: COMBINED LETHAL ACTIONS

Analysis

Under this alternative, sharpshooting would be used to reduce the deer herd size, along with capture and euthanasia where appropriate. The intent of this alternative would be to rapidly reduce deer density within the park to allow for the herbaceous vegetation and tree seedlings to recover from deer browsing pressure. Small caged areas and repellents would be implemented, as under alternative A.

Unlike alternative A, a reduced degree of deer browsing throughout the majority of the park would increase the availability of food and cover for species that depend on ground/shrub layer vegetation for survival. These species, including ground and/or shrub-nesting birds (e.g., ovenbirds, black-and-white warblers, northern cardinal, wood thrush, song sparrows, and rufous-sided towhee), turtles, toads, rabbits, and mice, would be able to maintain viable populations within the park. As the vegetation became more diverse and abundant with reduced browsing pressure, the number of wildlife species that would benefit from these changes would increase. This would be a beneficial, long-term impact on these species. Other species that have a more diverse diet (e.g., raccoons) or that spend more time in other habitat (e.g., frogs and salamanders) or the upper canopy (e.g., barred owls and woodpeckers) would be less affected by a reduced deer density, although a long-term benefit to upper canopy species would be gained in the future as forest regeneration maintained the upper canopy.

Predators that use deer as a food source, such as coyotes, could be somewhat adversely affected by a lower deer density or denser understory conditions. Other animals that feed on deer carcasses, such as crows and raccoons, could also be adversely affected. However, none of these species solely depend on deer as a food source, so the adverse impacts to these species would be long term and minor at most. Predators could find a denser understory more difficult for hunting small prey than the current open condition, but better habitat conditions and an increase in the abundance of prey species could also benefit these predators.

Wildlife, other than deer, would be temporarily disturbed by the presence of humans placing bait stations, shooting deer, setting traps, and observing deer behavior. Bait could provide a beneficial food source to other wildlife during the time reduction activities were conducted; however, the small quantity and short time periods that bait would be available would have a negligible impact on any species. There would be little surface disposal of deer waste and/or carcasses that would provide a beneficial food source to scavengers like the coyotes, crows, and raccoons since it is expected that the majority of carcasses would be disposed of through burial or offsite. The small number of carcasses left for natural decomposition would not be substantially different than what occurs through mortality from disease, old age, and car collisions. These human disturbances would be adverse, but temporary (less than 30 days per year), and negligible, as they would not cause any measurable change to the habitat or responses by other wildlife species.

Long-term reduction and controls on deer population growth would allow vegetation used as food and cover for other wildlife to become more abundant. Therefore, the impact of alternative C to other wildlife would be mostly beneficial and long term, depending on the species, and existing adverse impacts to other wildlife would be reduced to negligible or minor levels.

Cumulative Impacts

The same past, present, and future actions described under alternative A would also occur under alternative C. Management actions identified in alternative C, where deer browsing pressure would be drastically reduced through a rapid reduction of the deer population would provide beneficial, long-term impacts to other wildlife. Some adverse impacts would result to habitat as a result of disturbances when qualified federal employees or authorized agents were setting traps, placing bait stations, occupying shooting locations, and removing deer carcasses. However, these impacts would be temporary and

isolated, causing little interference with other species activities, resulting in adverse, short-term, negligible impacts.

Rapid deer density reduction would allow the forest to regenerate, improving habitat for other wildlife and resulting in beneficial impacts that would combine with the beneficial effects of exotic plant control, research, and disease and pest control. These beneficial impacts would offset adverse effects from increased development and other cumulative adverse actions. Therefore, cumulative impacts to wildlife habitat, and thus other wildlife species, under this alternative would be mostly beneficial and long term.

Conclusion

Under alternative C, impacts on other wildlife species and habitat would be beneficial and long term as a result of rapid reductions in deer numbers in the park, thereby reducing deer browsing pressure on woody and herbaceous vegetation and allowing increased abundance and diversity of other wildlife that depend on understory vegetation. Adverse, long-term impacts would be reduced to negligible or minor levels over time. A few predators and scavengers that use deer and their carcasses as a food source could be adversely affected by a lower deer density or denser understory conditions, but this alternative could also increase the availability of other prey. Adverse, long-term impacts would be reduced to negligible or minor levels over time. Human disturbances from trampling at bait stations, shooting sites, trapping locations, or deer carcass disposal sites would be temporary and isolated within the park. Therefore, adverse impacts of these actions on other wildlife species would be short term and negligible. Past, present, and future activities, when combined with the reduced browsing pressure on understory habitat expected under this alternative, would result in long-term, beneficial, cumulative impacts to other wildlife. There would be no impairment of other wildlife species or habitat under this alternative.

ALTERNATIVE D: COMBINED LETHAL AND NON-LETHAL ACTIONS

Analysis

Under alternative D, the size of the deer herd would be directly reduced through sharpshooting and capture and euthanasia and reproductive control, or direct reduction (if needed) would be used to maintain the population at the desired level. Small caged areas and repellents would be implemented, as under alternative A.

Similar to alternative C, a reduced degree of deer browsing throughout the majority of the park would increase the availability of food for species that depend on ground/shrub layer vegetation for survival, such as ground and/or shrub-nesting birds (e.g., ovenbirds, black-and-white warblers, northern cardinal, wood thrush, song sparrows, and rufous-sided towhee), turtles, toads, rabbits, and mice. These species would be able to maintain viable populations within the park. As the vegetation became more diverse and abundant with reduced browsing pressure, the number of wildlife species that would benefit from these changes would increase. This would be a beneficial, long-term impact on these species. Other species that have a more diverse diet (e.g., raccoons) or that spend more time in other habitats (e.g., salamanders and frogs) or the upper canopy (e.g., barred owls and woodpeckers) would be less affected by a reduced deer density, although a long-term benefit to upper canopy species would be gained in the future as forest regeneration maintained the upper canopy.

Also similar to alternative C, a few species that use deer as a food source, such as coyotes, might be adversely affected by fewer deer or denser understory conditions. Other animals that feed on deer carcasses, such as box turtles, crows, and chickadees, would also be adversely affected. However, none of these species depends solely on deer as a food source, so the adverse impacts would be minor. Predators such as foxes, hawks, skunks, and raccoons would find a denser understory more difficult to hunt in than the current open condition. However, better habitat conditions and resulting increases in the abundance of prey species would also benefit these predators.

Wildlife other than deer would be temporarily disturbed by the presence of humans placing bait stations, shooting deer, setting traps, implementing reproductive control techniques, and observing deer behavior, similar to alternative C. Bait could provide a beneficial food source to other wildlife during the time that reduction activities were conducted; however, the small quantity and short time periods that bait would be available would have a negligible impact on any species. Limited surface disposal of deer waste and/or carcasses would provide a beneficial food source to scavengers like certain birds and turtles; however, under this alternative, it is expected that the majority of carcasses would be disposed of through burial or offsite. The small number of carcasses left for natural decomposition would not be substantially different than what occurs today through mortality from disease, old age, and car collisions. These human disturbances would be adverse, but temporary (less than 30 days per year), and negligible, as they would not cause any measurable change to the habitat or responses by other wildlife species.

Long-term reduction and controls on deer population growth would allow vegetation used as food and cover by other wildlife to become more abundant. Therefore, the impact of alternative D to other wildlife would be mostly beneficial and long term, depending on the species, and existing adverse impacts would be reduced to negligible or minor levels.

The impacts of each method (sharpshooting, euthanasia, or reproductive control) on other wildlife would be essentially the same, as long as habitat was improved by reducing deer browsing pressure. Potential differences in impacts would relate to the time required for implementation and the resulting deer population size.

Cumulative Impacts

The same past, present, and future actions described under alternative A would also occur under alternative D. Rapidly reducing the deer population and alleviating browsing pressure on the majority of park habitat under alternative D would provide long-term beneficial impacts to other wildlife species.

Some adverse impacts would result to other wildlife as a result of disturbance by humans setting traps and bait stations, occupying shooting locations, and removing deer carcasses. However, these impacts would be temporary and isolated, causing little interference with other species' activities, resulting in adverse, short-term, negligible impacts.

Rapid deer density reduction would give the forest the opportunity to regenerate, improving habitat for other wildlife and resulting in beneficial impacts that would combine with the beneficial effects of exotic plant control, research, and disease and pest control, resulting in primarily beneficial cumulative impacts. These beneficial impacts would offset the adverse effects from increased development and other cumulative adverse actions. Therefore, cumulative impacts to wildlife under this alternative would be mostly beneficial and long term.

Conclusion

Under alternative D, impacts on other wildlife would be long term and beneficial because of rapidly reduced deer numbers in the park, resulting in decreased browsing pressure and natural forest regeneration, allowing increased abundance and diversity of other wildlife that depend on understory vegetation. Adverse, long-term impacts would be reduced to negligible or minor levels over time. A few predators and scavengers that use deer and their carcasses as a food source could be adversely affected by a lower deer density or denser understory conditions, but this alternative could also increase the availability of other prey. Other wildlife would be temporarily affected by trampling at bait stations, shooting sites, trapping locations, reproductive control techniques, or deer carcass disposal sites. The adverse impacts of these isolated actions on other wildlife would be short term and negligible. Past, present, and future activities, when combined with the reduced pressure on understory habitat expected under this alternative, would result in beneficial, long-term cumulative impacts to other wildlife. There would be no impairment of other wildlife species or habitat under this alternative.

RARE, UNIQUE, THREATENED, OR ENDANGERED SPECIES

GUIDING REGULATIONS AND POLICIES

The *Endangered Species Act* (16 USC 1531 et seq.) and amendments (1973) mandate that all federal agencies consider the potential effects of their actions on species listed as threatened or endangered. If the NPS determines that an action may adversely affect a federally listed species, consultation with the U.S. Fish and Wildlife Service is required to ensure that the action will not jeopardize the species' continued existence or result in the destruction or adverse modification of critical habitat. In addition, the Migratory Bird Treaty Act and Bald and Golden Eagle Protection Act require protection and consideration of effects on migratory bird species and their nests and the named eagle species during any management action .

The NPS *Management Policies 2006* state that potential effects of agency actions will also be considered on state or locally listed species (NPS 2006). The NPS is required to control access to important habitat for such species and to perpetuate the natural distribution and abundance of these species and the ecosystems upon which they depend. NPS *Management Policies 2006* state that "[the NPS will] manage state and locally listed species in a manner similar to its treatment of federally listed species to the greatest extent possible" (NPS 2006, sec. 4.4.2.3).

Rock Creek Park's General Management Plan (2005a) includes the following desired conditions that pertain to rare, unique, or listed species:

- federal- and District of Columbia-listed threatened or endangered species and their habitats are protected and sustained
- native species populations that have been severely reduced or extirpated are restored where feasible and sustainable
- native plant and animal species function in as natural condition as possible, except where special management considerations are allowable under policy
- invasive species are reduced in numbers and area or eliminated from natural areas of the park

The endangered Hay's spring amphipod (*Stygobromus hayi*), discovered in five groundwater springs in Rock Creek Park in 1998, is the only known federally listed species that inhabits the park. The analysis also addresses 34 rare plants and 9 rare or uncommon animals (2 invertebrates and 7 birds) of Maryland that have been documented in Rock Creek Park, as well as 11 mammals, 23 reptiles, 16 amphibians, and 12 fish listed as species of greatest conservation need within the District of Columbia (see tables 14, 15, and 16).

ASSUMPTIONS, METHODOLOGY, AND INTENSITY THRESHOLDS

To assess impacts on listed species, the following process was used:

- identification of which species are in areas likely to be affected by management actions described in the alternatives
- analysis of habitat loss or alteration caused by the alternatives
- analysis of disturbance potential of the actions and the species' potential to be affected by the actions

The information in this analysis was obtained through best professional judgment of park staff and experts in the field (as cited in the text) and by conducting a literature review. The following thresholds were used to determine impacts to sensitive and rare species.

FEDERALLY LISTED SPECIES

The U.S. Fish and Wildlife Service and National Oceanic and Atmospheric Administration Fisheries guidance for implementing section 7 consultation under the Endangered Species Act defines the terminology used to assess impacts to listed species as follows (USFWS and NMFS 1998):

No effect: the appropriate conclusion when the action agency determines its proposed action will not affect a listed species or designated critical habitat.

May affect, is not likely to adversely affect: the appropriate conclusion when effects on listed species are expected to be discountable, insignificant, or completely beneficial. Beneficial effects are contemporaneous positive effects without any adverse effects to the species. Insignificant effects relate to the size of the impact and should never reach the scale where take occurs. Discountable effects are those extremely unlikely to occur. Based on best judgment, a person would not: (1) be able to meaningfully measure, detect or evaluate insignificant effects; or (2) expect discountable effects to occur.

May affect, likely to adversely affect: the appropriate finding in a biological assessment (or conclusion during informal consultation) if any adverse effect to listed species may occur as a direct or indirect result of the proposed action or its interrelated or interdependent actions, and the effect is not: discountable, insignificant, or beneficial (see definition of "is not likely to adversely affect"). In the event the overall effect of the proposed action is beneficial to the listed species, but is also likely to cause some adverse effects, then the proposed action "is likely to adversely affect" the listed species. If incidental take is anticipated to occur as a result of the proposed action, an "is likely to adversely affect" determination should be made. An "is likely to adversely affect" determination requires the initiation of formal section 7 consultation.

The following thresholds were used to determine the magnitude of effects on federally listed special status species and their associated habitat, including designated critical habitat that would result from implementation of any of the alternatives. The Endangered Species determinations pursuant to section 7 of the Act are included.

ADVERSE

Negligible: There would be no observable or measurable impacts to federally listed species, their habitats, or the natural processes sustaining them in the proposed project area. This impact intensity would equate to a determination of "no effect" under section 7 of the *Endangered Species Act*.

Minor: Individuals may temporarily avoid areas. Impacts would not affect critical periods (e.g., breeding, nesting, denning, feeding, or resting) or habitat. This impact intensity would equate to a determination of "not likely to adversely affect" under section 7 of the *Endangered Species Act*.

Moderate: Individuals may be impacted by disturbances that interfere with critical periods (e.g., breeding, nesting, denning, feeding, or resting) or habitat; however, the level of impact would not result in a physical injury, mortality, or extirpation from the park. This impact intensity would equate to a determination of "likely to adversely affect" under section 7 of the *Endangered Species Act*.

Major: Individuals may suffer physical injury or mortality or populations may be extirpated from the park. This impact intensity would equate to a determination of "likely to adversely affect" under section 7 of the *Endangered Species Act*.

BENEFICIAL

Negligible: There would be no observable or measurable impacts to federally listed species, their habitats, including critical habitat designated under the *Endangered Species Act*, or the natural processes sustaining them in a park site. This impact intensity would equate to a determination of "no effect" under section 7 of the *Endangered Species Act*.

Minor: Impacts would result in slight increases to viability of the species in the park as species-limiting factors (e.g., habitat loss, competition, and mortality) are kept in check. Nonessential features of critical habitat in a park site would be slightly improved. This impact intensity would equate to a determination of "not likely to adversely affect" under section 7 of the *Endangered Species Act*.

Moderate: Impacts would result in improved viability of the species, population structure, and species population levels in the park, as species-limiting factors (e.g., habitat loss, competition, and mortality) are reduced. Some essential features of critical habitat would be improved. This impact intensity would equate to a determination of "not likely to adversely affect" under section 7 of the *Endangered Species Act.*

Major: Impacts would result in highly noticeable improvements to species viability, population structure, and species population levels in the park, as species-limiting factors (e.g., habitat loss, competition, and mortality) are nearly eliminated. All essential features of the critical habitat would be improved. This impact intensity would equate to a determination of "not likely to adversely affect" under section 7 of the *Endangered Species Act*.

STATE / DISTRICT OF COLUMBIA LISTED AND SPECIAL STATUS SPECIES

The assessment of impacts on both plant and animal species listed by either the state of Maryland or the District of Columbia (but not at the federal level under the *Endangered Species Act*) uses the same thresholds developed for the assessment of impacts on wildlife, as follows:

Negligible: There would be no observable or measurable impacts to native species, their habitats, or the natural processes sustaining them.

Minor: Impacts on native species, their habitats, or the natural processes sustaining them may not be detectable, and changes to population numbers, population structure, genetic variation, or other demographic factors would not occur. Occasional responses to disturbance by some individuals could be expected, but without interference to factors affecting population levels. Sufficient habitat would remain functional to maintain viability of all species. Impacts would be outside critical reproduction periods for sensitive native species.

Moderate: Impacts on native species, their habitats, or the natural processes sustaining them would be detectable, and changes to population numbers, population structure, genetic variation, or other demographic factors would occur, but species would remain stable and viable. Frequent responses to disturbance by some individuals could be expected, with some negative impacts to factors affecting population levels. Sufficient habitat would remain functional to maintain the viability of all native species. Some impacts might occur during critical periods of reproduction or in key habitat.

Major: Impacts on native species, their habitats, or the natural processes sustaining them would be detectable and extensive. Population numbers, population structure, genetic variation, or other demographic factors might experience large declines. Frequent responses to disturbance by some individuals would be expected, with negative impacts to factors resulting in a decrease in population levels. Loss of habitat might affect the viability of at least some species.

AREA OF ANALYSIS

The area of analysis for assessing impacts on rare, unique, threatened, or endangered species is Rock Creek Park. The area of analysis for cumulative impacts includes the park.

IMPACTS OF THE ALTERNATIVES

ALTERNATIVE A: NO-ACTION ALTERNATIVE (EXISTING MANAGEMENT CONTINUED)

Analysis

Federally Listed Species. The one federally listed species in the park, Hay's spring amphipod, is a groundwater species that spends the majority of its life below the surface feeding on detritus and other invertebrates, but that also occurs occasionally at the surface. Although the primary threats to this species are related to degradation of the subsurface groundwater (e.g., change in flows, pollution from fertilizers, pesticides, and petroleum leaks, and loss of detritus), disturbance of surface springs is also a concern. Monitoring of the deer population and use of some controls to protect important resources under alternative A would not affect groundwater or disturb springs and would not impact this species. However, the continued growth of the deer population and related effects of overabundance (i.e., trampling, browsing, nonnative species seed dispersal, etc.) could degrade surface springs by increasing erosion and sedimentation, compacting soils, and altering vegetation composition, in turn affecting the surface habitat in which the amphipod species is found infrequently. However, as described in the analysis for "Soils and Water Quality," the effects would be localized and are within historical or baseline water quality conditions. In addition, the relative abundance of rare amphipods in the park has been attributed to the long-term protection of groundwater quality afforded by the park. This protection is expected to continue despite the growth of the deer population, and therefore, the impacts are not expected to critically affect this species. As a result, there would be long-term, negligible to minor, adverse impacts on the Hay's spring amphipod.

State/District of Columbia Listed and Special Status Species

Amphipods. Four other species of amphipods, including the Kenk's amphipod (*Stygobromus kenki*), have been located in or near the park. As with the Hay's spring amphipod, the primary effects on these species under alternative A would be potential degradation of and water quality impacts to surface springs that

support these groundwater species from the effects of deer overabundance (e.g., trampling, browsing, nonnative species seed dispersal, etc.). If surface erosion can affect the groundwater beneath the spring, this could have long-term, negligible to minor, adverse impacts on these amphipods. Monitoring of the deer population and use of some controls to protect important resources under alternative A would not affect groundwater or disturb springs and would not impact this species.

Invertebrates. Two invertebrates, the Appalachian spring snail (*Fontigens bottimeri*) and gray petaltail dragonfly (*Tachopteryx thoreyi*), are considered rare or uncommon by the state of Maryland. These species are generally found in seeps, which, like the springs described above for amphipods, could be affected by potential degradation of and water quality impacts to surface springs as a result of deer overabundance (e.g., trampling, browsing, seed dispersal, etc.). This could have long-term, negligible to minor, adverse impacts on these invertebrates. Monitoring of the deer population and use of some controls to protect important resources under alternative A would not affect seeps and would not impact these species.

Plants. Based on reviews of available information on plant resistance or palatability to deer, 14 of the 34 listed plants have been identified as palatable or possibly palatable to deer (see table 14 in chapter 3): single-headed pussytoes (*Antennaria solitaria*), hairy rock cress (*Arabis hirsute*), Virginia snakeroot (*Aristolochia serpentaria*), cornel-leaf whitetop (*Doellingeria infirma* [*Aster infirmus*]), pubescent sedge (*Carex hirtifolia*), American chestnut (*Castanea dentata*), pointed-leaved tick-trefoil (*Desmodium glutinosum*), butternut (*Juglans cinerea*), two-leaved solomon's-seal (*Maianthemum canadense*), elliptic shinleaf (*Pyrola elliptica*), shingle oak (*Quercus imbricaria*), overcup oak (*Quercus lyrata*), table mountain pine (*Pinus pungens*), and little ladies tresses (*Spiranthes tuberosa*). Listed plants considered unpalatable or resistant to deer browsing include gold star (*Chrysogonum virginianum*), whorled coreopsis (*Coreopsis verticillata*), Kentucky coffee-tree (*Gymnocladus dioica*), common clubmoss (*Lycopodium clavatum*), basil balm (*Monarda clinopodia*), yellow passionflower (*Passiflora lutea*), Virginia ground cherry (*Physalis virginiana*), orange coneflower (*Rudbeckia fulgida*), decumbent pearlwort (*Sagina decumbens*), snowy skullcap (*Scutellaria serrata*), three-leaved cup plant (*Silphium trifoliatum*), hispid goldenrod (*Solidago hispida*), and golden alexanders (*Zizia aurea*). No information on deer palatability was found on the remaining seven plants (green dragon arum [*Arisaema dracontium*], Lancaster sedge [*Cyperus lancastriensis*], low kyllinga sedge [*Kyllinga pumila*], narrow melic grass [*Melica mutica*], Carolina leaf-flower [*Phyllanthus caroliniensis*], and long-beaked arrowhead [*Sagittaria longirostra*]) listed for the park, but it is likely that some of these are palatable to deer.

Under alternative A, the park would protect rare understory plant species that deer browse with caging if they are found in the park. Placing and maintaining caging around known locations of listed species protect these plants from deer browsing, resulting in localized beneficial, long-term impacts. However, impacts to state-listed species outside of these caged areas would be similar to what was described for vegetation. The primary impact to these species in the park would be the result of not taking action to control deer numbers and the potential for overbrowsing. Based on observations and research conducted within the park, deer browsing has already caused noticeable changes to the vegetation, including a substantial reduction in plant cover.

Browsing impacts to those sensitive species palatable or preferred by deer could result in a reduction of the species in the plant community, either because of mortality resulting directly from browsing or due to impacts to overall plant health, and its ability to produce seed stock or otherwise spread. Continuous browsing of preferred plants over time could result in the loss of individual species from the community. Similar impacts to sensitive species considered to be less palatable to deer would also be expected if food resources were limited due to deer population growth, seasonal or climate variations (e.g., drought), or reductions in plant abundance resulting from disease or insect impacts. As a result, providing no control on the growth of the deer population would have adverse, long-term, moderate to major impacts on the listed plant species not protected by caging.

Wildlife. The vegetation/habitat conditions described in chapter 3, for both vegetation and other wildlife and wildlife habitat indicates that deer have already affected the vegetation, and thus habitat, for other wildlife species within the park, including those listed or considered special status species by Maryland and the District of Columbia. The herbaceous and woody seedling layers of the forest have been browsed by deer, and monitoring results indicate a substantial decline in vegetation in paired unfenced plots compared to paired fenced plots, suggesting that the abundance and diversity of the animals using this understory habitat today is less than what it would be if deer browsing pressure was lower.

As described for "Other Wildlife and Wildlife Habitat," the continued growth of the deer population and heavy deer browsing can degrade habitat and result in lack of food or cover for species that require ground vegetation to maintain viable populations within the park. This includes several species listed or considered special status species by Maryland and the District of Columbia (see tables 15 and 16 in chapter 3), including ground-nesting or feeding birds (e.g., mourning warbler [*Oporornis philadelphia*], Nashville warbler [*Vermivora ruficapilla*], bobolink [*Dolichonyx oryzivorus*], Acadian flycatcher [*Empidonax virescens*], American woodcock [*Scolopax minor*], brown thrasher [*Toxostoma rufum*] and eastern towhee [*Piplio erythrophthalmus*]), as well as some small mammals (e.g., the southern bog lemming [*Synaptomys cooperi*], Alleghany woodrat [*Neotoma magister*], eastern chipmunk [*Tamias striatus*], and eastern cottontail [*Sylvilagus floridanus*]), and possibly some reptiles (e.g., corn snake [*Elaphe guttata guttata*], eastern garter snake [*Thamnophis sirtalis*], eastern hognose snake [*Heterodon platirhinos*], eastern worm snake [*Carphophis amoenus amoenus*], northern copperhead [*Agkistrodon controtrix*], northern ringneck snake [*Didophis punctatus edwardsii*], the eastern fence lizard, and the eastern box turtle [*Terrapene carolina*]), and amphibians (e.g., American toad [*Bufo americanus*], Fowler's toad [*Bufo fowleri*]).

Predatory wildlife listed or considered special status species by Maryland and the District of Columbia (see table 16 in chapter 3), such as the broad-winged hawk (*Buteo playtpterus*), great-horned owl (*Bubo virginianus*), gray fox (*Urocyon cinereoargenteus*), and several snakes (e.g., corn snake, eastern hognose snake, northern copperhead, northern ringneck snake, northern scarlet snake [*Cemophora coccinea copei*], timber rattlesnake [*Crotalus horridus*]) could benefit from a more open understory because prey would be easier to find. However, if the habitat of the prey species deteriorated to the point where prey (mice, rabbits, and ground-nesting birds) could no longer maintain viable populations within the park, then predator species would also decline. Animals that may feed on deer carcasses, like Virginia opossum (*Didelphis virginiana*), could benefit slightly by higher deer densities.

Species that depend primarily on other habitats would be less affected by high or increased deer density. This would include species that occur primarily near wetlands and/or water (e.g., yellow-crowned night-heron [*Nyctanassa violacea*], American bittern [*Botaurus lentiginosus*], American black duck [*Ana rubripes*], black-crowned night-heron [*Nycticorax nycticorax*], and Wilson's snipe [*Gallinago delicate*]; northern river otter [*Lutra canadensis*] and American mink [*Mustela vison*]; queen snake [*Regina septemvittata*], common musk turtle [*Sternotherus odoratus*], bog turtle [*Clemmys muhlenbergii*], eastern mud turtle [*Kinosternon subrubrum*], spotted turtle [*Chrysemys guttata*], and eastern redbelly turtle [*Pseudemys rubriventris*]; bullfrog [*Rana catesbeiana*], eastern mud salamander [*Pseudotriton m. montanus*], northern cricket frog [*Acris crepitans*], northern dusky salamander [*Desmognathus fuscus*], northern spring peeper [*Pseudacris crucifer*], northern two-lined salamander [*Eurycea bislineata*], pickerel frog [*Rana palustris*], northern red salamander [*Pseudotriton ruber ruber*], spotted salamander [*Ambystoma maculatum*], and upland chorus frog [*Pseudacris feriarum feriarum*]; and fish); in grasslands (e.g., eastern meadowlark [*Sturnella magna*], field sparrow [*Spizella pusilla*], grasshopper sparrow [*Ammodramus savannarum*]); those that use the canopy and sub-canopy layers (e.g., olive-sided flycatcher [*Contopus cooperi*], blackburnian warbler, cerulean warbler [*Dendroica cerulean*], Bicknell's thrush [*Catharus bicknelli*], bald eagle [*Haliaeetus leucocephalus*], chimney swift [*Chaetura pelagica*], and great horned owl); or those that generally den or roost in tree cavities or behind bark (e.g., southern flying squirrel [*Glaucomys volans*], eastern small-footed myotis [*Myotis lebii*], or eastern red bat

[*Lasiurus borealis*). However, some of these species (e.g., birds, snakes, turtles, toads, salamanders, and some frogs) are dependent on vegetation, fruits, and/or insects found within the understory of the forest that would be affected by high deer numbers.

Those species noted above that require ground vegetation to maintain viable populations within the park, would be adversely affected by high deer densities (greater than 20 deer per square mile) because available food and cover would be greatly reduced by browsing. In addition, as browsing impacts increased, more and more species listed or considered special status species by Maryland and the District of Columbia would be adversely affected by these changes.

Therefore, the impact of alternative A to species listed or considered special status species by Maryland and the District of Columbia would be adverse, long-term, and negligible to major, depending on the species. Those that depend on ground cover, young tree seedlings, and the habitat they provide for food or cover for these species could be severely reduced or possibly eliminated from the park, while impacts on species that depend primarily on other habitats (not woodlands) or on the canopy for food and cover would be negligible.

Cumulative Impacts

Actions resulting in cumulative impacts to rare, unique, threatened, or endangered wildlife species would be similar to those described for deer, wildlife, and vegetation. These include vehicle collisions and disturbances from traffic, visitor use (including off-trail users and social trails), illegal camping, and the presence of unrestrained pets. These actions would all continue to have long-term, minor adverse impacts by displacing rare, unique, threatened, or endangered species and potentially causing some mortality. Disease (e.g., rabies and West Nile virus) may also affect some species, and cell towers may result in bird collisions, which is being studied. The return of coyotes to the area has a beneficial effect on rare, unique, threatened, or endangered wildlife by helping to reestablish predator-prey relationships. Deer management plans and programs of local, state, and other federal agencies have limited contributions to long-term beneficial effects on rare, unique, threatened, or endangered species and their habitat by helping maintain a more balanced ecosystem. Past improvements to fish passages in the park also contribute beneficial effects on aquatic habitats and fish considered species of greatest conservation need within the District of Columbia.

Actions resulting in cumulative impacts to the state-listed plants, as well as habitat for rare, unique, threatened, or endangered wildlife, would be similar to those described for vegetation. Urban development has and would continue to cause long-term minor localized adverse impacts from the loss of state-listed plants and habitat for rare, unique, threatened, or endangered species. Other effects would include those from acts of vandalism, dumping, illegal camping, and off-trail use that have had and would continue to cause minor localized adverse impacts from trampling and burying of vegetation, or spreading of noxious weed seeds; past fires that have affected some areas, which have regrown but with more nonnative species; and past actions within the park, such as construction of facilities and roads, that have resulted in removal of habitat. Plant diseases and pests (e.g., gypsy moths) have had a large, relatively widespread adverse impact in the past, but have been somewhat reversed by the park's efforts to control such diseases and pests that continue to benefit forest resources. The park's exotic plant management efforts would also benefit state-listed plants, as well as habitat for rare, unique, threatened, or endangered wildlife, in the long term by removing plants that compete with native species. Continued park maintenance operations would have long-term minor adverse impacts on edge habitat for these species, limited to the areas affected. Nearly all visitor uses affect habitat for rare, unique, threatened, or endangered wildlife, and possibly some state-listed plants, to some extent, but particular activities like horseback riding, dog walking, and hiking lead to more social trails and spread of exotic weed seeds. Scientific research benefits park vegetation and habitat for rare, unique, threatened, or endangered species by supplying information needed for management decisions, but even the use of an area for research plots limits natural growth in those areas. All of these activities, when combined with the negligible to major

impacts of continued pressure on woody and herbaceous vegetation that makes up habitat for rare, unique, threatened, or endangered species, and the limited natural regeneration expected under alternative A because of continued deer browsing, would result in cumulative impacts that would be adverse, long term, and minor to major depending on the species.

Conclusion

Impacts to rare, unique, threatened, or endangered species under alternative A would be both beneficial and adverse. Adverse impacts to the federally listed Hay's spring amphipod could be long term and negligible to minor. Beneficial impacts to state-listed plants would result from establishing caging around known individual plants and from establishing caging around newly discovered plants in the park. Overall, there would be adverse, long-term, negligible to major impacts to rare, unique, threatened, or endangered species, from excessive deer browsing and the associated habitat degradation that could result in lack of food or cover for such species. Past, present, and future activities, when combined with the continued pressure on rare, unique, threatened, or endangered species expected under this alternative, would result in both adverse and beneficial impacts, with overall long-term, minor to major, adverse cumulative impacts.

Impairment under alternative A would be possible for some of the state-listed plants, because alternative A would not reverse the expected long-term continued growth in the deer population and damage to vegetation would likely continue, as described under "Vegetation" above. The park's enabling legislation calls for protection of park "timber, animals, and curiosities" in their natural conditions, and the GMP also calls for preservation of ecological resources, which would include special status species. Therefore, it is expected that impairment of certain state-listed plants that are palatable to deer, as well as habitat for rare, unique, threatened, or endangered species, could occur over the long term.

ALTERNATIVE B: COMBINED NON-LETHAL ACTIONS

Analysis

Under this alternative, several non-lethal actions would be implemented in combination to protect wildlife habitat and reduce deer numbers in the park. Actions include the use of large, fenced exclosures and reproductive control of does. Small caged areas and repellents would be implemented, as under alternative A.

Federally Listed Species. The Hay's spring amphipod, a groundwater spring species that spends the majority of its life below the surface feeding on detritus, but also occurs occasionally at the surface, is the only federally-listed species found in the park. The construction of large-scale exclosures and administration of reproductive control agents, including the associated human presence, would not contribute to the primary threats to this species, which are related to degradation of the subsurface groundwater (e.g., change in flows, pollution from fertilizers, pesticides, and petroleum leaks, and loss of detritus). However, disturbance of surface springs is also a concern. Any springs known or with the potential to support the Hay's spring amphipod would be avoided during construction of the exclosures and administration of reproductive control agents, and as a result, the potential for trampling of the surface springs would be limited.

As explained previously in this chapter under "Vegetation," approximately 5% of the park would be protected from deer browsing in this manner at a given time, and about 5% to 10% of the woody vegetation would be protected over the life of the plan. If any of the springs that support Hay's spring amphipod are within an exclosure, there could be long-term beneficial effects by reducing the impacts of deer overbrowsing (i.e., trampling, browsing, seed dispersal, etc.) on the surface springs that connect to the groundwater habitat. However, because only 5% of the park would be fenced off from browsing deer at any one time, and because deer density outside the protected areas would continue to remain high for many years (see following discussion), the beneficial impact would be limited.

Under this alternative, the use of reproductive controls would eventually help reduce the deer population in the park, but the time required to see these results could be substantial (Hobbs et al. 2000; Nielsen et al. 1997; Rudolph et al. 2000) (see discussion in analysis for "Wildlife"). The benefit of this action would be proportional to the amount of population reduction that it achieved, and the corresponding reduction in impacts from overbrowsing.

Hobbs et al. (2000) described a model where if 90% of the breeding does in the park were effectively treated annually, mortality would need to exceed the number of surviving offspring from the 10% of untreated does in order to achieve a population reduction. An average mortality rate in urban/suburban deer populations is 10% (Hobbs et al. 2000). Based on these factors, it is expected that reproductive controls could stop population growth, but it would not be possible to achieve the density goals for the park during the life of this management plan.

Similar to alternative A, the continued growth of the deer population and related effects of overabundance outside the large-scale exclosures could degrade the surface spring by increasing erosion and sedimentation, compacting soils, and altering vegetation composition, in turn affecting the habitat for the amphipod species. However, as described in the analysis for "Soils and Water Quality," the effects would be localized and are expected to be within historical or baseline water quality conditions. In addition, the relative abundance of rare amphipods in the park has been attributed to the long-term protection of groundwater quality afforded by the park. This protection is expected to continue despite the growth of the deer population, and therefore, the impacts are not expected to critically affect this species. As a result, there would be long-term, negligible to minor, adverse impacts on the Hay's spring amphipod under alternative B.

State/District of Columbia Listed and Special Status Species

Amphipods. Four other species of amphipods, including the Kenk's amphipod, have been located in or near the park. As described for Hay's spring amphipod, the construction of large-scale exclosures and administration of reproductive control agents would not contribute to the primary threats to these species, degradation of the subsurface groundwater. Any springs known or with the potential to support these amphipods would be avoided during construction of the exclosures and administration of reproductive control agents, and as a result, the potential for trampling of the surface springs would be minimal. As explained for the Hay's spring amphipod, if any of the springs that support these species are within an exclosure, there could be long-term beneficial effects by reducing the impacts of deer overbrowsing (i.e., trampling, browsing, seed dispersal, etc.) on the surface springs that connect to the groundwater habitat.

However, because only 5% of the park would be fenced off from browsing deer at any one time, and because deer density outside protected areas would continue to remain high for many years (see discussion for Hay's spring amphipod), the beneficial impact would be limited. The potential for effects from deer overabundance, including increased erosion and sedimentation, soil compaction, and changes in vegetation composition would continue, and could in turn affect the habitat for the amphipod species outside of the exclosures. As described for alternative A, if surface erosion can affect the groundwater beneath the spring, this could have long-term, negligible to minor, adverse impacts on these species.

Invertebrates. Two invertebrates, the Appalachian spring snail and gray petaltail dragonfly, are considered rare or uncommon by the state of Maryland. These species are generally found in seeps and could be disturbed by human presence during construction of the large exclosures or administration of reproductive control agents under alternative B. However, small areas of the park would be affected for a short period and the adverse impact would be short term and negligible.

As explained for the amphipods, if any of the seeps that support these invertebrates are within an exclosure, there could be long-term beneficial effects by reducing the impacts of deer overbrowsing (i.e., trampling, browsing, seed dispersal, etc.) on the surface springs that connect to the groundwater habitat. However, because only 5% of the park would be fenced off from browsing deer at any one time, and

because deer density outside protected areas would continue to remain high for many years (see discussion for Hay's spring amphipod), the beneficial impact would be limited.

The potential for effects from deer overabundance, including increased erosion and sedimentation, soil compaction, and changes in vegetation composition, would continue and could in turn affect the habitat for the Appalachian spring snail and gray petaltail dragonfly outside of the exclosures. As described for alternative A, this could have long-term, negligible to minor, adverse impacts on these species.

Plants. Construction of the large scale exclosures and administration of reproductive control agents would result in ground disturbances, including trampling by workers, which could affect state-listed plant species and their habitat. Exclosure areas would be surveyed for state-listed plants prior to construction and any plants identified would be avoided. Personnel involved in these activities would also be educated about these plants and the potential impacts. In addition, small areas of the park would be affected for only a short period, and as a result, the adverse impact would be short term and negligible.

If any of the state-listed plants are within an exclosure, there could be long-term beneficial effects by removing the impacts of deer overbrowsing (i.e., trampling, browsing, seed dispersal, etc.) in these areas. However, because only 5% of the park would be fenced off from browsing deer at any one time, and because deer density outside protected areas would continue to remain high for many years (see discussion for Hay's spring amphipod), the beneficial impact would be limited.

As described for alternative A, 14 of the 34 state-listed plants have been identified as palatable or possibly palatable to deer, 13 are considered unpalatable or resistant to deer browsing, and no information on deer palatability was found on the remaining seven plants listed for the park, but it is likely that some of these are palatable to deer (see table 14 in chapter 3). Based on observations and research conducted within the park, deer browsing has already caused noticeable changes to the vegetation, including a substantial reduction in density. Browsing impacts to those sensitive species palatable to or preferred by deer could result in a reduction of the species in the plant community, either because of mortality resulting directly from browsing or due to impacts to overall plant health, and its ability to produce seed stock or otherwise spread. Continuous browsing of preferred plants over time could result in the loss of individual species from the community. Similar impacts to sensitive species considered to be less palatable to deer would also be expected if food resources were limited due to deer population growth, seasonal or climate variations (e.g., drought), or reductions in plant abundance resulting from disease or insect impacts. As a result, alternative B would continue to have adverse, long-term, moderate to major impacts on the listed plant species not protected by fencing.

Wildlife. Large, fenced exclosures would be constructed to allow forest regeneration within localized areas of the park. Human presence associated with the installation of fenced exclosures could adversely affect wildlife listed or considered special status species by Maryland and the District of Columbia by causing displacement while the actions were being carried out. However, small areas of the park would be affected for such a short period that the adverse impact would be short term, negligible, and localized. In addition, surveys for wildlife listed or considered special status species by Maryland and the District of Columbia would be conducted prior to constructing the exclosures and locations and timing would be shifted as practicable to minimize impacts on wildlife listed or considered special status species by Maryland and the District of Columbia.

As explained previously, approximately 5% of the park would be protected from deer browsing in this manner at a given time, and about 5% to 10% of the woody vegetation would be protected over the life of the plan. The size of the openings in the exclosure fence (4 inches square) would allow small birds and mammals listed or considered special status species by Maryland and the District of Columbia to pass in and out of these exclosures. The added fence posts and fence would also provide perches for some birds, such as hawks, but the fence could be an obstacle to others. This action would make more ground/shrub layer habitat available to wildlife listed or considered special status species by Maryland and the District of Columbia than alternative A. However, because only 5% of the park would be fenced off from

browsing deer at any one time, and because deer density outside the protected areas would continue to remain high for many years (see discussion for Hay's spring amphipod), the beneficial impact would be limited.

Implementation of sterilization would have short-term, negligible adverse effects on wildlife listed or considered special status species by Maryland and the District of Columbia in the vicinity of the operations from temporary noise and human presence, as well as the construction of bait stations and temporary holding pens. Bait could provide a beneficial food source to some species during the time reduction activities were conducted; however, the small quantity and short time periods that bait would be available would have a negligible impact on any species. The use of reproductive controls could help reduce impacts to these species; however, the benefit of this action would be proportional to the amount of population reduction that it achieved and a corresponding improvement to understory habitat. As described previously, it is expected that reproductive controls could slow population growth, but it would not be possible to achieve the density goals for the park during the life of this management plan.

Similar to alternative A, a continued high deer density and the associated browsing throughout the majority of the park would reduce the availability of food for wildlife listed or considered special status species by Maryland and the District of Columbia that depend on ground/shrub layer vegetation for survival. This includes (see table 15 in chapter 3) ground and/or shrub-nesting birds (e.g., mourning warbler, Nashville warbler, bobolink, Acadian flycatcher, American woodcock, brown thrasher, and eastern towhee), as well as some small mammals (e.g., southern bog lemming, Alleghany woodrat, eastern chipmunk, and eastern cottontail), reptiles (e.g., corn snake, eastern garter snake, eastern hognose snake, eastern worm snake, northern copperhead, northern ringneck snake, northern fence lizard, and eastern box turtle), and amphibians (e.g., American toad, Fowler's toad, marbled salamander [*Ambystoma opacum*], redback salamander [*Plethodon cinereus*], and redspotted newt [*Notophthalmus viridescens*]).

Predatory wildlife listed or considered special status species by Maryland and the District of Columbia (see table 16 in chapter 3), such as the broad-winged hawk, great-horned owl, gray fox, and several snakes (e.g., corn snake, eastern hognose snake, northern copperhead, northern ringneck snake, northern scarlet snake, timber rattlesnake) could benefit from a more open understory because prey would be easier to find. However, if the habitat of the prey species deteriorated to the point where prey (mice, rabbits, and ground-nesting birds) could no longer maintain viable populations within the park, then predator species would also decline. Animals that may feed on deer carcasses, like Virginia opossum, could benefit slightly by higher deer densities.

Species that depend primarily on other habitats would be less affected by high or increased deer density. This would include species that occur primarily near wetlands and/or water (e.g., yellow-crowned night-heron, American bittern, American black duck, black-crowned night-heron, and Wilson's snipe; northern river otters and American minks; queen snake, common musk turtle, bog turtle, eastern mud turtle, spotted turtle, and eastern redbelly turtle; bullfrog, eastern mud salamander, northern cricket frog, northern dusky salamander, northern spring peeper, northern two-lined salamander, pickerel frog, northern red salamander, spotted salamander, and upland chorus frog, and fish); in grasslands (e.g., eastern meadowlark, field sparrow, and grasshopper sparrow); those that use the canopy and sub-canopy layers (e.g., olive-sided flycatcher, blackburnian flycatchers, cerulean warbler, Bicknell's thrush, bald eagle, chimney swift, and great-horned owl); or those that generally den or roost in tree cavities or behind bark (e.g., southern flying squirrel, eastern small-footed myotis, or eastern red bat). However, some of these species (e.g., birds, snakes, turtles, toads, salamanders, and some frogs) are dependent on vegetation, fruits, and/or insects found within the understory of the forest that would be affected by high deer numbers.

Those species noted above that require ground vegetation to maintain viable populations within the park would be adversely affected by high deer densities (greater than 20 deer per square mile) because available food and cover would be greatly reduced by browsing. In addition, as browsing impacts

increased, more and more species listed or considered special status species by Maryland and the District of Columbia would be adversely affected by these changes.

Therefore, the impact of alternative B to wildlife species listed or considered special status species by Maryland and the District of Columbia would continue to be adverse, long term, and negligible to major, depending on the species. Those that depend on ground cover, young tree seedlings, and the habitat they provide for food or cover for these species could be severely reduced, while impacts on species that depend primarily on other habitats (not woodlands) or on the canopy for food and cover would be negligible.

Cumulative Impacts

The same past, present, and reasonably foreseeable actions described under alternative A would also occur under alternative B. All of these actions, when combined with an extended use of large-scale exclosures and a long-term reduction in deer browsing pressure resulting from the use of reproductive controls, would result in both beneficial and adverse cumulative impacts to species listed or considered special status species by Maryland and the District of Columbia. Adverse cumulative impacts would be long term and minor to moderate.

Conclusion

Adverse impacts to the federally listed Hay's spring amphipod could be long term and negligible to minor. Impacts to species listed or considered special status species by Maryland and the District of Columbia under alternative B would be adverse, long term, and moderate to major, until reproductive controls on the park deer herd were effective. The placement and maintenance of large exclosures would protect herbaceous vegetation in about 5% of the park at any one time, and woody vegetation in up to 10% of the park over the life of the plan. The areas selected for exclosures would include many species listed or considered special status species by Maryland and the District of Columbia, resulting in beneficial, long-term impacts. However, adverse, long-term, negligible to moderate impacts due to deer browsing would continue outside the exclosures. Past, present, and future activities, when combined with the continued pressure on species listed or considered special status species by Maryland and the District of Columbia expected under this alternative, would result in both beneficial and adverse impacts. Although alternative B would not be expected to reverse the expected long-term continued growth in the deer population, reproductive controls (if successful) would stop the growth in population. Damage to rare plants would be reduced over the long term and would be mitigated to some extent by the use of exclosures and caging. Therefore, it is not expected that impairment of state-listed plants, or habitat for rare, unique, threatened, or endangered species, would occur over the long term.

ALTERNATIVE C: COMBINED LETHAL ACTIONS

Analysis

Under this alternative, sharpshooting would be used to reduce the deer herd size, along with capture and euthanasia where appropriate. The intent of this alternative would be to rapidly reduce deer density within the park to allow for the herbaceous vegetation and tree seedlings to recover from deer browsing pressure. Small caged areas and repellents would be implemented, as under alternative A.

Federally Listed Species. The implementation of sharpshooting and capture and euthanasia (where appropriate) would not contribute to primary threats to the Hay's spring amphipod, which are related to degradation of the subsurface groundwater (e.g., change in flows, pollution from fertilizers, pesticides, and petroleum leaks, and loss of detritus). Bait stations could be used and would be located such that the ground would serve as a backstop for bullets that do not remain in the target animal, and shooting locations would be cleaned up to remove shells or bullets that miss their target. Although disturbance of surface springs is also a concern, any springs known or with the potential to support the Hay's spring

amphipod would be avoided during implementation of sharpshooting or capture and euthanasia, and the potential for trampling of the surface springs would be limited. Any human disturbances related to implementation of alternative C would be adverse, but temporary (less than 30 days per year), and negligible, as they would not cause any measurable change to the habitat or responses by the Hay's spring amphipod.

Under alternative C, a reduced deer density throughout the majority of the park would minimize the potential for surface springs to be degraded by decreasing erosion, sedimentation, and soil compaction, as well as helping to restore native plant communities. This would, in turn, minimize potential impacts on the habitat for the Hay's spring amphipod which would result in long-term, beneficial effects that would reduce adverse impacts to negligible.

State/District of Columbia Listed and Special Status Species

Amphipods. As described for the Hay's spring amphipod, the implementation of sharpshooting and capture and euthanasia (where appropriate) would not contribute to primary threats to state-listed amphipods. Although bullets containing lead may be used, bait stations and trained sharpshooters could be used and would minimize the potential for groundwater impacts from lead contamination. Although disturbance of the surface spring is also a concern, any springs known or with the potential to support state-listed amphipods would be avoided during implementation of sharpshooting or capture and euthanasia as practicable. As a result, the potential for trampling of the surface springs would be limited. These human disturbances would be adverse, but temporary (less than 30 days per year), and negligible, as they would not cause any measurable change to the habitat for or responses by these amphipods.

Under alternative C, a reduced deer density throughout the majority of the park would minimize the potential for surface springs to be degraded by decreasing erosion, sedimentation, and soil compaction, as well as helping to restore native plant communities. This would, in turn, minimize potential impacts on the habitat for the state-listed amphipods which would result in long-term, beneficial effects that reduce existing impacts to negligible.

Invertebrates. The two invertebrates considered rare or uncommon by the state of Maryland, the Appalachian spring snail and gray petaltail dragonfly, could be disturbed by trampling during implementation of sharpshooting and capture and euthanasia (where appropriate) under alternative C. However, small areas of the park would be affected for a short period and the adverse impact would be short term and negligible.

As explained for the amphipods, a reduced deer density throughout the majority of the park would minimize the potential for seeps that support the Appalachian spring snail and gray petaltail dragonfly to be degraded by decreasing erosion, sedimentation, and soil compaction, as well as helping to restore native plant communities. This would, in turn, minimize potential impacts on the habitat for the state-listed invertebrates, which would result in long-term, beneficial effects over time.

Plants. The implementation of sharpshooting and capture and euthanasia (where appropriate) would result in ground disturbances, including trampling by workers, that could affect state-listed plant species and their habitat. However, small areas of the park would be affected for only a short period and by relatively few individuals. As a result, the adverse impact would be short term and negligible.

A reduced deer density throughout the majority of the park would promote the growth of sensitive species if suitable habitat characteristics and seed stock were present. A smaller deer herd density would reduce browsing pressure on native plant communities over time, resulting in a reestablishment and an increase in the extent of natural communities in the park. Increased areas of native vegetation would be expected to promote the reestablishment of special concern species. Reducing deer herd density would decrease the potential for deer browsing impacts to sensitive species, resulting in beneficial, long-term impacts. Some browsing of preferred sensitive plant species (see alternatives A and B) occurring outside small, caged

exclosures would be expected to occur, even with herd density maintained at target levels (15 to 20 deer per square mile). As a result, potential impacts to palatable sensitive plant species occurring outside exclosures would be reduced to adverse, long term, and minor.

Wildlife. As described for alternative C in the "Wildlife" section of this chapter, wildlife listed or considered special status species by Maryland and the District of Columbia would be temporarily disturbed by the presence of humans placing bait stations, shooting deer, setting traps, and observing deer behavior. Bait could provide a beneficial food source to some species during the time reduction activities were conducted; however, the small quantity and short time periods that bait would be available would have a negligible impact on any species. There would be little surface disposal of deer waste and/or carcasses that would provide a beneficial food source to scavengers like Virginia opossum, because it is expected that the majority of carcasses would be disposed of through burial or off-site. The small number of carcasses left for natural decomposition would not be substantially different than what occurs through mortality from disease, old age, and car collisions. These human disturbances would be adverse, but temporary (less than 30 days per year), and negligible, as they would not cause any measurable change to the habitat or responses by wildlife listed or considered special status species by Maryland and the District of Columbia.

A reduced degree of deer browsing throughout the majority of the park would increase the availability of food and cover for wildlife listed or considered special status species by Maryland and the District of Columbia and that depend on ground/shrub layer vegetation for survival (see table 15 in chapter 3). This includes ground and/or shrub-nesting birds (e.g., mourning warbler, Nashville warbler, bobolink, Acadian flycatcher, American woodcock, brown thrasher, and eastern towhee), as well as some small mammals (e.g., southern bog lemming, Alleghany woodrat, eastern chipmunk, and eastern cottontail), reptiles (e.g., corn snake, eastern garter snake, eastern hognose snake, eastern worm snake, northern copperhead, northern ringneck snake, northern fence lizard, and eastern box turtle), and amphibians (e.g., American toad, Fowler's toad, marbled salamander, redback salamander, and redspotted newt). These species would be able to maintain viable populations within the park, and as the vegetation became more diverse and abundant with reduced browsing pressure, the number of species that would benefit from these changes would increase. This would be a beneficial, long-term impact on these species.

Wildlife listed or considered special status species by Maryland and the District of Columbia that depend primarily on other habitats would be less affected by a reduced deer density, although a long-term benefit to upper canopy species would be gained in the future as forest regeneration maintained the upper canopy. This would include species that occur primarily near wetlands and/or water (e.g., yellow-crowned night-heron, American bittern, American black duck, black-crowned night-heron, and Wilson's snipe; northern river otter and American mink; queen snake, common musk turtle, bog turtle, eastern mud turtle, spotted turtle, and eastern redbelly turtle; bullfrog, eastern mud salamander, northern cricket frog, northern dusky salamander, northern spring peeper, northern two-lined salamander, pickerel frog, northern red salamander, spotted salamander, and upland chorus frog, and fish); in grasslands (e.g., eastern meadowlark, field sparrow, and grasshopper sparrow); those that use the canopy and sub-canopy layers (e.g., olive-sided flycatcher, blackburnian flycatcher, cerulean warbler, Bicknell's thrush, bald eagle, chimney swift, and great-horned owl); or those that generally den or roost in tree cavities or behind bark (e.g., southern flying squirrel, eastern small-footed myotis, or eastern red bat).

Predatory wildlife listed or considered special status species by Maryland and the District of Columbia (see table 16 in chapter 3), such as the broad-winged hawk, great-horned owl, gray fox, and several snakes (e.g., corn snake, eastern hognose snake, northern copperhead, northern ringneck snake, northern scarlet snake, timber rattlesnake) would find a denser understory more difficult for hunting small prey than the current open condition. However, better habitat conditions and an increase in the abundance of prey species would also benefit these predators. Other wildlife listed or considered special status species by Maryland and the District of Columbia that potentially feed on deer carcasses, such as Virginia opossum, would also be slightly adversely affected.

Overall, long-term reduction and controls on deer population growth would allow vegetation used as food and cover for other wildlife to become more abundant. Therefore, the impact of alternative C to wildlife listed or considered special status species by Maryland and the District of Columbia would be mostly beneficial and long term, depending on the species and existing adverse impacts would be reduced to negligible or minor levels.

Cumulative Impacts

The same past, present, and future actions described under alternative A would also occur under alternative C. Management actions identified in alternative C, where deer browsing pressure would be drastically reduced through a rapid reduction of the deer population, would provide beneficial, long-term impacts to species listed or considered special status species by Maryland and the District of Columbia. Some adverse impacts would result to habitat as a result of disturbances when qualified federal employees or authorized agents were setting traps, placing bait stations, occupying shooting locations, and removing deer carcasses. However, these impacts would be temporary and isolated, causing little disturbance and resulting in adverse, short-term, negligible impacts.

Rapid deer density reduction would allow the forest to regenerate, improving habitat and reducing impacts of overbrowsing for species listed or considered special status species by Maryland and the District of Columbia. This would result in beneficial impacts that would combine with the beneficial effects of exotic plant control, research, and disease and pest control. These beneficial impacts would offset adverse effects from increased development and other cumulative adverse actions. Therefore, cumulative impacts to species listed or considered special status species by Maryland and the District of Columbia under this alternative would be mostly beneficial and long term.

Conclusion

Under alternative C, the reduced deer density would minimize potential impacts on the habitat for the Hay's spring amphipod, resulting in long-term, beneficial effects that would reduce adverse impacts to negligible. Impacts on species listed or considered special status species by Maryland and the District of Columbia, as well as their habitat, would be beneficial and long term as a result of rapid reductions in deer numbers in the park that would reduce deer browsing pressure on woody and herbaceous vegetation and allow increased abundance and diversity of other species that depend on understory vegetation. A few predators that use deer as a food source could be adversely affected by a lower deer density, as could scavengers that feed on deer carcasses, but this alternative could also increase the availability of other prey. Adverse, long-term impacts would be reduced to negligible or minor levels over time. Human disturbances from trampling at bait stations, shooting sites, trapping locations, or deer carcass disposal sites would be temporary and isolated within the park. Therefore, adverse impacts of these actions on species listed or considered special status species by Maryland and the District of Columbia would be short term and negligible. Past, present, and future activities, when combined with the reduced browsing pressure on understory habitat expected under this alternative, would result in long-term, beneficial, cumulative impacts to species listed or considered special status species by Maryland and the District of Columbia. There would be no impairment of rare, unique, threatened or endangered species or their habitat under this alternative.

ALTERNATIVE D: COMBINED LETHAL AND NON-LETHAL ACTIONS

Analysis

Under alternative D, the size of the deer herd would be directly reduced through sharpshooting and capture and euthanasia, and reproductive control or direct reduction (if needed) would be used to maintain the population at the desired level. Small caged areas and repellents would be implemented, as under alternative A.

Federally Listed Species. As described for alternative C, the implementation of sharpshooting, capture, and euthanasia (where appropriate), and/or reproductive control would not contribute to primary threats to the Hay's spring amphipod. Although disturbance of the surface spring is also a concern, any springs known or with the potential to support the Hay's spring amphipod would be avoided during implementation of sharpshooting or capture and euthanasia as practicable. As a result, the potential for trampling of the surface springs would be limited. These human disturbances would be adverse, but temporary (less than 30 days per year), and negligible, as they would not cause any measurable change to the habitat or responses by the Hay's spring amphipod.

Under alternative D, a reduced deer density throughout the majority of the park would minimize the potential for surface springs to be degraded by decreasing erosion, sedimentation, and soil compaction, as well as helping to restore native plant communities. This would, in turn, minimize potential impacts on the habitat for the Hay's spring amphipod which would result in long-term, beneficial effects that reduce existing adverse impacts to negligible.

State/District of Columbia Listed and Special Status Species

Amphipods. As described for the Hay's spring amphipod, the implementation of this alternative would not contribute to primary threats to state-listed amphipods, and any springs known or with the potential to support state-listed amphipods would be avoided during deer management activities. As a result, the potential for trampling of the surface springs would be limited, and these temporary (less than 30 days per year), adverse impacts from human disturbance would be negligible, as they would not cause any measurable change to the habitat for or responses by these amphipods.

Alternative D would reduce deer density throughout the majority of the park and minimize the potential impacts on surface spring habitat for the state-listed amphipods, by reducing erosion, sedimentation, and soil compaction, as well as helping to restore native plant communities. This would, in turn, result in long-term, beneficial effects that reduce existing impacts to negligible.

Invertebrates. The two invertebrates considered rare or uncommon by the state of Maryland, the Appalachian spring snail and gray petaltail dragonfly, could be disturbed by trampling during implementation of alternative C. However, small areas of the park would be affected for a short period and the adverse impact would be short term and negligible.

As explained for the amphipods, a reduced deer density throughout the majority of the park would minimize the potential for seeps that support the Appalachian spring snail and gray petaltail dragonfly to be degraded by decreasing erosion, sedimentation, and soil compaction, as well as helping to restore native plant communities. This would, in turn, minimize potential impacts on the habitat for the state-listed invertebrates which would result in long-term, beneficial effects that reduce existing adverse impacts to negligible.

Plants. The implementation of alternative D would result in ground disturbances, including trampling by those implementing the alternative, which could affect state-listed plant species and their habitat. However, small areas of the park would be affected for only a short period, and personnel involved in these activities would also be educated about these plants and the potential impacts. As a result, the adverse impact would be short term and negligible.

Alternative D would result in a reduced deer density throughout the majority of the park. As described for alternative C, this would promote the growth of sensitive species, reduce browsing pressure on native plant communities over time, and result in the reestablishment of special concern species. Reducing deer herd density would decrease the potential for deer browsing impacts to sensitive species, resulting in beneficial, long-term impacts. Some browsing of preferred sensitive plant species (see alternatives A and B) occurring outside small, caged exclosures would be expected to occur, even with herd density

maintained at target levels (15 to 20 deer per square mile). As a result, potential impacts to palatable sensitive plant species occurring outside exclosures would be reduced to adverse, long term, and minor.

Wildlife. As described for alternative C, wildlife listed or considered special status species by Maryland and the District of Columbia would be temporarily disturbed during implementation of alternative D during sharpshooting activities. The small quantity and short time periods that bait would be available would have a slightly beneficial impact on any species by providing additional food sources. The majority of carcasses would be disposed of through burial or off-site disposal, and the small number of carcasses left for natural decomposition would not be substantially different than what occurs through mortality, resulting in a limited beneficial effect for scavengers like Virginia opossum. These human disturbances would be adverse, but temporary (less than 30 days per year), and negligible, as they would not cause any measurable change to the habitat or responses by wildlife listed or considered special status species by Maryland and the District of Columbia.

A reduced degree of deer browsing throughout the majority of the park would increase the availability of food and cover for wildlife listed or considered special status species by Maryland and the District of Columbia and that depend on ground/shrub layer vegetation for survival (see table 15 in chapter 3). This includes ground and/or shrub-nesting birds (e.g., mourning warbler, Nashville warbler, bobolink, Acadian flycatcher, American woodcock, brown thrasher, and eastern towhee), as well as some small mammals (e.g., the southern bog lemming, Alleghany woodrat, eastern chipmunk, and eastern cottontail), reptiles (e.g., corn snake, eastern garter snake, eastern hognose snake, eastern worm snake, northern copperhead, northern ringneck snake, the northern fence lizard, and eastern box turtle), and amphibians (e.g., American toad, Fowler's toad, marbled salamander, redback salamander, and redspotted newt). These species would be able to maintain viable populations within the park and as the vegetation became more diverse and abundant with reduced browsing pressure, the number of species that would benefit from these changes would increase. This would be a beneficial, long-term impact on these species.

Wildlife listed or considered special status species by Maryland and the District of Columbia that depend primarily on other habitats would be less affected by a reduced deer density, although a long-term benefit to upper canopy species would be gained in the future as forest regeneration maintained the upper canopy. This would include species that occur primarily near wetlands and/or water (e.g., yellow-crowned night-heron, American bittern, American black duck, black-crowned night-heron, and Wilson's snipe; northern river otter and American mink; queen snake, common musk turtle, bog turtle, eastern mud turtle, spotted turtle, and eastern redbelly turtle; bullfrog, eastern mud salamander, northern cricket frog, northern dusky salamander, northern spring peeper, northern two-lined salamander, pickerel frog, northern red salamander, spotted salamander, and upland chorus frog, and fish); in grasslands (e.g., eastern meadowlark, field sparrow, and grasshopper sparrow); those that use the canopy and sub-canopy layers (e.g., olive-sided flycatcher, blackburnian flycatcher, cerulean warbler, Bicknell's thrush, bald eagle, chimney swift, and great-horned owl); or those that generally den or roost in tree cavities or behind bark (e.g., southern flying squirrel, eastern small-footed myotis, or eastern red bat).

Predatory wildlife listed or considered special status species by Maryland and the District of Columbia (see table 16 in chapter 3), such as the broad-winged hawk, great-horned owl, gray fox, and several snakes (e.g., corn snake, eastern hognose snake, northern copperhead, northern ringneck snake, northern scarlet snake, timber rattlesnake) would find a denser understory more difficult for hunting small prey than the current open condition. However, better habitat conditions and an increase in the abundance of prey species would also benefit these predators. Other wildlife listed or considered special status species by Maryland and the District of Columbia that potentially feed on deer carcasses, such as the Virginia opossum and the eastern box turtle, would also be adversely affected.

Overall, long-term reduction and controls on deer population growth would allow vegetation used as food and cover for other wildlife to become more abundant. Therefore, the impact of alternative D to wildlife listed or considered special status species by Maryland and the District of Columbia, would be mostly

beneficial and long term, depending on the species, and existing adverse impacts would be reduced to negligible or minor levels.

Cumulative Impacts

The same past, present, and future actions described under alternative A would also occur under alternative D. Management actions identified in alternative D, where deer browsing pressure would be drastically reduced through a rapid reduction of the deer population would provide beneficial, long-term impacts to species listed or considered special status species by Maryland and the District of Columbia. Some adverse impacts would result to habitat as a result of disturbances when qualified federal employees or authorized agents were implementing sharpshooting, capture and euthanasia, and/or reproductive control. However, these impacts would be temporary and isolated, causing little disturbance and resulting in adverse, short-term, negligible impacts.

Rapid deer density reduction would allow the forest to regenerate, improving habitat and reducing impacts of overbrowsing for species listed or considered special status species by Maryland and the District of Columbia. This would result in beneficial impacts that would combine with the beneficial effects of exotic plant control, research, and disease and pest control. These beneficial impacts would offset adverse effects from increased development and other cumulative adverse actions. Therefore, cumulative impacts to species listed or considered special status species by Maryland and the District of Columbia under this alternative would be mostly beneficial and long term.

Conclusion

Under alternative D, the reduced deer density would minimize potential impacts on the habitat for the Hay's spring amphipod, resulting in long-term, beneficial effects that would reduce adverse impacts to negligible. Impacts on species listed or considered special status species by Maryland and the District of Columbia, as well as their habitat, would be beneficial and long term as a result of rapid reductions in deer numbers in the park that would reduce deer browsing pressure on woody and herbaceous vegetation and allow increased abundance and diversity of other species that depend on understory vegetation. Adverse, long-term impacts would be reduced to negligible or minor levels over time. A few predators and scavengers that use deer and their carcasses as a food source could be adversely affected by a lower deer density or denser understory conditions, but this alternative could also increase the availability of other prey. Adverse, long-term impacts would be reduced to negligible or minor levels over time. Human disturbances from trampling during implementation of sharpshooting, capture and euthanasia, and/or reproductive control would be temporary and isolated within the park. Therefore, adverse impacts of these actions on species listed or considered special status species by Maryland and the District of Columbia, would be short term and negligible. Past, present, and future activities, when combined with the reduced browsing pressure on understory habitat expected under this alternative, would result in long-term, beneficial, cumulative impacts to species listed or considered special status species by Maryland and the District of Columbia. There would be no impairment of these species or their habitat under this alternative.

CULTURAL LANDSCAPES

GUIDING REGULATIONS AND POLICIES

Federal actions that have the potential to affect cultural resources are subject to a variety of laws. The *National Historic Preservation Act* (1966, as amended) is the principal legislative authority for managing cultural resources associated with NPS projects. Generally, Section 106 of the act requires all federal agencies to consider the effects of their actions on cultural resources listed on or determined eligible for listing in the National Register of Historic Places. Such resources are termed historic properties. Agreement on how to mitigate effects to historic properties is reached through consultation with the State Historic Preservation Officer; the Tribal Historic Preservation Officer, if applicable; and the Advisory Council on Historic Preservation, as necessary. In addition, federal agencies must minimize harm to historic properties that would be adversely affected by a federal undertaking. Section 110 of the act requires federal agencies to establish preservation programs for the identification, evaluation, and nomination of historic properties to the National Register of Historic Places. Other important laws or EOs designed to protect cultural landscapes include *EO 11593*, "Protection and Enhancement of the Cultural Environment."

Through legislation the NPS is charged with the protection and management of cultural resources in its custody. This is furthered implemented through Director's Order 28: *Cultural Resource Management*, NPS *Management Policies 2006* (NPS 2006), and the 1995 "Servicewide Programmatic Agreement among the National Park Service, the Advisory Council on Historic Preservation, and the National Conference of State Historic Preservation Officers." These documents charge NPS managers with avoiding or minimizing to the greatest degree practicable, adverse impacts on park resources and values. Although the NPS has the discretion to allow certain impacts in parks, that discretion is limited by the statutory requirement that park resources and values remain unimpaired, unless a specific law directly provides otherwise.

ASSUMPTIONS AND METHODOLOGY

The NPS categorizes cultural resources as archeological resources, cultural landscapes, historic structures, museum objects, and ethnographic resources. As noted under "Issues and Impact Topics" in chapter 1, only impacts to cultural landscapes have been retained for detailed analysis in this plan/EIS.

The descriptions of effects on cultural resources that are presented in this section are intended to comply with the requirements of both NEPA and Section 106 of the *National Historic Preservation Act*. In accordance with the regulations of the Advisory Council on Historic Preservation on implementing Section 106 (36 CFR Part 800, Protection of Historic Properties), impacts on cultural resources are to be identified and evaluated by (1) determining the area of potential effects; (2) identifying cultural resources present in the area of potential effects that are either listed on or eligible to be listed in the National Register of Historic Places; (3) applying the criteria of an adverse effect to affected cultural resources either listed on or eligible to be listed in the national register; and (4) considering ways to avoid, minimize, or mitigate adverse effects.

Under the Advisory Council's regulations, a determination of either *adverse effect* or *no adverse effect* must also be made for affected cultural resources eligible for listing in the National Register of Historic Places. An *adverse effect* occurs whenever an impact alters, directly or indirectly, any of the characteristic that qualifies the resource for inclusion in the national register (for example, diminishing the integrity of the resource's location, design, setting, materials, workmanship, feeling, or association). Adverse effects also include reasonably foreseeable effects caused by the proposal that would occur later in time, be farther removed in distance, or be cumulative (36 CFR 800.5, Assessment of Adverse Effects). A determination of *no adverse effect* means there would either be no effect or that the effect would not

diminish in any way the characteristics that qualify the cultural resource for inclusion in the National Register of Historic Places.

Council on Environmental Quality regulations and the NPS Director's Order 12 also call for a discussion of the appropriateness of mitigation, as well as an analysis of how effective the mitigation would be in reducing the intensity of a potential impact (e.g., reducing the intensity of an impact from major to moderate or minor). Any resultant reduction in the intensity of an impact due to mitigation, however, is an estimate of the effectiveness of mitigation under NEPA only. Cultural resources are nonrenewable resources, and adverse effects generally consume, diminish, or destroy the original historic materials or form, resulting in a loss in the integrity of the resource that can never be recovered. Therefore, although actions determined to have an adverse effect under Section 106 of the *National Historic Preservation Act* may be mitigated, the effect remains adverse.

A Section 106 summary is included in the impact analysis sections for cultural landscapes. The Section 106 summary is an assessment of the effect of the undertaking (implementation of the alternative) only on cultural resources listed on or eligible for the National Register of Historic Places, based on the criteria of effect and criteria of adverse effect found in the regulations of the Advisory Council on Historic Preservation.

METHODOLOGY AND INTENSITY THRESHOLDS

Cultural landscapes are landscapes that have been adapted for or influenced by human use. Cultural landscapes that are designated within national parks have been determined to have historic significance and integrity.

In analyzing how alternative approaches for deer management would affect the cultural landscape of Rock Creek Park, attention was paid to the program's effect on vegetation as a character-defining feature of the cultural landscape and on views and vistas.

For the assessment of potential impacts to cultural landscapes, the principal sources reviewed were Dumbarton Oaks Park Cultural Landscape Report (NPS 2000a), Montrose Park Cultural Landscape Report (NPS 2004d), Linnaean Hill Cultural Landscape Inventory (NPS 2003a), and Peirce Mill Cultural Landscape Inventory (NPS 2003b).

For purposes of analyzing potential impacts to cultural landscapes, the thresholds of change for the intensity of an impact are defined as follows:

Negligible: The impact would be at the lowest level of detection, with neither adverse nor beneficial consequences. For purposes of Section 106 of the *National Historic Preservation Act*, the determination of effect would be *no adverse effect*.

Minor: **Adverse impact**: Alteration of a pattern(s) or feature(s) of the cultural landscape listed on or eligible for listing in the National Register of Historic Places would not diminish the overall integrity of the landscape. For purposes of Section 106 of the *National Historic Preservation Act*, the determination of effect would be *no adverse effect*.

Beneficial impact: Preservation of landscape patterns and features would be in accordance with the Secretary of the Interior's Standards for the Treatment of Historic Properties with Guidelines for the Treatment of Cultural Landscapes (NPS 1996b), therefore maintaining the integrity of the cultural landscape. For purposes of Section 106 of the *National Historic Preservation Act*, the determination of effect would be *no adverse effect*.

Moderate: **Adverse impact**: The impact would alter a pattern(s) or feature(s) of the cultural landscape, diminishing the overall integrity of the landscape. For purposes of Section 106 of the *National Historic Preservation Act*, the determination of effect would be *adverse effect*. A memorandum of agreement would be executed among the NPS and the State Historic Preservation Officer and, if necessary, the Advisory Council on Historic Preservation in accordance with 36 CFR 800.6(b). Measures identified in the memorandum of agreement to minimize or mitigate adverse impacts would reduce the intensity of impact under NEPA from major to moderate.

Beneficial impact: The landscape or its features would be rehabilitated in accordance with the Secretary of the Interior's Standards for the Treatment of Historic Properties, with Guidelines for the Treatment of Cultural Landscapes (NPS 1996b), to make possible a compatible use of the landscape while preserving its character-defining features. For purposes of Section 106 of the *National Historic Preservation Act*, the determination of effect would be *no adverse effect*.

Major: **Adverse impact**: The impact would alter a pattern(s) or feature(s) of the cultural landscape, diminishing the overall integrity of the resource. For purposes of Section 106 of the *National Historic Preservation Act*, the determination of effect would be *adverse effect*. Measures to minimize or mitigate adverse impacts could not be agreed upon, and the NPS and the State Historic Preservation Officer and/or Advisory Council on Historic Preservation would be unable to negotiate and execute a memorandum of agreement in accordance with 36 CFR 800.6(b).

Beneficial impact: The cultural landscape would be restored in accordance with the Secretary of the Interior's Standards for the Treatment of Historic Properties, with Guidelines for the Treatment of Cultural Landscapes (NPS 1996b) to accurately depict the features and character of a landscape as it appeared during its period of significance. For purposes of Section 106 of the *National Historic Preservation Act*, the determination of effect would be *no adverse effect*.

AREA OF ANALYSIS

There are 25 units (listed in chapter 1) in Rock Creek Park covered by the plan/EIS that contain cultural landscapes, as determined by the NPS. For the purpose of this analysis, including cumulative impacts, the area of potential effect includes these 25 units.

IMPACTS OF THE ALTERNATIVES

ALTERNATIVE A: NO-ACTION ALTERNATIVE (EXISTING MANAGEMENT CONTINUED)

Analysis

One of the greatest impacts on park vegetation has been the growth in the deer population and subsequent deer browsing, which has caused a depletion in the forest's herbaceous and shrub vegetation and has adversely affected numerous cultural landscape plantings. This has a potential impact on cultural landscape elements, both natural and designed, because much of the natural or planted vegetation is a key component of the park's cultural landscapes. For example, the park's *Dumbarton Oaks Cultural*

Landscape Report states that forest vegetation contributes to the significance of the cultural landscape (NPS 2000a).

Under alternative A, park staff would continue monitoring the deer population and would conduct activities to protect native plants, such as creating small caged areas and applying repellents to a small number of landscaped areas. However, deer populations would be expected to remain at high levels or slightly increase over the long term, and browsing would continue throughout the park, causing a decline in the long-term abundance and diversity of native plant species, contributing to further establishment of invasive exotic species within the park, and reducing or eliminating palatable landscape plantings. As a result, the plant species and cultural plantings that have existed historically in the park would continue to be reduced and in some cases could be lost. This continued decline in these plant communities would result in an adverse, long-term, minor to moderate impact to the park's cultural landscape (depending on the landscape and the plant's importance to the landscape), because native and introduced plant communities comprise a component of most cultural landscape character-defining features. The degree of impact would depend on the size of the future deer population and the associated degree of impact on the park plant communities and the susceptibility of the particular planting to deer browse.

Small caged areas and repellents would continue to be used to protect landscape plantings, new restoration plantings, or rare plant species from deer browsing in specified areas. In addition, protection of these landscape features would result in beneficial, long-term, minor impacts in localized areas, but this would not compensate for the severe impacts caused by overbrowsing throughout the park's cultural landscapes.

Cumulative Impacts

Various past and present actions and events have affected the vegetation at Rock Creek Park that is an important component of the cultural landscape. Gypsy moths, which cause large-scale tree defoliation and can lead to mortality, are a serious concern throughout northern Maryland and Washington D.C. They have become sufficiently abundant so as to require aerial spraying to prevent deforestation and related impacts. Fires have affected various areas of the park and suppression has also reduced the number of fire-dependent native species. In the decades before the park was established, a blight destroyed the American chestnut, at one time a major element of the Rock Creek Park forest, as well as most of the eastern deciduous forest. All diseases and activities that affect the native woodlands would also affect the historic character of the site, resulting in adverse, long-term, minor to moderate impacts.

Invasive exotic vegetation is a problem inside and outside the park. Disturbance from natural events or from human activities can make conditions favorable for invasive exotic plant species. The spread of exotic species could have adverse impacts on cultural landscapes if the species overtake the established native and planted species that constitute the cultural landscape. An intensive program to prevent the spread of invasive exotic vegetation in the park over the long term would result in beneficial, minor impacts to the park's cultural landscapes.

Land use changes in areas adjacent to Rock Creek Park affect views and vistas, gradually eroding the sense of place that used to surround the park. Character-defining features of a historic landscape include changes, either individually or collectively, that have occurred over time. Particularly affected is land along the various parkways leading into the main body of Rock Creek Park and other vulnerable sites on the immediate boundary of the park. Development or new construction has the potential to degrade the views of the natural and designed cultural landscapes that comprise the park. Park development and maintenance would have short- and long-term negligible impacts because recognized cultural landscapes would be protected by park policy. Similarly, telecommunications facilities development would have to comply with park policy to preserve cultural landscapes when facilities are sited.

The practice of riding mountain/motor bikes on embankments and Civil War era earthworks contributes to long-term, moderate, adverse impacts on those particular features of the various landscapes within the park units.

Overall, impacts from the actions described above, coupled with the continued decline of native plant communities and cultural plantings under alternative A, would result in adverse, long-term, minor to moderate cumulative impacts to the cultural landscape.

Conclusion

The use of small cages and repellents to protect landscape plantings, new restoration plantings, or rare plant species at specified areas could result in beneficial, long-term, minor impacts to these parts of the park's vegetation. However, continued growth of the deer population and the associated ongoing decline in the abundance and diversity of the native plant communities and cultural plantings would result in an adverse, long-term, minor to moderate impact to the park's cultural landscapes. Adverse, long-term, minor to moderate cumulative impacts would result from the ongoing decline of native plant communities as a result of disease processes, development, vandalism, and deer browsing, despite benefits from the use of small cages and repellents and exotic species control. No impairment of cultural landscapes would occur under alternative A.

ALTERNATIVE B: COMBINED NON-LETHAL ACTIONS

Analysis

Several non-lethal actions would be implemented under this alternative, in addition to actions described under alternative A, to protect forest resources, including the use of large-scale exclosures (figure 4) and reproductive control for does. The large-scale exclosures would vary in size, depending on the landscape, and each would enclose from 7 to 25 acres. Assuming 14 exclosures were erected, 167 acres or about 5% to 10% of the forested area would be protected from deer browsing over the life of the plan, allowing for the regeneration of forest vegetation within the exclosures. This represents approximately 5% of the entire park and approximately 10% of the main park reservation. Although habitat is becoming limited within the park, deer browsing would be more concentrated outside the exclosures and could cause some continued decline in native and landscaped plants in these areas. In addition, the woven-wire, 8-foot fenced exclosures would introduce new structural elements into the park's overall landscape. The exclosures are planned for the Rock Creek unit only; no cultural landscapes in other Rock Creek Park units would be affected. The exclosures would be inconsistent with the park's designed and historic landscapes that reflect the significance of early 1900s buildings, gardens, and natural features. To mitigate potential impacts to the historic landscapes, the exclosures would be located some distance from common visitor use areas so that they would not intrude on these landscapes. The exclosures might be visible during the winter and spring from locations within the park, such as Parkside Drive trail where the views are contributing features to the cultural landscape. However, due to their materials and construction, they would be difficult to see. Regardless, the presence of these exclosures would result in long-term minor to moderate adverse impacts to the cultural landscapes in which they are located.

The regeneration of native vegetation within the exclosures would begin to rehabilitate portions of the cultural landscape. As described in alternative A, small cages and repellents would also be used to protect other character-defining vegetation features. These small-scale cages, combined with the protection afforded by the large exclosures, would result in localized beneficial, long-term, minor impacts to the cultural landscape because of expected vegetation regeneration in these areas.

Reproductive controls under alternative B would involve the use of bait piles and possibly temporary holding pens. Bait piles would be placed in unobtrusive locations so as not to impact the visitor's appreciation of the cultural landscape. The same is true of temporary holding areas or pens; these would be placed in locations away from gardens, structures, and other cultural landscape features, limiting

adverse impacts to negligible or minor levels. Reproductive control techniques for does would gradually limit deer population growth over the long term and allow for regeneration of native plant communities outside the exclosures, with long-term beneficial minor impacts to the park's cultural landscapes, but this benefit would not be experienced during the life of this plan. Since reproductive controls would take a long time to reduce the size of the deer population, deer numbers would be expected to remain at high levels over the life of the plan. Browsing would continue throughout the park and cause a decline in the long-term abundance and diversity of native plant species, particularly to susceptible cultural and landscape plantings that are integral to many of the park's cultural landscapes. As a result, there would be adverse, long-term, minor to moderate impact to the park's cultural landscapes (depending on the landscape and the plants importance to the landscape) over the life of the plan. The degree of impact would depend on the size of the future deer population and the associated degree of impact on the park plant communities and the susceptibility of the particular planting to deer browse.

Cumulative Impacts

The same past, present, and future actions described under alternative A would also occur under alternative B. Management actions identified in alternative B, where approximately 5% to 10% of the park's vegetation would be protected from browsing, combined with reproductive control, could reduce the deer density after more than 15 years of implementation, would provide some beneficial impacts over the long term, but not immediately. Adverse effects from increased development and other cumulative adverse actions, in conjunction with continued deer browsing pressure on the majority of the herbaceous and woody vegetation and delayed reduction in the deer population, would not be offset by the beneficial effects of proposed actions. Therefore, cumulative impacts to cultural landscapes under this alternative would be adverse, long term, and moderate.

Conclusion

Under alternative B, overall approximately 5% of the entire park and up to 10% of the main park reservation would benefit from constructing exclosures over the life of this plan. However, remaining vegetation within the park would continue to be adversely affected by deer browsing over the long term until reproductive controls became effective and the population decreased. Also, presence of the exclosures would result in long-term minor to moderate adverse impacts to the cultural landscapes in which they are located. Since the benefits of reproductive control would not be fully realized within the life of this plan, overall impacts to vegetation would be adverse, long term, and minor to moderate as the young vegetation and ground cover decreased in quantity and diversity in the majority of the park and cultural plantings would continue to be affected where not fenced. Past, present, and future activities, when combined with the continued pressure on vegetation expected under this alternative, would result in long-term, moderate adverse cumulative impacts. Because alternative B would provide continued protection of certain areas of the park over the long term, it would meet the minimum of protecting 5 to 10% of the forested area at any one time (Bowersox, pers. comm. 2005), and would introduce reproductive controls that could reduce deer numbers gradually over an extended period of time, it is not expected that impairment of cultural landscapes would occur under this alternative.

ALTERNATIVE C: COMBINED LETHAL ACTIONS

Analysis

Under this alternative sharpshooting activities would reduce the herd size, along with capture and euthanasia where appropriate. Similar to alternative A, placing small cages around individual or small groups of plants or landscaping would also be part of this alternative.

Reducing the deer population from 82 deer per square mile (as of 2007) to 15 to 20 deer per square mile within approximately three years would result in diminished browsing pressure. This reduced pressure

would allow park plant populations to regenerate and would improve the abundance and diversity of native species within the park over the long term. Decreased browsing, as well as small caged areas and repellent use, would also help protect landscape plantings, new restoration plantings, and/or rare plant species at specified areas. Because native plant populations and cultural plantings are character-defining vegetation features of the park's cultural landscape, the re-establishment or rehabilitation of this feature would result in beneficial, long-term, moderate impacts to the park and component landscapes.

Sharpshooting activities related to deer reduction, including setting up bait stations, occupying shooting areas, and dragging deer to locations for processing, transport, or burial would have some temporary effects on vegetation and, as a result, the cultural landscape. Sharpshooting could require portable tree stands to be temporarily hung in trees. Removing deer carcasses from the kill site could require dragging over vegetation, which would temporarily trample some herbaceous and woody vegetation. However, the area of impact from these actions would be small (less than 1% of park vegetation), resulting in an adverse, short-term, negligible impact to the park and component landscapes.

The park intends to donate all deer meat to local charitable organizations to the maximum extent possible. If this is done, field dressing would occur in the park and the entrails would be buried or placed in barrels for disposal at a processing facility. Surface disposal methods would occur in areas that would not be visible from or within easy access of trails, roads, facilities, or neighboring properties, resulting in adverse, short-term, negligible impacts. Burial pits would be in previously disturbed sites in or near developed areas of the park that are not components of cultural landscapes. These sites would be generally devoid of vegetation except for weeds and would not be located in designed landscapes or next to historic features. In addition, burial pits would not be located within an area identified as an archeological site or as having archeological resources. These areas would be fully covered, fenced to prevent entry, and reseeded when the weather and season are appropriate. The impact to the component cultural landscapes would be temporary, adverse, short term, and negligible.

Cumulative Impacts

The same past, present, and future impacts described under alternative A would also occur under alternative C. Quickly reducing the park's deer population would provide beneficial, long-term effects, with adverse impacts being reduced to negligible or minor levels over time. These effects, combined with other beneficial effects, would result in cumulative impacts that would be primarily beneficial. These beneficial impacts would somewhat offset the adverse effects from increased development and other cumulative adverse actions. Therefore, cumulative impacts to cultural landscapes under this alternative would be mostly beneficial, minor, and long term.

Conclusion

Enhancing natural forest regeneration by quickly reducing deer browsing pressure under alternative C, and by maintaining a smaller deer population through direct reduction, would result in beneficial, long-term impacts because vegetation in cultural landscapes throughout the park could thrive and recover where effects have been noted. Over time as natural forest regeneration occurred, beneficial, long-term, moderate impacts on cultural landscapes could be expected. Past, present, and future activities, when combined with the reduced pressure on vegetation and subsequent forest regeneration, would result in beneficial, long-term cumulative impacts. Cultural landscapes would not be impaired under this alternative.

ALTERNATIVE D: COMBINED LETHAL AND NON-LETHAL ACTIONS

Analysis

Direct reduction would be implemented under alternative D to quickly reduce the size of the deer herd and reproductive control and direct reduction (if needed) would be used as a maintenance tool to keep the

deer herd at reduced numbers. Small caged areas and repellents would be used as described under alternative A and deer waste and carcasses would be disposed of as described under alternative C. Impacts under this alternative would be the same as alternative C. Native plant populations would be rehabilitated by the direct reduction in deer populations, and other character-defining vegetation features would be potentially protected through some small-scale caging and repellent use, resulting in beneficial, long-term, moderate impacts to the park and component landscapes. Some adverse, short-term, negligible impacts could also result from sharpshooting and deer waste disposal activities.

Cumulative Impacts

The same past, present, and reasonably foreseeable actions described under alternative A would also occur under alternative D. Rapidly reducing the deer population would relieve browsing pressure on a majority of the park's vegetation, providing moderate, long-term, beneficial impacts to cultural landscapes. Some adverse impacts would affect woody and herbaceous vegetation as a result of trampling due to setting bait stations, occupying shooting locations, removing deer carcasses, and using traps. However, these impacts would be isolated, affecting less than 1% of the park, resulting in adverse, short-term, negligible impacts.

Rapid deer density reduction would give the forest the opportunity to thrive and regenerate, resulting in beneficial impacts that would combine with other beneficial effects, resulting in cumulative impacts that would be primarily beneficial. These beneficial impacts would somewhat offset the adverse effects from increased development and other cumulative adverse actions. Therefore, cumulative impacts to vegetation under this alternative would be mostly beneficial, minor, and long term.

Conclusion

Enhancing natural forest regeneration by quickly reducing deer browsing pressure under alternative D, and by maintaining a smaller deer population through the use of reproductive control (and direct reduction if needed), would result in beneficial, moderate, long-term impacts because vegetation that is an important component of cultural landscapes could thrive and recover throughout the park. Under alternative D less than 1% of the park's vegetation would be affected by trampling at bait stations, shooting sites, trapping locations or disposal sites. Therefore, adverse impacts of these actions on cultural landscapes would be short term and negligible. Past, present, and future activities, when combined with the reduced pressure on vegetation (forest regeneration) expected under this alternative, would result in beneficial, long-term cumulative impacts. Cultural landscapes would not be impaired under this alternative.

NATIONAL HISTORIC PRESERVATION ACT SECTION 106 SUMMARY

This plan/EIS analyzes the impacts of four alternatives on cultural landscapes in Rock Creek Park. The alternatives include a no-action alternative and three action alternatives. All of Rock Creek Park and associated administrative units are potentially eligible for listing in the National Register of Historic Places as a historic cultural landscape. Dumbarton Oaks Park was individually listed in the National Register in 2004, and Montrose Park was individually listed in 2006. Historic districts, or features of cultural landscapes within the park, such as the Rock Creek and Potomac Parkway Historic District, the Civil War Fort Sites, the Peirce-Klingle Mansion, and the Peirce Mill have already been listed in the National Register of Historic Places.

Under alternative A, continued growth in the existing deer population and excessive deer browsing would continue to limit successful regeneration of native plant communities within the park, resulting in an adverse, long-term, moderate impact to the park's cultural landscape. Potential beneficial impacts to the park's cultural landscapes could result from the use of small caged areas to protect small groups of native plants and, if threatened by deer browsing, to protect landscape plantings, reducing the need for replanting trees to maintain the desired landscape. Because there would be a continued decline of native plant

communities and little natural tree regeneration due to continued deer browsing, implementation of alternative A would result in an *adverse effect* on the park's cultural landscape.

Under alternative B, large fenced exclosures would be constructed to allow up to 10% of the park's forest, a character-defining vegetation feature in the park's cultural landscape, to regenerate over the life of the plan, resulting in long-term beneficial impacts. The fences would be a new structural element within the landscape, but they would be temporary and would be placed in areas not easily visible to visitors. Reproductive control measures would take several years to be effective under alternative B, so there would be long-term moderate adverse impacts for the life of this plan, since the deer population would not be reduced enough to reduce impacts on cultural plantings and native vegetation that contributes to cultural landscapes. Therefore, alternative B would result in an *adverse effect* on the park's cultural landscape.

Under alternative C, the quick reduction of the deer population would cause a substantial decline in browsing of native plant populations. Native plants would begin to regenerate, resulting in long-term benefits to native plants, a character-defining vegetation feature in the park's cultural landscape. Therefore, *no adverse effect* would result from actions taken under alternative C.

Alternative D would be a combination of reproductive controls described in alternative B and lethal controls described in alternative C. These combined actions would result in a direct reduction in the deer population and the protection of vegetation that is an identifying characteristic of the cultural landscape, resulting in a *no adverse effect* under alternative D.

In accordance with Section 106 of the *National Historic Preservation Act*, potential adverse impacts (as defined in 36 CFR 800) on cultural landscapes listed on or eligible for listing in the National Register of Historic Places would be coordinated between the NPS and the State Historic Preservation Officer to determine the level of effect on the property and to determine any necessary mitigation measures. Continuing implementation of the *Cultural Resource Management Guideline* (NPS 2002b) and adherence to NPS *Management Policies 2006* (NPS 2006) and the 1995 Servicewide programmatic agreement with the Advisory Council on Historic Preservation and National Conference of State Historic Preservation Officers would all aid in reducing the potential to adversely impact historic properties.

Copies of this plan/EIS will be distributed to the District of Columbia State Historic Preservation Officer *and the Advisory Council on Historic Preservation* for review and comment related to compliance with Section 106 of the *National Historic Preservation Act*.

SOUNDSCAPES

GUIDING REGULATIONS AND POLICIES

The National Park System includes some of the quietest places on earth, as well as a rich variety of sounds intrinsic to park environments. These intrinsic sounds are recognized and valued as a park resource in keeping with the NPS mission (NPS *Management Policies 2006* [NPS 2006, sec. 1.4.6]), and are referred to as the park's natural soundscape. The natural soundscape, sometimes called natural quiet, is the aggregate of all the natural sounds that occur in parks, absent human-caused sound, together with the physical capacity for transmitting the natural sounds (NPS *Management Policies 2006* [NPS 2006, sec. 4.9]). It includes all of the sounds of nature, including such "nonquiet" sounds as birds calling, waterfalls, thunder, and waves breaking against the shore. Some natural sounds are also part of the biological or other physical resource components of parks (e.g., animal communication, sounds produced by physical processes, such as wind in trees, thunder, and running water).

National Park Service policy requires the protection of natural soundscapes from degradation due to noise (undesirable human-caused sound) (NPS *Management Policies 2006* [NPS 2006, sec. 4.9]). The NPS is specifically directed to "take action to prevent or minimize all noise that, through frequency, magnitude, or duration, adversely affects the natural soundscape or other park resources or values, or that exceeds levels that have been identified as being acceptable to, or appropriate for, visitor uses at the sites being monitored" (NPS *Management Policies 2006* [NPS 2006, sec. 4.9]). Overriding all of this is the fundamental purpose of the National Park System, established in law (e.g., 16 USC 1 et seq.), which is to conserve park resources and values (NPS *Management Policies 2006* [NPS 2006, sec. 1.4.3]). National Park Service managers must always seek ways to avoid or to minimize, to the greatest degree practicable, adverse impacts on park resources and values (NPS *Management Policies 2006* [NPS 2006, sec 1.4.3]).

Director's Order 47: Soundscape Preservation and Noise Management, and the methodology being developed for the reference manual for Director's Order 47 states:

> An important part of the NPS mission is to preserve and/or restore the natural resources of the parks, including the natural soundscapes associated with units of the national park system. Natural sounds are intrinsic elements of the environment that are often associated with parks and park purposes. They are inherent components of "the scenery and the natural and historic objects and the wild life" protected by the NPS Organic Act. They are vital to the natural functioning of many parks and may provide valuable indicators of the health of various ecosystems. Intrusive sounds are of concern to the NPS because they sometimes impede the Service's ability to accomplish its mission (NPS 2000b).

ASSUMPTIONS, METHODOLOGY, AND INTENSITY THRESHOLDS

Impacts to soundscapes were assessed by considering context, time, and intensity. For example, noise for a certain period and intensity would be a greater impact in a highly sensitive context, and a given intensity would be a greater impact if it occurred more often or for a longer duration. It is usually necessary to evaluate all three factors together to determine the level of noise impact. In some cases, an analysis of one or more factors may indicate one impact level, while an analysis of another factor may indicate a different impact level, according to the criteria below. In such cases, best professional judgment based on a documented rationale is used to determine which impact level best applies to the situation being evaluated.

National literature was used to estimate the average decibel levels of proposed actions and areas of use by visitors were identified in relation to where the actions were proposed. Other considerations, such as topography, were then used to identify areas where noise levels could be exacerbated or minimized.

The following thresholds were used to determine the magnitude of effects on soundscapes.

Negligible: Natural sounds would prevail; (activity) noise would be very infrequent or absent, mostly immeasurable.

Minor: Natural sounds would predominate in areas where management objectives call for natural processes to predominate, with (activity) noise infrequent at low levels. In areas where (activity) noise is consistent with the park's purpose and objectives, natural sounds could be heard occasionally.

Moderate: In areas where management objectives call for natural processes to predominate, natural sounds would predominate, but (activity) noise could occasionally be present at low to moderate levels. In areas where (activity) noise is consistent with the park's purpose and objectives, (activity) noise would predominate during daylight hours and would not be overly disruptive to noise-sensitive visitor activities in the area; in such areas, natural sounds could still be heard occasionally.

Major: In areas where management objectives call for natural processes to predominate, natural sounds would be impacted by (activity) noise sources frequently or for extended periods of time. In areas where (activity) noise is consistent with the park's purpose and zoning, the natural soundscape would be impacted most of the day; noise would disrupt conversation for long periods of time and/or make enjoyment of other activities in the area difficult; natural sounds would rarely be heard during the day.

AREA OF ANALYSIS

The area of analysis, including assessment of cumulative impacts, is the entire park and immediately adjacent landowners.

IMPACTS OF THE ALTERNATIVES

ALTERNATIVE A: NO-ACTION ALTERNATIVE (EXISTING MANAGEMENT CONTINUED)

Analysis

Under the "no-action" alternative, Rock Creek Park would continue to implement current management actions and policies related to deer and the deer's effects on the park. Current management would include deer population monitoring, as well as caging of small areas and using small amounts of repellents to protect native plants and ornamental landscaping. Noise from constructing caging around landscape plants and applying repellents by hand would be minimal. Under alternative A, park staff may use trucks to reach areas to be caged or monitored. Traffic, construction, and application sound impacts would likely be adverse, localized, short term, and negligible.

Cumulative Impacts

Adverse impacts to soundscapes within and surrounding the park have occurred and will continue to occur from several actions related to park maintenance and operations, traffic and transportation, and special community events. Past maintenance and operations actions within the park, such as construction of facilities, roads, and landscaping work have all resulted in increased noise levels within the park, thus adversely affecting soundscapes to a minor extent in limited areas. Noise generated from highways, planes, helicopters, and emergency vehicles has, and would continue to further impact the park's natural soundscape in both the short and long term. Although there are places in the park where visitors can experience a natural setting and listen to the sounds of bird calls, water, and animals, complete solitude in the park is unlikely given its urban setting and discontinuous nature. Special and community events, especially at the Carter Barron Amphitheater, have occurred and will continue to occur within the park, thus adversely affecting soundscapes to a minor extent within the park. The future reconstruction of Rock Creek and Potomac Parkway and continued park maintenance operations would have long-term minor adverse impacts on soundscapes in limited areas within the foreseeable future. All of these activities, when combined with the negligible impacts on soundscapes expected under alternative A, would result in cumulative impacts that would be adverse, short and long term, and minor to moderate.

Conclusion

Under alternative A, the actions taken to protect plants and monitor the deer population and park vegetation would result in a short-term, negligible adverse impact on soundscapes. Cumulative impacts would range from minor to moderate and adverse depending on the source, due to the variety and abundance of noise sources that already exist around and within the park. No impairment of the park's soundscapes would occur under this alternative.

ALTERNATIVE B: COMBINED NON-LETHAL ACTIONS

Analysis

A combination of non-lethal actions would be implemented under alternative B, in addition to the actions described under alternative A, to protect forest seedlings, promote forest regeneration, and gradually reduce deer numbers in the park. The additional actions would include constructing large-scale fenced exclosures and controlling doe reproduction through surgical sterilization and reproductive control. As deer were excluded from feeding within the large exclosures, open (nontreated) areas would be monitored for changes in vegetation because of probable increased browsing pressure. Forest regeneration would be monitored both inside and outside the exclosures as described under alternative A.

Park staff would construct up to 14 large exclosures of various configurations to fit the landscape, each covering from about 7 to 25 acres or up to a total of approximately 167 acres. Construction of the exclosures would require approximately 150 days. This represents approximately 5% of the entire park and approximately 10% of the main park reservation. The exclosures would be initially located throughout the main park unit (Reservation 339), where they would be relatively easy to access, yet away from high use visitor areas or scenic views. Residents and visitors would experience minor, short-term, adverse noise impacts due to construction of fencing and exclosures in specific, localized areas, which would last only during the 150-day construction period. Such construction would not affect all residents and visitors, only those in areas where fencing and exclosures have been identified. The need for additional fencing would result in adverse noise impacts over the long term, as such actions would occur for several years into the future, but the duration of the specific activities and their associated noise would be intermittent and short term.

Minimal noise impacts are expected from administering reproductive control of does. There would be some noise resulting from vehicles entering and exiting the park to set up bait stations, construction activities to set up holding pens, firing of dart guns, and vehicles entering and exiting the park to deliver

the reproductive control agents. Visitors to the park's popular attractions, such as trails and forested areas would most likely be the most affected. However, reproductive control activities would be restricted to remote areas of the park as much as possible so that adverse impacts would be primarily short term and negligible. Therefore, under alternative B, noise impacts to residents and visitors would be primarily short term, negligible to minor (depending on the location), and adverse.

Cumulative Impacts

The same past, present, and future actions described under alternative A would also occur under alternative B. Management actions described in alternative B, where up to 10% of the park's forested area would be protected by large exclosures over the life of the plan, combined with reproductive control of does, would provide short term, negligible to minor adverse impacts on soundscapes within and immediately surrounding the park. Noise generated by highways, planes, helicopters and emergency vehicles, as well as special and community events would continue, as described under alternative A, and would combine with the minimal amount of noise that would be generated under this alternative. Therefore, when combined with the short-term, negligible to minor adverse impacts to soundscapes expected under alternative B, cumulative impacts would be minor to moderate and adverse in the short and long term.

Conclusion

Impacts to soundscapes would be short term, negligible to minor, and adverse under alternative B due to intermittent construction of exclosures and reproductive control activities. The degree of the impact would vary by location. However, even though individual construction and reproductive control activities would be short term, they would continue indefinitely into the future, resulting in both short- and long-term, negligible to minor, adverse impacts. Cumulative impacts due primarily to the variety and abundance of existing noise sources would be minor to moderate and adverse in the short and long term. No impairment of the park's soundscapes would occur under this alternative.

ALTERNATIVE C: COMBINED LETHAL ACTIONS

Analysis

Alternative C would continue the actions described under alternative A, with two types of lethal action used to reduce and control deer herd numbers. National Park Service staff or their authorized agents would conduct sharpshooting and capture and euthanasia to reduce the deer population. Bait stations may be used to attract deer. In most locations, high-power, small caliber rifles would be used from close range. Efforts would be made to make the shootings as humane as possible; it is anticipated that only one shot or possibly two would be required per deer as highly trained staff would be used. Noise suppression devices and night vision equipment would be employed to reduce disturbance to the public.

Sharpshooting with firearms would primarily occur at night (between dusk and dawn), primarily during late fall and winter months when deer are more visible and fewer visitors are in the park. In some restricted areas, sharpshooting may be done during the day if needed, which could maximize effectiveness and minimize overall time of restrictions. If this is done, the areas would be closed to park visitors. In addition, exhibits would be displayed at visitor centers, and information would be posted on the park's website to educate the public regarding deer management actions. Visitor access would be restricted as necessary during the time the reduction is taking place, and the park would be patrolled by NPS personnel and U.S. Park Police to ensure safety of the public. Also, shooting would occur during the winter months, when visitation levels would be low.

Bait stations could be used to attract deer to safe removal locations, concentrate deer, improve removal success, and to allow the use of ground as a backstop. Bait stations would consist of small grains, apples,

hay, or other food placed on the ground. The stations would be placed in park-approved locations away from public use areas to maximize the efficiency and safety of the reduction program.

Noise impacts to park visitors would be minimal, as implementation of this alternative is planned for fall or winter and would primarily occur after sunset, when fewer visitors would be in the park. Local residents would likely experience the most impacts. As described in chapter 3, noise from a small caliber rifle would be approximately 160 dBa (decibels, A-weighted decibel scale) at the source (table 17). Assuming that the sound level decreases 6 decibels (dB) with a doubling of the distance (MN Pollution Control Agency 1999; Komanoff and Shaw 2000; OPTI 2002), an individual approximately 500 feet from the source of a firearm discharged without a suppressor would experience a noise level of about 106 dBa, which is considered very loud and comparable to highway construction noise. Use of a suppressor (see chapter 2) would bring that down to approximately 76 dBa at 500 feet from the source, which is comparable to busy traffic. However, this does not consider attenuation from soft surfaces and topography, factors that would decrease the decibel levels even more, assuming a decrease of 7.5 dB with doubling of distance from a point source (Caltrans 1998), particularly if residents were indoors at night. For example, sound impacts would likely be somewhat less in densely vegetated or hilly areas of the main park unit. Sound would also be attenuated if shooting blinds were carefully positioned in areas that are heavily wooded; beside a hill, or unoccupied structure; and located as far from residences as possible. These conditions would result in a level of about 62.5 dBa at 500 feet from the source in a wooded area, which is considered lower than a conversational speech level (table 17). Because the park intends to perform sharpshooting primarily at night when there is less overall traffic and other day-time noise, the perceived annoyance level to neighboring residents would likely be higher than if conducted during the day. The sounds of such noise during meal times or leisure times could increase levels of annoyance. In addition, efforts would be made to schedule sharpshooting activities during the fall or winter when visitation is lower and to expedite the process as quickly and humanely as possible. Therefore, impacts to soundscapes under this alternative would be adverse, minor to moderate, and short term, given the duration of the action. Long-term impacts would occur as the activity is repeated over time (possibly several years) to maintain herd numbers at a specified level.

The intensity of the adverse impacts would vary depending on several factors, particularly perceived levels of annoyance. Individuals who are farther from the source of the firearm, support the removal efforts, and have experienced hunting efforts in the past would likely experience minor adverse impacts. Individuals who are closer to the source of the firearm would likely experience moderate adverse impacts if such sounds made enjoyment of other activities in the area difficult. However, because most of the park closes at night and visitation is lowest during fall and winter when sharpshooting activities would occur, impacts to visitors would likely be minimized.

Overall, impacts under alternative C would be adverse, both short and long term, and range from minor to moderate, depending on the proximity and attenuation factors between the source and the general public or visitor.

Cumulative Impacts

The same past, present, and future activity impacts described under alternative A would also occur under alternative C. Noise generated by highways, planes, helicopters and emergency vehicles, as well as special and community events would continue, as described under alternative A, and would combine with the firearm noise that would be generated under this alternative. Therefore, when combined with the short-term, minor to moderate adverse impacts to soundscapes expected under alternative C, cumulative impacts would be minor to moderate and adverse in the short and long term. These impacts would be expected to decrease as the need for removal efforts decreases as well.

Conclusion

Impacts to soundscapes from sharpshooting would be adverse, short and long term, and minor to moderate, primarily affecting nearby residents because sharpshooting would occur mostly at night and during off-peak visitation seasons. Perception of the intensity of the impacts would vary depending on several factors, including timing, attenuation levels, and distance from the source, resulting in minor to moderate impacts to individuals experiencing the sound. Cumulative impacts would be adverse, short and long term, and minor to moderate. However, these impacts would be expected to decrease in the long term, as deer populations in all affected areas decrease and the need for direct reduction decreases as well. No impairment of the park's soundscapes would occur under this alternative.

ALTERNATIVE D: COMBINED LETHAL AND NON-LETHAL ACTIONS

Analysis

Alternative D would include all actions described under alternative A, plus a combination of certain additional lethal and non-lethal actions from alternatives B and C to reduce deer herd numbers. The lethal actions would include both sharpshooting and capture/euthanasia, and these actions would be taken initially to quickly reduce the deer herd numbers. Reproductive control of does would be implemented to maintain the reduced herd numbers through sterilization or reproductive control, if feasible. If reproductive controls meeting required criteria become available sooner than expected, the park could select to use these first (before the initial sharpshooting), so that deer are not as hard to capture and more can be treated. However, for this analysis, it is assumed that sharpshooting would be conducted first, and that population maintenance would be conducted via the most practicable method and could include a combination of lethal and non-lethal methods (i.e., sharpshooting could be used for maintaining the deer herd if necessary).

Noise related to construction of fencing, reproductive control activities, and ensuing monitoring would continue, as described under alternative B. Noise impacts related to this component of this alternative would be short term, adverse, and negligible. Long-term impacts would continue as more fencing, exclosures, reproductive control, and spraying is required; however, the need for such actions is expected to decrease because implementation of this alternative also contains elements to control the size of the overall deer herd.

The greatest impact from noise would be from the use of firearms. As described under alternative C, intensity of the noise impacts would vary based on several factors, including proximity to the firearm, use of noise suppression devices, and perceived annoyance level. The need for further sharpshooting efforts would likely decrease over the long term as the effects of this action and the use of reproductive controls would result in a decrease in the size of the deer herd. Therefore, the overall effect of implementation of all components of this alternative would be short and long term, adverse, and minor to moderate, with expected decreases in intensity over the long term.

Cumulative Impacts

The same past, present, and future activity impacts described under alternative A would also occur under alternative D. Noise generated by highways, planes, helicopters and emergency vehicles, as well as special and community events would continue, as described under alternative A, and would combine with the firearm noise that would be generated under this alternative. Therefore, when combined with the short-term, minor to moderate adverse impacts to soundscapes expected under alternative D, cumulative impacts would be minor to moderate and adverse in the short and long term. As explained under alternative C, these impacts would be expected to decrease as the need for removal efforts decreases as well.

Conclusion

Overall impacts to soundscapes under this alternative would be short and long term, adverse, and minor to moderate, particularly due to the use of firearms. Perception of impact intensity would vary based on several factors, particularly timing, distance, and attenuation from the source. However, long-term impacts would be expected to decrease as the overall herd population decreases, reducing the need for direct reduction. Cumulative impacts would be adverse, short and long term, and minor to moderate. However, these impacts would be expected to decrease in the long term, as deer populations in all affected areas decrease and the need for direct reduction decreases as well. No impairment of the park's soundscapes would occur under this alternative.

VISITOR USE AND EXPERIENCE

GUIDING REGULATIONS AND POLICIES

The NPS *Management Policies 2006* (NPS 2006) state that the enjoyment of park resources and values by the people of the United States is part of the fundamental purpose of all parks and that the NPS is committed to providing appropriate, high-quality opportunities for visitors to enjoy the parks. Management goals include making available to the public traditional outdoor recreational opportunities that are not detrimental to the natural or cultural resources of the park.

While preservation and conservation are key components of the NPS *Management Policies 2006*, they also instruct park units to provide for recreational opportunities. The NPS achieves its preservation and conservation purposes by working to maintain all native plants and animals as parts of the natural ecosystem, emphasizing preservation and conservation over recreation. The NPS will achieve this by preserving and restoring the natural abundances, diversities, dynamics, distributions, habitats, and behaviors of native plant and animal populations and the communities and ecosystems in which they occur (NPS 2006, sec. 4.4.1).

Rock Creek Park's General Management Plan (2005a) includes the following desired conditions that pertain to visitor use and experience:

- visitors have opportunities to enjoy the park in ways that leave park resources unimpaired for future generations
- visitors understand and appreciate park values and resources and have the information necessary to adapt to the park's environments

ASSUMPTIONS, METHODOLOGY, AND INTENSITY THRESHOLDS

Past visitor use data, comments from the public, and personal observations of visitation patterns were used to estimate the effects of the alternative actions on visitors. It is assumed that annual visitation over the life of the plan will remain relatively steady at about 2 million visitors per year, with slight variations from year to year. The thresholds for the intensity of an impact are defined as follows:

Negligible: The impact would be barely detectable and/or would affect few visitors. Visitors would not likely be aware of the effects associated with management actions.

Minor: The impact would be detectable and/or would only affect some visitors. Visitors would likely be aware of the effects associated with management actions. The changes in visitor use and experience would be slight but detectable; however, visitor satisfaction would not be measurably affected.

Moderate: The impact would be readily apparent and/or would affect many visitors. Visitors would be aware of the effects associated with management actions. Visitor satisfaction might be measurably affected (visitors could be either satisfied or dissatisfied). Some visitors would choose to pursue activities in other available local or regional areas.

Major: The impact would affect the majority of visitors. Visitors would be highly aware of the effects associated with management actions. Changes in visitor use and experience would be readily apparent. Some visitors would choose to pursue activities in other available local or regional areas.

AREA OF ANALYSIS

The area of analysis is the entire park and adjacent landowners, who constitute a large number of visitors, for all alternatives, including cumulative assessments.

IMPACTS OF THE ALTERNATIVES

ALTERNATIVE A: NO-ACTION ALTERNATIVE (EXISTING MANAGEMENT CONTINUED)

Analysis

Park staff would continue monitoring the deer population under alternative A and would conduct activities to protect native plants, such as creating small caged areas and applying a minimal amount of repellents to landscaped areas.

The most common reasons for visiting Rock Creek Park are exercise (61%), followed by escaping the city environment (47%), and spending time with family/friends (37%). The reason least often listed was commuting to work (6%). "Other" reasons included attending a concert, walking the dog, golfing, gardening, enjoying nature, eating lunch, commuting home, visiting the planetarium, and studying (29%) (Littlejohn 1999). Small caged areas would not adversely impact those who visit the park to exercise, as these caged areas would not be located on paths nor recreational areas. Depending on the methods visitors use to escape the city environment, they could be adversely impacted by the sight of small caged areas throughout the park. Conversely, the caged areas protect rare plants and vegetation that visitors would not otherwise see due to excessive deer browsing. Visitors who primarily escape the city environment by driving through the park would be the least affected, as caged areas would be difficult to detect while driving. Visitors who primarily escape the city environment by hiking would be affected to a greater degree, depending on the location of the trail and the number of cages encountered.

Visitors who come to the park primarily to enjoy natural history (14%) or learn about history/nature (10%) would be most affected under this alternative, as impacts to natural and historical vegetation from excessive deer browsing would continue under this alternative, diminishing the likelihood of appreciating such vegetation. Adverse impacts to visitor experience from the heavily browsed vegetation would be long term, localized, and range from minor to moderate.

When asked to rate the importance of selected features or qualities of the park (extremely important, very important, moderately important, somewhat important, or not important), “scenic beauty” received the highest importance ratings when “extremely important” and “very important” ratings were combined (73% ranked it extremely important, and 21% ranked it very important, a total of 94%) (Littlejohn 1999). Under this alternative, visitors who value the scenic beauty could be adversely affected by manmade fences that would disrupt views and by the lack of shrubbery and flowering plants in the forest understory. These impacts would adversely affect a large percentage of the park’s visitors, resulting in adverse, long-term, minor to moderate impacts.

Visitors also placed a high importance on native plants and wildlife in the park, with 44% ranking this as extremely important and 23% as very important. Under this alternative, the deer population would continue to grow and/or remain at high levels, adversely impacting native plants and, as a result, wildlife and wildlife habitat. Therefore, the majority of park visitors who value native plants and wildlife, including the many birdwatchers that use the park, could experience long-term, adverse, minor to moderate impacts as the diversity and abundance of native vegetation in the park decreases as a result of deer browsing. In addition, overbrowsing by deer gives invasive exotic plant species an opportunity to become established, which could potentially out compete native plants and contribute to adverse impacts to visitors who value native vegetation. Although it is not known what percent of visitors place a high importance specifically on seeing deer, any visitors who do would have a higher chance of viewing deer

under this alternative. However, the condition of the deer may decline as the population grows and food becomes less available. Therefore, if visitors viewed ill or emaciated deer, visitor experience could be adversely affected.

Picnickers, photographers, and visitors who visit historic or cultural sites could be adversely affected by the sight of small cages and the effects of deer browsing on native vegetation and wildlife. However, these visitors are primarily focused on specific activities or areas, and they would be less likely to see cages or notice browsing impacts.

Impacts of alternative A would not likely adversely affect cross-country skiers, or horseback riders to a measurable extent. These visitors comprise a small percentage of overall visitation and engage in specific activities in areas that may not be as affected by deer management activities or the impacts of overbrowsing.

Minimal application of repellents at the park would also result in short-term, negligible adverse impacts to visitors who might view this activity or smell the applied herbicides, as use would be limited primarily to landscaped areas.

Educational efforts included under this alternative, such as communication with the public about deer management activities as described in chapter 2, would help offset adverse impacts to all park visitors, who would be informed of the reasons for implementing the management activities. Monitoring efforts described under this alternative, such as deer population surveys and vegetation monitoring, would have little to no impact on visitors since surveys would be conducted at night when the park is closed, and most visitors would likely interpret vegetation monitoring as consistent with scientific efforts expected at a unit of the National Park System.

Cumulative Impacts

Adverse impacts to visitor use and experience within the park have occurred and would continue to occur under alternative A. The growing deer population has adversely affected the scenic quality of the park as extensive deer browsing has reduced the abundance of native vegetation and wildlife that visitors value. The presence of rabies, Lyme disease, and West Nile virus would continue under alternative A, which would affect the wildlife that many visitors come to see. Acts of illegal camping, off-trail users, unrestrained pets, poaching, and dumping have all had and continue to have minor localized adverse impacts to visitor use and experience. Exotic plant control has had a primarily beneficial impact on visitor use and experience, as exotic and invasive species have been reduced to allow for the regeneration of native species that comprise the natural beauty of the park. Park management and operations have had, for the most part, beneficial impacts to visitor use and experience, as interpretive programs have been developed, and trails have been established and maintained. Slight short-term negligible to minor adverse impacts from park management and operations have resulted from noise caused from construction of facilities, roads, and landscaping work, which as a result has impacted visitor experience.

Traffic and vehicle collisions have occurred and would continue to occur under alternative A, adversely impacting visitor use and experience. Urban development has impacted visitor use and experience both adversely and beneficially, and would continue to do so under each alternative. While noticeable urban development immediately outside park boundaries may diminish the feeling of "wildness" within the park, this same urban development has increased accessibility for neighboring residents. Current shrinking of green space surrounding the park under alternative A would continue to have negligible to minor adverse impacts on visitor use and experience. The future reconstruction of Rock Creek and Potomac Parkway, as well as park trails would have short-term minor adverse impacts on visitor use as it may inconvenience access and local commutes through the park; however, long-term beneficial impacts to visitor use and experience would result from the improvement of the parkway and trails.

All of these activities, when combined with the continued pressure on forest resources expected under alternative A from continued deer browsing, would result in both adverse and beneficial cumulative impacts to visitor use and experience. Adverse cumulative impacts would be long term and minor to moderate.

Conclusion

Impacts to visitor use and experience under alternative A would be both beneficial and adverse to those visitors who maybe primarily interested in viewing deer (beneficial in that there would be more deer to see, adverse in that the appearance of the herd could be poor). However, overall impacts related to a decreased ability to view scenery (including native vegetation) and other wildlife, which a large majority of visitors rated as important, would be long term, minor to moderate and adverse. Past, present, and future activities, when combined with the continued pressure on forest resources expected under this alternative, would result in both adverse and beneficial (depending on an individual visitor's goals) impacts. Overall cumulative impacts would be long term, minor to moderate and adverse.

ALTERNATIVE B: COMBINED NON-LETHAL ACTIONS

Analysis

A combination of non-lethal actions would be implemented under alternative B, in addition to the actions described under alternative A, to protect forest seedlings, promote forest regeneration, and gradually reduce deer numbers in the park. The additional actions would include constructing large-scale fenced exclosures, and controlling doe reproduction through surgical sterilization and reproductive control. As deer were excluded from feeding within the large exclosures, open (nontreated) areas would be monitored for changes in vegetation because of probable increased browsing pressure. Forest regeneration would be monitored as described under alternative A.

Repellents and small caged areas described under alternative A would continue to be used under alternative B, but large fenced exclosures would be constructed to allow reforestation. Park staff would construct up to 14 large exclosures of various configurations to fit the landscape, each covering from about 7 to 25 acres or up to a total of approximately 167 acres. This represents approximately 5% of the entire park and approximately 10% of the main park reservation. The exclosures would be initially located throughout the main park unit (Reservation 339) where they would be relatively easy to access, yet away from high use visitor areas or scenic views. Visitors hiking in the park to view wildlife and scenery would be most affected under this alternative. Birdwatchers, cross-country skiers, and nature photographers who may desire a more natural, primitive park experience would also be adversely affected. Visitors to the park's historic or cultural sites might also be adversely affected by intrusions on the cultural landscape. Those who primarily experience the park by car might not be as affected by the sight of the exclosures, which would probably not be detectable from vehicles. To protect park resources and minimize visual impacts of the exclosures, park staff would consider locating them in areas not visible from visitor use areas.

Visitors would also be affected by fence construction activities, which would result in visual intrusions, such as the presence of work crews and employees in certain areas of the forest. Not all visitors would be impacted, only those in areas where the activities occurred. These adverse impacts would be negligible to minor and short term during construction, but would occur repeatedly over the life of the plan, resulting in long-term impacts.

The use of reproductive controls on does would be based on available technology. Initially, sterilization would be used to reduce the herd's ability to reproduce, followed by use of a reproductive control agent. If more does were captured at once than could be treated, temporary holding areas may be necessary to house deer prior to treatment. Holding areas would be in compliance with American Veterinarian Medical Association standards, and the holding period would not be more than a day. To ensure that visitors

would understand the nature of the treatment efforts, the park would conduct educational programs to inform visitors about the procedures and explain why the treatments are necessary. However, visitors may see various aspects of the reproductive control operations, which could result in minor adverse impacts to their visitor experience.

The park plans to implement deer management educational and interpretive efforts under all alternatives, and visitors would be made aware of the reasons for the exclosures and their benefit to forest regeneration, which would beneficially impact visitors with the knowledge that the natural environment would eventually improve. Such information could offset adverse impacts related to visual aesthetics caused by the exclosures. Adverse impacts would be negligible to minor and short term, gradually changing to negligible beneficial in the long term as the forest regenerates due to protection afforded by the exclosures.

With reproductive control, deer would be marked with ear tags. Visitors could be troubled by the sight of deer with artificial markings, particularly those who primarily come to the park to see deer. Again, educational material would alert visitors to deer management activities and explain their purpose and expected outcomes.

As reproductive controls eventually take effect and the deer population begins to decrease over time, some park visitors might notice reductions in the excessive browsing pressure that has been damaging forest resources. There would be an increased ability to view native plants and animals, including birds, wildflowers, and other wildlife. However, many years would be required to achieve these beneficial impacts. Overall, short-term impacts would be adverse and minor, gradually becoming beneficial in the long term.

Those visitors who are interested primarily in seeing deer would be adversely affected. However, the herd size would not be reduced to the extent that deer would become rare in the park, rather they would still be visible, but they would be more in balance with other elements of the ecosystem. The herd might be healthier under this alternative as compared to alternative A. Therefore, visitors who value seeing deer might also prefer seeing fewer deer if it means maintaining a healthy, viable herd, which could lessen the intensity of the adverse impact to these visitors to negligible or minor.

Cumulative Impacts

The same past, present, and future actions described under alternative A would also occur under alternative B. Management actions described in alternative B, where approximately 5% to 10% of the park's forested area would be protected by large exclosures, combined with reproductive control of does, would provide short-term, negligible to minor adverse impacts on visitor use and experience in the short term, gradually becoming beneficial in the long term. Therefore, cumulative impacts to visitor use and experience would be mostly beneficial, negligible to minor and long term due to combined forest regeneration activities, which would enhance the overall visitor experience.

Conclusion

Under alternative B, approximately 10% of the main park reservation would benefit from constructing exclosures over the life of this plan. Visitors under alternative B would experience adverse, short-term impacts primarily due to aesthetics and closures of certain areas of the park, as well as a slight increase in noise levels during construction of exclosures and reproductive control efforts that would take place primarily between October and April. These impacts would be offset by the educational and interpretive information that would explain the purpose of deer management activities, which would reduce adverse impacts to minor. Short-term impacts would eventually give way to beneficial, long-term impacts as the need for exclosures diminished and the deer population declined, resulting in a restored forest ecosystem throughout the park. However, many years would be required to achieve these beneficial results. Visitors focused primarily on seeing deer could be adversely impacted by the reduction in the herd size, but such

an impact would be negligible to minor, as opportunities to view deer would still exist. Cumulative impacts to visitors would be mostly beneficial and long term due to the effects of combined forest regeneration activities.

ALTERNATIVE C: COMBINED LETHAL ACTIONS

Analysis

Alternative C would continue the actions described under alternative A, with two types of lethal action used to reduce and control deer herd numbers. The NPS or their authorized agents would conduct sharpshooting and capture and euthanasia to reduce the deer population. Visitors would be affected primarily by closures required to conduct the direct reduction activities. Sharpshooting with firearms would primarily occur at night (between dusk and dawn), primarily during late fall and winter months when deer are more visible and fewer visitors are in the park. In some restricted areas, sharpshooting may be done during the day if needed, which could maximize effectiveness and minimize overall time of restrictions. If this is done, the areas would be closed to park visitors. The public would be notified of any park closures in advance, exhibits regarding deer management would be displayed at visitor centers, and information would be posted on the park's website to inform the public of deer management actions. Visitor access could be limited as necessary while reductions were taking place, and NPS park personnel and U.S. Park Police would patrol public areas to ensure compliance with park closures and public safety measures. Noise suppression equipment would be used to decrease impacts to the soundscape, and visitors would only be affected by noise if sharpshooting occurred during the day and in areas that were not restricted or closed to visitor use.

Because sharpshooting activities would occur when visitation is lower (during fall and winter months), and primarily at night (when the park is closed), adverse impacts to visitors related to closures or noise from high-power, small caliber rifles would be negligible. Impacts would be both short and long term, as limited sharpshooting activities would continue beyond the initial 3-year reduction period to maintain the target population in the future.

Visitors could be adversely affected by deer being removed by archery or by being captured and euthanized in certain circumstances. If archery is used, there is a possibility of a deer not succumbing immediately and fleeing the area, and it could then be seen by the public. However, all sharpshooters would be trained in removal of deer using archery, would shoot only at close range, and would take deer only in limited circumstances. Therefore, the likelihood of this happening is slight. For capture and euthanasia, deer would be captured as humanely as possible using methods such as nets or box traps, which visitors could see if hiking, jogging, walking dogs, etc. However, capture and euthanasia would primarily be used in special circumstances, and activities would occur at dawn or dusk when visitation is low. In most cases, euthanasia would apply to individual deer. If this method was required to remove several deer at one time, the area would be temporarily closed to visitors. Under either circumstance, capture and euthanasia would occur when needed, rather than as a scheduled activity. Because this method would be used only in limited circumstances, the likelihood of visitors being exposed to deer being captured and euthanized would be low. Impacts to visitor use would be sporadic over the life of this plan, adverse, and negligible.

The waste and/or carcasses would be disposed of primarily in pits created at developed areas or offsite. Because the priority would be to donate meat, disposal would only include the few carcasses that might be unsuitable for donation. The majority of carcasses buried would be done so offsite. If onsite surface disposal were used, it would occur only in remote areas, which would be unlikely to be noticed by visitors. Burial would occur soon after shooting, when the park is closed to visitors. In addition, sharpshooting would occur during fall and winter months when fewer people visit Rock Creek Park. Therefore, few, if any, visitors would be exposed to deer remains or burial activities under this alternative.

The park plans to implement deer management educational and interpretive efforts under all alternatives, and visitors would be made aware of the reasons for the activities and their benefit to forest regeneration.

As under alternative B, long-term beneficial impacts would occur to most visitors because the forest would regenerate, creating increased ability to view foliage and wildflowers, and providing improved habitat for a variety of species. Beneficial impacts and forest regeneration would be realized fairly quickly, as direct reduction would have an immediate impact on the size of the deer herd. Maintaining a viable herd size would help ensure a more balanced ecosystem into the future.

Also mentioned under alternative B, the ability to see deer would decrease, and those visitors who are interested primarily in seeing deer would be adversely affected. However, the herd size would not be reduced to the extent that deer would become rare in the park, rather they would still be visible, but they would be more in balance with other elements of the ecosystem. The herd might be healthier under this alternative as compared to alternative A. Therefore, visitors who value seeing deer might also prefer seeing fewer deer if it means maintaining a healthy, viable herd, which could lessen the intensity of the adverse impact to these visitors to negligible or minor.

Cumulative Impacts

The same past, present, and future activities expected under alternative A would also occur under alternative C. Quickly reducing the park's deer population would provide beneficial, long-term effects, with adverse impacts being reduced to negligible or minor levels over time. These effects, combined with other beneficial effects, would result in cumulative impacts that would be primarily beneficial, negligible to minor, and long term. These beneficial impacts would somewhat offset the adverse effects from increased development and other cumulative adverse actions described under alternative A. Therefore, cumulative impacts to visitor use and experience under this alternative would be mostly beneficial and long term.

Conclusion

Few visitors under alternative C would see lethal deer management actions occur, since they would primarily occur during fall and winter and at night, when few, if any, visitors are in the park. These impacts would be offset by the educational and interpretive information that would explain the purpose of the deer management activities. Therefore, adverse impacts would be long term and negligible. Long-term beneficial impacts would occur as a result of forest regeneration, which would have a moderate effect on visitors, due to the restoration of natural resources. Visitors focused primarily on seeing deer could be adversely impacted by the reduction in herd size, but such impacts would be negligible to minor as opportunities to view deer would still exist. As under alternative B, cumulative impacts to visitors would be mostly beneficial and long term due to combined forest regeneration activities.

ALTERNATIVE D: COMBINED LETHAL AND NON-LETHAL ACTIONS

Analysis

Alternative D would include all actions described under alternative A, plus a combination of certain additional lethal and non-lethal actions from alternatives B and C to reduce deer herd numbers. The lethal actions would include both sharpshooting and capture/euthanasia, and these actions would be taken initially to quickly reduce the deer herd numbers. Reproductive control of does would be implemented to maintain the reduced herd numbers through sterilization or reproductive control, if feasible. If reproductive controls meeting required criteria become available sooner than expected, the park could select to use these first (before the initial sharpshooting), so that deer are not as hard to capture and more can be treated. However, for this analysis, it is assumed that sharpshooting would be conducted first, and that population maintenance would be conducted via the most practicable method and could include a

combination of lethal and non-lethal methods (i.e., sharpshooting could be used for maintaining the deer herd if necessary).

Adverse impacts related to sharpshooting activities would be long term and negligible, since they would primarily occur during fall and winter and at night, but beneficial impacts would result from a relatively rapid reduction in deer herd size, which would result in enhanced forest regeneration. Disposal of deer carcasses and waste would occur as described under alternative C. Visitors would only be slightly affected by the continued use of small caged areas and repellents, a negligible impact. Reproductive control would be applied after sharpshooting efforts had reduced the deer population. Therefore, reproductive control activities would augment direct reduction to reduce deer browsing pressure and allow forest regeneration, increasing the quality of Rock Creek Park's scenery and the diversity of its plants and animals. Resulting impacts to visitors would be beneficial and long term. Adverse impacts could occur from visitors being exposed to reproductive control activities and associated area closures. Educational and interpretive activities would help explain why deer management is needed.

As under the other action alternatives, visitors interested primarily in seeing deer could be adversely affected by the long-term reduction in the deer population. However, adverse impacts to these visitors would be negligible for the reasons mentioned under alternatives B and C.

Cumulative Impacts

The same past, present, and future activity impacts described under alternative A would also occur under alternative D. Quickly reducing the park's deer population would provide beneficial, long-term effects, with adverse impacts being reduced to negligible or minor levels over time. These effects, combined with other beneficial effects, would result in cumulative impacts that would be primarily beneficial. These beneficial impacts would somewhat offset the adverse effects from increased development and other cumulative adverse actions described under alternative A. Therefore, cumulative impacts to vegetation under this alternative would be mostly beneficial and long term.

Conclusion

Adverse, short-term impacts could occur if visitors were exposed to direct reduction or reproductive control actions described under alternative D. These impacts would be offset by educational and interpretive information that would explain the purpose of the deer management actions, resulting in negligible adverse impacts. Beneficial impacts would occur in the long term, as the forest regenerated and visitors could see increased plant and animal diversity, and enjoy enhanced scenery. Visitors focused primarily on seeing deer could be adversely impacted by the reduction in the herd size, but such impact would be negligible to minor, as opportunities to view deer would still exist. Cumulative impacts to visitors' ability to enjoy Rock Creek Park's scenery and species diversity, regardless of the type of activity involved, would be primarily beneficial and long term.

VISITOR AND EMPLOYEE SAFETY

The safety of both visitors and NPS employees at Rock Creek Park could be affected by implementation of the proposed deer management actions. Impacts to visitor safety would be related to the presence of fences, the use of dart guns and firearms, as well as any additional associated deer management activities. Impacts to employee safety would be related to the use of firearms and dart guns, and the potential for any accidents that could result from implementation of the other proposed actions.

GUIDING REGULATIONS AND POLICIES

The NPS *Management Policies 2006* state that, "while recognizing that there are limitations on its capability to totally eliminate all hazards, the Service . . . will seek to provide a safe and healthful environment for visitors and employees." The policies also state that "the Service will reduce or remove known hazards and apply other appropriate measures, including closures, guarding, signing, or other forms of education" (NPS 2006, sec. 8.2.5.1).

Rock Creek Park's General Management Plan (2005a) includes the following desired condition that pertains to visitor and employee safety: visitor and employee safety and health are protected.

ASSUMPTIONS, METHODOLOGY, AND INTENSITY THRESHOLDS

The purpose of this impact analysis is to identify the level of impact that implementing each of the proposed alternatives would have on the safety of visitors and employees at Rock Creek Park. Past accident data, park goals, and personal observations of safety issues were used to assess the effects of the alternative actions on the safety of visitors and employees.

VISITOR SAFETY

The impact thresholds for visitor safety are defined below.

Negligible: There would be no discernible effects to visitor safety; slight injuries could occur, but none would be reportable.

Minor: Any reported visitor injury would require first aid that could be provided by park staff.

Moderate: Any reported visitor injury would require further medical attention beyond what was available at the park.

Major: A visitor injury would result in permanent disability or death.

AREA OF ANALYSIS

The study area for this analysis, including analysis of cumulative impacts, is Rock Creek Park and any surrounding properties.

IMPACTS OF THE ALTERNATIVES

ALTERNATIVE A: NO-ACTION ALTERNATIVE (EXISTING MANAGEMENT CONTINUED)

Analysis

Park staff would continue to erect small cages around sensitive plants and apply repellents to landscaped areas under alternative A. They would also continue monitoring activities and deer population surveys.

No accidents or injuries have occurred to visitors as a result of such activities, and no accidents are anticipated from their continuation, resulting in negligible impacts. However, the high deer population would continue to contribute to vehicle accidents experienced by visitors using park roads, resulting in minor to possibly moderate adverse effects on these visitors. Therefore, adverse, long-term impacts are expected, which could range from negligible (from regular monitoring and maintenance) to moderate (from potential vehicle accidents), with most visitors experiencing no or only slight injuries.

Cumulative Impacts

Visitation at Rock Creek Park is expected to remain relatively steady in future years, with continued pressure for various recreational uses and the potential for accidents and vehicle collisions. In addition, some visitors engage in certain activities at Rock Creek Park that are inherently more dangerous than others, such as horseback riding, and accidents involving trips and falls would always be expected, with negligible adverse impacts to visitor safety. Urbanization and associated crime unfortunately would be expected to continue at some level in the future, despite the continued presence of the U. S. Park Police, who patrol 1,800 acres of Rock Creek Park and adjacent parks. Overall, the impacts to park visitors that have and would be expected to occur, combined with the impacts expected under this alternative, would result in long-term, minor adverse cumulative impacts.

Conclusion

Adverse, long-term, negligible to moderate adverse impacts could occur under this alternative, as it is expected that no discernible effects to visitor safety would result from deer management actions, but vehicle collisions would continue. Cumulative impacts would primarily be related to other injuries that visitors could sustain in the park; these impacts would also be adverse, long term, and minor.

ALTERNATIVE B: COMBINED NON-LETHAL ACTIONS

Analysis

Several non-lethal actions would be implemented under alternative B, including the use of large exclosures and reproductive control of does, which would include sterilization using the services of a veterinarian, use of a dart gun, and possible construction of temporary holding pens. Actions described under alternative A (e.g., use of small cages and limited application of repellents) would continue.

Large exclosures would be constructed throughout the park and would be relocated as vegetation regrowth exceeded deer browsing height (60 inches or 150 centimeters). Visitors would not be able to use the fenced areas during or after construction, which would ensure no one would get hurt trying to get into or out of the exclosures. Park staff would place exclosures in locations so as to minimize impacts to visitor use wherever possible, offsetting any related safety issues. Some visitors could walk off-trail and into an exclosure. However, the likelihood of this happening would be very slight.

Under this alternative, initial sterilization would involve gathering of does for treatment in a confined area around bait piles, possible use of holding pens, and transport of the does to the field station where the procedure would be performed. This would occur in closed areas not near park borders, so injuries to visitors would be negligible. Later, does would be treated with a reproductive control agent that would most likely be administered remotely with a dart gun. The application of annual treatments would also be required. As with sterilization, bait piles would be placed to lure does to certain locations chosen to minimize visitor inconvenience. These areas would be closed to public use for the duration of the activity. Treatment would occur during September and October, but during off-peak visitor hours (early morning and evening). To reduce impacts to visitor safety, preference would be given to conducting the treatment on weekdays. If dart guns were not used, does would be lured into a trap site so that they could be treated with the drugs and tagged. Again, these areas would be closed to visitor use, and precautions would be taken to minimize safety impacts.

No impacts to visitor safety from increased monitoring are expected, as such activities would apply primarily to monitoring exclosures, which would be closed to visitors, and open forested areas, where park staff would exercise safety precautions. However, the continued presence of a large number of deer over the life of the plan would continue to contribute to vehicle deer collisions on park roads and result in minor to moderate adverse impacts.

Cumulative Impacts

The actions described under the cumulative scenario for alternative A would also apply to alternative B. Any increase in overall visitation could lead to an increase in visitor accidents or injuries. However, the combined effects of these actions combined with the accidents expected under alternative B are expected to remain minor, as few visitors engage in higher risk activities. Therefore, cumulative impacts would be adverse, long term, and minor.

Conclusion

This alternative includes measures to protect visitors from accident or injury, such as closing deer-treatment areas to visitor use. In addition, reproductive control activities would be conducted by qualified federal employees or authorized agents, whose training and experience with such activities would help ensure safety. Therefore, any adverse impacts to visitors would be short and long term and negligible from deer management, although the continued presence of a large number of deer over the life of the plan would continue to contribute to vehicle deer collisions on park roads and result in minor to moderate adverse impacts. Cumulative impacts would be adverse, long term, and minor.

ALTERNATIVE C: COMBINED LETHAL ACTIONS

Analysis

Qualified federal employees or authorized agents would conduct direct reduction of the deer herd through sharpshooting, and capture and euthanasia of individual deer would be used where sharpshooting is not appropriate due to safety concerns (e.g., near adjacent residences).

Deer would be shot with high-power, small caliber rifles at close range. Measures taken to ensure the safety of Rock Creek Park's visitors would include shooting at night during late fall or winter months when visitation is low, closing areas to visitors if shooting is required, notifying the public in advance of any park closures, providing exhibits regarding deer management actions in the visitor center, and posting information on the park's website. Law enforcement personnel would also patrol the perimeter areas where sharpshooting would occur, and a safe distance would be maintained from any occupied building. Bait stations would be used to attract deer to safe removal locations. Park staff would approve the location of bait stations before sharpshooting took place. The park would comply with all federal firearm laws administered by the Bureau of Alcohol, Tobacco, and Firearms. The majority of deer reduction activities would occur during the first three years of this plan, decreasing in scope (and the potential for accidents) during ensuing years as the deer population declined.

The safety of visitors and adjacent property owners could also be affected by capturing and euthanizing deer. It is unlikely that visitors would be exposed to such action, which would occur primarily at dawn or dusk. If this method was required to remove multiple deer, the area would be temporarily closed to visitors.

The safety measures used under this alternative would ensure the safety of all visitors, and the sizeable reduction of the deer herd would reduce the number of vehicle-deer collisions on park roads. Therefore, adverse impacts would be primarily negligible to minor. Impacts related to deer management would be mostly short term, as the activities would occur for a short period of time each year over primarily a three-year period. However, long-term impacts would also occur as annual deer removal would be required

following the initial herd reduction in order to maintain the herd at the desired level and the continued presence of deer near park roadways.

Cumulative Impacts

The cumulative scenario described under alternative A would also apply to alternative C. Any increase in park visitation would lead to an increase in the number of visitors potentially exposed to lethal removal activities. Accidents that might occur as a result of high-risk or other visitor activities would combine with the negligible to minor impacts expected under this alternative. However, few visitors engage in higher-risk activities at Rock Creek Park, and park staff would implement precautions to ensure the safety of park visitors. Therefore, cumulative impacts would be adverse, long term, and negligible to minor.

Conclusion

Although this alternative includes actions that could be dangerous to visitors, the extent of safety measures would result in adverse, short- and long-term, negligible to minor impacts, as it is expected that no discernible effects to visitor safety would occur from deer management actions and the possibility of deer-vehicle collisions would be diminished. Cumulative impacts would be adverse, long term, and negligible to minor.

ALTERNATIVE D: COMBINED LETHAL AND NON-LETHAL ACTIONS

Analysis

Under alternative D, direct reduction would be implemented to reduce the size of the deer herd, and reproductive control would be used to maintain reduced herd numbers. Small caged areas and repellents would be used as under alternative A.

As described under alternative A, visitors could experience negligible, short- and long-term, adverse impacts as a result of park staff erecting small caged areas and applying repellents. Sharpshooting and capture and euthanasia would be implemented over the first three years of the plan to reduce the size of the deer herd. Reproductive controls would then be administered if available and feasible, most likely through remote injection with a dart gun. However, in both cases, qualified federal employees or authorized agents trained in safety measures would perform these activities, and areas of the park would be closed to visitation, reducing the potential for injury to visitors under this alternative. Sharpshooting would occur primarily at night during off-peak seasons (fall and winter), and darting would occur primarily on weekdays during off-peak hours (early morning and evening). Sharpshooting would not occur within 100 feet of a building or within 400 feet of the park boundary. Treatment areas would be closed to the public, and educational material would inform visitors of deer management actions and the reasons for them. Bait stations would be used to attract deer to safe treatment locations. Park staff would approve the location of bait stations before sharpshooting took place. The park would comply with all federal firearm laws administered by the Bureau of Alcohol, Tobacco, and Firearms.

If dart guns were not used to administer reproductive controls, deer would be lured into a trap site so they could be treated and tagged. These areas would be closed to visitor use, and precautions would be taken to minimize safety impacts. However, this type of treatment would be more time-consuming than the remote dart gun, likely extending the period of time for performing activities to weekends and times of high visitation. In addition, deer would be more sensitive to either type of reproductive control treatment, as they would have become sensitized to human presence and noise after three years of sharpshooting. This would increase the amount of time required to treat the animals, which could increase the amount of visitor exposure to safety risks.

The safety of visitors could also be affected by capturing and euthanizing deer, similar to alternative C. It is unlikely that visitors would be exposed to such action, which would occur primarily at dawn or dusk. If this method was required to remove multiple deer, the area would be temporarily closed to visitors.

No impacts related to additional monitoring called for under this alternative are expected to affect visitor safety, and the sizeable reduction of the deer herd would reduce the number of vehicle-deer collisions on park roads. Therefore, adverse impacts would be primarily negligible to minor.

Cumulative Impacts

The cumulative scenario described under alternative A would also apply to alternative D. An increase in park visitation would increase the number of visitors potentially exposed to firearm and dart gun activities. Accidents that might occur as a result of high-risk or other visitor activities would combine with the negligible impacts expected under this alternative. However, few visitors engage in higher-risk activities at Rock Creek Park, and the park would implement safety measures to ensure visitor welfare. Therefore, cumulative impacts would be adverse, long term, and negligible to minor.

Conclusion

While deer management actions under this alternative could be dangerous to park visitors, including park neighbors who visit the park, the extent of safety measures that would be used, such as area closures and periods of action, and locating activities away from park boundaries, would result in adverse, short- and long-term, negligible impacts. The possibility of deer-vehicle collisions would be greatly diminished. Cumulative impacts would be adverse, long term, and negligible to minor.

EMPLOYEE SAFETY

The impact thresholds for employee safety are defined below.

Negligible: There would be no discernible effects to employee safety; slight injuries could occur and would be reportable.

Minor: Any reported employee injury would require first aid provided by the park or require a doctor's attention.

Moderate: Any reported employee injury would require medical attention beyond what is available at the park and would result in time off.

Major: An employee injury would result in permanent disability or death.

AREA OF ANALYSIS

The study area for this analysis, including the cumulative impact analysis, is Rock Creek Park.

IMPACTS OF THE ALTERNATIVES

ALTERNATIVE A: NO-ACTION ALTERNATIVE (EXISTING MANAGEMENT CONTINUED)

Analysis

Park staff would continue to erect small cages around sensitive plants and apply repellents to landscaped areas under alternative A. They would also continue monitoring activities and surveys. No accidents or injuries have occurred to employees as a result of such activities, and no accidents are anticipated from their continuation, as the park is currently meeting its employee safety goals. No discernible effects to employee safety are expected, and impacts would be adverse, long term, and negligible.

Cumulative Impacts

Accidents also affect park employees. Most injuries or accidents have been usually sustained by maintenance staff and park rangers, who often perform manual work outdoors, including research monitoring. This has resulted in a few injuries every year, but below park safety goals, a negligible adverse impact. Other actions anticipated for the future, such as implementation of research monitoring and exotic plant control could increase risks to employees. Any type of law enforcement needs are handled by the U.S. Park Police, which reduces the risk for other park employees. Since the park is currently meeting its employee safety goal and staff engage in a variety of safety-related training activities, impacts from all activities, including any deer management actions, are expected to remain adverse, long term, and negligible.

Conclusion

Impacts would be adverse, long term, and negligible under this alternative, as it is expected that no discernible effects to employee safety would occur as a result of deer management actions. Cumulative impacts would be mainly related to other injuries that employees could sustain while working in the park; these impacts would also be adverse, long term, and negligible.

ALTERNATIVE B: COMBINED NON-LETHAL ACTIONS

Analysis

Several non-lethal actions would be implemented under alternative B, including the use of large exclosures and reproductive control for does. Actions described under alternative A (e.g., use of small cages) would continue.

Large exclosures would be constructed throughout the park and would be relocated as vegetation regrowth exceeded 60 inches or 150 centimeters (deer-browsing height). Employees could be injured while constructing the exclosures; however, park staff typically exercise caution and apply safety techniques in all construction projects, as defined by the park's training and awareness activities.

Under this alternative, initial sterilization would involve gathering of does for treatment in a confined area around bait piles, possible use of holding pens, and transport of the does to the field station where the procedure would be performed. This could involve injuries to employees from deer handling and rounding up (such as being kicked or stabbed by antlers), but use of qualified federal employees or authorized agents, whose training and experience with such activities would help ensure safety, would minimize hazards. Additional reproductive control would involve treating does with a reproductive agent, which would most likely be remotely administered with a dart-type gun. Bait piles would be placed to lure does to treatment locations, concentrating efforts in safe areas. This activity would increase the potential of employee accident or injury. However, safety precautions would be followed, and training in the use of treatment methods would help ensure employee safety. If more than one shooting location was used to administer reproductive controls with dart guns, these areas would be adequately separated. If dart guns were not used, does would be captured and reproductive controls applied manually. Few if any injuries to employees are expected from this method since the capture and treatment of deer would be conducted by qualified federal employees or authorized agents who are professionally trained to perform these tasks. In addition, federal employees or authorized agents would also be qualified to handle live deer in order to prevent disease transmission and prevent harm to employees.

Although the level of employee involvement in deer management activities under this alternative would increase compared to alternative A, impacts would remain negligible to minor due to the safety precautions that would be taken and the use of properly trained personnel. Any adverse impacts to employees would also be short and long term for the reasons described above.

No impacts to park staff are expected from increased monitoring defined under this alternative.

Cumulative Impacts

The cumulative scenario described under alternative A would also apply to alternative B. Accidents that might occur to employees conducting other park tasks, combined with the negligible impacts expected under this alternative, are expected to be adverse, long term, and negligible.

Conclusion

Employees could be injured while constructing exclosures; however, park staff are trained to exercise caution and apply safety techniques in all construction projects. Reproductive control activities described under this alternative would be conducted by qualified federal employees or authorized agents, whose training and experience would help ensure their safety. Therefore, any adverse impacts to government employees would be short and long term and negligible to minor. Cumulative impacts would also be adverse, long term, and negligible.

ALTERNATIVE C: COMBINED LETHAL ACTIONS

Analysis

Qualified federal employees or authorized agents would conduct direct reduction of deer through sharpshooting, and capture and euthanasia of individual deer would be used where sharpshooting would not be appropriate. Small caged areas and repellents would be used as under alternative A.

As described under alternative A, adverse, short- and long-term, negligible impacts related to erecting small caged areas and applying repellents would apply to this alternative as well.

The safety of park employees could be affected by sharpshooting and capture and euthanasia activities proposed under this alternative. Qualified federal employees or authorized agents would conduct the sharpshooting activities, and their experience in such efforts would help ensure the safety of park employees. If more than one shooting location was used to administer reproductive controls with dart guns, these areas would be adequately separated. Qualified federal employees or authorized agents would also capture and euthanize deer, as such actions would occur sporadically on an as-needed basis. Therefore, impacts to the safety of employees could increase from potential injuries (kicks, bites, stabbing with antlers) that could occur during deer handling. Every precaution would be taken to ensure the safety of employees, and employees would apply safety training and awareness activities designed to reduce safety risks. Activities would be in compliance with all federal firearm laws administered by the Bureau of Alcohol, Tobacco, and Firearms. Although more risks would be involved due to the use of firearms, adverse impacts to the safety of employees would be expected to be negligible to minor due to the safety precautions park staff would follow.

Cumulative Impacts

The cumulative scenario described under alternative A would also apply to alternative C. Accidents that could occur to employees conducting other park tasks would combine with the negligible to minor impacts expected under this alternative from increased employee involvement in potentially dangerous deer management activities. Therefore, cumulative impacts would be adverse, long term, and negligible to minor.

Conclusion

Although this alternative includes actions that could be dangerous to employees, adverse, short- and long-term, negligible to minor impacts would occur, due to safety precautions and property trained staff. Cumulative impacts would also be adverse, long term, and negligible.

ALTERNATIVE D: COMBINED LETHAL AND NON-LETHAL ACTIONS

Analysis

Under alternative D, direct reduction would be implemented to reduce the size of the deer herd, and reproductive control would be used to maintain reduced deer herd numbers if feasible. Small caged areas and repellents would be used as under alternative A.

As described under alternative A, adverse, short- and long-term, negligible impacts related to erecting small caged areas and applying repellents would apply to this alternative as well. In addition, as described under alternative C, sharpshooting and capture and euthanasia would be used to reduce the deer herd during the first three years of this plan, which would increase the potential risk of injury due to the use of firearms and the need to capture and euthanize some deer. However, safety precautions taken by park staff would offset these risks, as described under alternative C. Reproductive controls would be implemented as described under alternative B to maintain the lowered deer population level after direct reduction efforts had reduced the population size. This would most likely involve remotely injecting deer with a reproductive control agent using a dart gun. This type of treatment could take more time than under alternative B because deer would probably become sensitive to the presence of humans and guns during the initial sharpshooting activities. Again, safety precautions would be followed to limit the potential for injury. Therefore, overall impacts to employees would be adverse, long term, and negligible to minor as park staff would engage in more potentially dangerous deer management tasks under this alternative. It is expected that any injuries sustained would be treatable by park staff and would result in less than eight hours of lost work time.

Cumulative Impacts

The cumulative scenario described under alternative A would also apply to alternative D. Accidents that might occur to employees conducting other park tasks, combined with the negligible to minor impacts expected under this alternative, would result in long term, negligible to minor adverse cumulative impacts.

Conclusion

Like alternative C, this alternative includes activities that would be potentially dangerous to employees. However, the extent of safety measures that would be employed would result in adverse, short- and long-term, negligible to minor impacts, as it is expected that any injuries sustained would be treatable by park staff and would result in less than eight hours of lost work time. Cumulative impacts would also be adverse, long term, and negligible to minor.

SOCIOECONOMIC RESOURCES

GUIDING REGULATIONS AND POLICIES

The *National Environmental Policy Act* requires that economic and social impacts be analyzed in an EIS when they are interrelated with natural or physical impacts. Economic impacts would potentially result from deer browsing damage to landscaping on private lands adjacent to the park as a result of changes in deer populations at Rock Creek Park; therefore, they are addressed in this document.

ASSUMPTIONS, METHODOLOGY, AND INTENSITY THRESHOLDS

Because of the limited supply of deer forage within the park, deer that frequent the park may also browse on landscaping plants outside the park on adjacent public and private lands. It is assumed that deer that are habituated to the park may seek food sources outside the park as the quality and quantity of browse within the park decreases. The Maryland Department of Natural Resources indicates that the sex and age of the deer and habitat types will result in home foraging ranges of varying sizes. Yearling males will move many miles, whereas adult females usually have smaller, more consistent annual home ranges. Deer in quality habitat will travel less than deer in poorer quality habitat (MD DNR 2005).

Impact threshold definitions for socioeconomic conditions focus on landscaping depredation to neighboring lands and the number of complaints related to deer damage received by the park, and were defined as follows:

Negligible: No effects would occur, or the effects on neighboring landowners or other socioeconomic conditions would be below or at the level of detection.

Minor: The effects on neighboring landowners or other socioeconomic conditions would be small but detectable. The impact would be slight, but would not be detectable outside the neighboring lands and would affect only a few adjacent landowners.

Moderate: The effects on neighboring landowners or other socioeconomic conditions would be readily apparent. Changes in economic or social conditions would be limited and confined locally, and they would affect more than a few landowners.

Major: The effects on neighboring landowners or other socioeconomic conditions would be readily apparent. Changes in social or economic conditions would be substantial, extend beyond the local area, and affect the majority of landowners.

AREA OF ANALYSIS

The area of analysis includes Rock Creek Park and the adjacent landowners.

IMPACTS OF THE ALTERNATIVES

ALTERNATIVE A: NO-ACTION ALTERNATIVE (EXISTING MANAGEMENT CONTINUED)

Analysis

Under this alternative, park staff would continue to implement current management actions and policies related to deer and their effects. This would include deer population monitoring, as well as caging of small areas and using small amounts of repellents to protect native plants and ornamental landscaping. Current monitoring efforts would continue to record deer browsing impacts and deer population numbers within the park, although specific monitoring actions may be modified or discontinued over time, depending on the results and need for monitoring. Educational and interpretive activities would continue to be used to inform the public about deer ecology and park resource issues, and cooperation with regional entities and inter-jurisdictional agencies would continue. No additional deer management actions to reduce the deer population would occur under this alternative.

These controls would serve to protect important resources, but they would not affect the size of deer populations in the park. Deer populations would continue to remain at high levels and likely grow over time, although numbers would fluctuate annually due to winter temperatures, snow depths and duration of snow cover, food availability, reproduction and mortality rates due to herd health, and other factors.

Landscaping Damage. Private landowners adjacent to the park could experience increased deer browsing on plants in landscaped areas over the short and long term as food sources decreased within the park due to population pressures. Damage to landscaping may result in a decline in property values for affected landowners unless they undertake measures to replace damaged landscaping or pursue the protection mechanisms discussed below. These increases in the deer population could result in adverse, short- and long-term, moderate impacts.

Protection Mechanisms and Costs. Landowners would most likely incur additional costs for caging, repellents, and other forms of deer control to protect their landscaping as the deer population grows under this alternative. The time and monetary costs associated with acquiring additional protection measures would result in adverse, long-term, minor impacts to private landowners, depending on the number of landowners that used such measures.

Cumulative Impacts

Several factors have affected and may affect the landscaping in properties surrounding the park. The area around Rock Creek Park is densely developed, with very little open space. Development and activities within the park may cause increased habitat disruption, and as a result, more deer may forage outside the park during construction or times of disruption. This would result in short- and long-term minor impacts to adjacent landowners. Exotic plants both inside and outside the park have reduced deer forage, and other animals or pests may also damage landscaping. The socioeconomic impacts of all these activities would be both short and long term, adverse, and minor. Combined with the impacts of a continued high number of deer under alternative A, cumulative impacts would be long term, adverse, minor to moderate, and mostly localized to those properties along the park boundary.

Conclusion

Under alternative A, the continued high numbers of deer and likely long-term increase in the deer population in Rock Creek Park would result in additional damage to landscaping in the surrounding areas. Large fluctuations in annual deer populations could result in varying impacts, ranging from minor to moderate and adverse. Landowners would also incur additional costs for caging, repellents, and other

forms of deer control to protect their landscaping. Cumulative impacts would be adverse, long term, and minor to moderate due to the cost to replace landscaping and install deer protection mechanisms.

ALTERNATIVE B: COMBINED NON-LETHAL ACTIONS

Analysis

A combination of non-lethal actions would be implemented under alternative B, in addition to the actions described under alternative A, to protect forest seedlings, promote forest regeneration, and gradually reduce deer numbers in the park. The additional actions would include constructing large-scale fenced exclosures, and controlling doe reproduction through surgical sterilization and reproductive control. Repellents and small caged areas described under alternative A would continue to be used under alternative B.

Reproductive control of deer, if successful, would gradually reduce the population over the long term. However, deer numbers within the park would not be immediately reduced, and numbers would fluctuate annually. The forage range of the deer could expand due to reduced forage availability due to exclosures, resulting in greater deer browsing outside the park where food may be more plentiful. The number of deer that would seek food sources outside the park could be slightly greater under this alternative because the large-scale exclosures in the park would exclude deer from browsing on about 167 acres or about 10% of the main park reservation at any given time.

Landscaping Damage. Private landowners adjacent to the park could anticipate increased deer browsing on plants within landscaped areas over both the short and long terms. The degree of impact on landscaping could be greater than under alternative A because exclosures would prevent browsing on about 10% of the main park reservation at any one time and reduce the amount of forage in the park available to deer, which would result in the deer going outside the park for a food source. Adverse impacts would likely be moderate. The introduction of reproductive controls could reduce long-term impacts on landscaping to minor.

Protection Mechanisms and Costs. Landowners adjacent to the park would continue to incur additional costs for caging, repellents, and other forms of deer control to protect their landscaping. Because deer would be displaced from the park due to the exclosures, these costs would most likely be greater than in alternative A.

The time and monetary costs associated with additional protection measures would result in adverse, long-term, minor to moderate impacts to private landowners because protection costs could increase, similar to alternative A. The availability and effectiveness of reproductive controls in the future could reduce the intensity of these impacts because the deer population would decrease gradually, minimizing landscaping damage and reducing the need for protection mechanisms.

Cumulative Impacts

The cumulative impacts of alternative B would be similar to those described for alternative A, but with more intensity because of the continued reduction in available foraging areas within the park due to the construction of the large exclosures. This would force the existing deer population, which would not see any immediate decline due to the sterilization methods employed, to forage for food in adjacent properties, increasing the damage to landscaping and the expenditures needed to prevent and recover from deer damage. Over time, the deer population would decline as a result of sterilization of does in the herd; however, those effects would be slowly realized. The result of alternative B, in combination with other cumulative actions as described above, would be long term, adverse, and moderate.

Conclusion

Under alternative B reproductive controls (if successful) would allow for only a gradual reduction in the number of deer, and there could be some displacement of deer from the park due to exclosures. The net effect on surrounding property could result in slightly greater damage to landscaping, the impacts of which would be long term and moderate. Landowners would also incur additional costs for caging, repellents, and other forms of deer control to protect their landscaping. Cumulative impacts would be long term, adverse, and moderate.

ALTERNATIVE C: COMBINED LETHAL ACTIONS

Analysis

Under alternative C, sharpshooting (or capture and euthanasia) activities would quickly reduce the deer population, and subsequent actions would maintain the population at the desired density. This approach would primarily be implemented over 3 years, bringing the population down from the current level of approximately 82 deer per square mile to between 15 and 20 deer per square mile. Actions described under alternative A, such as small caging and use of repellents, would also continue.

Landscaping Damage. The removal of nearly 80% of the existing deer herd in Rock Creek Park in the short and long term would likely result in far fewer deer leaving the park to search for food because the habitat in the park could better support the reduced population. Acreage within the park would most likely provide sufficient browse for a reduced deer population. With this reduction in the deer population, the related reduction in landscaping damage would result in beneficial, long-term impacts to private landowners, assuming that park deer populations are currently foraging on private lands adjacent to the park. Adverse, short- and long-term impacts would be reduced from moderate under alternative A to negligible to minor under alternative C. However, if deer populations outside the park remained high, benefits would be more limited.

Protection Mechanisms and Costs. A corresponding decline in costs for caging, repellents, and other forms of deer control to protect landscaping could also occur as the park deer population was reduced. As a result, reduced time and monetary costs associated with protection measures would reduce adverse, long-term impacts to private landowners to minor because they might still incur protection costs, but the cost would likely decrease noticeably.

Cumulative Impacts

The cumulative impacts of alternative C would be less intense than alternative A, due to the dramatic initial decline in deer population. Although some of the cumulative actions described in alternative A would reduce the availability of land available to deer for foraging, the reduced population would offset this impact; therefore, the deer population would be less likely to venture outside the park for food sources. Although some deer browsing-related damage would continue, it would be reduced, and the impacts would be reduced to a minor level. The result of alternative C, in combination with other cumulative actions, would result in overall long-term, adverse, and minor cumulative impacts to socioeconomics (neighboring landscaping).

Conclusion

The reduction of the existing deer populations by approximately 80% in both the short and long term could result in fewer deer leaving the park and browsing landscaping on adjacent lands, assuming that these private lands are currently within the home range of the park deer population, with long-term beneficial effects that would reduce adverse impacts to negligible or minor levels. A corresponding decline in costs for caging, repellents, and other forms of deer control to protect landscaping could also

occur. Cumulative impacts would be beneficial compared to alternative A; long-term cumulative adverse impacts would be reduced to minor.

ALTERNATIVE D: COMBINED LETHAL AND NON-LETHAL ACTIONS

Analysis

Under alternative D, a combination of certain additional lethal and non-lethal actions would be used to reduce deer herd numbers. The lethal actions would include both sharpshooting and capture/euthanasia, and these actions would be taken initially to quickly reduce the deer herd numbers. Reproductive control of does would also be implemented initially through sterilization. Population maintenance would be conducted via reproductive control, if feasible.

As demonstrated in the analysis for alternative C, direct reduction methods would be the most effective in limiting damage to landscaping resulting from deer. Non-lethal methods, such as small-scale caging and repellents that are analyzed in alternative A, would protect park resources from further damage, but would not reduce landscaping damage on lands adjacent to the park. Of the combined lethal and non-lethal methods under this alternative, the direct reduction method would most affect the degree of landscaping damage. Therefore, the impacts associated with alternative D would be the same as alternative C. Over the long-term, adverse impacts to adjacent landowners would be reduced to negligible or minor.

Cumulative Impacts

Cumulative impacts would be similar to those described for alternative C. Impacts associated with past, present, and future actions, when combined with the overall beneficial impacts of alternative D, would result in beneficial impacts compared to alternative A. Cumulative impacts would be long term, adverse and minor because some level of deer-browsing impacts would continue.

Conclusion

Of the combined lethal and non-lethal methods under this alternative, direct reduction methods would affect landscaping damage to the same degree as alternative C. Therefore, landscaping damage would be reduced, resulting in beneficial impacts. Deer browsing impacts would continue at some level, but adverse impacts to landowners, due to improved harvest yields and preserved landscaping, would be reduced to negligible or minor levels over the short and long term. Costs for caging, repellents, and other forms of deer control to protect landscaping would also decline. Cumulative impacts would be beneficial compared to alternative A, and adverse impacts would be reduced to minor.

PARK MANAGEMENT AND OPERATIONS

Park management and operations refers to the current staff available to adequately protect and preserve vital park resources and provide for an effective visitor experience. This topic also includes the operating budget necessary to conduct park operations.

METHODOLOGY AND INTENSITY THRESHOLDS

The discussion of impacts to park operations focuses on (1) the amount of staff available to ensure visitor and employee safety, and (2) the ability of park staff to protect and preserve resources given current funding and staffing levels. It was assumed that under all alternatives the park's annual budget would be increased to implement a particular alternative. However, this funding is not guaranteed; each alternative discusses the impacts of receiving or not receiving additional funding. Park staff knowledge was used to evaluate the impacts of each alternative, and the evaluation is based on the description of park operations presented in chapter 3. Definitions of impact levels are as follows:

Negligible: Park operations would not be affected.

Minor: Park operations would be affected, and the effect would be detectable, but current levels of funding and staff would be adequate and other park operations would not be reduced.

Moderate: Park operations would be affected, the effect would be readily apparent, and increased staff and funding would be needed or other park operations would have to be reduced and/or priorities changed.

Major: Park operations would be affected, the effect would be readily apparent, increased staff and funding would be needed or other park programs would have to be eliminated.

AREA OF ANALYSIS

The area of analysis is Rock Creek Park, including the cumulative impacts analysis.

IMPACTS OF THE ALTERNATIVES

ALTERNATIVE A: NO-ACTION ALTERNATIVE (EXISTING MANAGEMENT CONTINUED)

Analysis

Under alternative A, the existing deer management plan which calls for limited caging, use of repellents in landscaped areas, monitoring, and data management and research, would continue, with assistance from the Student Conservation Association (1 to 2 volunteers) and the NPS Center for Urban Ecology. No new deer management actions would be taken. These controls would serve to protect important resources, but they would not affect the size of the deer population in the park.

The park's deer population would continue at high levels and would likely grow over time, although numbers would fluctuate annually due to winter temperatures, snow depths and snow duration, food availability, reproduction and mortality rates due to herd health, and other factors. Existing park staff would be sufficient to continue performing current deer management functions at the present population level. However, as the deer population continued to grow, more time would have to be devoted to these activities, which would leave less time for other duties. Two resource management employees work with deer management activities, and these actions comprise about 10% to 15% of their time. Additional

management responsibilities, as well as any additional funding that might be needed to build and maintain additional caging and purchase repellents, would result in long-term, minor to moderate adverse impacts. Current deer management would become a permanent component of Rock Creek Park's resource management activities, as adverse impacts to forest health would continue indefinitely into the future. The NPS Center for Urban Ecology would continue to provide inventory and monitoring services. The use of the Student Conservation Association would be expected to continue, which includes payment of a stipend and provision of housing.

Under this alternative, Rock Creek Park staff would also monitor the costs of the deer management program, including costs related to staff time, training, administrative, legal, public relations, and monitoring. If deer management costs increased substantially, funds and personnel from other park divisions might have to be reallocated (e.g., from administration and maintenance), resulting in adverse, long-term, minor impacts to other divisions. Also, if a need arose for additional education and interpretation programs conducted at the park, present funding and staffing would need to be supplemented, resulting in a minor adverse effect.

Cumulative Impacts

Needs related to park operations and maintenance have been, and would continue to be, affected by outside influences, as well as demands related to the implementation of other park plans and resource programs. Increased traffic on park roadways and continued high levels of visitation would continue to require staff time and resources to deal with road maintenance, accident response, and visitor needs and inquiries. U.S. Park Police would continue to assist the park with law enforcement, a long-term positive impact. As the cost of goods and services rises faster than the park's operating budget, staff continue to accomplish the park's mission and maintain the visitor experience with fewer financial resources. These demands result in long-term, minor adverse impacts to park operations.

Under alternative A, it is expected that funding would continue for current deer management activities, but the demand for those activities could increase if the deer population continued to grow and/or remain at high levels and cause impacts to park resources. Responding to other needs would result in reduced funding to carry out park activities. Therefore, the effects of all other actions that place demands on park management and operations, along with the expected demands of deer management, would result in, long-term, moderate adverse impacts to park operations and maintenance.

Conclusion

Impacts to park operations and maintenance under alternative A would be adverse, long term, and minor to moderate. Because present deer management actions would continue, the park's deer population is expected to continue to fluctuate and remain at high levels or increase over the long term, resulting in long-term demands on park staff and funding for managing the deer herd and protecting other park resources. Past, present, and future activities, when combined with actions under this alternative, would result in adverse, long-term, moderate cumulative impacts.

ALTERNATIVE B: COMBINED NON-LETHAL ACTIONS

Analysis

Under this alternative several non-lethal actions would be implemented to protect forest resources and reduce deer numbers in the park, including the use of large-scale exclosures and doe reproductive control. Repellents and the small caged areas described under alternative A would continue to be used. The participation of the Center for Urban Ecology and the Student Conservation Association in park programs would be expected to continue.

Similar to alternative A, deer populations would continue to remain at high levels, pending the allocation of reproductive controls, and numbers would likely continue to fluctuate annually. The non-lethal management measures outlined under alternative B would require additional staff time and seasonal staff, for which additional funding would be needed. Additional temporary staff would likely be needed for the initial construction of the large enclosures, and additional staff time would be needed for long-term maintenance. It is anticipated that the construction of 14 exclosures would take up about 150 days to complete (K. Ferebee, pers. comm. 2008d). If staff from other park divisions were used, park operations in those divisions would be adversely affected during the construction period.

In addition to an increase in temporary staffing, additional funding would be required, as the initial cost of installing the 14 exclosures would be approximately $227,700 for supplies and labor. After the initial construction, the exclosures would be relocated every 10 years, at an estimated cost of $170,775 for supplies and labor. These costs would be in addition to the park's present budget.

Maintaining the large exclosures would require additional staff, especially if large storm events or natural disasters required the exclosures to be repaired or removed. Furthermore, to reduce impacts to visitors as much as possible, some exclosures would be located in more remote areas of the park, adding to maintenance costs. Additional staff time would be needed to inspect and maintain the exclosures, estimated at approximately four visits per year and assuming 48 days to cover all of the exclosures, the yearly labor cost would be approximately $17,535. An additional $10,317 per year would be estimated for materials and additional visits for weather-related maintenance needs. The additional staff time and funds required for regular maintenance of the large exclosures would result in increased funding needs, with adverse, long-term, moderate impacts.

Alternative B would include reproductive control of does, with sterilization completed in the first five years, at an estimated cost of $225,000. Costs for continued reproductive control would depend on the number of deer treated and the current available technology. Assuming the use of leuprolide (or similar agent) as described in chapter 2, costs would be approximately $1,000 per deer. If 10 does are treated, the annual cost would total $10,000, with $5,000 yearly monitoring costs.

Labor for the reproductive control efforts would be provided by qualified federal employees or authorized agents, including funding for a veterinarian to perform the surgery. This option would likely result in adverse, long-term, moderate impacts to the park budget because of the large amount of time and labor involved, most likely reducing the time available for other efforts. Impacts are expected to be adverse, long term, and moderate for reproductive control.

This alternative would also involve increased educational and interpretive activities, and would therefore require additional funding and/or additional staff time to implement these activities. Increased responses to inquiries about the actions taken under this alternative would likely increase the workload of park biologists, rangers, and the Superintendent. This would result in moderate adverse impacts to resource education and resource protection staff, which would decline to minor levels over time.

Overall, the activities associated with alternative B would result in adverse, long-term, moderate impacts for installing large exclosures, conducting reproductive control, and increased educational/interpretive activities.

Cumulative Impacts

The same past, present, and future actions described under alternative A would continue under this alternative, including additional demands on the park's budget for other resource programs and to respond to natural phenomena. In conjunction with actions under this alternative, impacts to park management and operations would be long term, moderate, and adverse.

Conclusion

Alternative B would result in, long-term, moderate adverse impacts on park management and operations from installing and maintaining large exclosures and implementing and monitoring reproductive controls. Past, present, and future activities, when combined with actions under this alternative, would result in adverse, long-term, moderate cumulative impacts.

ALTERNATIVE C: COMBINED LETHAL ACTIONS

Analysis

Sharpshooting would be used to quickly reduce the herd size, with capture and euthanasia applied in certain circumstances. The existing deer population would be reduced over a period of three years to about 15 deer per square mile, or a park population of 69 deer. Additional deer would be removed in subsequent years to maintain the population. Alternative C would include the actions described under alternative A, including limited caging, use of repellents in landscaped areas, monitoring, and data management and research. It is assumed that the participation of the NPS Center for Urban Ecology and the Student Conservation Society in park programs would continue.

The addition of these lethal management measures would require additional staff time to accompany the qualified federal employees or authorized agents conducting sharpshooting activities. Removal activities would require obtaining permits, setting up bait stations, locating deer, sharpshooting, and handling the disposition of meat. In addition to the actual reduction activity, time would be required to coordinate the details of the reduction activity.

Costs to the park for direct reduction through sharpshooting would vary, depending on a number of factors, including the number of deer to be removed each year, access to deer, number and location of bait stations, training requirements, equipment availability, amount of data to be collected from the deer, and processing or disposal requirements. Based on similar removal efforts, the estimated cost for the park to implement direct reduction through sharpshooting would be $200 per deer initially, increasing to $400 per deer as the population decreased and more effort was required to locate deer, including actions to maintain the herd at the reduced level once the initial goal was achieved. Over the 15-year planning period for the deer management plan, sharpshooting efforts are estimated to cost approximately $399,100, with a large portion of that total for support of USPP security and park closure requirements. The majority of project funding, including all deer reduction activities and management of these, would be the responsibility of the park. Any assistance offered by the park's staff would be considered part of regular duties, rather than project specific, and would not require additional project funding. Due to the amount of time required by park staff to participate in these activities and the funding increase that would need to be applied for, impacts would be adverse and moderate during the period of the reduction efforts.

Where direct reduction by sharpshooting was not possible due to safety concerns (e.g., near adjacent properties), capture and euthanasia would be implemented by qualified federal employees or authorized agents. Because this method would only be used in certain situations, the cost would vary depending on the conditions at each removal site, including the location of the removal, accessibility, type of trap or immobilization drug used, how deer were disposed of, and the type of euthanasia used. Based on experience of park personnel and the range of costs identified for capturing deer under the reproductive control action, the costs could range from $100 to $1,000 per deer, and an average of about $500 per deer was assumed for costing purposes. This action would require increased funding and result in adverse, long-term, moderate impacts.

As part of this alternative, both deer population studies and vegetation monitoring would be conducted to document any changes in deer browsing and forest regeneration that may result from reduced deer numbers. This monitoring program would continue after the density goals were reached to determine if vegetation was showing signs of recovery. This monitoring would be similar to current park efforts that

are already scheduled to continue and would result in long-term minor impacts to park operations and maintenance.

This alternative would also involve increased educational and interpretive and management activities, and would therefore require additional funding and/or additional staff time to implement these activities. This would result in moderate adverse impacts to resource education and resource protection staff. Moderate adverse impacts could also be expected due to time needed to answer public inquiries about the actions taken, particularly sharpshooting. This need would likely decline over the years, and adverse impacts would be expected to be reduced to minor levels over time.

The combination of these lethal reduction alternatives would result in a greater reduction of deer over a shorter period of time, when compared to alternative A. As the number of deer declined in the park, the need for deer management and associated educational/interpretative activities would decline, allowing park staff to apply their efforts to other management areas. This would result in a reduction of adverse, long-term impacts from moderate to minor under this alternative.

Cumulative Impacts

Cumulative impacts would be similar to those described under alternative A. Under alternative C, it is expected that funding would continue for current deer management activities and that funding for additional lethal management measures would be received, resulting in minor impacts as discussed above. With the expected funding needed for other resource programs and to respond to natural phenomena, the cumulative impact to park management and operations would be long term, adverse, and minor to moderate, depending on the severity of these future actions.

Conclusion

Alternative C would result in adverse, moderate impacts during the period of direct reduction efforts because of the need for additional staff time for monitoring and coordinating activities. However, the use of qualified federal employees or authorized agents would reduce the amount of park staff time needed for implementation. With the greater reduction of deer over a shorter period of time, park staff would have more time to apply their efforts to other areas of the park when compared to alternative A, which would reduce adverse, long-term impacts from moderate to minor over time. Past, present, and future activities, when combined with actions under this alternative, would result in adverse, long-term, minor to moderate cumulative impacts.

ALTERNATIVE D: COMBINED LETHAL AND NON-LETHAL ACTIONS

Analysis

Alternative D would include the actions described under alternative A plus direct reduction to initially reduce the deer herd. Then reproductive control would be used to maintain the herd at acceptable levels. The participation of the NPS Center for Urban Ecology and the Student Conservation Association in park programs would be expected to continue.

The lethal management measures under alternative D would be the same as those described under alternative C. Costs to the park would vary from $200 to $400 per deer, as described under alternative C. Over the 15-year life of the deer management plan, sharpshooting efforts would cost approximately $241,900, with a large portion of that supporting USPP security and closure activities (assuming this occurs only in years 1-3). The majority of project funding, including all deer reduction activities, and management of these, would be the responsibility of the park. Any assistance offered by the park's staff would be considered part of regular duties. Impacts are expected to be adverse, long term, and moderate.

Where direct reduction by sharpshooting was not possible due to safety concerns, capture and euthanasia would be implemented by qualified federal employees or authorized agents. As described under

alternative C the costs would average about $500 per deer, but could vary based on situation conditions. Although limited staff time would be required since actions would be carried out by qualified federal employees or authorized agents, park staff would be involved in coordinating activities and an increase in funding would be required, resulting in adverse, long-term, moderate impacts.

After the initial reduction in density, alternative D would use reproductive control of the park's deer population by the methods described under alternative B if feasible. Costs for reproductive control are estimated at $567,000, assuming treatment of 41 does annually starting in year 4, including an annual $5,000 cost for additional surveys. Park staff would need to spend additional time and labor to coordinate and monitor activities, resulting in adverse, long-term, moderate impacts.

This alternative would also involve increased educational and interpretive activities, and would therefore require additional funding and/or additional staff time to implement these activities. There would be moderate adverse impacts to resource education and visitor protection staff as a result, which would decline to minor adverse levels over time.

Overall, the combination of non-lethal and lethal management alternatives and the associated educational/interpretive activities would have adverse, long-term, moderate impacts to park management and operations during the period of direct reduction and reproductive control. Once the deer herd was reduced, more staff time would be available for other activities, resulting in adverse, long-term, minor impacts.

Cumulative Impacts

Cumulative impacts would be similar to those described under alternative A. Under alternative D, funding would continue for current deer management activities, resulting in minor to moderate impacts as discussed above. With the expected funding needed for other resource programs and response to natural phenomena, the cumulative impact to park operations and maintenance would be adverse, long term, and minor to moderate, depending on the severity of these future actions.

Conclusion

Alternative D would result in adverse, long-term, moderate impacts, as park staff involvement would be required for coordination and monitoring. Funding for these activities would be applied for and expected to be received. Once the deer herd was reduced, more staff time would be available for other activities, resulting in adverse, long-term, minor impacts. Past, present, and future activities, when combined with actions under this alternative, would result in adverse, long-term, minor to moderate cumulative impacts.

UNAVOIDABLE ADVERSE IMPACTS

The NPS is required to consider if the alternative actions would result in impacts that could not be fully mitigated or avoided (NEPA section 101[c][ii]).

ALTERNATIVE A: NO-ACTION ALTERNATIVE (CONTINUE EXISTING MANAGEMENT)

Under alternative A, there would be long-term, unavoidable adverse impacts to vegetation (including some wetland vegetation), deer and other wildlife, and rare or unique species due to the continued high number of deer in the park over time and the associated damage to park vegetation. In addition, there would be continued unavoidable minor adverse impacts to soils and water quality due to the removal of vegetation from deer browsing and subsequent erosion and sedimentation, and unavoidable adverse impacts to those wildlife species that depend on ground cover and seedlings for their food and/or cover. There would also be long-term unavoidable adverse impacts on cultural landscapes and on visitor use and experience, because of the lack of vegetation and the associated wildlife and scenery which many park visitors enjoy, and unavoidable adverse impacts to visitor safety related to deer-vehicle collisions. Unavoidable adverse impacts would continue on park management and operations, due to the demand on park staff related to continued deer monitoring and resource management.

ALTERNATIVE B: COMBINED NON-LETHAL ACTIONS

Alternative B would include most of the unavoidable adverse impacts described for alternative A over the life of the plan, since the benefits of reproductive control would not be realized until much later, given the length of time needed to realize a reduction in deer herd numbers based solely on reproductive control. Unavoidable adverse effects may occur to other wildlife species affected by the exclosures. Unavoidable adverse impacts may occur to some sensitive plant species due to the continued high numbers of deer and their browsing; this would be mitigated somewhat by the use of the exclosures, however. Reproductive control may have some unavoidable adverse impacts if the actions taken were visible or disturbingly audible to park visitors. Providing interpretive materials may help mitigate some of this effect; however, reproductive control as proposed under this alternative could occur during relatively high visitor use periods and would require a substantial effort to treat the required number of deer. Unavoidable adverse impacts to park operations and management would increase compared to alternative A, due to the demands on staff for implementation of the program.

ALTERNATIVE C: COMBINED LETHAL ACTIONS

Unavoidable adverse impacts for this alternative would be greatly reduced compared to alternatives A and B, because the reduction in deer numbers would occur rapidly and the park's vegetation would begin to recover over the life of the plan. This would mitigate adverse effects to vegetation, deer and other wildlife, and sensitive/rare plants. Some wildlife that prefer more open habitat would be unavoidably impacted as the vegetation recovered. There may be some unavoidable adverse effects to visitors relating to the implementation of the sharpshooting or capture and euthanasia, if the visitors happened to be near areas where this was occurring and were disturbed by these actions. Conducting sharpshooting at night and providing interpretive materials would help mitigate some adverse effects. Unavoidable adverse impacts to park operations and management would increase compared to alternative A, due to the demands on staff for implementation of the program.

ALTERNATIVE D: COMBINED LETHAL AND NON-LETHAL ACTIONS

Unavoidable adverse impacts for this alternative would be essentially the same as those described for alternative C, although use of reproductive controls for long-term maintenance of the deer herd would

involve a greater commitment of staff and resources and result in greater unavoidable adverse impacts to park management and operations.

SUSTAINABILITY AND LONG-TERM MANAGEMENT

In accordance with NEPA, and as further explained in Director's Order 12, consideration of long-term impacts and the effects of foreclosing future options should pervade any NEPA document. According to Director's Order 12, and as defined by the World Commission on Environment and Development, "sustainable development is that which meets the needs of the present without compromising the ability of future generations to meet their needs." For each alternative considered in a NEPA document, considerations of sustainability must demonstrate the relationship between local short-term uses of the environment and the maintenance and enhancement of long-term productivity. This is described below for each alternative.

The NPS must consider if the effects of the alternatives involve tradeoffs of the long-term productivity and sustainability of park resources for the immediate short-term use of those resources. It must also consider if the effects of the alternatives are sustainable over the long term without causing adverse environmental effects for future generations (NEPA section 102(c)(iv)).

ALTERNATIVE A: NO-ACTION ALTERNATIVE (CONTINUE EXISTING MANAGEMENT)

Alternative A would trade any long-term productivity for short-term use of park resources. The deer population would likely continue to grow over time or remain at high levels, and use the park's vegetation at the expense of the long-term productivity and sustainability of the vegetation and other affected wildlife in the park, as well as the park's cultural landscapes. Impairment of the park's vegetation, certain wildlife and wildlife habitat, and ground-dependent sensitive/rare species would likely occur over the long term.

ALTERNATIVE B: COMBINED NON-LETHAL ACTIONS

Alternative B would involve a similar trade for short-term use of park resources at the expense of long-term productivity for the duration of the plan, since the reproductive controls would not reduce the numbers of deer in the park over the life of the plan. The construction of the exclosures would involve short-term impacts related to their construction and visual impacts to visitors, but they would help preserve some of the park's long-term productivity. They would only protect a small portion of the park's woody vegetation over time, and only 5% of the park's herbaceous vegetation at any one time. This 5% would meet the suggested need to protect a minimum of 5% to 10% of the park's forested area at any one time (Bowersox, pers. comm. 2005), and therefore, impairment of vegetation and certain wildlife or rare species is not expected over the long term. However, for this alternative to be truly sustainable, the reproductive control aspect must be continually managed and successful, and exclosures would need to be relocated to many areas of the park over time.

ALTERNATIVE C: COMBINED LETHAL ACTIONS

Under alternative C, there would be a short-term commitment of human resources and short-term impacts to the park's visitors and environment during deer removal actions, but with the result of long-term productivity of the park's vegetation and habitat and a sustainable use of the resources in the park. No impairment of park resources would occur, but to be sustainable, this alternative will require long-term management, including monitoring and adaptive management to protect park productivity.

ALTERNATIVE D: COMBINED LETHAL AND NON-LETHAL ACTIONS

Alternative D would have the same long-term sustainability characteristics as alternative C, except that it would require more resources focused on the reproductive control aspect, since it is experimental in a free-ranging population.

IRREVERSIBLE OR IRRETRIEVABLE COMMITMENTS OF RESOURCES

The NPS must consider if the effects of the alternatives cannot be changed or are permanent (that is, the impacts are irreversible). The NPS must also consider if the impacts on park resources would mean that once gone, the resource could not be replaced; in other words, the resource could not be restored, replaced, or otherwise retrieved (NEPA section 102[c][v]).

ALTERNATIVE A: NO-ACTION ALTERNATIVE (CONTINUE EXISTING MANAGEMENT)

Under alternative A, impacts to vegetation (particularly the forest understory) from continued overbrowsing by deer could result in irreversible impacts to Rock Creek Park's forests if no actions are ever taken to reduce deer numbers. Exotic plants that are not palatable to deer would continue to exploit openings in the understory, and animal species that rely on native ground vegetation might not remain in or return to Rock Creek Park if the forest understory does not regenerate. Deer browsing has already resulted in the reduction of understory plant species at Rock Creek Park. Even if caging were used to protect some of the sensitive species, it would be impossible to identify all individual plants, and overbrowsing of new plants located outside the caged areas could occur. In addition, the health of deer herd at Rock Creek Park could suffer irretrievable adverse effects if no action is taken.

ALTERNATIVE B: COMBINED NON-LETHAL ACTIONS

Alternative B has the potential for some irreversible impacts, if some areas of the park's forests are adversely affected to the point of nonregeneration or if invasive exotic plants take over some denuded areas before reproductive controls have had time to stabilize the deer herd numbers. Exclosures will not cover the entire park, and so some of the irreversible impacts described for alternative A would likely occur under alternative B as well.

ALTERNATIVE C: COMBINED LETHAL ACTIONS

This alternative presents the least potential for irreversible or irretrievable commitments of resources. Although deer would be removed, the deer population would continue at a sustainable level. Because the herd would be reduced rapidly, there would be little chance that park vegetation (including sensitive/rare species) or other species that are dependent upon forest understory and native ground cover would be irretrievably lost, since forest regeneration would begin within the life of the plan.

ALTERNATIVE D: COMBINED LETHAL AND NON-LETHAL ACTIONS

This alternative is essentially the same as alternative C, with very little potential for irreversible or irretrievable commitments of resources. Because the herd would be reduced rapidly, there would be little chance that park vegetation (including sensitive/rare species) or other species that are dependent upon forest understory and native ground cover would be irretrievably lost, since forest regeneration would begin within the life of the plan.

CONSULTATION AND COORDINATION

The intent of the *National Environmental Policy Act* (NEPA) is to encourage the participation of federal and state-involved agencies and affected citizens in the assessment procedure, as appropriate. This section describes the consultation that occurred during development of this *Draft White-tailed Deer Management Plan / Environmental Impact Statement* (plan/EIS), including consultation with scientific experts and other agencies. This chapter also includes a description of the public involvement process and a list of the recipients of the draft document.

HISTORY OF PUBLIC INVOLVEMENT

The public involvement activities for this plan/EIS fulfill the requirements of NEPA and the National Park Service (NPS) Director's Order 12 (NPS 2001).

THE SCOPING PROCESS

The NPS divides the scoping process into two parts: internal scoping and external or public scoping. Internal scoping involved discussions among NPS personnel regarding the purpose of and need for management actions, issues, management alternatives, mitigation measures, the analysis boundary, appropriate level of documentation, available references and guidance, and other related topics.

Public scoping is the early involvement of the interested and affected public in the environmental analysis process. The public scoping process helps ensure that people have an opportunity to comment and contribute early in the decision-making process. For this planning document and impact statement, project information was distributed to individuals, agencies, and organizations early in the scoping process, and people were given opportunities to express concerns or views and to identify important issues or even other alternatives.

Taken together, internal and public scoping are essential elements of the NEPA planning process. The following sections describe the various ways scoping was conducted for this impact statement.

INTERNAL SCOPING

The internal scoping process began on July 13, 2005, at Rock Creek Park, Washington, D.C. During the three-day meeting, NPS employees identified the purpose of and need for action, management objectives, issues, and impact topics. Various roles and responsibilities for developing the deer management plan were also clarified. The results of the meetings were captured in an "Internal Scoping Report," now on file as part of the administrative record.

In addition, the park had coordinated with many technical experts for over 10 years prior to starting the planning process and established a Science Team to provide input to this plan, as described in "Chapter 1: Purpose of and Need for Action." Comprised of subject matter experts, the Science Team was chartered to advise and provide technical recommendations to the NPS on matters regarding scientific data and analysis. The team met five times over a period of five months to review and supplement necessary background information and needed data. The team also recommended impact analysis techniques and various management options, and they provided technical review of draft documents. Members of the Science Team are listed with the document preparers in this chapter.

PUBLIC SCOPING

Public Meetings and Comments

In addition to internal scoping within the NPS and with other public officials, public scoping for the plan/EIS began with the publishing of the Notice of Intent in the Federal Register on September 20, 2006, and concluded on December 8, 2006. During this time, two public scoping meetings were held (November 1 and November 2, 2006) that included an open house, presentation by the NPS, and an opportunity for formal public comment. The purpose of these meetings was to solicit public input, especially on issues and ideas for alternatives. The meetings were held at the Rock Creek Nature Center in Washington, D.C. Notices of the meetings were posted on the NPS's Planning, Environment, and Public Comment (PEPC) website. Additionally, a newsletter was mailed in October 2006 to the project's preliminary mailing list of government agencies, organizations, businesses, and individuals. The newsletter announced the public scoping meetings and summarized the purpose of and need for a deer management plan, the plan objectives, and the history of Rock Creek Park's deer research and management.

During the comment period, 34 pieces of correspondence were received that contained 140 comments. The majority of the public comment received focused on various alternatives and alternative elements. Other comments expressed concern about the impacts to vegetation from the deer herd and while others encouraged the NPS to ensure that the proper methodologies and assumptions were made with regard to the deer population as well as other components of the Rock Creek Park ecosystem.

AGENCY CONSULTATION

Letters initiating consultation under Section 7 of the Endangered Species Act and Section 106 of the National Historic Preservation Act , and and/or requesting information or comments, were sent to the following agencies:

- U.S. Fish and Wildlife Service – June 17, 2008
- Maryland Department of Natural Resources Wildlife and Heritage Service – October 27, 2008
- District Of Columbia Historic Preservation Office – June 18, 2008
- National Capital Planning Commission- June 18, 2008
- The Commission of Fine Arts – June 18, 2008

Copies of these letters are provided in appendix F. One response was received on July 18, 2008 from the District Historic Preservation Office; it is included at the end of appendix F. A copy of this draft plan/EIS will be sent to the District Historic Preservation Office to complete Section 106 compliance and to U.S. Fish and Wildlife Service to complete Section 7 consultation.

LIST OF RECIPIENTS OF THE DRAFT PLAN ENVIRONMENTAL IMPACT STATEMENT

This plan/EIS will be sent to the following agencies, organizations, and businesses, as well as to other entities and individuals who requested a copy.

CONGRESSIONAL DELEGATES

- Eleanor Holmes Norton, District of Columbia Delegate
- Christopher Van Hollen, Jr., 8th Congressional District, Maryland

- Donna F. Edwards, 4th Congressional District, Maryland
- Barbara Mikulski, U.S. Senate, MD
- Benjamin L. Cardin, U.S. Senate, MD

FEDERAL AGENCIES

- Chesapeake and Ohio Canal National Historic Park
- Smithsonian National Zoo and National Zoo Police
- State Department—Embassies
- U.S. Department of Agriculture, Wildlife Services
- U.S. Environmental Protection Agency
- U.S. Geological Survey
- U.S. Fish and Wildlife Service, Chesapeake Bay Field Office
- U.S. Navy, Naval Observatory
- U.S. Park Police
- U.S. Secret Service

DISTRICT OF COLUMBIA AND LOCAL GOVERNMENTS

- Advisory Neighborhood Commissions
- Commission of Fine Arts
- D.C. City Council
- D.C. Department of Environment, Fisheries and Wildlife Division
- D.C. Department of Health, Animal Disease Prevention Division
- D.C. Department of Recreation, Office of Planning and Policy
- D.C. Department of Transportation
- D.C. Fire and Emergency Services
- D.C. Historic Preservation Office, State Historic Preservation Officer
- D.C. Metropolitan Police Department
- D.C. Office Of Planning
- D.C. Office of Tourism and Promotion
- Maryland Department of Natural Resources, Wildlife and Heritage Service
- Maryland National Capital Park and Planning Commission – Montgomery County
- Metropolitan Washington Council of Governments
- National Capital Park and Planning Commission
- Washington Metropolitan Area Transit Authority

ORGANIZATIONS/OTHER

- AAA Potomac
- Adjacent Property Owners
- American Automobile Association, National Office
- American Recreation Coalition
- Animal Welfare Institute
- Arizona Bowhunters Association
- Audubon Naturalist Society Central Atlantic States
- Audubon Naturalist Society of the District of Columbia
- Blair Road Garden Association
- Chesapeake Bay Foundation, District of Columbia Office
- Chesapeake Bay Program Office, NPS

- Chevy Chase Citizens Association
- Crestwood Citizen's Association
- Defenders of Wildlife
- Earth Justice
- Fort Reno Garden Association
- Fort Stevens Garden Association
- Friends of Animals
- Friends of Montrose and Dumbarton Oaks Park
- Friends of Peirce Mill
- Friends of Rock Creeks Environment (FORCE)
- Friends of the Earth
- Glover Park Garden Association
- Glover Park Citizens' Association
- Golf Course Specialists Inc
- Green Peace
- Hillandale Citizens Association
- Hillwood Museum
- Humane Society of the United States
- Interstate Commission of Potomac River Basin
- Izaak Walton League of America
- Jonathan Woodner C., Woodner Apts.
- Mamie D. Lee Garden Association
- Maryland Native Plant Society
- Maryland Ornithological Society
- Meadowbrook Riding Stables
- Melvin Hazen Garden Association
- National Park Foundation
- National Parks and Conservation Association
- National Wildlife Federation
- National Zoological Park, Smithsonian
- Nature Conservancy
- Oak Hill Cemetery
- Peabody Garden Association
- People for the Ethical Treatment of Animals (PETA)
- Potomac Appalachian Trail Club
- Rock Creek Garden Association
- Rollingwood Citizens Association
- Sierra Club, DC Chapter
- The Northwest Current
- The Shoreham North
- The Washington DC Examiner
- Tilden Gardens
- Trail Riders of Tomorrow (TROT)- 50
- Walter Reed Army Medical Center
- Washington Area Bicycle Association
- Washington City Paper
- Washington Human Society

- Washington Parks and People
- Washington Post
- Washington Regional Network for Livable Community
- Washington Tennis Foundation
- Washington Times
- Whitehaven Garden Association
- William H.G. Fitzgerald Tennis Center
- Woodland Normanstone Neighborhood Association

SCIENCE TEAM MEMBERS

Name	Title	Organization / Location
Ken Ferebee	Natural Resource Management Specialist/Park Contact	NPS – Rock Creek Park
William McShea	Research Scientist	National Zoological Park (NZP)/WCS Joint Appalachian Forest Ecology Program
Bill Hamilton	Wildlife Ecologist in charge of deer management program	Maryland National Capital Park and Planning Commission (MNCPPC) Wheaton Regional Park Natural Resources Management Offices
Allan O'Connell, Jr.	Wildlife Biologist	USGS Patuxent Wildlife Research Center
Diane Pavek	National Capital Region (NCR) Botanist	NPS/NCR – Center for Urban Ecology
Scott Bates	NCR Wildlife Biologist	NPS/NCR – Center for Urban Ecology
Jim Sherald	Chief, Natural Resources and Science	NPS/NCR – Center for Urban Ecology
Sue Salmons	NCR Exotic Plant Management Team Liaison	NPS/NCR – Center for Urban Ecology
Shawn Carter	NCR Inventory and Monitoring Coordinator	NPS/NCR – Center for Urban Ecology
Beth Kunkel	Wildlife Biologist – Team Facilitator	Kimley–Horn and Associates, Inc.
Rusty Schmidt	Biologist	URS Corporation
Kevin Sullivan	Director for the states of Maryland; Delaware; and Washington, D.C.	U.S. Department of Agriculture (USDA), Wildlife Services
Zach Bolitho	Resources Planning Office Natural Resource Specialist	NPS – Gettysburg National Military Park and Eisenhower National Historic Site
Bert Frost	Deputy Associate Director	NPS – Natural Resource Stewardship and Science, Gettysburg
Jon Siemien	Program Manager for Fisheries and Wildlife Management in District of Columbia	District of Columbia – Department of Health Environmental Health Administration
Mary Pfaffko	Wildlife Biologist for Fisheries and Wildlife Management in District of Columbia	District of Columbia – Department of Health Environmental Health Administration
Michael Mayer	Wildlife Biologist	NPS Environmental Quality Division (EQD)
Randy Knutson	Wildlife Biologist for Indiana Dunes National Lakeshore (IDNL)	National Park Service, IDNL

LIST OF PREPARERS AND CONSULTANTS

Name	Title	Education/Responsibility	Experience
National Park Service			
Ken Ferebee	Natural Resource Management Specialist, Rock Creek Park	B.S. in Forestry and Wildlife. Provided input and review; point of contact for Rock Creek Park.	19 years with NPS
James Sherald	Chief of Natural Resources and Science, Center for Urban Ecology	B.S. Ornamental Horticulture, M.S., Ph.D. in Plant Pathology. Provided input and review.	
Dan Sealy	Deputy Chief of Natural Resources and Science, Center for Urban Ecology	B.S. Natural Resource Management. Provided input and review.	33 years with NPS
Adrienne Coleman	Superintendent, Rock Creek Park	Manages Rock Creek Park.	22 years with NPS
Cindy Cox	Deputy Superintendent, Rock Creek Park	B.S. Ornamental Horticulture. Manages Rock Creek Park.	22 years with NPS
Scott Bates	Regional Wildlife Biologist NPS — Center for Urban Ecology	B.S. Biology; M.S. Wildlife Management. Provided technical input.	8 years with NPS NCR and 9 years with DoD as a wildlife biologist
Diane Pavek	Research Coordinator and Botanist	B.S. in Botany and Zoology; M.S., Ph.D. in Botany. Provided technical input.	25 years in botany; 9 years with NPS
Michael Mayer	Environmental Protection Specialist (EQD) – no longer with NPS	B.S. Wildlife and Fisheries Biology; M.S. Wildlife Conservation; J.D. Environmental Law. Responsible for NEPA policy, guidance, and technical review. Project manager, technical reviewer.	10 years
Melissa Stedeford	Environmental Protection Specialist (EQD)	B.S. Environmental Science; M.S. Environmental Science. Responsible for NEPA policy, guidance and technical review. Project manager.	3 years
Kimley-Horn and Associates, Inc.			
Beth Kunkel	Wildlife Biologist and Environmental Planner	B.S. Wildlife Management. Responsible for facilitation of Science Team meetings, helped developed action thresholds, prepared alternatives description (chapter 2).	18 years
The Louis Berger Group, Inc.			
Juanita Barboa	Technical Editor – The Final Word (subcontractor)	B.S. Technical Communication. Responsible for editing document.	17 years
Rebecca Byron	Planner/Environmental Scientist	B.S. Environmental Science and Policy; drafted affected environment	3 years

Name	Title	Education/Responsibility	Experience
		information for vegetation, safety, rare species.	
Lori Fox, AICP	Senior Planner	B.S. Natural Resources and Environmental Policy; M.C.P., Land Use, Environmental and Economic Development Planning. Responsible for internal and public scoping.	8 years
Joel Gorder, AICP	Planner and Environmental Scientist	B.S. Limnology, Biology, M.S., Urban and Regional Planning; Responsible for draft of soils and water quality affected environment	15 years
Dan Niosi	Environmental Scientist	B.A. Environmental Studies – Natural Resources. Responsible for the species sections of chapters 3 and 4	8 years
Nancy Van Dyke	Senior Consultant	B.A. Biology and Geography; M.S. Environmental Sciences. Responsible for project management and senior technical review and content additions to all sections.	26 years
Jeff Gutierrez	Planner/Environmental Scientist	B.A. Environmental Studies	2 years
Lucy Bambrey	Senior Cultural Resources Specialist	M.A. Anthropology. Responsible for cultural landscapes sections	29 years

APPENDIX A. DEER POPULATION AND VEGETATION / REGENERATION MONITORING METHODS

DEER POPULATION MONITORING METHODS

Park staff will continue to use the Distance Sampling method to annually estimate the deer population density within the park (NPS 2004). Distance Sampling is a reliable analytical method for estimating population densities (Buckland et al. 2001; Thompson et al. 1998).It is conducted by an observer traveling along a transect and recording how far away deer are. The method models the way a person sees so that a proportion of deer further from the observer are expected to be missed. Unbiased estimates of population density can be obtained from the distance data if three assumptions are met: (1) deer on the line or point are detected with 100% certainty, (2) deer are detected at their initial location, and (3) distance measurements are exact (Buckland et al. 2001; Thompson et al. 1998; Underwood et al. 1998). Rock Creek Park uses laser range finders to ensure this last assumption.

A problem with Distance Sampling in past surveys has been the use of roads and trails as the transect. However, the use of roads and trails carries the risk of bias because of an unrepresentative sampling of available habitats (Buckland et al. 2001; Hiby and Krishna 2001).

Buckland et al. (2001) state that few studies have attempted to verify whether the resulting density estimates are unbiased in reference to the wider study area. McShea et al. (2007, unpublished report) used remote digital scouting cameras placed in seven distance categories to test for differences in deer activity with respect to roads used in distance surveys at Catoctin Mountain Park (nearly 100% forest cover). They found no significant difference in deer activity among the distance categories. These conditions are similar for Rock Creek Park.

After eight years of Distance Sampling from 2000 to 2007, National Park Service (NPS) staff at Rock Creek Park were able to detect population change at an annual rate of 4% (Bates 2008e).

Surveys are conducted at night during mid-November; surveys begin no earlier than 30 minutes after sunset (actual time sunset). Deer are most active at night. Most of the tree leaves have fallen by mid-November, allowing for observations at further distances from the road. Surveys take place on weekends because of the heavy commuter traffic on weekday evenings. Surveys are postponed if viewing conditions are poor or observer safety is threatened (e.g., heavy traffic).

Distance Sampling surveys are conducted for a minimum of three nights, depending on the size of the coefficient of variation estimated for the sampling results. Additional surveys are added when the variability in the data exceeds certain statistical standards: specifically, when the coefficient of variation associated with the number of deer groups encountered after three nights of sampling exceeds 20%, or if the detection probability variation exceeded 30%. This is the most important step in ascertaining sufficient sampling. The coefficient of variation and the detection probability variation will not be calculated until the second survey has been completed. The coefficients will be recalculated after each subsequent survey until the above-mentioned criteria are satisfied.

Spotlighting equipment is assembled and checked at least two weeks before the first survey. Laser rangefinders will also be checked for operability and battery life.

Ambient conditions will meet minimum standards (wind is less than 19 mph; rain is less than heavy; normal visibility is greater than two miles at the nearest airport [Reagan National Airport]; temperature is higher than 35°F at sunset), as reported from the nearest official National Oceanographic and Atmospheric Administration weather data site (www.erh.noaa.gov/er/lwx/) before each survey. Surveys are postponed if ambient conditions exceed minimum standards during the survey route.

A minimum three-person crew, consisting of a driver, who serves as data recorder, and two observers, are required to execute each survey. Survey routes are driven at speeds ranging from 6 to 10 mph. Observers use handheld spotlights to illuminate the survey area on both sides of the transect extending the light out; one person observes each side of the transect. Upon detection of a deer, the observer directs the driver to position the vehicle such that the perpendicular distance (90° angle to the transect) is measured.

If the transect is curved, more than one perpendicular distance might be available; the shortest perpendicular distance should be measured (Hiby and Krishna 2001). In cases where a perpendicular distance is not possible, a radial distance may be measured. When measuring a radial distance, the bearing of the transect and the white-tailed deer (*Odocoileus virginianus*) location would be obtained using a handheld compass. The radial distance is multiplied by the sine of the angle (the difference of the bearing measurements) to obtain the perpendicular distance.

In all instances, the distance measured should be to the initial location of the deer prior to any movement. The distance is measured using a laser rangefinder and is measured to an individual deer or, in the case of a group of deer, to the deer closest to the center of a group. In order to detect deer directly on the transect, the driver observes the groups of deer on the transect line and records the distance of the deer or group, if any, from the transect line using the laser range finder.

Deer are categorized by group size (e.g., an individual deer is a group of one, and five deer are a group of five). Deer are partitioned into groups by using behavioral cues and the nearest neighbor criterion (LaGory 1986). For instance, deer that repeatedly look back at other deer are counted as part of a group. Additionally, if an individual deer is less than half the distance from the closest deer than from its next nearest neighbor, then that individual deer is counted as part of a group. When large groups of deer are seen in open fields, group classification is attempted before positioning the vehicle for a distance measurement, which minimizes a flight response. In cases where the deer run away, the observer will note the initial location of the group and obtain a distance measurement to the location of first detection. Data are recorded on a standard deer Distance Sampling datasheet or in a handheld data recorder. Demographic classification is collected only when bucks, does, and fawns are clearly identified; “unknown” is the demographic classification default.

Data is analyzed using the most current version of Distance (which is 5.0 in 2008) (Thomas et al. 2006). With the technical assistance of the National Capital Region Wildlife Biologist, models are generated that provide estimates of population density (deer per square mile) with well-defined confidence intervals. The minimum amount of data required includes the survey dates, park area, transect length, number in group, and distance.

VEGETATION/REGENERATION MONITORING METHODS

Deer populations are managed based on the success of forest regeneration. Tree seedlings are monitored to determine at what point browsing impacts would warrant the implementation of the possible management action. Rock Creek Park has both long-term monitoring and exclosure (fenced) plots. Long-term monitoring plots show changes in the park’s vegetation over time. Exclosure plots show the size of the impact that deer are having on the vegetation.

Since 1990 various vegetation monitoring projects have been conducted at Rock Creek Park. In 1990, 26 long-term plots (no fencing), each 400 m^2, were established and have been monitored once every four years since 1991. In 2000, 20 paired fenced and unfenced plots were installed in Rock Creek Park and Glover-Archbold Park to look specifically at the amount of deer browse on park vegetation. These plots are 1 × 4 m. The enclosed plot has an 8-foot woven wire fence surrounding it, and its companion plot is located 1 meter outside the fence. These 20 paired plots are measured annually. Of the 20 plots established in 2000, only 15 were measured in 2008. Trees have fallen on three plots, erosion has removed most of one plot next to a small creek, and the other plot was overgrown with nonnative vegetation.

The basic plot design for the long-term plots established in 1990 follows protocols adopted by Russel (1989) and Storm and Ross (1992) for public lands in the Mid-Atlantic States. Rock Creek Park (Reservation 339) was divided into three zones: north, central, and south. Plot locations were randomly selected using GIS. Ten plot locations were selected for each zone. Plots that landed on roads, buildings, or bodies of water were rejected. Twenty-six plots were chosen: 10 in the northern, 7 in the central, and 9 in the southern regions of the park.

The outside dimensions of the plot are 20 x 20 m, making it 1/25th of a hectare. The 20 × 20-m plots have two main diagonals that run from corners A to C and B to D. These diagonals each have a total length of 28.28 m, and a center located at 14.14 m. The "B" corner of the plot was established first and using a tape the "A" corner was established. A new tape was used at corner A and a 45 degree angle was approximated to side AB to establish diagonal AC. At the same time another tape was run from corner B approximately 45 degrees from line AB to establish diagonal BD. The center point of the plot was established at the intersection of the two diagonal tapes at the 14.14-m mark. The two diagonals were extended to 28.28 m to establish the remaining corners C and D. Once all corners and the center point were established, each plot was squared and a piece of rebar was driven into the ground to permanently mark corners A, C, D, and the center point. A reference bench mark with an aluminum dome was set at corner B. The plot number was stamped on the aluminum disc. A live, healthy tree was chosen near each corner of the plot as the place to locate a corner relocation tag. Each corner tag was marked with the plot number and letter of the corner.

Within the plot, smaller subplots were established to measure vegetation of different sizes: 10-m-square quadrants for trees and overall canopy cover, 10-m-linear transects for tree and shrub cover, 1-m-square subplots for herbaceous vegetation and tree seedlings, and 1.7-m-radius circular subplots to detect deer browse.

The long-term plots are measured the same time of year each July and August when the vegetation is fully developed. The first tapes are laid out from corner B to the other corners and then diagonally from opposite corners to reestablish the center point. Next, tapes are laid from the center point (10 m) of each side to divide the plot into four quadrants for tree sampling.

Reference photographs are taken of the center of the plot from the B corner, of the plot center from halfway to the B corner, and the entire 20 × 20-m area from the best angle. Photos should attempt to duplicate placement and orientation of previous years.

Tree sampling occurs in the four 10 × 10-m subplots represented by the quartering of the plot along its cardinal points. Measurements are taken on trees and shrubs at 1.4 m high and 1-cm or greater diameter at breast height (dbh) in each of the 10 × 10-m subplots. The heights of five live trees in each subplot are taken, giving a total of 20 tree heights for each plot.

Species data is entered onto standard data sheets. Trees and shrubs are identified by a six letter code, defined by the first three letters of the genus and species. For a tree branching below the l.4-m mark, the dbh is taken for each stem equal to or greater than 5-cm dbh. Those greater than 5-cm dbh are treated as individual trees but are noted in the tree record. For situations such as shrubs with multiple stems that originate from the same base, the largest stem is chosen and its dbh taken. The vigor is noted for each tree by assigning a number as follows: 1 = living, 2 = dead, and 3 = injured.

The heights of the five tallest living trees in each of the four subplots are recorded. Clinometers are used to measure tree heights, but other instruments can be used. The five trees are visually identified in each subplot and marked with flagging, and a number from 1 to 5 is assigned to each tree in the subplot. The method of measuring tree heights should be recorded on the data sheet.

Browse is estimated as the amount of damage to woody twig ends that occurs during the non-growing season and is measured by the twig-count method (Shafer 1965). It is estimated or "read" by examining

the growing tips of all woody plants below 2.0 m in height in two randomly chosen circular subplots. Browsed and unbrowsed twigs are counted to determine a browsed/unbrowsed ratio.

A random distance (1–8 m) and direction (1–360 degrees) are generated using a random numbers table. The distance is measured in the direction of the bearing from the center of the plot to establish the center of the browse plot. The browse plot is a circle with a 1.69-m radius, giving an area of 9.3 m^2. A tape or length of string is secured at the browse plot center and is used to circumscribe the sampling area. The numbers of woody twigs below 2.0 m that are browsed and unbrowsed are recorded. Species of each twig or stem are recorded.

Shrub cover is measured using two randomly generated transects within the plot, each 10 m long. The extent to which this line is directly covered by the leaves of any qualifying plant material provides an index of shrub cover within the plot. Two sets of random numbers are generated. The first ranges from 1 to 4 and represents one of the four sides of the 20 × 20-m plot. The second random number represents a point on the line, selected by the first random number, in centimeters. The side and location on that side are located, and a 10-m line is run toward the parallel side. Any woody growth intersecting the line is measured. Any intercept up to 2.0 m is measured to the nearest centimeter, even when the layers created by two different individuals overlap. The estimate of cover for each species is calculated by summing the intercept distance for a given species, dividing the result by 2000, and then multiplying by 100. The result is the percent cover.

Tree canopy coverage within each 10 × 10-m subplot is estimated with a densitometer. Counts of dots shown on the densitometer that are shaded by canopy foliage (including vines) are taken from the center of subplots in four directions: towards the marked quadrant corner, at 3 o'clock, toward the plot center, and at 9 o'clock.

Seedling, herbaceous, and substrate data are collected from 1 × 1-m plots selected at random from four possible positions in a given 2 × 2-m subplot within each quadrant of the 20 × 20-m plot. A 2 × 2-m subplot is located at the center point of the diagonal, formed by stretching a tape between the plot center and a plot corner (A–D). From this 2 × 2-m subplot, a randomly selected 1 × 1-m plot was selected to collect data.

All tree seedlings in each of the 1 × 1-m subplots are identified using the six letter identification code and counted, and the heights are measured in centimeters.

Percent cover of substrate in the 1 × 1-m plot is estimated by looking at the amount of horizontal space covered by each of four categories: rock/soil, moss/lichen, leaf litter, and herbaceous. The herbaceous cover should be identified to the species level if possible.

DATA ANALYSIS

Repeated measures analysis of variance (ANOVA), implemented with the mixed models procedure within SAS (2003), tests for differences among regions, years, and their interactions for each variable (Littell et al. 1996). The subject factor for each ANOVA is plot nested within region. Four variance–covariance structures are modeled (compound symmetry, autoregressive, Toeplitz, and unstructured) and the best model is selected via AIC_c comparisons (Littell et al. 1996). Residuals are tested for normality (Kery and Hatfield 2003) and, for many variables, a natural log transformation is used to help achieve normality.

For tree seedling counts and species richness, height class is also included in the model, along with the various interactions. A separate variance is fit for each seedling height class due to a possible pattern of different variances among height classes. Least square means and Tukey's multiple comparison procedure are used to sort out significant differences ($P \leq 0.05$) among years for all variables.

To calculate tree seedling weighted measure and action threshold, see the section below.

Importance Values (Storm and Ross 1992) are calculated for the 10 most important tree species in each of the three regions of Rock Creek Park as of 1991, and then graphed for each region for each of the four years. Importance Values are calculated by taking the sum of the relative dominance, relative frequency, and relative density of each tree species over the plots in each region. As such, they represent a summary measure indicative of the "importance" of each species in the tree community in each region. Increases or decreases in the Importance Value of a species imply that the tree community is changing over time.

EXCLOSURES—METHODS

The second method of vegetation monitoring is by paired fenced and unfenced plots. In 2000, twenty fenced (exclosure) plots and paired unfenced (control) plots, each 4 × 1 m in size, were established in Rock Creek Park and Glover-Archbold Park. Fenced plots are contained within a 5 × 15-foot fence made of woven wire fence, 8 feet high.

The paired plots were created using a stratified random design. Ten plots were located on long-term open vegetation plots that had been randomly selected; 10 were randomly located in other parts of the park where deer were known to be and that were not represented in the long-term plots. Percent cover per species, vertical distribution of vegetation in height classes, and dbh of trees greater than 2 m in height in each plot is recorded.

The paired plots are measured annually in July through early September. A series of 10 transects each 200 cm long and spaced 10 cm apart are laid out within each plot for a total of 200 points per plot. An observer carefully walks along transects and records vegetation that "hits" a vertical string attached to a plumb bob that is held perpendicular to the transect every 20 cm. All vegetation up to 2 m in height is included. At a given point, each species intercepted is recorded. Multiple hits on a species are not recorded. Points not intercepting vegetation are recorded as litter (leaf litter and woody debris less than 1 inch in diameter), wood (coarse woody debris, logs), soil, rock, or moss. For each species, the number of hits divided by 200 provides an estimate of percent cover.

The vertical distribution of vegetation is recorded in each of the following height classes: 0–30 cm, 30–110 cm, 110–200 cm. A Mylar grid comprised of 10 × 10-cm squares is suspended on the wire fence outside each plot, along the long edge. The recorders position themselves 1 m from the opposite edge of the plot and estimate the number of squares covered by foliage, to the nearest ¼ square. The number recorded is divided by the number of squares in each height class. The grid is moved four times along the sides of the fence to cover the entire plot.

The dbh of trees located within the fenced or unfenced plot are measured if greater than 2 m in height.

DATA ANALYSIS

This section is being developed and will be completed by June 2009.

CALCULATING TREE SEEDLING ACTION THRESHOLDS

Forest regeneration dynamics are influenced by environmental and demographic factors. At the seedling stage, tall tree seedlings have a greater likelihood of survival compared to small seedlings. Therefore, to reflect this difference in survival, the number of seedlings needed to ensure the regeneration of a forest, which is called a stocking rate or a **tree seedling weighted measure**, is calculated as the number of tree seedlings weighted by Height Class. A certain proportion of the monitoring plots must equal or exceed this number for sufficient regeneration. This is the **action threshold**, where management action will occur when that proportion is not met.

Stout (1998) recommends weighting the seedlings by size; so if a seedling is taller, it is worth more in the total. The sum of these weighted numbers of seedlings gives the stocking rate or a **tree seedling weighted measure.** For example, following Stout (1998), seedlings that measure less than 30 cm tall have a weight of 1, i.e., the total number of seedlings that are less than 30 cm tall is multiplied by 1. For heights from 30

to 100 cm, the number of seedlings is multiplied by 2. Seedlings from 100 to 150 cm tall have a weight of 15, and for heights greater than 150 cm, the number of seedlings is multiplied by 30. All of the weighted seedling numbers are added up, and this total is the tree seedling weighted measure per plot. In Rock Creek Park the Height Classes were measured in 25-cm intervals, so a weight of 2 is used for seedlings from 25 to 100 cm tall instead of from 30 to 100 cm tall. Otherwise, the weights are identical to those recommended by Stout (1998).

Using a weight of 2 for tree seedlings starting at a height of 25 cm instead of 30 cm may lead to a slightly higher estimated tree seedling threshold for Rock Creek Park, but the bias is probably small, and this modification is conservative given the low stocking rates found in Rock Creek Park. Since the actual seedling heights were measured during 2007, future calculations of stocking rate will follow Stout (1998) without modification.

Stout (1998) recommends that for successful forest regeneration, 67% of the plots (or 18 out of 26 plots in Rock Creek Park) must reach or exceed a tree seedling threshold of 51 per plot at low deer densities (13–21 deer per square mile) and more than 153 per plot at high deer densities (56–64 deer per square mile). These are the **action thresholds** for the management of white-tailed deer.

Action thresholds for tree seedlings in 67% of plots required for successful forest regeneration[1]

Deer density[2] (deer/mile^2)	**Tree seedling threshold for 18 or more plots** (0.0016 ha each)
Low (13–21)	≤ 51
High (56–64)	≤ 153

[1]Stout 1998

[2]Horsley et al. 2003

ha = hectare (about 2.47 acres)

References for Appendix A

Bates, S. E. 2008. National Capital Region Network
2007 *Deer Monitoring Report*. Natural Resource Technical Report NPS/NCRN/ NRTR—2008/XXX. Fort Collins, CO: National Park Service.

Buckland, S.T., D.R. Anderson, K.P. Burnham, J.L. Laake, D.L. Borchers, and L. Thomas
2001 *Introduction to Distance Sampling: Estimating Abundance of Wildlife Populations*. New York: Oxford University Press.

Hiby, L., and M. B. Krishna
2001 "Line transect sampling from a curving path." *Biometrics* 57:727–731.

Horsley, S. B., S. L. Stout, and D. S. deCalesta.
2003 "White-tailed deer impact on the vegetation dynamics of a northern hardwood forest." *Ecological Applications* 13(1):98–118.

Kery, M., and J. S. Hatfield
2003 "Normality of raw data in general linear models: the most widespread myth in statistics." *Bulletin of the Ecological Society of America* 84:92–94.

LaGory, K. E.
1986 "Habitat, group size, and the behavior of white-tailed deer." *Behavior* 98:168–179.

Littell, R. C., G. A. Milliken, W. W. Stroup, and R. D. Wolfinger
1996 *SAS System for Mixed Models*. Cary, North Carolina: SAS Institute, Inc.

McShea, W. S., C. Stewart, L. Kearns, A. Little, and D. Guertin
2007 "Bias Estimation for the National Capital Region Deer Distance Sampling Protocol: Antietam National Battlefield and Catoctin Mountain Park." Draft Final Report.

NPS
2004 "Inventory and Monitoring Program: White-tailed Deer Density Monitoring Protocol Version 1.0: Distance and Pellet Group Surveys." National Capital Region Network, Washington, DC.

Russell, F. L., D. B. Zippin, and N. L. Fowler
2001 "Effects of white-tailed deer (Odocoileus virginianus) on plants, plant populations, and communities: a review." *American Midland Naturalist* 146:1–26.

Shafer, E. L.
1965 *Deer Browsing of Hardwoods in the Northeast*. Warren, PA: U.S. Forest Service Research Paper NE-33, Northeast Forest Experiment Station.

Storm, G. L., and A. S. Ross
1992 *A Manual for Monitoring Vegetation on Public Lands in the Mid-Atlantic United States*. University Park, PA: Pennsylvania Cooperative Fish and Wildlife Unit, MANV-00192.

Stout, S. L.
1998 "Assessing the Adequacy of Tree Regeneration on the Cuyahoga Valley National Recreation Area: A Literature Review and Recommendations." Draft Report. Irvine, PA: U.S. Forest Service, Northeastern Research Station.

Thomas, L., J. L. Laake, S. Strindberg, F.F.C. Marques, S. T. Buckland, D. L. Borchers, D. R. Anderson, K. P. Burnham, S. L. Hedley, J. H. Pollard, J.R.B. Bishop, and T. A. Marques
2006 *Distance 5.0*. Release 2. UK: Research Unit for Wildlife Population Assessment, University of St. Andrews, UK.

Thompson, W. L., G. C. White, and C. Gowan
1998 *Monitoring Vertebrate Populations*. San Diego: Academic Press.

Underwood, H. B, F. D. Verret, and J. P. Fischer
1998 *Density and Herd Composition of White-tailed Deer on Fire Island National Seashore*. Technical Report NPS/NESO-RNR/NRTR/98-4.

APPENDIX B. CHRONIC WASTING DISEASE

This appendix summarizes guidance provided by the National Park Service (NPS) in response to chronic wasting disease (CWD), and it outlines management options available to parks for implementation in the absence of a specific CWD plan.

As of December 2008, CWD has been diagnosed in only two national parks — Rocky Mountain and Wind Cave national parks. However, several national park system units are at high risk because of their proximity to known CWD cases in many areas of the United States. The closest outbreak of CWD is approximately 90 miles from Rock Creek Park centered near Slanesville, West Virginia. There is a high likelihood that the disease will be detected in other areas of the country following increases in disease surveillance as well as disease spread. CWD presents population decline risks to wild cervids and incompletely understood risks to domestic animal and human health. Therefore, CWD has become an issue of national importance to wildlife managers and other interested publics, as well as NPS managers.

NPS POLICY AND GUIDANCE

DIRECTOR'S CWD GUIDANCE MEMORANDUM (JULY 26, 2002)

The NPS director provided guidance to regions and parks on NPS response to CWD in a memorandum dated July 26, 2002. Even though the memo pre-dates current CWD distribution in the national park system, the guidance remains pertinent. The guidance addresses surveillance, management, and communication regarding the disease. It also strictly limits human assisted translocation of deer and elk into or out of national park system units. Deviation from the guidance memo requires a waiver approved by the director.

A NATIONAL PARK SERVICE MANAGER'S REFERENCE NOTEBOOK TO UNDERSTANDING CHRONIC WASTING DISEASE (VERSION 4: JULY 2007)

This notebook serves as an informational reference that summarizes some of the most pertinent CWD literature, management options, and policies as they pertain to units of the national park system. It is not meant to be an all-inclusive review of current literature or management options. CWD is an emerging disease, and the knowledge base is continuing to expand. This document will be updated as necessary to include information pertinent to the NPS.

HUMAN CONSUMPTION OF ELK AND DEER MEAT GATHERED FROM AREAS WITH ENDEMIC CHRONIC WASTING DISEASE (DECEMBER 22, 2005; REVISED JULY 2007)

This document provides an overview of the issues surrounding CWD as it relates to public health, and includes NPS recommendations for the use of cervid meat for human consumption from parks affected by CWD surveillance and management actions within or near areas where CWD has been identified.

DESCRIPTION AND DISTRIBUTION

CWD is a slowly progressive, infectious, self propagating, neurological disease of captive and free-ranging mule deer (*Odocoileus hemionus*), white-tailed deer (*O. virginianus*), Rocky Mountain elk (*Cervus elaphus nelsoni*), and moose (*Alces alces*). The disease belongs to the transmissible spongiform encephalopathy (TSE) group of diseases (similar to scrapie and bovine spongiform encephalopathy). CWD is the only TSE currently found in free-ranging animals. TSEs are characterized by accumulations of abnormal prion (proteinaceous infectious particle) proteins in neural and lymphoid tissues (Prusiner 1982, 1991, 1997).

There is evidence that human-associated movement of cervids has aided in the spread of the disease in captive, and likely free-ranging, deer and elk (Miller and Williams 2003; Salman 2003; Williams and

Miller 2003). Localized artificial concentration of cervids in areas with few natural predators likely aids in disease transmission (Spraker et al. 1997; Samuel et al. 2003; Farnsworth et al. 2005). There is strong evidence to suggest that anthropogenic factors, such as land use, influence CWD prevalence (Farnsworth et al. 2005). Therefore, human influences are likely a significant component of observed CWD distribution and prevalence.

As of December 2008, CWD had been found in captive/farmed cervids in 11 states and 2 Canadian provinces and in free-ranging cervids in 10 states and 2 provinces. The historic area of CWD infection encompasses northeastern Colorado, southeastern Wyoming, and the southwest corner of the Nebraska panhandle (Williams and Miller 2002; Williams et al. 2002b). However, with increased surveillance that has occurred since 2001, the disease has been found with increasing frequency in other geographically distinct areas (Joly et al. 2003).

CLINICAL SIGNS

The primary clinical signs of CWD in deer and elk are changes in behavior and body condition (Williams et al. 2002b). Signs of the disease are progressive. Initially only someone who is quite familiar with a particular animal or group of animals would notice a change in behavior. As the clinical disease progresses over the course of weeks to months, animals demonstrate increasingly abnormal behavior and additional clinical signs (Williams and Young 1992). Affected animals can lose their fear of humans, show repetitive movements, and/or appear depressed but quickly become alert if startled. Affected animals rapidly lose body condition, despite having an appetite (Williams et al. 2002b). In the end stages of the disease they become emaciated. Once an animal demonstrates clinical signs, the disease is invariably fatal. There is no treatment or preventative vaccine for the disease.

DIAGNOSIS AND TESTING

CWD was initially diagnosed in deer and elk by testing a portion of the brain (histopathology techniques) (Williams and Young 1993). While this method is effective at diagnosing relatively advanced cases, it is not sensitive enough to detect early disease stages (Spraker et al. 1997; Peters et al. 2000).

In contrast, immunohistochemistry (IHC) is a sensitive, specific, and reliable test that can be used to identify relatively early stages of chronic wasting disease. This technique can detect CWD prions in many tissues (brain, retropharyngeal lymph nodes, and tonsils) (O'Rourke et al. 1998).

In addition to immunohistochemistry, which takes several days to complete, new rapid tests also employ antibody technology to diagnose CWD. Each has various advantages and disadvantages. Only certified laboratories can perform immunohistochemistry or the rapid CWD tests.

No test available is 100% sensitive for CWD, which means that a negative test result is not a guarantee of a disease-free animal.

TRANSMISSION

There is strong evidence that CWD is infectious and is spread by direct lateral (animal to animal) or indirect transmission (Miller et al. 2000; Miller and Williams 2003). Bodily secretions such as feces, urine, and saliva have all been suggested as possible means of transmitting the disease between animals and disseminating infectious prions into the environment (Miller et al. 2000; Williams et al. 2002b; Williams and Miller 2003). Maternal transmission cannot be ruled out, but it does not play a large role in continuing the disease cycle in either deer or elk (Miller et al. 1998; Miller et al. 2000; Miller and Williams 2003; Miller and Wild 2004).

Like other contagious diseases, CWD transmission increases when animals are highly concentrated. High animal densities and environmental contamination are important factors in transmission among captive cervids. These factors may also play a role in transmission in free-ranging animals (Miller et al. 2004).

Management actions that increase mortality rates in diseased populations can retard disease transmission:

1) It reduces the average lifetime of infected individuals. Reduced lifespan, in turn, can compress the period of time when animals are infectious, thereby reducing the number of infections produced per infected individual.

2) The effect of reduced intervals of infectivity is amplified by reductions in population density. Both of these mechanisms may retard the transmission of disease. If these mechanisms cause the number of new infections produced per infected individual to fall below one, then the disease will be eliminated from the population (Tompkins et al. 2001).

DISPOSAL OF CWD INFECTED ORGANIC MATERIAL

Discarding known or suspect CWD-contaminated organic material, such as whole or partial carcasses, is likely to become an important issue for national park system units in the future. Each state, Environmental Protection Agency region, and refuse disposal area is likely to have different regulations and restrictions for disposal of potentially infected tissues. Currently there is no national standard for disposal. Because infected carcasses serve as a source of environmental contamination (Miller et al. 2004), it is recommended that known and suspect CWD-positive animals be removed from the environment.

Given the type of infectious agent (prions), there are limited means of effective disposal. In most cases, however, off-site disposal of infected material is recommended in approved locations. The available options for each park will vary and will depend on the facilities present within a reasonable distance from the park. Disposal of animals that are confirmed to be infected should be disposed of in one of the following ways:

- Alkaline Digestion — Alkaline digestion is a common disposal method used by veterinary diagnostic laboratories. This method uses sodium hydroxide or potassium hydroxide to catalyze the hydrolysis of biological material (protein, nucleic acids, carbohydrates, lipids, etc.) into an aqueous solution consisting of small peptides, amino acids, sugars, and soaps. During this process the prion proteins are destroyed.
- Incineration — Incineration is another disposal method commonly used by veterinary diagnostic laboratories. This method burns the carcass at intense temperatures (600 – 1000 degrees centigrade).
- Landfill — The availability of this option varies by region, state, and local regulations. Therefore, local landfills must be contacted for more information regarding carcass disposal, to determine if they can and will accept CWD positive carcasses or carcass parts.

MANAGEMENT

Chronic wasting disease has occurred in a limited geographic area of northeastern Colorado and southeastern Wyoming for over 30 years. Relatively recently, it has been detected in captive and free-ranging deer and elk in several new locations, including Nebraska, South Dakota, New Mexico, Utah, new areas of Wyoming and Colorado, and east of the Mississippi River in Wisconsin, Illinois, West Virginia, New York, and most recently Michigan.

The NPS does not have a single overarching plan to manage chronic wasting disease in all parks. However, it has provided guidance to parks in how to monitor for and minimize the potential spread of the disease, as well as remove infected animals from specific areas. Generally, two levels of action have been identified, based on risk of transmission: (1) when CWD is not known to occur within a 60-mile radius from the park, and (2) when the disease is known to occur within the park or within a 60-mile radius.

The chance of finding CWD in a park is related to two factors: the risk of being exposed to the disease (the likelihood that the disease will be introduced into a given population), and the risk of the disease being amplified once a population of animals has been exposed. The first risk is important for national park system units where no CWD cases have been identified within 60 miles of their border. The second risk applies to units where chronic wasting disease is close to or within their borders, as well as in proactive planning efforts. By evaluating the risk of CWD exposure and amplification, managers can make better decisions regarding how to use their resources to identify the disease.

Actions available to identify CWD are linked to the risk factors present in and around the park. When risk factors are moderate, surveillance for chronic wasting disease can be less intense (e.g., opportunistic) than when risk is high (NPS 2005e). When the risk is higher, surveillance (e.g., targeted) should be increased. Other management actions that are in place for the host species may limit risk of exposure or transmission by maintaining appropriate population densities. Whether CWD is within 60 miles of a unit or not, coordination with state wildlife and agriculture agencies is strongly encouraged.

OPPORTUNISTIC SURVEILLANCE

Opportunistic surveillance involves taking diagnostic samples for testing from deer found dead or harvested through a management activity within a unit of the national park system. Cause of death may be culling, predation, disease, trauma (hit by car), or undetermined. Opportunistic surveillance has little, if any, negative impact on current populations. Unless deer are culled, for either population management or research goals, relatively small sample sizes may be available for opportunistic testing. Animals killed in collisions with vehicles may be a biased sample that could help detect CWD. Research has indicated that CWD-infected mule deer may be more likely to be hit by vehicles than non-CWD infected deer (Krumm et al. 2005).

Opportunistic surveillance is an excellent way to begin surveying for presence of CWD without changing management of the deer population. This is a good option for park units where CWD is a moderate risk but where it has not yet been encountered within 60 miles of the park.

TARGETED SURVEILLANCE

Targeted surveillance entails lethal removal of deer that exhibit clinical signs consistent with CWD. Targeted surveillance has negligible negative effects on the entire population, removes a potential source of CWD infection, and is an efficient means of detecting new centers of infection (Miller et al. 2000). One limitation to targeted surveillance is that environmental contamination and direct transmission may occur before removal. Additionally, there is no available method to extrapolate disease prevalence when using targeted surveillance because actions are focused only on those individuals thought to be infected. Targeted surveillance is moderately labor intensive and requires educating park staff in recognition of clinical signs and training in identifying and removing appropriate samples for testing, as well as vigilance for continued observation and identification of potential CWD suspect animals. Training is available through the NPS Biological Research Management Division. Targeted surveillance is recommended in areas with moderate to high CWD risk (within 60 miles of known CWD occurrence) or in park units where CWD has already been identified.

POPULATION REDUCTION

Population reduction involves randomly culling animals within a population in an attempt to reduce animal density, and thus decrease transmission rates. In captive situations, where animal density is high, the prevalence of CWD can be substantially elevated compared to that seen in free-ranging situations. Thus, it is hypothesized that increased animal density and increased animal-to-animal contact, as well as increased environmental contamination, enhance the spread of CWD. Therefore, decreasing animal densities may decrease the transmission and incidence of the disease. However, migration patterns and

social behaviors may make this an ineffective strategy if instead of dispersing across the landscape, deer and elk stay in high-density herds in small home ranges throughout much of the year (Williams et al. 2002b). Population reduction is an aggressive and invasive approach to mitigating the CWD threat. It has immediate and potentially long-term effects on local and regional populations of deer and the associated ecosystem. This may be an appropriate response if animals are above population objectives and/or the need to know CWD prevalence with a high degree of accuracy is vital.

COORDINATION

Regardless of which surveillance method is used, each park should cooperate with state wildlife and agriculture agencies in monitoring CWD in park units, working within the park's management policies. CWD is not contained by political boundaries, thus coordination with other management agencies is important.

Additionally, as stated above, the NPS Biological Resource Management Division provides assistance to parks for staff training (e.g., sample collection, recognizing clinical signs of CWD) and testing (e.g., identifying qualified/approved labs or processing samples).

References for Appendix B

Farnsworth, M. L., L. L. Wolfe, N. T. Hobbs, K. P. Burnham, E. S. Williams, D. M. Theobald, M. M. Conner, and M. W. Miller.
2005 Human land use influences chronic wasting disease prevalence in mule deer. Ecological Applications 15:119-126.

Johnson, C. J., J. A. Pedersen, R. J. Chappell, D. McKenzie, and J. M. Aiken.
2007 Oral transmissibility of prion disease is enhanced by binding to soil particles. PLoS Pathogens 3:1-8.

Joly, D. O., C. A. Ribic, J. A. Langenberg, K. Beheler, C. A. Batha, B. J. Dhuey, R. E. Rolley, G. Bartelt, T. R. Van Deelen, and M. D. Samuel.
2003 Chronic wasting disease in freeranging Wisconsin White-tailed Deer. Emerging Infectious Diseases 9:599-601.

Joly, D. O., M. D. Samuel, J. A. Langenberg, J. A. Blanchong, C. A. Batha, R. E. Rolley, D. P. Keane, and C. A. Ribic.
2006 Spatial epidemiology of chronic wasting disease in Wisconsin white-tailed deer. Journal of Wildlife Diseases 42:578-588.

Krumm, C. E., M. M. Conner, and M. W. Miller.
2005 Relative vulnerability of chronic wasting disease infected mule deer to vehicle collisions. Journal of Wildlife Diseases 41:503-511.

Mathiason, C. K., J. G. Powers, S. J. Dahmes, D. A. Osborn, K. V. Miller, R. J. Warren, G. L. Mason, S. A. Hays, J. Hayes-Klug, D. M. Seelig, M. A. Wild, L. L. Wolfe, T. R. Spraker, M. W. Miller, C. J. Sigurdson, G. C. Telling, E. A. Hoover.
2006 Infectious prions in the saliva and blood of deer with chronic wasting disease. Science 314:133-136

Miller, M. W., N. T. Hobbs, and S. J. Tavener.
2006 Dynamics of prion disease transmission in mule deer. Ecological Applications 16:2208-2214.

Miller, M. W., and M. A. Wild.
2004 Epidemiology of chronic wasting disease in captive whitetailed and mule deer. Journal of Wildlife Diseases 40:320-327.

Miller, M. W., M. A. Wild, and E. S. Williams.
1998 Epidemiology of chronic wasting disease in captive Rocky Mountain elk. Journal of Wildlife Diseases 34:532-538.

Miller, M. W., and E. S. Williams.
2003 Prion disease: horizontal prion transmission in mule deer. Nature 425:35-36.

Miller, M. W., E. S. Williams, N. T. Hobbs, and L. L. Wolfe.
2004 Environmental sources of prion transmission in mule deer. Emerging Infectious Diseases 10:1003-1006.

Miller, M. W., E. S. Williams, C. W. McCarty, T. R. Spraker, T. J. Kreeger, C. T. Larsen, and E. T. Thorne
2000 Epizootiology of chronic wasting disease in free-ranging cervids in Colorado and Wyoming. Journal of Wildlife Diseases 36:676-690.

National Park Service.
2007 A National Park Service Manager's Reference Notebook to Understanding Chronic Wasting Disease. Version 4. July 26, 2007. Prepared by Jenny Powers and Margaret Wild, NPS Biological Resource Management Division

O'Rourke, K. I., T. V. Baszler, J. M. Miller, T. R. Spraker, I. Sadler-Riggleman, and D. P. Knowles.
1998 Monoclonal antibody F89/160.1.5 defines a conserved epitope on the ruminant prion protein. Journal of Clinical Microbiology 36:1750-1755.

Peters, J., J. M. Miller, A. L. Jenny, T. L. Peterson, and K. P. Carmichael.
2000 Immunohistochemical diagnosis of chronic wasting disease in preclinically affected elk from a captive herd. Journal of Veterinary Diagnostic Investigation 12:579-582.

Prusiner, S. B.
1982 Research on scrapie. Lancet 2:494-495.

1991 Molecular biology of Prion diseases. Science (Washington) 252:1515-1522.

1997 Prion diseases and the BSE crisis. Science (Washington) 278:245-251.

Salman, M. D.
2003 Chronic wasting disease in deer and elk: scientific facts and findings. Journal of Veterinary Medical Science 65:761-768.

Samuel, M. D., D. O. Joly, M. A. Wild, S. D. Wright, D. L. Otis, R. W. Werge, and M. W. Miller.
2003 Surveillance strategies for detecting chronic wasting disease in free-ranging deer and elk. National Wildlife Health Center, United States Geological Survey, Madison, Wisconsin, USA. 41pp.

Spraker, T. R., M. W. Miller, E. S. Williams, D. M. Getzy, W. J. Adrian, G. G. Schoonveld, R. A. Spowart, K. I. O'Rourke, J. M. Miller, and P. A. Merz.
1997 Spongiform encephalopathy in free-ranging mule deer (Odocoileus hemionus), white-tailed deer (Odocoileus virginianus) and rocky mountain elk (Cervus elaphus nelsoni) in northcentral Colorado. Journal of Wildlife Diseases 33:1-6.

Spraker, T. R., T. L. Gidlewski, A. Balachandran, K. C. VerCauteren, L. Creekmore, and R. D. Munger.
2006 Detection of PrPCWD in postmortem rectal lymphoid tissues in Rocky Mountain elk (Cervus elaphus nelsoni) infected with chronic wasting disease. Journal of Veterinary Diagnostic Investigation 18:553-557.

Tompkins, D. M., A. P. Dobson, P. Arneberg, M. E. Begon, I. M. Cattadori, J. V. Greenman, J. A. P. Heesterbeek, P. J. Hudson, D. Newborn, A. Pugliese, A. P. Rizzoli, R. Rosa, F. Rosso, and K. Wilson.
2002 Parasites and host population dynamics. Pages 45-62 in P. J. Hudson, A. Rizzoli, B. T. Grenfell, H. Heesterbeek, and A. P. Dobson, editors. The ecology of wildlife diseases. Oxford University Press, New York.

Williams, E. S., and M. W. Miller.
2002 Chronic wasting disease in deer and elk in North America. Revue Scientifique et Technique - Office International des Epizooties 21:305- 316.

2003 Transmissible spongiform encephalopathies in non-domestic animals: origin, transmission and risk factors. Revue Scientifique et Technique - Office International des Epizooties 22(1):145-156.

Williams, E. S., M. W. Miller, T. J. Kreeger, R. H. Kahn, and E. T. Thorne.
2002 Chronic wasting disease of deer and elk: a review with recommendations for management. Journal of Wildlife Management 66:551-563.

Williams, E. S., and S. Young.
1980 Chronic wasting disease of captive mule deer: aspongiform encephalopathy. Journal of Wildlife Diseases 16:89-98.

Williams, E. S. and S. Young.
1992 Spongiform encephalopathies in Cervidae. Revue Scientifique et Technique - Office International des Epizooties 11(2):551-567.

Williams, E. S. and S. Young.
1993 Neuropathology of chronic wasting disease of mule deer (*Odocoileus hemionus*) and elk (*Cervus elaphus nelsoni*). Veterinary Pathology 30(1):36-45.

APPENDIX C. REVIEW OF WHITE-TAILED DEER FERTILITY CONTROL

INTRODUCTION

Managing the overabundance of certain wildlife species has become a topic of public concern (Rutberg et al. 2004). Species such as Canada geese (Branta canadensis), coyotes (Canis latrans), and white-tailed deer (Odocoileus virginianus) have become either locally or regionally overabundant throughout the United States (Fagerstone et al. 2002). In addition, traditional wildlife management techniques such as hunting and trapping are infeasible in many parks and suburban areas, forcing wildlife managers to seek alternative management methods.

The use of reproductive control in wildlife management has been assessed for several decades. Its use has gained more attention, as the public has become more involved in wildlife management decisions. Interest in reproductive control as an innovative alternative to traditional management methods, has led to the current state of the science (Baker et al. 2004). Often, the use of reproductive control is promoted in urban and suburban areas where traditional management tools, such as hunting, are publicly unacceptable or illegal due to firearm restrictions (Kilpatrick and Walter 1997; Muller, Warrnen, and Evans 1997).

In order for reproductive control agents to effectively reduce population size, treatment with an agent must decrease the reproductive rate to less than the mortality rate. In urban deer populations, mortality rates are generally very low (approximately 10%). Therefore, it would be necessary to treat 70-90% of the female deer, with a highly efficacious product, to effectively reduce or halt population growth (Rudolph, Porter, and Underwood 2000).

The purpose of this document is to provide NPS managers at Rock Creek Park with: (1) a brief overview of reproductive control options as they pertain to white-tailed deer; (2) an outline of the primary advantages, disadvantages and challenges related to the application of wildlife fertility control agents including population management challenges, regulatory issues, potential logistical issues, and consumption issues; (3) evaluate current fertility control agents against criteria established by the park for use of a reproductive control agent; and (4) provide a relatively comprehensive list of literature to refer to for additional information. This document is not intended to be exhaustive but to provide a scientifically sound basis for understanding and evaluating deer management alternatives that include reproductive control of does.

It is important to note that some of the most critical elements of a successful population level fertility control program focus on ecological and logistical questions rather than on the biological action of fertility control agents in individual animals. These issues can lead to less than optimal results when analyzing fertility control as a method of population regulation in free-ranging wildlife populations. It should also be noted that technology is changing rapidly in this field of research and updated information should be reviewed prior to implementation of a deer management program that involves fertility control.

CURRENT TECHNOLOGY

The area of wildlife contraception is constantly evolving as new technologies are developed and tested. For the sake of brevity, this appendix will only discuss reproductive control as it applies to female deer. There is a general understanding in white-tailed deer biology that managing the female component of the population is more important than managing the male component. Based on the polygamous breeding behavior of white-tailed deer, treating males with reproductive control would be ineffective if the overall goal is population management (Warren 2000).

There are three basic categories of reproductive control technology: (1) immunocontraceptives (vaccines), (2) non-immunological methods (pharmaceuticals), and (3) physical or chemical sterilization.

IMMUNOCONTRACEPTIVES

It is suggested that immunocontraceptive vaccines offer significant promise for future wildlife management (Rutberg et al. 2004). Immunocontraceptive treatment involves injecting an animal with a vaccine that "stimulates its immune system to produce antibodies against a protein (antigen) involved in reproduction" (Warren 2000). In order to provide for sufficient antibody production, an adjuvant is combined with the vaccine. An adjuvant is a product that increases the intensity and duration of the immune system's reaction to the vaccine. There are two primary types of antigens used in reproductive control vaccines in deer: porcine zona pellucida (PZP) and gonadotropin releasing hormone (GnRH).

Neither PZP nor GnRH vaccines are 100% effective in preventing pregnancy. Curtis et al. (2002) demonstrated approximately 85-90% efficacy for both GnRH and PZP immunocontraceptive vaccines in white-tailed deer. Over a 13-year period on Assateague Island National Seashore, contraceptive efficacy in PZP-treated horses ranged from 92 to 100% (Kirkpatrick and Turner 2008). However, efficacy generally decreases as antibody production wanes. Decreases in pregnancy rates can usually be expected for 1-2 years post-treatment with immunocontraceptive vaccines. How long infertility lasts is strongly related to the conjugate antigen design, the adjuvant used, and how the vaccine is delivered (Miller et al. 2008).

Porcine Zona Pellucida (PZP). The majority of immunocontraceptive research in wildlife has been conducted using PZP vaccines. PZP vaccines stimulate production of antibodies directed towards specific outer surface proteins of domestic pig eggs. Pig eggs are sufficiently similar to many other mammals' eggs that antibodies produced will cross-react with the vaccinated animal's own egg. PZP antibodies prevent fertilization, presumably by blocking the sperm attachment site on the zona. This type of vaccine stimulates an immune response to the egg coat proteins and is therefore only effective in female deer. There are currently two PZP vaccine products being developed, one is simply called PZP and the other SpayVac®. SpayVac® (ImmunoVaccine Technologies, Halifax), uses a liposome preparation of PZP (with adjuvant) and has been evaluated in a variety of species, including white-tailed deer (Brown et al. 1997, Fraker et al. 2002, Locke et al. 2007, Rutberg and Naugle 2009). The other PZP vaccine, often referred to as "native" PZP, does not use liposome technology but also has been used extensively in white-tailed deer and other species in the course of investigating its effectiveness (Rutberg and Naugle 2008a; Kirkpatrick et al. 1997; Turner, Kirkpatrick, and Liu 1992, 1996; Walter et al. 2002a, 2002b).

PZP vaccines have been tested in more than 70 captive wildlife species with variable success in preventing reproduction for variable durations of time (Kirkpatrick et al. 1997, 1996b). The native PZP vaccine has also been tested extensively in free-ranging white-tailed deer (Rutberg and Naugle, 2008a, Naugle et al. 2002, Rudolph et al. 2000, Rutberg et al. 2004, Walter et al. 2002a, 2002b, Walter et al. 2003). Native PZP was first used successfully to control reproduction in white-tailed deer in 1992 (Turner et al. 1992). Potential benefits of this vaccine include the ability to deliver the vaccine remotely, safety in pregnant deer and non-target species (e.g. dogs, horses) (Barber and Fayrer-Hosken 2000), and the availability of at least some long-term data on population level effects. The currently available PZP vaccine formulation is effective for two years (Turner et al. 2007), though longer multiyear applications are also being studied.

SpayVac® provides the same advantages as native PZP but may result in infertility for up to seven years (Miller et al. 2009). Potential advantages of SpayVac® compared to the native PZP vaccine are: "1) a more rapid immune response, 2) higher antibody titers, 3) a higher proportion of antibodies that bind to target sites, and 4) longer duration of efficacy" (Fraker and Bechert 2007). Although little long-term data on population level effects exists for SpayVac®, it is assumed they are similar to those for the native PZP formulation.

There are few field studies that have evaluated population-level effects of fertility control (Rutberg et al. 2004, Hobbs et al. 2000, Rudolph et al. 2000). Research evaluating the effectiveness of PZP in reducing the size of deer populations has focused on moderate to high density deer populations of relatively small

size (< 300-500 individuals). Within these populations, long-term (> 10 years) data indicates that population size of long-lived species (e.g. deer, horses) may be gradually decreased using PZP treatments (Kirkpatrick and Turner 2008, Rutberg and Naugle 2008a). Rutberg and Naugle (2008a) reported a 27% decline in the size of a small, suburban deer population (approximately 250 deer) between 1997 and 2002, as a result of PZP treatments and potentially other stochastic events. However, level of success in reducing population size, reported for white-tailed deer, varies widely. For example, deer density on Fire Island National Seashore was significantly reduced in some areas but reduced very little in other areas (Rutberg and Naugle 2008a, Underwood 2005). Success in controlling deer populations is dependent on a variety of factors including population size (ability to treat a sufficient number of does), "vaccine effectiveness, accessibility of deer for treatment, and site-specific birth, death, immigration, and emigration rates" (Rutberg and Naugle 2008a).

Additionally, PZP-treated wildlife may experience increased body condition and a longer life span compared to untreated individuals as a result of reduced energetic costs of pregnancy and lactation (Warren 2000, Hone 1992). For example, at Assateague Island National Seashore, the life span of horses treated with PZP has been extended from an average age at death of 20 years to 26-30 years (Kirkpatrick and Turner 2008, Zimmerman 2009 pers. comm.). Longer life span may extend the time needed to observe a decline in population size (Kirkpatrick and Turner 2008; Rutberg and Naugle 2008a). Additional research is needed to determine how fast a population can be reduced, how deep a reduction can be achieved, and what landscapes are best suited to use of fertility control as a management tool (Rutberg and Naugle 2008a).

Challenges to the use of PZP include behavioral impacts, frequency of treatment (need for booster shots), use of meat for human consumption, and the need to permanently mark treated animals. PZP based vaccines often cause abnormal out of season breeding behavior in treated deer populations (Fraker et al. 2002; McShea and Rappole 1997), as treatment with PZP leads to repeated estrous cycling in females and associated behavioral changes. This may result in late pregnancies, higher fawn mortality, and possibly an extended breeding season or rut (Fraker et al. 2002; McShea et al. 1997). Additionally, any effect that could extend the rut also has the potential for secondary effects to the individual deer. Increased attempts to breed may result in increased deer movements. This may be problematic in areas with high vehicle use, as there could be increases in deer-vehicle collisions. However, the only known research evaluating this specific issue reported that deer treated with PZP were at no greater risk of being involved in a deer-vehicle collision than untreated deer (Rutberg and Naugle 2008b). It should be noted that in a small number of cases, permanent infertility in horses has been reported in association with SpayVac® (Fraker 2009). Additional research is needed to evaluate the potential for sterility in white-tailed deer.

Successful field application of a fertility control program requires both an effective agent and a practical delivery system (Cowan et al. 2002). Although PZP vaccines may be successfully delivered remotely through darting, the PZP vaccine also currently require periodic boosters in order to maintain infertility, usually two injections, at least three weeks apart, during the first year. The need for booster shots leads to significant logistical issues when working with free-ranging white-tailed deer, particularly when the number of deer to be treated is high. New research involving controlled-release native PZP formulations incorporates primer and booster immunizations into one injection and may extend the period of infertility (Turner et al. 2008). Turner et al. (2008) provides an overview of the current status of research related to controlled-release components of native PZP contraceptive vaccines. SpayVac® currently does not require an immediate booster and may prove to be easier to implement since booster shots would only be required every 3-7 years (Fraker 2009). It is expected that development of a long-acting, single shot treatment will improve the ability of NPS units to implement this vaccine as a deer management tool.

If a product is intended for use in a food-producing animal, it must be tested for safety to human consumers, and the edible animal products must be free of unsafe drug residues (http://www.fda.gov/cvm/aboutona.htm; Accessed 1/30/09). The Food and Drug Administration (FDA),

Office of New Animal Drug Evaluation is the current regulatory agency responsible for this determination for PZP vaccines. FDA has not yet determined whether PZP vaccine components pose a human health risk. Although FDA approval is the standard for drugs being considered for human consumption, PZP may still be used under an Investigational New Animal Drug (INAD) exemption as a research tool. It is expected that regulatory authority for PZP vaccines will shift to the Environmental Protection Agency (EPA) in the near future. Once it becomes transferred to EPA regulation and until it becomes an EPA-registered contraceptive for wild deer, it would have to be used in a research context under an EPA "experimental use" permit.

Until approved by the FDA or registered by the EPA, treated animals should be permanently marked so as not to enter the human food chain. Marking is also required for long-term monitoring of contraceptive efficacy, determining which deer have been treated during implementation, and evaluating management success through an adaptive management approach. At Fire Island National Seashore, treated deer are only marked temporarily using dye packs and therefore researchers have been unable to assess reproduction in treated deer or contraceptive efficacy since 1995 (Rutberg and Naugle 2008a). Additionally, NPS units are mandated to cooperate and coordinate with state agencies to manage cross boundary wildlife resources whenever possible (43 CFR part 24). Therefore, parks should also consult with appropriate state agencies regarding marking of treated animals in areas where deer may cross park boundaries.. The disadvantages of permanent marking are primarily related to the substantial additional labor and costs of the first year's capture and marking of treated animals, sustainability over the long-term, and associated stress to individual deer (compared to remote delivery).

Finally, there is general agreement that because of the logistical difficulties of treating significant numbers of deer that controlling large, free-ranging populations of wild ungulates solely with a contraception vaccine is impractical and unlikely to succeed (Rutberg et al. 2004, McCullough 1996, Garrott 1991 and 1995, Curtis et al. 1998, Warren et al. 1992 and 2000, Rudolph et al. 2000, Cowan et al. 2002, Merrill et al. 2003). There is also agreement that fertility control as a sole means of managing populations cannot reduce wildlife population size rapidly (Rutberg and Naugle 2008a, Kirkpatrick and Turner 2008). The few long-term (> 10 years) research projects evaluating population level effects of PZP on long-lived species (horses and deer) support this statement. At Assateague Island National Seashore, PZP treatments were successful in reducing the wild horse population 16% (from 160 to 135 individuals) between 1994 and 2009 (15 years). The park expects to reach the target population size of 135 horses in another 8-9 years (Zimmerman 2009 pers. comm.). At Fire Island National Seashore, park managers report a 33% reduction in overall deer population size (from approximately 600 to 400 individuals) between 1994 and 2009 (Bilecki 2009 pers. comm.). In the most intensively treated areas of the park deer population size decreased up to 55% over 15 years (Rutberg and Naugle 2008a). Therefore, the appropriateness of fertility control as a deer management tool also is heavily dependent on specific park objectives and the purpose and need for management.

Additional information on PZP may be obtained at:

http://www.aphis.usda.gov/wildlife_damage/nwrc/research/reproductive_control/index.shtml OR http://www.pzpinfo.org.

Gonadotropin Releasing Hormone (GnRH) Vaccines. GnRH is a small neuropeptide (a protein-like molecule made in the brain) that plays a necessary role in reproduction. It is naturally secreted by the hypothalamus (a region of the brain that regulates hormone production), which directs the pituitary gland to release hormones (luteinizing hormone and follicle stimulating hormone) that control the proper functioning of reproductive organs (Hazum and Conn 1998). In an attempt to interrupt this process, research has focused on eliminating the ability of GnRH to trigger the release of reproductive hormones. One solution that has been investigated is a vaccine that, when combined with an adjuvant, stimulates the production of antibodies to GnRH. These antibodies likely attach to GnRH in the hypothalamic region

and prevent the hormone from binding to receptors in the pituitary gland, thus suppressing the secretion of reproductive hormones and preventing the release of eggs/sperm.

The use of GnRH vaccines has been investigated in a variety of both wild and domestic ungulates (hoofed mammals) (Curtis et al. 2002; Miller et al. 2000; Miller, Rhyan, and Drew 2004). In recent years, a great deal of research has been done on their effectiveness. One such GnRH vaccine being researched and developed is GonaCon™. Regulatory authority for GnRH vaccines was moved from the FDA to the EPA in 2006. Although not yet commercially available, GonaCon™ is expected to be submitted for EPA approval in 2009, as a contraceptive "pesticide" for managing white-tailed deer populations (Fagerstone et al. 2008, USDA 2008). Approval could occur within 12-18 months and it is expected to be registered as a "Restricted Use" product (USDA 2008). Labeling is likely to require hand injection, since an effective remote delivery system has yet to be developed, as well as permanent marking of treated individuals.

As with PZP, GonaCon™ has been shown to successfully control reproduction in wildlife species including white-tailed deer (Miller et al. 2000). Potential benefits of this vaccine include a longer-lasting contraceptive effect and possibly the lack of repeated estrous cycles. In white-tailed deer, GnRH is estimated to be approximately 85-100% effective in preventing pregnancy during the first year post-treatment (Miller et. al. 2008, USDA 2008), however long-term field efficacy data currently does not exist (USDA 2008). The contraceptive effect typically last two years but may last for up to four years in some individuals (Fagerstone et al. 2008, USDA 2008). GnRH applications are currently being researched to determine the potential for use as a wildlife management tool (USDA 2008).

Repeated estrous cycling and other behavioral changes in white-tailed deer have not been documented in association with GnRH vaccines due to their mode of action (Curtis et. al. 2008). Preventing the release of eggs results in no estrous cycle and may reduce breeding behaviors in female deer (Killian et al. 2008). However, Killian et al. (2008) reported that behavioral expressions of estrus were only decreased for 1-2 years post-treatment and increased in subsequent years despite does remaining infertile.

GnRH vaccines have many of the same challenges associated with PZP including frequency of treatment (booster shots), human consumption issues, and the need to permanently mark treated animals. Additionally, as with PZP, immune response to the adjuvant also may cause difficulties with a population of treated deer when determining the Johne's disease status (a gastrointestinal disease of potential regulatory importance for domestic livestock).

Although longer-acting (1-4 years), infertility in deer treated with GnRH vaccines is reversible as antibody levels wane. Studies of penned and free-ranging deer indicated GonaConTM was 88-100% effective in year 1 and 47-70% effective in the second year post-treatment (Fagerstone et al. 2008). As with PZP, multiple injections or booster shots are needed to increase the contraceptive efficacy and longevity of the vaccine (Fagerstone et al. 2008). However, with GnRH vaccines booster shots may be required less frequently. Research is expected to continue to improve the single-shot, multiyear vaccine (Miller et. al. 2008).

It is currently unknown how issues related to human consumption will be addressed by the EPA. EPA approval requires Toxicology or Human Health Hazard studies to evaluate potential threats to humans based on the duration and route of exposure to pesticides (Fagerstone et al. 2008). It should be noted that the adjuvant used in GonaCon™, an adaptation of the commercially available vaccine Mycopar™, is approved for use in food animals and that the FDA had indicated that 'in general, the components of this product do not raise a human food safety concern' (Fagerstone et al. 2008). However, until GonaCon is EPA-registered and product labeling known, treated animals should be permanently tagged to avoid entry into the human food chain and promote identification of treated versus untreated individuals. Once EPA-registered as a contraceptive 'pesticide', it is possible that product labeling will require permanent marking of treated animals. As indicated above, the disadvantages of permanent marking are primarily

related to the substantial additional labor and costs of the first year's capture and marking of treated animals, sustainability over the long-term, and associated stress to individual deer (compared to remote delivery).

Other challenges to use of GnRH vaccines including health effects on target (deer) and non-target species, lack of information related to effectiveness at the population level in free-ranging deer, and lack of an adequate remote delivery application. Killian et al. 2006a concluded that GonaConTM was safe for deer and that there were no adverse health impacts associated with unintentional repeated vaccination. However, a variety of health problems have been associated with certain types of GnRH adjuvants (e.g. Freund's Complete Adjuvant) ranging from granulomas to loss of primary and secondary sexual characteristics (males) and occasionally death (Curtis et al. 2008, Killian et al. 2006). A ganuloma is a localized inflammatory response to components of the GnRH adjuvant that may occur at the site of injection for up to three years post-treatment (Curtis et al. 2008). This is the most commonly reported physiological side effect of GnRH vaccines, including GonaConTM (USDA 2008). There is little information regarding vaccination of pregnant animals and although GnRH vaccines are not believed to be harmful to non-target species, there is little information regarding the theoretical human and non-target species health risks.

Overall, no significant, long-term impacts to health or changes in behavior have been consistently documented in female deer in association with GnRH vaccines (USDA 2008, Killian et al. 2006). However, GnRH vaccines are not recommended for use in male deer due to an increased mortality rate (compared to treated female deer) and impacts associated with loss of primary and secondary sexual characteristics such as smaller gonads, failure of antlers to harden and shed velvet, malformed (atypical) antlers, and associated changes in breeding behaviors (Curtis et al. 2008, Miller et al. 2000c).

As stated above, GnRH applications are currently being researched to determine the potential for use as a wildlife management tool (USDA 2008). Long-term field efficacy data currently does not exist (USDA 2008) and thus questions still remain regarding whether populations can be reduced, how deep a reduction could be achieved, how fast reduced would occur, and what landscapes would be best suited to use of fertility control as a management tool (Rutberg and Naugle 2008a).

Lastly, successful field application of a fertility control program requires both an effective agent and a practical delivery system (Cowan et al. 2002). The ability to deliver contraceptive vaccines using a remote delivery application is an important logistical issue. A well-developed system of remote delivery eliminates the need to capture and handle deer after initial immunizations and may substantially reduce implementation costs. Additionally, as described under PZP, there is general agreement that controlling large, free-ranging populations of wild ungulates solely with a contraception vaccine (PZP or GnRH) is impractical, unlikely to succeed (McCullough 1996, Garrott 1991 and 1995, Curtis et al. 1998, Warren et al. 1992 and 2000, Rudolph et al. 2000, Cowan et al. 2002, Merrill et al. 2003), and cannot reduce wildlife population size rapidly. Therefore, the appropriateness of fertility control as a deer management tool also is heavily dependent on specific park objectives and the purpose and need for management.

Additional information may be obtained at:
http://www.aphis.usda.gov/wildlife_damage/nwrc/research/reproductive_control/index.shtml

NON-IMMUNOLOGICAL REPRODUCTIVE CONTROL METHODS

This group of reproductive control agents includes GnRH agonists, GnRH toxins, steroid hormones, and contragestives.

GnRH Agonists. GnRH agonists are highly active analogs of GnRH which are similar in structure and action to the endogenous hormone. These agonists attach to receptors in the pituitary gland. By attaching to the receptors, these agonists reduce the number of binding sites available and thereby temporarily suppress the effect of the GnRH. As a result of this suppression, reproductive hormones are not released

(Aspden et al. 1996; D'Occhio, Aspden, and Whyte 1996). Continuous administration of the agonist is necessary to maintain infertility. This can be accomplished with controlled-release formulations or surgically implanted pumps in addition to daily administration.

Not all agonists have the same effects in all species. In fact, some can have an effect that is the opposite of what is intended. The wide variation in response is likely due to a combination of type of agonist, dose, treatment regime, reproductive status, sex, and species (Becker and Katz 1997). Therefore, it is important to fully understand the effects of a product on a given species. Although many GnRH agonists are used in human as well as veterinary medicine only a few have been investigated in wildlife species (Becker and Katz 1997, Vickery 1986). GnRH agonists have been tested primarily in mule deer and elk and been shown to both suppress reproductive hormones and prevent pregnancy (Baker et al. 2005, Baker et al. 2004). Additionally, GnRH agonists have not been documented as causing behavioral changes when applied to female deer (Baker et al. 2004). Researchers believe this may be a useful tool in the future for preventing pregnancy in white-tailed deer as well.

- Leuprolide acetate: Leuprolide is one GnRH agonist that has been studied. Tests reveal that when it is administered as a controlled-release formulation, it results in 100% pregnancy prevention in treated female elk and mule deer (Baker et al. 2002, 2004, Conner et al. 2007). In addition, the treatment is reversible, and the effects last only for a specific period of time (90-120 days) (Baker et al. 2004; Trigg et al. 2001). Advantages of leuprolide acetate are that it is 100% effective in preventing pregnancy, is safe for human consumption (Baker et al. 2004), can be delivered remotely (Baker et al. 2005), does not result in physiological side effects, and short-term behavioral effects are minimal (Conner et al. 2007).

  Leuprolide has been FDA-approved for use in humans and can be used with a veterinary prescription under the Animal Drug Use and Clarification Act of 1994. The prescribing veterinarian and the client (NPS unit) must clearly understand how and why the drug would be used in an off-label manner. It is the responsibility of the prescribing veterinarian to give an appropriate meat withdrawal period (the time it takes for the animal to metabolize and clear the drug from its tissue) for food-producing animals that may enter the human food chain.

  The need to deliver leuprolide through a subcutaneous hand injection has traditionally been considered a significant barrier to the long-term application of this drug as a wildlife management tool. However, Baker et al. (2005) recently developed a successful dart delivery system that may extend the practical application of this contraceptive. This research also demonstrated the effectiveness of leuprolide when delivered via an intramuscular injection.

  Treatment using leuprolide differs from GnRH vaccines in that it does not require an adjuvant and does not induce an antibody reaction. Therefore, inflammatory responses to adjuvant components and other physiological effects, often observed with immunocontraceptives, have not been observed in association with leuprolide. It does, however, require a slow release implant that remains under the skin or in the muscle for the duration of the treatment effectiveness. Additionally, leuprolide is not likely pose a threat to the environment or nontarget species (Baker et al. 2004), however, this hypothesis has not been extensively researched.

  In addition to the paucity of information specific to use of leuprolide in white-tailed deer, there are significant challenges to the practical application of leuprolide to control or stabilize deer populations. As stated above, contraceptive efficacy lasts only 90-120 days (Baker et al. 2004; Trigg et al. 2001) and therefore females must be treated within a very short timeframe prior to the breeding season (Conner et al. 2007). If a female is not retreated then she has the same chances of becoming pregnant as an animal that was never treated. The need to treat a potentially large number of individuals within a very short period of time, on an annual basis, reduces the

feasibility of leuprolide as a wildlife management tool, particularly for large, free-ranging deer populations.

- Histrelin acetate: Histrelin acetate has been found to be effective in suppressing a key reproductive hormone in white-tailed deer (Becker and Katz 1995). However, testing was administered using a mini-pump that was surgically implanted under the animal's skin. This is an infeasible route of administration in free-ranging animals. In the future, a delivery system with slow release characteristics may help to make this a more feasible option for free-ranging wildlife. It is likely that histrelin acetate will also suppress ovulation and pregnancy in white-tailed deer, although this remains to be tested.

GnRH Toxins. GnRH toxins consist of a cellular toxin that is combined with a GnRH analog (or analogue). A GnRH analog is a synthetic peptide drug modeled after the human hypothalamic gonadotropin-releasing hormone which allows the toxin to attach to GnRH receptors. The toxin is then carried to the receptors in the pituitary gland and is internalized or absorbed. Once absorbed, the toxin disrupts the production of cellular proteins and can lead to cellular death. When this occurs, the production of reproductive hormones (leuteinizing hormone and follicle stimulating hormone) is affected. This process has been studied in male dogs (Sabeur et al. 2003), domestic sheep (Nett et al. 1999), rats (Kovacs et al. 1997), and female mule deer (Baker et al. 1999) but the technology is still in the developmental stages.

Steroid Hormones. The field of wildlife contraception began with research examining the manipulation of reproductive steroid hormones. Treatments using steroids can include administering high doses of naturally occurring hormones, such as estrogen or progesterone. However, the treatment usually entails the application of synthetic hormones, such as norgestomet, levangesterol, and melangestrol acetate. Available products are administered via slow release implants or repeated feeding have demonstrated variable efficacy and duration of infertility. Most products that are available are used in domestic animal or zoological veterinary medicine and have not been used widely in free-ranging wildlife. Some issues related to using steroids include difficulties in treating large numbers of animals for extended periods of time, negative side effects experienced by the treated animals, and concerns over the consumption of treated animals by nontarget species, including humans. Animals treated with steroids must be permanently marked to prevent entry into the human food chain.

Contragestives. Contragestives are products that terminate pregnancy. Progesterone is the primary gestational hormone for maintaining pregnancy in mammals. Many contragestives act by preventing progesterone production or blocking its effect, thereby affecting pregnancy. The primary contragestive that has been researched for use in domestic animals and white-tailed deer is an analog of Prostaglandin F2α (PGF2α) (Becker and Katz 1994; DeNicola, Kesler, and Swilhart 1997; Waddell et al. 2001). Lutalyse® is a commercially available form of PGF2α. Unlike many of the other alternatives, there are no issues related to consumption of the meat when it has been previously treated with this product. Challenges with contragestives include timing of administration, efficacy, potential to rebreed if breeding season is not finished, and the potential for aborted fetuses on the landscape.

Sterilization. Sterilization can be either a surgical or chemical treatment process. Chemical sterilization, disrupting reproductive organs using tissue irritating agents, is typically performed on males as a contraceptive measure. Surgical sterilization is an invasive procedure generally performed on females. Successful implementation is generally 100% effective in preventing pregnancy and this method is common in managing domestic animal fertility. Implementation requires capture, general anesthesia, and surgery conducted by a qualified veterinarian which is generally considered labor intensive and costly and calls into question the long-term sustainability of sterilization as a wildlife management tool, except under limited circumstances.

Depending on the method of sterilization, this procedure may have behavior effects on both male and female deer. If gonads are removed, then the source of important reproductive hormones will be removed.

This is likely to change deer social interactions. If gonads are not removed, females will continue to ovulate and show behavioral signs of estrus and consequently may extend the breeding season.

Additionally, the majority of research involving sterilization as a wildlife management tool has made assumptions that may limit its general applicability. These assumptions are: "(1) complete control in targeting and sterilizing segments of the population, (2) deterministic models reliably predict outcomes, (3) no behavioral changes occur due to sterilization, and (4) population closure" (Merrill et al. 2006: 268). Rarely can these assumptions be met in free-ranging wildlife populations. In open populations, where there may be significant immigration and imprecise control over the capture process, it is unlikely that sterilization would be an effective means of reducing populations (Merrill et al. 2006).

Conditions that may contribute to successful use of sterilization to reduce abundant deer populations include small population size and demographic closure (or nearly so) (Merrill et al. 2006). It should also be noted that reversibility is often considered a desirable trait for long-term wildlife management methods. Therefore, the appropriateness of sterilization as a deer management tool also is heavily dependent on specific park objectives and the purpose and need for management.

EVALUATION OF FERTILITY CONTROL AGENTS BASED ON SELECTION CRITERIA ESTABLISHED BY ROCK CREEK PARK

Five criteria were established for Rock Creek Park that reflect minimum desired conditions for using a reproductive control agent. Only when these criteria are met would reproductive control be implemented. These criteria assume that the agent poses no significant health risk to the deer.

1. There is a federally approved fertility control agent for application to free-ranging populations;
2. The agent provides multiple year (more that three years) efficacy to minimize the cost and labor required to administer the drug to a large number of deer every year ;
3. The agent can be administered through remote injection to avoid capturing the animal and to increase the efficiency of distribution;
4. The agent would leave no hormonal residual in the meat (meat would be safe for human consumption); and
5. Overall there is substantial proof of success in a free-ranging population, based on science team review.

TABLE C-1. EVALUATION OF FERTILITY CONTROL AGENTS BASED ON SELECTION CRITERIA FOR ROCK CREEK PARK

Agent	Criterion 1 Federally Approved	Criterion 2 Multi-year efficacy	Criterion 3 Administered Remotely	Criterion 4 Meat Safe for Humans	Criterion 5 Success in Free-ranging Populations
Immunocontraceptives					
"Native" PZP	No	No[a]	Yes	No	No
SpayVac®	No	Possibly[b]			
GnRH	No	Possibly[c]	No	No	No
GnRH Agonists					
Leuprolide Acetate	No	No	Yes	Yes	No
Histrelin Acetate	No	No	No	Yes	No
GnRH Toxins	No	Unknown	Unknown	Unknown	No
Steroid Hormones	No	No	No	No	No
Contragestives	No	No	Yes	Yes	No

a Initial research on one-shot, multiyear PZP vaccine has demonstrated 88.3% efficacy in Year 1 and 75% efficacy in the second year post-treatment (Turner et al. 2008). Research is currently on-going to evaluate effectiveness in year 3 and beyond. Dr. Allen Rutberg has indicated that "based on the design of the vaccine and our experience with horses, it's unlikely that the vaccine would have much effect past the third year" (Rutberg 2009). However, research on this vaccine is still developing and is expected to continue into the future.

b SpayVac® has demonstrated 80%-100% efficacy for up to 5-7 years in horses and deer (Fraker 2009, Miller et al. 2009, Killian et al. 2006). The term "possibly is used because long-term studies (>5 years) have been conducted only in captive deer and had a small sample size in each treatment group (N=5) (Miller et al. 2009).

c Recently published research on one-shot, multiyear GnRH vaccine in penned/captive deer indicates GonaConTM is 88-100% effective in Year 1 and 47-100% effective in year 2 and 25-80% effective up to 5 years post-treatment (Miller et al. 2008). The term "possibly" is used because the multi-year formulation has been used only in captive deer, had a small sample size, and lacks confidence intervals on the data.

References and Selected Bibliography for Appendix C

Adams, T. H., and B. M. Adams
1990 Reproductive function and feedlot performance of beef heifers actively immunized against GnRH. Journal of Animal Science 68:2793-2802

Asa, C. S., L. J. D. Zaneveld, L. Munson, M. Callahan, and A. P. Byers
1996 Efficacy, safety, and reversibility of a bisdiamine male-directed oral contraceptive in gray wolves (*Canis lupus*). Journal of Zoo and Wildlife Medicine 27:501-506

Aspden, W. J., A. Rao, P. T. Scott, I. J. Clark, T. E. Trigg, J. Walsh, and M. J. D'Occhio
1996 "Direct Actions of the Luteinizing Hormone-releasing Hormone Agonist, Deslorelin, on Anterior Pituitary Contents of Luteinizing Hormone (LH) and Follicle-Stimulating Hormone (FSH), LH and FSH Subunit Messenger Ribonucleic Acid, and Plasma Concentrations of LH and FSH in Castrated Male Cattle." *Biology of Reproduction* 55:386–92. Available on the Internet at <http://www.biolreprod.org/cgi/reprint/55/2/386>.

Ataja, A. M., T. N. Barry, R. M. Hoskinson, and P. R. Wilson
1992 Effects of active immunization on growth and plasma hormone concentrations in red deer stags during their second year. Journal of Agricultural Science 118:371-377

Atkinson, S., W. G. Gilmartin, and B. L. Lasley
1993 Testosterone response to a gonadotrophin-releasing hormone agonist in Hawaiian monk seals (*Monachus schauinslandi*). Journal of Reproduction and Fertility 97:35-38

Baker, D. L., M. A. Wild, M. D. Hussain, R. L. Dunn, and T. M. Nett
2005 Evaluation of remotely delivered leuprolide acetate as a contraceptive agent in female elk (*Cervus elaphus nelsoni*). Journal of Wildlife Diseases, 41(4): 758-767.

Baker, D. L., T. M. Nett, N. T. Hobbs, R. B. Gill, and M. M. Miller
1999 Evaluation of GnRH-toxin conjugate as an irreversible contraceptive in female mule deer. The Wildlife Society 6th Annual Conference, Austin, Texas, USA. pp61

Baker, D. L., M. A. Wild, M. M. Conner, H. B. Ravivarapu, R. L. Dunn, and T. M. Nett
2002 Effects of GnRH agonist (leuprolide) on reproduction and behavior in female wapiti (*Cervus elaphus nelsoni).* Reproduction Supplement 60:155-167

2004 Gonadotropin-releasing hormone agonist: a new approach to reversible contraception in female deer. Journal of Wildlife Diseases 40:713-724

Baker, D. L., M. A. Wild, M. D. Hussain, R. L. Dunn, and T. M. Nett
2005 Evaluation of remotely delivered leuprolide acetate as a contraceptive agent in female elk (*Cervus elaphus nelsoni*). Journal of Wildlife Diseases 41:in press

Barber, M. R. and R. A. Fayrer-Hosken
2000 Evaluation of somatic and reproductive immunotoxic effects of the porcine zona pellucida vaccination. Journal of Experimental Zoology 286:641-646

Barlow, N. D.
1997 Modeling immunocontraception in disseminating systems. Reproduction Fertility and Development 9:51-60

Barlow, N. D., J. M. Kean, and C. J. Briggs
1997 Modeling the relative efficacy of culling and sterilization for controlling populations. Wildlife Research 24:129-141

Becker, S. E., W. J. Enright, and L. S. Katz
1999 Active immunization against gonadotropin-releasing hormone in female white-tailed deer. Zoo Biology 18:385-396

Becker, S. E., and L. S. Katz
1994 Effects of exogenous prostaglandin-$F_{2\alpha}$ ($PGF_{2\alpha}$) on pregnancy status in white-tailed deer. Zoo Biology 13:315-323

1995 Effects of a gonadotropin-releasing hormone agonist on serum luteinizing hormone concentrations in female white-tailed deer. Small Ruminant Research 18:145-150

1997 Gonadotropin-releasing hormone (GnRH) analogs or active immunization against GnRH to control fertility in wildlife. *In:* Kreeger, T. J. ed. Contraception in Wildlife Management. USDA-APHIS Technical Bulletin 1853, Washington, D.C., USA. pp11-19

Beekman, N. J. C. M., W. M. M. Schaaper, J. A. Turkstra, and R. H. Meloen
1999 Highly immunogenic and fully synthetic peptide-carrier constructs targeting GnRH. Vaccine 17:2043-2050

Bertschinger, H. J., C. S. Asa, P. P. Calle, J. A. Long, K. Bauman, K. DeMatteo, W. Jochle, T. E. Trigg, and A. Human
2001 Control of reproduction and sex related behaviour in exotic wild carnivores with the GnRH analogue deslorelin: preliminary observations. Journal of Reproduction and Fertility Supplement 57: 275-283

Bertschinger, H. J., T. E. Trigg, W. Jochle, and A. Human
2002 Induction of contraception in some African wild carnivores by down regulation of LH and FSH secretion using the GnRH analogue deslorelin. Reproduction Supplement 60:41-52

Bickle, C. A., J. F. Kirkpatrick, and J. W. Turner
1991 Contraception in striped skunks with norplant® implants. Wildlife Society Bulletin 19:334-338

Bilecki, M
2009 Personal communication between Mike Bilecki, Natural Resource Manager, FIIS and Kristina Heister, Natural Resource Manager, VAFO on 3/10/2009 regarding the use of fertility control on FIIS.

Bonneau, M., R. Dufour, C. Chouvet, C. Roulet, W. Meadus, and E. J. Squires
1994 The effects of immunization against luteinizing hormone-releasing hormone on performance, sexual development, and levels of boar taint-related compounds in intact male pigs. Journal of Animal Science 72:14-20

Boone, J. L., and R. G. Wiegert
1994 Modeling deer herd management: sterilization is a viable option. Ecological Modeling 72:175-186

Bradley, M. P.
1997 Immunocontraceptive vaccines for control of fertility in the European red Fox (*Vulpes vulpes*). *In:* Kreeger, T. J. ed. Contraception in Wildlife Management. USDA-APHIS Technical Bulletin 1853, Washington, D.C., USA.. pp 195-203

Bradley, M. P., L. A. Hinds, and P. H. Bird
1997 A bait-delivered immunocontraceptive vaccine for the European red fox (*Vulpes vulpes*) by the year 2002? Reproduction, Fertility, and Development 9:111-116

Brooks, R. P., M. W. Flemming, and J. J. Kennelly
1980 Beaver colony response to fertility control: evaluating a concept. Journal of Wildlife Management 44:568-575

Brown, B. W., P. E. Mattner, P. A. Carroll, E. J. Holland, D. R. Paull, R. M. Hoskinson, and R. D. G. Rigby
1994 Immunization of sheep against GnRH early in life: Effects on reproductive function and hormones in rams. Journal of Reproduction and Fertility 101:15-21

Brown, R. G., W. D. Bowen, J. D. Eddington, W. C. Kimmins, M. Mezei, J. L. Parsons, and B. Pohajdak
1997 Evidence for a long-lasting single administration contraceptive vaccine in wild grey seals. Journal of Reproductive Immunology 35:53-64

Concannon, P. W., A. Yeager, D. Frank, and A. Iyampillai
1990 Termination of pregnancy and induction of premature luteolysis by the antiprogetagen, mifeprestone, in dogs. Journal of Reproduction and Fertility 88:99-104

Conner, M. M., D. L. Baker, M. A. Wild, J. G. Powers, M. D. Hussain, and R. L. Dunn
2007 Fertility control in free-ranging elk using gonadotropin-releasing hormone agonist leuprolide: Effects on reproduction, behavior, and body condition. Journal of Wildlife Management, 71:2346-2356.

Curtis, P. D., M. E. Richmond, L. A. Miller, and F. W. Quimby
2008 Physiological effects of gonadotropin-releasing hormone immunocontraception on white-tailed deer. Human-Wildlife Conflicts. 2(1): 68-79.

Curtis, P. D., M. E. Richmond, L. A. Miller, and F. W. Quimby
2007 Pathophysiology of white-tailed deer vaccinated with porcine zona pellucida immunocontraceptive. Vaccine 25: 4623-4630.

Curtis, P. D., R. L. Pooler, M. E. Richmond, L. A. Miller, G. F. Mattfeld, and F. W. Quimby
2002 Comparative effects of GnRH and porcine zona pellucida (PZP) immunocontraceptive vaccines for controlling reproduction in white-tailed deer (*Odocoileus virginianus*). Reproduction Supplement 60:131-141

Daels, P. F., and J. P. Hughes
1995 Fertility control using intrauterine devices: an alternative for population control in wild horses. Theriogenology 44:629-639

Dalin, A. M., O. Andresen, and L. Malmgren
2002 Immunization against GnRH in mature mares: antibody titres, ovarian function, hormonal levels and oestrous behaviour. Journal of Veterinary Medicine Series A 49:125-131

Davis, S. A., and R. P. Pech
2002 Dependence of population response to fertility control on the survival of sterile animals an their role in regulation. Reproduction Supplement 60:89-103

Deigert, F. A., A. E. Duncan, K. M. Frank, R. O. Lyda, and J. F. Kirkpatrick
2003 Immunocontraception of captive exotic species. III. Contraception and populations management of fallow deer (*Cervus dama*). Zoo Biology 22:261-268

de Jersey, J., P. H. Bird, N. K. Verma, and M. P. Bradley
1999 Antigen-specific systemic and reproductive tract antibodies in foxes immunized with *Salmonella typhimurium* expressing bacterial and sperm proteins. Reproduction Fertility and Development 11:219-228

DeLiberto, T. J., A. Seglund, W. Jochle, and B. Kimball
2002 Assessment of cabergoline as a reproductive inhibitor in coyotes (*Canis latrans*). Reproduction Supplement 60:53-64

DeNicola, A. J., D. J. Kesler, and R. K. Swihart
1997a Dose determination and efficacy of remotely delivered norgestomet implants on contraception of white-tailed deer. Zoo Biology 16:31-37

1997b Remotely delivered prostaglandin $F_{2\alpha}$ implants terminate pregnancy in white-tailed deer. Wildlife Society Bulletin 25:527-531

DeNicola, A. J. and R. K. Swihart
1997 "Capture-induced Stress in White-tailed Deer." *Wildlife Society Bulletin* 25(2):500-3.

D'Occhio, M. J., W. J. Aspden, and T. R. Whyte
1996 "Controlled, Reversible Suppression of Oestrous Cycles in Beef Heifers and Cows Using Agonists of Luteinizing Hormone Gonadotropin-Releasing Hormone." *Journal of Animal Science* 74:218–25.

Dowsett, K. F., U. Tshewang, L. M. Knott, A. E. Jackson, and T. E. Trigg
1993 Immunocastration of colts and immunospeying of fillies. Immunology and Cell Biology 71:501-508

Dunshea, F. R., C. Colantoni, K. Howard, I. McCauley, P. Jackson, K. A. Long, S. Lopaticki, E. A. Nugent, J. A. Simons, J. Walker, and D. P. Hennessy
2001 Vaccination of boars with a GnRH vaccine (Improvac) eliminates boar taint and increases growth performance. Journal of Animal Science 79:2524-2535

Eilts, B. E.
2002 Pregnancy termination in the bitch and queen. Clinical Techniques in Small Animal Practice 17:116-123

Fagerstone, K. A., M. A. Coffey, P. D. Curtis, R. A. Dolbeer, G. J. Killian, L.A. Miller, and L. M. Wilmot
2002 Wildlife fertility control. Wildlife Society Technical Review 02-2, 29 pp.

Fahim, M. S., M. Wang, M. F. Sutcu, Z. Fahim, and R. S. Youngquist
1993 Sterilization of dogs with intra-epididymal injection of zinc arginine. Contraception 47: 107-122

Ferro, V. A., R. Costa, K. C. Carter, M. J. A. Harvey, M. M. Waterston, A. B. Mullen, C. Matschke, J. F. S. Mann, A. Colston, and W. H. Stimson
2004a Immune responses to a GnRH-based anti-fertility immunogen, induced by different adjuvants and subsequent effect on vaccine efficacy. Vaccine 22:1024-1031

Ferro, V. A., M. A. H. Khan, D. McAdam, A. Colston, E. Aughey, A. B. Mullen, M. M. Waterston, and M. J. A. Harvey
2004b Efficacy of an anti-fertility vaccine based on mammalian gonadotrophin releasing hormone (GnRH-I) – a histological comparison in male animals. Veterinary Immunology and Immunopathology 101:73-86

Fraker, M. A., R. G. Brown, G. E. Gaunt, J. A. Kerr, and B. Pohajdak
2002 Long lasting, single dose immunocontraception of feral fallow deer in British Columbia. Journal of Wildlife Management 66(4):1141-1147.

Fraker, M. A. and U. Bechert
2007 SpayVac® – a long-lasting, single-dose PZP contraceptive vaccine for practical wildlife population control. Abstract. 6th International Conference on Fertility Control for Wildlife. September 3-5, 2007

Fraker, M. A.
2009 Personal communication between M. A. Fraker and Kristina Heister, Natural Resource Manager, Valley Forge National Historical Park, National Park Service, regarding SpayVac® use in white-tailed deer.

Frank, K. M., R. O. Lyda, and J. F. Kirkpatrick
2005 Immunocontraception of captive exotic species IV. Species differences in response to the porcine zona pellucida vaccine, timing of booster inoculations, and procedural failures. Zoo Biology 0:1-10

Freudenberger, D. O., P. R. Wilson, T. N. Barry, Y. X. Sun, R. W. Purchas, and T. E. Trigg
1993 Effects of immunization against GnRH upon body growth, voluntary food intake and plasma hormone concentration in yearling red deer stags (*Cervus elaphus*). Journal of Agricultural Sciences 121:381-388

Fromme, B., P. Eftekhari, M. Van Regenmortel, J. Hoebeke, A. Katz, and R. Millar
2003 A novel retro-inverso gonadotropin-releasing hormone (GnRH) immunogen elicits antibodies that neutralize the activity of native GnRH. Endocrinology 144:3262-3269

Garrott, R. A., J. G. Cook, M. M. Bernoco, J. F. Kirkpatrick, L. L. Cadwell, S. Cherry, and B. Tiller
1998 Antibody response of elk immunized with porcine zona pellucida. Journal of Wildlife Disease 34:539-546

Garrott, R. A., and D. B. Siniff
1992 Limitations of male-oriented contraception for controlling feral horse populations. Journal of Wildlife Management 56:456-464

Garza, F., D. L. Thompson, D. D. French, J. J. Wiest, R. L. St. George, K. B. Ashley, L. S. Jones, P. S. Mitchell, and D. R. McNeill
1986 Active immunization of intact mares against gonadotropin-releasing hormone: differential effects on secretion of luteinizing hormone and follicle-stimulating hormone. Biology of Reproduction 35:347-352

Gorman, S. P., J. K. Levy, A. L. Hampton, W. R. Collante, A. L. Harris, and R. G. Brown
2002 Evaluation of a porcine zona pellucida vaccine for the immunocontraception of domestic kittens (*Felis catus*). Theriogenology 58:135-149

Gross, J. E.
2000 A dynamic simulation model for evaluating effects of removal and contraception on genetic variation and demography of Pryor Mountain wild horses. Biological Conservation 96:319-330

Hardy, C. M., G. Clydesdale, K. J. Mobbs, J. Pekin, M. L. Lloyd, C. Sweet, G. R. Shellman, and M. A. Lawson
2004 Assessment of contraceptive vaccines based on recombinant mouse sperm protein PH20. Reproduction 127:325-334

Haight, R. G., and L. D. Mech
1997 Computer simulation of vasectomy for wolf control. Journal of Wildlife Management 61:1023-1031

Harrenstien, L. A., L. Munson, L. M. Chassy, I. K. M. Liu, and J. F. Kirkpatrick
2004 Effects of porcine zona pellucida immunocontraceptives in zoo felids. Journal of Zoo and Wildlife Medicine 35:271-279

Hazum, E., and P. M. Conn
1988 "Molecular Mechanisms of Gonadotropin Releasing Hormone (GnRH) Action: I. The GnRH Receptor." *Endocrine Review* 9 (4): 379–86.

Heilmann, T. J., R. A. Garrott, L. L. Cadwell, and B. L. Tiller
1998 Behavioral response of free-ranging elk treated with an immunocontraceptive vaccine. Journal of Wildlife Management 62:243-250

Hobbs, N. T., D. C. Bowden, and D. L. Baker
2000 Effects of fertility control on populations of ungulates: general, stage structured models. Journal of Wildlife Management 64:473-491

Hone, J.
1992 Rate of increase and fertility control. Journal of Applied Ecology 29:695-698

Hsu, C. T., C. Y. Ting, C. J. Ting, T. Y. Chen, C. P. Lin, J. Whang-Peng, and J. Hwang
2000 Vaccination against gonadotropin-releasing hormone (GnRH) using toxin receptor-binding domain-conjugated GnRH repeats. Cancer Research 60:3701-3705

Jacob J., J. Matulessy, and Sudarmaji
2004 Effects of imposed sterility on movement patterns of female ricefield rats. Journal of Wildlife Management 68:1138-1144

Jacobsen, N. K., D. A. Jessup, and D. J. Kesler
1995 Contraception in captive black-tailed deer by remotely delivered norgestomet ballistic implants. Wildlife Society Bulletin 23:718-722

Jewgenow, K., M. Quest, W. Elger, T. B. Hildebrandt, H. H. D. Meyer, G. Strauss, and F. Gortiz
2001 Administration of antiprogestin J956 for contraception in bears: a pharmacological study. Theriogenology 56:601-611

Jöchle, W., and M. Jöchle
1993 Reproduction in a feral cat population and its control with a prolactin inhibitor cabergoline. Journal of Reproduction and Fertility Supplement 47:419-424

Kennelly, J. J., and K. A. Converse
1997 Surgical Sterilization: an underutilized procedure for evaluating the merits of induced sterility. *In:* Kreeger, T. J. ed. Contraception in Wildlife Management. USDA-APHIS Technical Bulletin 1853, Washington, D.C., USA. pp21-27

Kerr, P. J., R. J. Jackson, A. J. Robinson, J. Swan, L. Silvers, N. French, H. Clarke, D. F. Hall, and M. K. Holland
1999 Infertility in female rabbits (*Oryctolagus cuniculus*) alloimmunized with the rabbit zona pellucida protein ZPB either as a purified recombinant protein or expressed by recombinant myxoma virus. Biology of Reproduction 61:606-613

Kesler, D.
1997 Remotely delivered contraception with needle-less norgestomet implants. *In:* Kreeger, T. J. ed. Contraception in Wildlife Management. USDA-APHIS Technical Bulletin 1853, Washington, D.C., USA pp171-184

Killian, G., L. Miller, N. K. Diehl, J. Rhyan, and D. Thain
2004 Evaluation of three contraceptive approaches for population control of wild horses. Proceedings of the Vertebrate Pest Conference 21:263-268

Killian, G., J. Eisemann, D. Wagner, J. Werner, D. Shaw, R. Engeman, and L. Miller
2006a Safety and toxicity evaluation of GonaConTM immunocontraceptive vaccine in white-tailed deer. Vertebrate Pest Conference 22:82-87.

Killian, G., D. Wagner and L. A. Miller
2006b Observation on the use of the GnRH vaccine GonaConTM in male white-tailed deer. Wildlife Damage Management Conference. 11:256-263.

Killian, G., L. Miller, J. Rhyan, and H. Doten
2006c Immunocontraception of Florida feral swine with a single-dose GnRH vaccine. American Journal of Reproductive Immunology 55:378-384

Killian, G. J. and L. A. Miller
2001 Behavioral observations and physiological implications for white-tailed deer treated with two different immunocontraceptives. Proceedings of the Ninth Wildlife Damage Management Conference. October 5-8, 2000. The Pennsylvania State University. University Park, PA. Pages 283-291.

Kilpatrick ,J. F., I. K. M. Liu, J. W. Turner, R. Naugle, and R. Keiper
1992 "Long term Effects of Porcine Zona Pellucidae Immunocontraception on Ovarian Function in Feral Horses (*Equus caballus*)." *Journal of Reproduction and Fertility* 94:437–44.

Kilpatrick, H. J., S. M. Spohr, and A. J. DeNicola
1997 "Darting Urban Deer: Techniques and Technology." *Wildlife Society Bulletin* 25 (2): 542-46.

Kilpatrick, H. J., and W. D. Walter
1997 "Urban Deer Management: A Community Vote." *Wildlife Society Bulletin* 25:388–91.

Kirkpatrick, J. F. and A. Turner
2008 Achieving population goals in a long-lived wildlife species (*Equus caballus*) with contraception. Wildlife Research 35:513-519.

Kirkpatrick, J. F.
2007 Measuring the effects of wildlife contraception: the argument for comparing apples with oranges. Reprod. Fert. Dev. 19:548-552.

Kirkpatrick, J. F., P. P. Calle, P. Kalk, I. K. M. Liu, and J. W. Turner
1996a Immunocontraception of captive exotic species. II. Formosan sika deer (*Cervus Nippon Taiouanus*), axis deer (*Cervus axis*), himalayan tahr (*Hemitragus jemlahicus*), roosevelt elk (*Cervus elaphus roosevelti*), reeves' muntjac (*Muntiacus reevesi*), and sambar deer (*Cervus unicolor*). Journal of Zoo and Wildlife Medicine 27:482-495

Kirkpatrick, J. F. I. K. M. Liu, and J. W. Turner Jr.
1990 Remotely-delivered immunocontraception in feral horses. Wildlife Society Bulletin 18:326-330

Kirkpatrick, J. F., R. Naugle, I. K. M. Liu, M. Bernoco, and J. Turner
1995 Effects of seven consecutive years of porcine zonae pellucidae contraception on ovarian function in feral mares. Biology of Reproduction Monograph Series 1:411-418

Kirkpatrick, J. F., and A. Turner
2003 Absence of effects from immunocontraception on seasonal birth patterns and foal survival among barrier island wild horses. Journal of Applied Animal Welfare Science 6:301-308

Kirkpatrick, J. F., and J. W. Turner Jr.
1985 Chemical fertility control and wildlife management. BioScience 35:485-491

1991 Reversible contraception in nondomestic animals. Journal of Zoo and Wildlife Medicine 22:392-408

2002 Reversibility of action and safety during pregnancy of immunization against porcine zona pellucida in wild mares (*Equus caballus).* Reproduction Supplement 60:197-202

Kirkpatrick, J. F., and J. W. Turner Jr., I. K. M. Liu, and R. Fayer-Hosken
1996b Applications of pig zona pellucida immunocontraception to wildlife fertility control. Journal of Reproduction and Fertility Supplement 50:183-189

Kirkpatrick, J. F., and J. W. Turner Jr., I. K. M. Liu, and R. Fayer-Hosken, and A. T. Rutberg
1997 Case studies in wildlife immunocontraception: wild and feral equids and white-tailed deer. Reproductive Fertility and Development 9: 105-110

Knox, W. M., K. V. Miller, and R. L. Marchinton
1988 "Recurrent Estrous Cycles in White-tailed Deer." *Journal of Mammalogy* 69:384-86.

Kovacs, M., A. V. Schally, A. Nagy, M. Koppan, and K. Groot
1997 Recovery of pituitary function after treatment with a targeted cytotoxic analog of luteinizing hormone-releasing hormone. Proceedings of the National Academy of Sciences 94:1420-1425

Kreeger, T. J. ed.
1997 Contraception in Wildlife Management. USDA-APHIS Technical Bulletin 1853, Washington, D.C., USA. 272pp

Ladd, A., G. Prabhu, Y. Y. Tsong, T. Probst, W. Chung, and R. B. Thau
1988 Active immunization against gonadotropin-releasing hormone combined with androgen supplementation is a promising antifertility vaccine for males. American Journal of Reproductive Immunology and Microbiology 17:121-127

Ladd, A., Y. Y. Tsong, A. M. Walfield, and R. Thau
1994 Development of an antifertility vaccine for pets based on active immunization against luteinizing hormone-releasing hormone. Biology of Reproduction 51:1076-1083

Lengwinat, T., H. H. D. Meyer, and W. Jöchle
2001 Effectiveness of cabergoline for termination of pregnancy in silver fox (*Vulpes vulpes fulva*). Reproduction in Domestic Animals 36:257-260

Levy, J. K., L. A. Miller, P. C. Crawford, J. W. Ritchey, M. K. Ross, and K. A. Fagerstone
2004 GnRH immunocontraception of male cats. Theriogenology 62(6):1116-1130

Lincoln, G. A.
1987 Long-term stimulatory effects of a continuous infusion of LHRH agonist on testicular function in male red deer (*Cervus elaphus*). Journal of Reproduction and Fertility 80:257-261

Lincoln, G. A., H. M. Fraser, and T. J. Fletcher
1982 Antler growth in male red deer (*Cervus elaphus*) after active immunization against LH-RH. Journal of Reproduction and Fertility 66:703-708

Liu, I. K. M., J. W. Turner, E. M. G. Van Leeuwen, D. R. Flanagan, J. L. Hedrick, K. Murata, V. M. Lane, and M. P. Morales-Levy
2005 Persistence of anti-zonae pellucidae following a single inoculation of porcine zonae pellucidae in the domestic equine. Reproduction 129:181-190

Locke, S. L., M. W. Cook, L. A. Harveson, D. S. Davis, R. R. Lopez, N. J. Silvy, and M. A. Fraker
2007 Effectiveness of SpayVac® for reducing white-tailed deer fertility. *Journal of Wildlife Diseases* 43:726-730.

Matschke, G. H.
1980 Efficacy of steroid implants in preventing pregnancy in white-tailed deer. Journal of Wildlife Management 44:756-758

1977a Antifertility action of two synthetic progestins in female white-tailed deer. Journal of Wildlife Management 41;194-196

1977b Fertility control in white-tailed deer by steroid implants. Journal of Wildlife Management 41:731-735

Malmgren, L., O. Andresen, and A. M. Dalin
2001 Effect of GnRH immunization of hormonal levels, sexual behaviour, semen quality and testicular morphology in mature stallions. Equine Veterinary Journal 33:75-83

McCue, P. M., V. J. Farquhar, and E. L. Squires
2000 Effect of the GnRH agonist deslorelin acetate on pituitary function and follicular development in the mare. Reproduction 46:355-356

McShea, W. J., S. L. Monfort, S. Hakim, J. Kirkpatrick, I. Liu, J. W. Turner, Jr., L. Chassy, and L. Munson
1997 The effect of immunocontraception on the behavior and reproduction of white-tailed deer. Journal of Wildlife Management 61:560-569

McShea, W. J., and J. H. Rappole
1997 "Herbivores and the Ecology of Forest Understory Birds." Pp. 298-309 in W. J. McShea, H. B. Underwood and J. H. Rappole (eds.), *The Science of Overabundance, Deer Ecology and Population Management*. Washington, D.C.: Smithsonian Institution Press.

Meloen, R. H., J. A. Turkstra, H. Lankhof, W. C. Puijk, W. M. M. Schaaper, G. Dijkstra, C. J. G. Wensing, and R. B. Oonk
1994 Efficient immunocastration of male piglets by immunoneutralization of GnRH using a new GnRH-like peptide. Vaccine 12:741-746

Merrill, J. A., E. G. Cooch, and P. D. Curtis
2003 Time to reduction: factors influencing management efficacy in sterilizing overabundant white-tailed deer. Journal of Wildlife Management 67:267-279

2006 Managing an overabundant deer population by sterilization: effects of immigration, stochasticity and the capture process. Journal of Wildlife Management 70:268-277

Miller, L. A., and K. A. Fagerstone
2000 Induced infertility as a wildlife management tool. Proceedings of the Vertebrate Pest Conference 19:160-168

Miller, L. A., B. E. Johns, and D. J. Elias
1998 Immunocontraception as a wildlife management tool: some perspectives. Wildlife Society Bulletin 26: 237-243

Miller, L. A., B. E. Johns, D. J. Elias and K. A. Crane
1997 Comparative efficacy of two immunocontraceptive vaccines. Vaccine. 15:1858-1862

Miller, L. A., B. E. Johns, and G. J. Killian
2000a Immunocontraception of white-tailed deer using native and recombinant zona pellucida vaccines. Animal Reproduction Science 63:187-195

2000b Long-term effects of PZP immunization on reproduction in white-tailed deer. Vaccine 18:568-574

2000c Immunocontraception of white-tailed deer with GnRH vaccine. American Journal of Reproductive Immunology 44:266-274

Miller, L. A., K. Crane, S. Gaddis, and G. J. Killian
2001 "Porcine Zona Pellucida Immunocontraception: Long-term Health Effects on White-tailed Deer." *Journal of Wildlife Management* 65 (4): 941-5.

Miller, L. A., and G. J. Killian
2002 In search of the active PZP epitope in white-tailed deer immunocontraception. Vaccine 20:2735-2742

Miller, L. A., J. C. Rhyan, and M. Drew
2004 Contraception of bison by GnRH vaccine: a possible means of decreasing transmission of brucellosis in bison. Journal of Wildlife Diseases 40:725-730

Miller, L. A., J. C. Rhyan, and G. Killian
2003 Evaluation of GnRH contraceptive vaccine using domestic swine as a model for feral hogs. Proceedings of the Wildlife Damage Management Conference 10:120-127

Miller, L. A., J. P. Gionfriddo, K. A. Fagerstone, J. C. Rhyan, and G. J. Killian
2008 The single-shot GnRH immunocontraceptive vaccine (GonaConTM) in white-tailed deer: comparison of several GnRH preparations. Am J Reprod Immunol. 60: 214-223.

Miller, L. A., K. A. Fagerstone, D. C. Wagner, and G. J. Killian
2009 Factors contributing to the success of a single-shot, multiyear PZP immunocontraceptive vaccine for white-tailed deer. Human-Wildlife Conflicts 3(1): 103-115.

Molenaar, G. J., C. Lugard-Kok, R. H. Meloen, R. B. Oonk, J. de Koning, and C. J. G. Wensing
1993 Lesions in the hypothalamus after active immunization against GnRH in the pig. Journal of Neuroimmunology 48:1-12

Moore, H. D. M., N. M. Jenkins and C. Wong
1997 Immunocontraception in rodents: a review of the development of a sperm based immunocontraceptive vaccine for the grey squirrel (*Sciurus carolinenis*). Reproduction Fertility and Development 9:125-129

Morell, V.
1993 Australian pest control by virus causes concern. Science 261:683-684

Muller, L. I., R. J. Warrnen, and D. L. Evans
1997 "Theory and Practice of Immunocontraception in Wild Animals." *Journal of Wildlife Management* 25 (2): 504–14.

Munson, L.
2006 Contraception in Felids. Theriogenology 66:126-134

Munson, L., J. E. Bauman, C. S. Asa, W. Jöchle, and T. E. Trigg
2001 Efficacy of the GnRH analogue deslorelin for suppression of oestrous cycles in cats. Journal of Reproduction and Fertility 57 Supplement:269-273.

Munson, L., A. Gardner, R. J. Mason, L. M. Chassy, and U. S. Seal
2002 Endometrial hyperplasia and mineralization in zoo felids treated with melengestrol acetate contraceptives. Veterinary Pathology 39: 419-427

Murty, T.S. and G.A. Sastry
1978 Effect of cadmium chloride ($CdCl_2$) injection on the histopathology of the testis and the prostate in dogs. I. Intratesticular procedure. Indian Veterinary Journal 55:368-371

Naugle, R. E., A. T. Rutberg, H. B. Underwood, J. W. Turner, Jr., and I. K. M. Liu
2002 Field testing of immunocontraception on white-tailed deer (*Odocoileus virginianus*) on Fire Island National Seashore, New York, USA. Reproduction Supplement 60:143-153

Nett, T. M., M. C. Allen, M. Wieczorek, and L. M. Glode
1999 A gonadotropin-releasing hormone agonist (GnRH-A) linked to pokeweed antiviral protein (PAP) decreases the ability of the pituitary gland to secrete LH. Biology of Reproduction 60 Supplement 1:227

Nash, P. B., J. K. James, L. T. Hui, and L. A. Miller
2004 Fertility control of California ground squirrels using GnRH immunocontraception. Proceedings of the 21st Vertebrate Pest Conference pp274-278

Nshimura, N., N. Kawate, T. Sawada, and J. Mori
1992 Chemical castration by a single intratesticular injection of lactic acid in rats and dogs. Journal of Reproduction and Development 38:263-266

Onclin, K., and J. P. Verstegen
1996 Practical use of a combination of a dopamine agonist and a synthetic prostaglandin analogue to terminate unwanted pregnancy in dogs. Journal of Small Animal Practice 37:211-216

Oonk, H. B., J. A. Turkstra, W. M. M. Schaaper, J. H. F. Erkens, M. H. Schuitemaker-de Weerd, A. van Nes, J. H. M. Verheijden, and R. H. Meloen
1998 New GnRH-like peptide construct to optimize efficient immunocastration of male pigs by immunoneutralization of GnRH. Vaccine 16:1074-1082

Pineda, M. H. and D. I. Hepler
1981 Chemical vasectomy in dogs. Long-term study. Theriogenology 16:1-12

Plotka, E. D., and U. S. Seal
1989 Fertility control in female white-tailed deer. Journal of Wildlife Disease 25:643-646

Plotka, E. D., D. N. Vevea, T. C. Eagle, D. B.. Siniff, and J. R. Tester
1989 Ovarian function in captive feral mares. Journal of Wildlife Diseases 25:574-579

Porter, W. F., H. B. Underwood, and J. L. Woodward
2004 Movement behavior, dispersal, and the potential for localized management of deer in a suburban environment. Journal of Wildlife Management 68:247-256

Powell, D. M.
1999 Preliminary evaluation of porcine zona pellucida (PZP) immunocontraception for behavioral effects in feral horses (*Equus caballus*). Journal of Applied Animal Welfare Science 2:321-335

Rabb, M. H., D. L. Thompson, Jr., B. E. Barry, D. R. Colborn, K. E. Hehnke, and F. Garza, Jr.
1990 Effects of active immunization against GnRH on LH, FSH, and prolactin storage, secretion, and response to their secretagogues in pony geldings. Journal of Animal Science 68:3322-3329

Raphael, B. L., P. Kalk, P. Tomas, P. P. Calle, J. G. Doherty, and R. A. Cook
2003 Use of melengesterol acetate in feed for contraception in herds of captive ungulates. Zoo Biology 22:455-463

Ringleb, J., M. Rohleder, and K. Jewgenow
2004 Impact of feline zona pellucida glycoprotein B-derived synthetic peptides on *in vitro* fertilization of cat oocytes. Reproduction 127:179-186

Robbins, S. C., J. M. Jelinski, and R. L. Stotish
2004 Assessment of the immunological and biological efficacy of two different doses of a recombinant GnRH vaccine in domestic male and female cats (*Felis catus*). Journal of Reproductive Immunology 64:107-119

Rudolph, B. A., W. F. Porter, and H. B. Underwood
2000 Evaluating immunocontraception for managing suburban white-tailed deer in Irondequoit, New York. Journal of Wildlife Management 64:463-473

Rutberg, A.
2009 Email communication to Kristina Heister, Natural Resource Manager, Valley Forge National Historical Park regarding updated results of research being conducted on one-shot, multi-year PZP vaccine on Fripp Island, SC. March 25, 2009.

Rutberg, A. T. and R. E. Naugle
2009 Testing the effectiveness of one-shot immunocontraceptives on white-tailed deer at Fripp Island, South Carolina. 2008 Progress Report. South Carolina Department of Natural Resources. Unpubl.

Rutberg, A. T. and R. E. Naugle
2008a Population-level effects of immunocontraception in white-tailed deer (*Odocoileus virginianus*). Wildlife Research 35: 494-501.

2008b Deer-vehicle collision trends at a suburban immunocontraception site. Human-Wildlife Conflicts 2(1): 60-67.

Rutberg, A. T., R. E. Naugle, L. A. Thiele, and I. K. M. Liu
2004 Effects of immunocontraception on a suburban population of white-tailed deer *Odocoileus virginianus*. Biological Conservation 116:243-250

Sabeur, K., B. A. Ball, T. M. Nett, H. H. Ball, and I. K. M. Liu
2003 Effect of GnRH conjugated to pokeweed antiviral protein on reproductive function in adult male dogs. Reproduction 125:801-806

Safir, J. M., R. G. Loy, and B. P. Fitzgerald
1987 Inhibition of ovulation in the mare by active immunization against LHRH. Journal of Reproduction and Fertility 35:229-237

Sankai, T., T. Endo, K. Kanayama, Y. Sakuma, M. Umezu, and J. Masaki
1991 Antiprogesterone compound, RU486 administration to terminate pregnancy in dogs and cats. Journal of Veterinary Medical Science 53:1069-1070

Seagle, S. W., and J. D. Close
1996 Modeling white-tailed deer *Odocoileus virginianus* population control by contraception. Biological Conservation 76:87-91

Shideler, S. E., M. A. Stoops, N. A. Gee, J. A. Howell, and B. L. Lasley
2002 Use of procine zona pellucida (PZP) vaccine as a contraceptive agent in free-ranging tule elk (*Cervus elaphus nannodes*). Reproduction Supplement 60:169-176

Skinner, S. M., G. J. Killian, L. A. Miller, and B. S. Dunbar
1994 Characteristics of antigenicity and immunogenicity patterns of native and recombinant zona pellucida proteins in the white-tailed deer. Journal of Reproduction and Fertility 101:295-303

Skinner, S., T. Mills, H. J. Kirchick, and B. S. Dunbar
1984 Immunization with zona pellucida proteins in abnormal ovarian follicular differentiation and inhibition of gonadotropin-induced steroid secretion. Endocrinology 115:2418-2432

Stith, C., and M. D. Hussain
2003 Determination of mifepristone levels in wild canid serum using liquid chromatography. Journal of Chromatography B 794:9-15

Stout, T. A. E., and B. Colenbrander
2004 Suppressing reproductive activity in horses using GnRH vaccines, antagonists or agonists. Animal Reproduction Science 82-83:633-643

Suri, A.
2004 Sperm specific proteins- potential candidate molecules for fertility control. Reproductive Biology and Endocrinology 2:pp 6

Suri, A.
2005 Contraceptive vaccines targeting sperm. Expert Opinion on Biological Therapy 5:381-392

Tast, A., R. J. Love, I. J. Clarke, and G. Evans
2000 Effects of active and passive gonadotropin-releasing hormone immunization on recognition and establishment of pregnancy in pigs. Reproduction Fertility and Development 12:277-282

Trigg, T. E., P. J. Wright, A. F. Armour, P. E. Williamson, A. Junaidi, G. B. Martin, A. G. Doyle, and J. Walsh
2001 Use of a GnRH analogue implant to produce reversible long-term suppression of reproductive function in male and female domestic dogs. Journal of Reproduction and Fertility Supplement 57:255-261

Tshewang, U., K. F. Dowsett, L. M. Knott, and T. E. Trigg
1997 Preliminary study of ovarian activity in fillies treated with a GnRH vaccine. Australian Veterinary Journal 75:663-667

Tung, K. S. K., P. Primakoff, L. Woolman-Gamer, and D. G. Myles
1997 Mechanism of infertility in male guinea pigs immunized with sperm PH-20. Biology of Reproduction 56:1133-1141

Turkstra, J. A., H. B. Oonk, W. M. M. Schaaper, and R. H. Meloen
2002 he role of the individual amino acids of a GnRH-tandem-dimer peptide used as an antigen for immunocastration of male piglets determined with systematic alanine replacements. Vaccine 20:406-412

Turkstra, J. A., F. J. U. M. van der Meer, J. Knaap, P. J. M. Rottier, K. J. Teerds, B. Colenbrander, and R. H. Meloen
2005 ffects of GnRH immunization in sexually mature pony stallions. Animal Reproduction Science 86:247-259

Turner, J. W., J. F. Kirkpatrick, and I. K. M. Liu
1996 ffectiveness, reversibility and serum antibody titers associated with immunocontraception in captive white-tailed deer. Journal of Wildlife Management 60:45-51

Turner, J. W., J. F. Kirkpatrick
2002 ffects of immunocontraception on population longevity and body condition in wild mares (*Equus caballus)*. Reproduction Supplement 60:187-195.

Turner, J. W., K. M. Liu, and J. F. Kirkpatrick
1992 Remotely delivered immunocontraception in captive white-tailed deer. Journal of Wildlife Management 56:154-157

Turner, J. W., K. M. Liu,, D. R. Flanagan, K. S. Bynum, and A. T. Rutberg
2002 Porcine zona pellucida (PZP) immunocontraception of wild horses (*Equus caballus*) in Nevada: a 10 year study. Reproduction Supplement 60:177-186

Turner, J. W., Jr., I. K. M. Liu, D. R. Flanagan, A. T. Rutberg, and J. F. Kirkpatrick
2007 "Immunocontraception in Wild Horses: One Inoculation Provides Two Years of Infertility." *The Journal of Wildlife Management* 71:662-7.

Turner, J. W., Jr., I. K. M. Liu, A. T. Rutberg, and J. F. Kirkpatrick
1997 Immunocontraception limits foal production in free-ranging feral horses in Nevada. Journal of Wildlife Management 61:873-880

Turner, J. W., A. T. Rutberg, R. E. Naugle, M. A. Kaur, D. R. Flanagan, H. J. Bertschinger, and I. K. M. Liu
2008 Controlled-release components of PZP contraceptive vaccine extend duration of infertility. Wildlife Research 35: 555-562.

Underwood, H. B.
2005 White-tailed deer ecology and management on Fire Island National Seashore. National Park Service Technical Report NPS/NER/NRTR-2005/022. National Park Service, Washington D.C.

U.S. Department of Agriculture (USDA)
2008 *GonaConTM Birth Control for Deer: Questions and Answers*. Animal and Plant Health Inspection Service, Wildlife Services. Fact Sheet. Available on the Internet at http://www.aphis.usda.gov/wildlife_damage/nwrc/research/reproductive_control/content/faq_gonacon_bc_deer_08.pdf.

Verdier, Y., G. Farre, N. Rouet, Z. Kele, T. Janaky, and F. Boue
2005 Identification of a new, testis-specific sperm antigen localized on the principal piece of the spermatozoa tail in the fox (*Vulpes vulpes*). Biology of Reproduction 72:502-508

Vickery, B. H.
1986 Comparison of the potential for therapeutic utilities with gonadotropin-releasing hormone agonists and antagonists. Endocrine Review 7:115-124

Vickery, B. H., G. I. McRae, W. Briones, A. Worden, R. Seidenberg, B. D. Schanbacher, and R. Falvo
1984 Effects of LHRH agonist analog upon sexual function in male dogs. Journal of Andrology 5:28-42

Vickery, B. H., G. I. McRae, J. C. Goodpasture, and L. M. Sanders
1989 Use of potent LHRH analogues for chronic contraception and pregnancy termination in dogs. Journal of Reproduction and Fertility 39:175-187

Von Berky, A. G., and W. L. Townsend
1993 The relationship between the prevalence of uterine lesions and the use of medroxyprogesterone acetate for canine population control. Australian Veterinary Journal 70:449-250

Waddell, R. B., D. A. Osborn, R. J. Warren, J. C. Griffin, and D. J. Kesler
2001 Prostaglandin $F_{2\alpha}$ –mediated fertility control in captive white-tailed deer. Wildlife Society Bulletin 29:1067-1074

Walter, W. D., H. J. Kilpatrick, and M. A. Gregonis
2003 Does immunocontraception improve condition of free-ranging female white-tailed deer? Journal of Wildlife Management 67:762-766

Walter, W. D., P. J. Perkins, A. T. Rutberg, and H. J. Kilpatrick
2002a Evaluation of immunocontraception in a free-ranging suburban white-tailed deer herd. Wildlife Society Bulletin 30:186-192.

Walter, W. D., P. J. Perkins, A. T. Rutberg, and H. J. Kilpatrick
2002b Evaluation of immunocontraceptive adjuvants, titers, and fecal pregnancy indicators in free-ranging white-tailed deer. Wildlife Society Bulletin 30:908-914

Wang, M.
no date Neutersol: intratesticular injection induces sterility in dogs. At: http://www.neutersol.com/Study.htm (6/22/05)

Warren, R. J.
2000 "Overview of Fertility Control in Urban Deer Management." In *Proceedings of the 2000 Annual Conference for the Society of Theriogenology, 2 December 2000, San Antonio, Texas*, 237–46. Nashville, TN: Society for Theriogenology.

Weikel Jr., J.H., and L.W. Nelson
1977 Problems in evaluating chronic toxicity of contraceptive steroids in dogs. Journal of Toxicology and Environmental Health 3:167-177

White, L. M., R. J. Warren, and R. A. Fayrer-Hosken
1994 Levonorgestrel implants as a contraceptive in captive white-tailed deer. Journal of Wildlife Diseases 30:241-246

Yang, W. H., M. Wieczorck, M. C. Allen, and T. M. Nett
2003 Cytotoxic activity of gonadotropin-releasing hormone (GnRH)-pokeweed antiviral protein conjugates in cell lines expressing GnRH receptors. Endocrinology 144:1456-1463

Yoder, C. A., W. F. Andelt, L. A. Miller, J. J. Johnston, and M. J. Goodall
2004 Effectiveness of twenty, twenty-five diazacholesterol, avian gonadotropin-releasing hormone, and chicken riboflavin carrier protein for inhibiting reproduction in coturnix quail. Poultry Science 83:234-244

Zeng, W., S. Ghosh, Y. F. Lau, L. E. Brown, and D. C. Jackson
2002 Highly immunogenic and totally synthetic pipopeptides as self-adjuvanting immunocontracpetive vaccines. Journal of Immunology 169:4905-4912

Zeng, X. Y., J. A. Turkstra, R. H. Meloen, X. Y. Liu, F. Q. Chen, W. M. M. Schaaper, H. B. R. Oonk, D. Z. Guo, and D. F. M. van de Wiel
2002a Active immunization against gonadotropin-releasing hormone in Chinese male pigs: effects of dose on antibody titer, hormone levels and sexual development. Animal Reproduction Science 70:223-233

Zeng, X. Y., J. A. Turkstra, A. Tsigos, R. H. Meloen, X. Y. Liu, F. Q. Chen, W. M. M. Schaaper, H. B. Oonk, D. Z. Guo, and D. F. M. van de Weil
2002b Effects of active immunization against GnRH on serum LH, inhibin A, sexual development and growth rate in Chinese female pigs. Theriogenlogy 58:1315-132

Zimmerman, C.
2009 Personal communication between Carl Zimmerman, Chief of Natural Resources, ASIS and Kristina Heister, Natural Resource Manager, VAFO on 2/19/2009 regarding use of fertility control at ASIS.

APPENDIX D. ADAPTIVE MANAGEMENT PHASES

The USDI Adaptive Management Technical Guide (Williams et al. 2007) suggests a two-phase approach to adaptive management, as illustrated below:

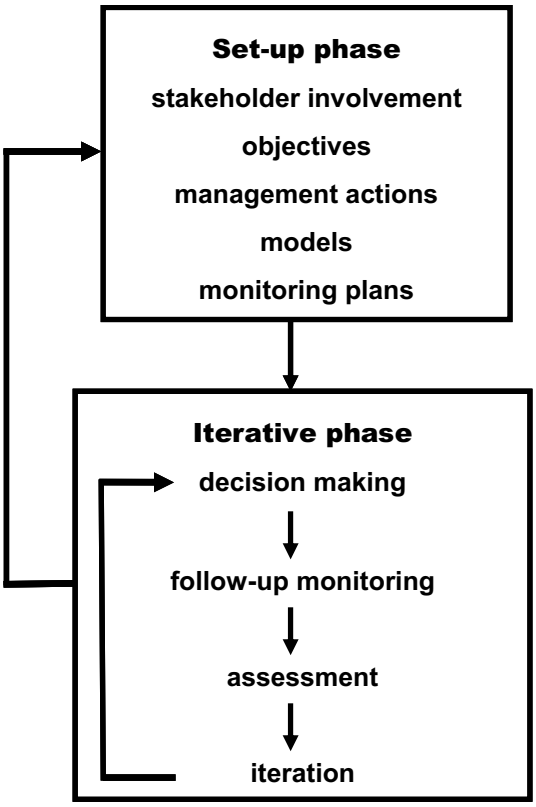


Figure D-1. The two-phase approach to adaptive management (modified from Williams et al. 2007, per Williams, pers. comm., September 16, 2008)

To implement adaptive management, certain elements must be put into place (the set-up phase), and then used in a cycle of iterative decision-making (the iterative phase) (Williams et al. 2007). For the Rock Creek White-tailed Deer Management Plan, the following are the phases and steps that follow the USDI guidance, with notations made that are specific to this plan.

SET-UP PHASE

Step 1: **STAKEHOLDER INVOLVEMENT** – Without active stakeholder involvement, an adaptive management process is unlikely to be effective. Stakeholders were identified during internal scoping and were conferred with during the public scoping process. The park completed this step at public scoping meetings held in November 2006 as part of the National Environmental Policy Act (NEPA) process. Interested members of the public, local government representatives, D.C. Fish and Wildlife personnel, and the media attended these meetings. Information about the plan has been posted to the park's website throughout the process to continue to keep the public informed. In addition, the NPS convened a team of government scientists (science team) to assist in developing density parameters and metrics to measure effectiveness in meeting plan objectives.

Step 2: **OBJECTIVES** – Objectives were prepared at the internal scoping meeting as part of the NEPA process and are detailed in chapter 1. Thresholds/metrics relating to vegetation condition and deer density were developed to measure success in meeting plan objectives.

Step 3: **ALTERNATIVES** – Alternative management actions were defined in an alternatives development meeting held in February 2007, using input from the public scoping comments and the science team. Elements of the alternatives were discussed and refined by the interdisciplinary team throughout the NEPA process. These actions were developed to test management hypotheses relating to deer management.

Step 4: **MODELS** – Operational models were developed to illustrate the natural resource system. Hypotheses relating to deer management, and specifically related to optimal deer density, are captured in these models, which predict different outcomes and impacts depending on actions taken. Questions that will generate hypotheses for modeling at Rock Creek Park include:

What is the magnitude of the white-tailed deer effects on the forest growth and survival of tree seedlings? (Proposed monitoring: paired plots)

What is the change in forest vegetation over time? (Proposed monitoring: permanent vegetation plots)

What is the density of deer in Rock Creek Park over time? (Proposed monitoring: Distance Sampling)

Step 5: **MONITORING PLANS** – Monitoring programs are created to collect data related to the testing of hypotheses and enhance operational models. The data is used later in the iterative phase to assess whether the objectives are being met. The vegetation data in the deer exclosures and the long-term vegetation monitoring plots would be used in this assessment. Monitoring data are documented and made available to the public.

ITERATIVE PHASE

Step 1: **DECISION-MAKING** – A management action would be recommended by the park (preferred alternative) and a decision made by the Regional Director. A Record of Decision is completed. A plan is developed to implement the selected alternative and to monitor the results (changes in the resources expected from reduced deer density).

Step 2: **FOLLOWUP MONITORING** – The park will implement the monitoring plan and collect data on key elements that will measure the success of the selected action and of the park meeting its objectives.

Step 3: **ASSESSMENT** – The park will evaluate the results of the monitoring, comparing actual outcome with desired condition or objectives. Monitoring data is analyzed and made available to the public. Based on the assessment, the park may change models, modify the action (e.g., increase or decrease the number of deer taken) or make adjustments in monitoring (look at different parameters or species to measure).

Step 4: ITERATION – This step can lead back to the set-up phase if substantial changes are needed or to Step 1 of the iterative phase if there is a need to adjust the management action through subsequent decision-making.

References for Appendix D

Williams, B. K, R. C. Szaro, and C. D. Shapiro
2007 *Adaptive Management: The U.S. Department of the Interior Technical Guide*. Washington, DC: Adaptive Management Working Group, U.S. Department of the Interior.

Williams, B. K., Lead author, USDI Adaptive Management Technical Guide
2008 Pers. comm. with M. Mayer, The Louis Berger Group, regarding language and diagrams in 2007 guidance and modifications needed. September 16, 2008.

APPENDIX E. AVIAN SPECIES IDENTIFIED DURING BREEDING BIRD SURVEYS AS POTENTIAL BREEDING SPECIES

Table 1. A.0VIAN SPECIES IDENTIFIED DURING BREEDING BIRD SURVEYS AS POTENTIAL BREEDING SPECIES

Species	1993	1994	1995	1996	1997	1998	2001	2002
Mallard				✓			✓	
Cooper's hawk				✓		✓		
Red-shouldered hawk								✓
Red-tailed hawk				✓			✓	✓
American woodcock			✓	✓				
Rock dove			✓					
Mourning dove	✓	✓	✓	✓	✓	✓	✓	✓
Yellow-billed cuckoo		✓	✓	✓				
Eastern screech owl	✓							
Chimney swift							✓	
Red-bellied woodpecker	✓	✓	✓	✓	✓	✓	✓	✓
Northern flicker	✓	✓	✓	✓	✓	✓	✓	✓
Downy woodpecker	✓	✓	✓	✓	✓	✓	✓	✓
Hairy woodpecker	✓	✓	✓	✓	✓	✓	✓	✓
Pileated woodpecker	✓	✓	✓	✓	✓	✓	✓	✓
Eastern wood-pewee	✓	✓	✓	✓	✓	✓	✓	✓
Eastern Phoebe	✓	✓	✓	✓	✓	✓	✓	✓
Acadian flycatcher	✓	✓	✓	✓	✓	✓	✓	✓
Great crested flycatcher	✓	✓	✓	✓	✓	✓	✓	✓
Eastern kingbird			✓	✓				
Red-eyed vireo	✓	✓	✓	✓	✓	✓	✓	✓
Yellow-throated vireo	✓			✓		✓	✓	✓
Blue jay	✓	✓	✓	✓	✓	✓	✓	✓
American crow	✓	✓	✓	✓	✓	✓	✓	✓
Tufted titmouse	✓	✓	✓	✓	✓	✓	✓	✓
Carolina chickadee	✓	✓	✓	✓	✓	✓	✓	
White-breasted nuthatch	✓	✓	✓	✓	✓	✓	✓	✓
Carolina wren	✓	✓	✓	✓	✓	✓	✓	✓
Blue-gray gnatcatcher	✓	✓	✓	✓	✓	✓	✓	✓
Veery	✓	✓	✓	✓	✓	✓	✓	✓
Wood thrush	✓	✓	✓	✓	✓	✓	✓	✓
American robin	✓	✓	✓	✓	✓	✓	✓	✓
Gray catbird	✓	✓		✓	✓	✓	✓	✓
Northern mockingbird			✓					
Brown thrasher	✓							
European starling		✓			✓		✓	✓
Northern parula						✓		
Black-and-white warbler				✓	✓		✓	✓
Yellow-throated warbler				✓		✓		
Hooded warbler	✓	✓	✓	✓				

Species	1993	1994	1995	1996	1997	1998	2001	2002
Worm-eating warbler	✓							
Ovenbird	✓	✓	✓	✓	✓	✓	✓	✓
Louisiana waterthrush				✓	✓		✓	
Common yellowthroat			✓	✓	✓			✓
Yellow-breasted chat					✓			
American redstart	✓			✓				
Summer tanager				✓				
Scarlet tanager	✓	✓	✓	✓		✓	✓	✓
Eastern towhee	✓	✓	✓	✓	✓	✓	✓	✓
Northern cardinal	✓	✓	✓	✓	✓	✓	✓	✓
Indigo bunting			✓		✓		✓	
Song sparrow				✓	✓		✓	✓
Common grackle	✓	✓				✓	✓	✓
Brown-headed cowbird	✓	✓	✓	✓	✓	✓	✓	✓
House finch		✓	✓		✓	✓		
House sparrow				✓				

Source: Wireless Telecommunications Plan, Rock Creek Park - February 2008

Table 2. WASHINGTON DC AUDUBON CHRISTMAS BIRD COUNT ROCK CREEK PARK - 1980–2002 ANNUAL AVERAGE

Species	Carter Barron	Nature Center	Species	Carter Barron	Nature Center
Mallard	2.2	5.0	Winter wren	0.1	0.6
Wood duck	0.2	0.8	Brown creeper	0.3	1.4
Barred owl	—	0.0	Northern mockingbird	3.2	2.6
Great horned owl	0.0	0.3	Mourning dove	3.6	12.3
Eastern screech owl	0.4	0.8	Rock dove	25.2	4.0
American crow	18.5	38.0	European starling	33.5	21.3
Fish crow	0.4	0.3	Ovenbird	—	0.1
Herring gull	0.3	—	House sparrow	22.7	15.4
Ring-billed gull	40.7	11.5	Eastern towhee	0.0	1.0
American kestrel	—	0.0	White-throated sparrow	10.7	21.9
Belted kingfisher	0.2	0.2	Song sparrow	1.7	8.0
Red-shouldered hawk	0.0	0.1	Dark-eyed junco	11.7	16.1
Red-tailed hawk	0.4	0.7	Purple finch	0.0	0.4
Sharp-shinned hawk	0.2	0.2	House finch	5.5	19.3
Cooper's hawk	0.1	—	American goldfinch	4.4	5.4
Turkey vulture	0.1	0.4	Northern cardinal	8.2	16.0
Black vulture	0.0	0.0	Evening grosbeak	—	0.1
Northern flicker	0.2	1.3	Field sparrow	—	0.2
Red-bellied woodpecker	4.9	9.6	American tree sparrow	—	0.0
Downy woodpecker	3.9	8.7	Fox sparrow	—	0.0
Hairy woodpecker	0.5	1.0	Brown-headed cowbird	—	0.0
Pileated woodpecker	0.8	2.3	Red-winged blackbird	—-	1.9

Avian Species Identified during Breeding Bird Surveys as Potential Breeding Species

Species	Carter Barron	Nature Center	Species	Carter Barron	Nature Center
Yellow-bellied sapsucker	0.3	0.7	Common grackle	0.1	28.0
White-breasted nuthatch	6.0	11.9	Blue jay	2.1	3.2
Red-breasted nuthatch	0.0	0.3	Cedar waxwing	1.3	3.5
Golden-crowned kinglet	0.6	3.6	American robin	3.3	2.6
Ruby-crowned kinglet	0.5	0.1	Hermit thrush	—	0.0
Tufted titmouse	13.3	30.7	Gull spp.	0.4	0.1
Carolina chickadee	12.5	43.0	Kinglet spp.	0.3	—
Carolina wren	4.1	8.8			
Total Individuals:	**247.0**	**366.2**			
Total Species:	**21.2**	**27.3**			

APPENDIX F. LETTERS OF CONSULTATION

United States Department of the Interior

NATIONAL PARK SERVICE
National Capital Region
Rock Creek Park
3545 Williamsburg Lane, N.W.
Washington, D.C. 20008-1207

IN REPLY REFER TO:

H3019 (NCA-ROCR)

JUN 17 2008

Mary Ratnaswamy, Program Supervisor
U.S. Fish and Wildlife Service
Chesapeake Bay Field Office
177 Admiral Cochrane Drive
Annapolis, Maryland 21401

Dear Ms. Ratnaswamy:

The National Park Service (NPS), Maryland National Capital Parks and Planning Commission (MNCPPC), and the District of Columbia Department of the Environment (DCDOE) are currently collaborating on an Environmental Impact Statement (EIS) for white-tailed deer management. The EIS will include an assessment of the park's deer population and a range of herd management alternatives to preserve park resources. The NPS is the lead agency and MNCPPC and DCDOE are Cooperating Agencies. In accordance with Section 7 of the Endangered Species Act, we wish to begin informal consultation with your agency so that we may fully evaluate the potential effects of deer management actions on federally listed species.

The EIS formally began with publication of the Notice of Intent on September 20, 2006. Two public scoping meetings were held in November 2006 and we are now working on the Draft EIS. Based on results of internal and public scoping, we have defined the geographic scope of the management actions considered in the EIS to include the entire administrative unit of Rock Creek Park. The EIS will govern deer management on park areas capable of sustaining a deer population.

We wish to request the most current list of Rare, Threatened and Endangered species that potentially inhabit Rock Creek Park, along with any pertinent critical habitat designations. We also understand that the Kenk's amphipod (*Stygobromus kenki*), which is known to occur in Rock Creek Park, was recently denied listing as endangered because its petition did not present substantial scientific or commercial information to demonstrate listing was warranted at that time.

For more technical information on the EIS, call or e-mail Natural Resource Specialist Ken Ferebee on 202-895-6221, ken_ferebee@nps.gov. You may also wish to visit the website at www.nps.gov/rocr which provides a link in which to view documents related to the EIS.

Sincerely,

for Adrienne A. Coleman
Superintendent, Rock Creek Park

United States Department of the Interior

TAKE PRIDE IN AMERICA

NATIONAL PARK SERVICE
National Capital Region
Rock Creek Park
3545 Williamsburg Lane, N.W.
Washington, D.C. 20008-1207

IN REPLY REFER TO:

N1615 (NCA-ROCR)

JUN 18 2008

David Maloney, State Historic Preservation Officer
Historic Preservation Office
Office of Planning
801 North Capitol Street, NE, #400
Washington, D.C. 20002

Dear Mr. Maloney:

The National Park Service (NPS), Maryland National Capital Parks and Planning Commission (MNCPPC), and the District of Columbia Department of the Environment (DCDOE) are currently collaborating on an Environmental Impact Statement (EIS) for white-tailed deer management. The EIS will include an assessment of the park's deer population and a range of herd management alternatives to preserve park resources. The NPS is the lead agency, and MNCPPC and DCDOE are Cooperating Agencies. In accordance with the National Historic Preservation Act of 1966 (NHPA), as amended, and the regulations of the Advisory Council on Historic Preservation, the NPS wishes to formally begin consultation with your office. We will be submitting the Draft EIS to your office for your review. The NPS wishes to coordinate the Section 106 review with its responsibilities under the National Environmental Protection Act (NEPA) as identified in 36 CFR 800.3(a)(2)(b). In accordance with 36 CFR 800.8(c)(2)(i), the Draft EIS will serves as the Determination of Effect for cultural resources under Section 106 of the NHPA.

The EIS formally began with publication of the Notice of Intent on September 20, 2006. Two public scoping meetings were held in November 2006 and we are now working on the Draft EIS. Based on results of internal and public scoping, we have defined the geographic scope of the management actions considered in the EIS to include the entire administrative unit of Rock Creek Park. The EIS will govern deer management on park areas capable of sustaining a deer population.

If you have any questions regarding the project, please contact Cultural Resource Specialist Simone Monteleone Moffett at (202) 895-6011. Please forward all Section 106 compliance concerns to my office. You may also wish to visit the website at www.nps.gov/rocr which provides a link in which to view documents related to the EIS. We look forward to hearing from you soon.

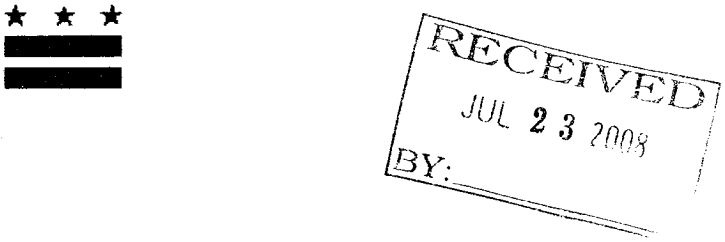
Sincerely,

Cynthia Cox

for Adrienne A. Coleman
Superintendent, Rock Creek Park

Bcc:
ROCR- CCox
ROCR- MHagerty
ROCR-SMoffett
rocr.files.deer

GOVERNMENT OF THE DISTRICT OF COLUMBIA
HISTORIC PRESERVATION OFFICE
OFFICE OF PLANNING



July 18, 2008

Ms. Adrienne A. Coleman
National Park Service
National Capital Region
3545 Williamsburg Lane, NW
Washington, DC 20008-1207

RE: Environmental Impact Statement for White-Tailed Deer Management, Rock Creek Park

Dear Ms. Coleman:

Thank you for contacting the DC State Historic Preservation Office (SHPO) regarding the above-referenced undertaking. We have reviewed the project information in accordance with Section 106 of the National Historic Preservation Act and are writing to provide our initial comments regarding effects on historic properties.

As you are aware, Rock Creek Park is listed in the National Register of Historic Places and the DC Inventory of Historic Sites. Therefore, we look forward to reviewing the Environmental Impact Statement (EIS) and to assisting the National Park Service in its efforts to ensure that its white-tailed deer management strategies will not have an adverse effect on historic properties.

If you should have any questions or comments regarding this matter, please contact me at andrew.lewis@dc.gov or 202-442-8841. Otherwise, we thank you for providing this opportunity to comment and we look forward to receiving the EIS as soon as it becomes available.

Sincerely,

C. Andrew Lewis
Senior Historic Preservation Specialist
DC State Historic Preservation Office

08-233

United States Department of the Interior

NATIONAL PARK SERVICE
National Capital Region
Rock Creek Park
3545 Williamsburg Lane, N.W.
Washington, D.C. 20008-1207

IN REPLY REFER TO:

TAKE PRIDE IN AMERICA

N1615 (NCA-ROCR)

JUN 18 2008

Marcel Acosta, Acting Executive Director
National Capital Planning Commission
401 9th Street, NW, Suite 500
Washington, D.C. 20004

Dear Mr. Acosta:

The National Park Service (NPS), Maryland National Capital Parks and Planning Commission (MNCPPC), and the District of Columbia Department of the Environment (DCDOE) are currently collaborating on an Environmental Impact Statement (EIS) for white-tailed deer management. The EIS will include an assessment of the park's deer population and a range of herd management alternatives to preserve park resources. The NPS is the lead agency, and MNCPPC and DCDOE are Cooperating Agencies.

The EIS formally began with publication of the Notice of Intent on September 20, 2006. Two public scoping meetings were held in November 2006 and we are now working on the Draft EIS. Based on results of internal and public scoping, we have defined the geographic scope of the management actions considered in the EIS to include the entire administrative unit of Rock Creek Park. The EIS will govern deer management on park areas capable of sustaining a deer population. We would appreciate any comments or suggestions you may have regarding important factors that should be considered and if there are any concerns within the project area that your agency feels needs to be addressed, please inform us.

If you have any questions regarding the project, please contact Cultural Resource Specialist Simone Monteleone Moffett at 202-895-6011. Please forward all concerns to my office. You may also wish to visit the website at www.nps.gov/rocr which provides a link in which to view documents related to the EIS. We look forward to hearing from you soon.

Sincerely,

Gudie Cox

for Adrienne A. Coleman
Superintendent, Rock Creek Park

Bcc:
ROCR- CCox
ROCR- MHagerty
ROCR-SMoffett
rocr.files.deer

United States Department of the Interior

NATIONAL PARK SERVICE
National Capital Region
Rock Creek Park
3545 Williamsburg Lane, N.W.
Washington, D.C. 20008-1207

IN REPLY REFER TO:

N1615 (NCR-ROCR)

JUN 18 2008

Thomas Luebke, Secretary
The Commission of Fine Arts
National Building Museum
401 F Street, NW, Suite 312
Washington, D.C. 20001

Dear Mr. Luebke:

The National Park Service (NPS), Maryland National Capital Parks and Planning Commission (MNCPPC), and the District of Columbia Department of the Environment (DCDOE) are currently collaborating on an Environmental Impact Statement (EIS) for white-tailed deer management. The EIS will include an assessment of the park's deer population and a range of herd management alternatives to preserve park resources. The NPS is the lead agency, and MNCPPC and DCDOE are Cooperating Agencies.

The EIS formally began with publication of the Notice of Intent on September 20, 2006. Two public scoping meetings were held in November 2006 and we are now working on the Draft EIS. Based on results of internal and public scoping, we have defined the geographic scope of the management actions considered in the EIS to include the entire administrative unit of Rock Creek Park. The EIS will govern deer management on park areas capable of sustaining a deer population. We would appreciate any comments or suggestions you may have regarding important factors that should be considered and if there are any concerns within the project area that your agency feels needs to be addressed,please inform us.

If you have any questions regarding the project, please contact Cultural Resource Specialist Simone Monteleone Moffett at 202-895-6011. Please forward all concerns to my office. You may also wish to visit the website at www.nps.gov/rocr which provides a link in which to view documents related to the EIS. We look forward to hearing from you soon.

Sincerely,

Cynthia Cox

for Adrienne A. Coleman
Superintendent, Rock Creek Park

Bcc:
ROCR- CCox
ROCR- MHagerty
ROCR-SMoffett
rocr.files.deer

United States Department of the Interior

TAKE PRIDE IN AMERICA

NATIONAL PARK SERVICE
National Capital Region
Rock Creek Park
3545 Williamsburg Lane, N.W.
Washington, D.C. 20008-1207

IN REPLY REFER TO:

OCT 27 2008

N1615 (NCA-ROCR)

Lori A. Byrne
DNR Wildlife and Heritage Service
580 Taylor Avenue
Tawes Office Building E-1
Annapolis, Maryland 21401

Dear Ms. Byrne:

The National Park Service (NPS), Rock Creek Park, Maryland National Capital Parks and Planning Commission (MNCPPC) and the District of Columbia Department of the Environment (DCDOE) are currently collaborating on an Environmental Impact Statement (EIS) for white-tailed deer management. The EIS will include an assessment of several alternatives to manage an increasing deer population in the park in order to preserve park resources. The NPS is the lead agency; MNCPPC and DCDOE are Cooperating Agencies.

Rock Creek Park is located within the District of Columbia but does share boundaries with Montgomery County, Maryland and the lower portion of Rock Creek Regional Park (see enclosed park brochure). We would like to request a list of any known rare, threatened, or endangered species that are known to exist or potentially could be found in the areas of common boundary between the NPS and Maryland. This species list will be incorporated into the impact analysis of the management alternatives being developed.

This National Environmental Protection Act (NEPA) process was started in 2006 and is targeted for completion in 2009-2010. A Draft EIS will be released to the public for comment in 2009. Please contact Natural Resource Specialist Ken Ferebee on 202-895-6221 if you have any questions or require additional information. Thank you for your assistance.

Sincerely,

Adrienne A. Coleman,
Superintendent, Rock Creek Park

Enclosure:
Rock Creek Park brochure

COPY FOR YOUR INFORMATION

REFERENCES

Alverson, W.S.
1988 "Forests too Deer: Edge Effects in Northern Wisconsin." *Conservation Biology* 2:348–58.

American Veterinary Medical Association (AVMA)
2001 "2000 Report of AVMA Panel of Euthanasia." *Journal of Animal Veterinary Medical Association* 218 (5):669–96.

Anderson, R.C.
1994 "Height of White-flowered Trillium (Trillium grandiflorum) as an Index of Deer Browsing Intensity." *Ecological Applications* 4:104–9.

Animal and Plant Health Inspection Service (APHIS), U.S. Department of Agriculture
2003 *Bluetongue*. Veterinary Services Fact Sheet. Available at <http://www.aphis.usda.gov/lpa/pubs/ fsheet_faq_notice/fs_ahbluetongue.html>. Site visited January 12, 2006.

Augustine, D.J., and D. DeCalesta
2003 "Defining Deer Overabundance and Threats to Forest Communities: From Individual Plants to Landscape Structure." *Ecoscience* 10:472–86.

Augustine D.J., and L.E. Frelich
1998 "Effects of White-tailed Deer on Populations of an Understory Forb in Fragmented Deciduous Forest." *Conservation Biology* 12:995–1004.

Backyard Gardener
2008a *Coreopsis verticillata (Zagreb Thread-leaved Tickseed)*. Available: http://www.backyardgardener.com/plantname/pda_fed9.html. Accessed October 13, 2008.

2008b *Gardening Support*. Available: http://www.backyardgardener.com/plant_detail.php?pid=6167. Accessed October 13, 2008.

Baker, D.L., M.A. Wild, M.M. Connor, H.B. Ravivarapu, R.L. Dunn, and T.M. Nett
2002 "Effects of GnRH Agonist (Leuprolide) on Reproduction and Behavior in Female Wapiti (Cervus elaphus nelsoni)." *Reproduction Supplement* 60:155–67.

2004 "Gonadotropin-Releasing Hormone Agonist: A New Approach to Reversible Contraception in Female Deer." *Journal of Wildlife Diseases* 40:713–24.

Behrend, D.F., G.F. Mattfeld, W.D. Tierson, and J.E. Wiley III
1970 "Deer Density Control for Comprehensive Forest Management." *Journal of Forestry* 68:695–700.

Bloomin' on the East End
2008 *Rudbeckia*. Available: http://www.e-bloomin.com/rudbeckia.htm. Accessed October 13, 2008.

Bormann, B.T, D.C. Lee, A.R. Kiester, D.E. Busch, J.R. Martin, and R.W. Haynes
2006 "Adaptive Management and Regional Monitoring." Chapter 10 In R.W. Haynes, B.T. Bormann, and J.R. Martin (eds). *Northwest Forest Plan – The First Ten Years (1994-2003):*

Synthesis of Monitoring and Research Results. PNW GTR 651, USDA Forest Service, Pacific Northwest Research Station, Portland, Oregon. Cited IN: Williams et al. 2007. *Adaptive Management: The U.S. Department of the Interior Technical Guide*. Washington, DC: Adaptive Management Working Group, U.S. Department of Interior.

Bowersox, T.W., D.S. Larrick, G.L. Storm, and W.M. Tzilkowski
2002 "Regenerating Mixed-Oak Historic Woodlots at Gettysburg National Military Park." School of Forest Resources, The Pennsylvania State University, University Park, PA.

Bratton, S.P.
1982 "The Effects of Exotic Plant and Animal Species on Nature Preserves." *Natural Areas Journal* 2(3):3–13.

Bushong, William
1990 *Historic Resource Study, Rock Creek Park*. Available online at http://www.nps.gov/history/history/online_books/rocr1/hrs.pdf. Accessed July 25, 2007.

California Department of Fish and Game, Wildlife Programs Branch
2008 *A Gardener's Guide to Preventing Deer Damage*. Available: http://www.dfg.ca.gov/keepmewild/docs/gardenersguide.pdf. Accessed April 10, 2008.

California Department of Transportation (Caltrans)
1998 "Technical Supplement to the Traffic Noise Analysis Protocol." California Department of Transportation Environmental Program, October 1998.

Coladonato, Milo
1991 *Juglans cinerea*. In *Fire Effects Information System*. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory. Available: http://www.fs.fed.us/database/feis/plants/tree/jugcin/all.html. Accessed April 10, 2008.

Conservation Management Institute of Virginia Tech
1996 *Taxonomy*. http://fwie.fw.vt.edu/WWW/esis/lists/e702013.htm. Accessed April 10, 2008.

Cordell, H. Ken and Nancy G. Herbert
2002 "The Popularity of Birding is Still Growing." In *Rock Creek Park and Rock Creek and Potomac Parkway. Final General Management Plan/ Environmental Impact Statement* (2005a). Athens, GA. U.S. Department of Agriculture, Forest Service, Southern Research Station.

Council on Environmental Quality (CEQ)
1981 "Forty Most Asked questions Concerning CEQ's National Environmental Policy Act Regulations." Federal Register 46(55):18026–38. Available at: http://ceq.eh.doe.gov/nepa/regs/40/40p.3.htm.

1997 "Considering Cumulative Effects under the National Environmental Policy Act ".January 1997.

Craven, S.R. and S.E. Hygnstrom
1994 "Deer." In *Prevention and Control of Wildlife Damage*, edited by S.E. Hygnstrom, R.M. Timm, and G.E. Larson, D25–40. Lincoln: University of Nebraska.

Crescent Bloom
2004a *Arabis spp*. Available: http://www.crescentbloom.com/Plants/Specimen/AO/Arabis%20spp.htm. Accessed October 13, 2008.

2004b *Aster spp*. Available: http://www.crescentbloom.com/Plants/Specimen/AO/Aster%20spp.htm. Accessed October 13, 2008.

2004c *Carex spp*. Available: http://www.crescentbloom.com/Plants/Specimen/CA/Carex%20spp.htm. Accessed October 13, 2008.

2004d *Pyrola elliptica*. Available: http://www.crescentbloom.com/Plants/Specimen/PU/Pyrola%20elliptica.htm. Accessed October 13, 2008.

Curtis, P.D., R.L. Pooler, M.E. Richmond, L.A. Miller, G.F. Mattfeld, and F.W. Quimby
2002 "Comparative Effects of GnRH and Porcine Zona Pellucida (PZP) Immunocontraceptive Vaccines for Controlling Reproduction in White-tailed Deer (Odocoileus virginianus)." *Reproduction Supplement* 60:131–41

deCalesta, D.S.
1992 "Impact of Deer on Species Diversity of Allegheny Hardwood Stands." *Proceedings of the Northeastern Weed Science Society* 46:135.

1994 "Effect of White-tailed Deer on Songbirds within Managed Forests in Pennsylvania." *Journal of Wildlife Management* 58:711–18.

1997 "Deer and Ecosystem Management." In *The Science of Overabundance: Deer Ecology and Population Management*, 267–279 edited by H.B. Underwood, W.J. McShea, and J.H. Rappole. Smithsonian Institution Press, Washington, DC.

DeNicola, A.J., D.J. Kesler, and R.K. Swihart
1997 "Remotely Delivered Prostaglandin F2α Implants Terminate Pregnancy in White-tailed Deer." *Wildlife Society Bulletin* 25:527–31.

DeNicola, Anthony J. and Robert K. Swihart
1997 "Capture-induced Stress in White-tailed Deer." *Wildlife Society Bulletin* 25(2):500–503.

DeNicola, Anthony J. and S.C. Williamson
2008 "Sharpshooting White-tailed Deer Reduces Deer-Vehicle Collisions ." Human –Wildlife Conflicts 2(1): 28-33.

Department of the Interior
2000 "Endangered and Threatened Wildlife and Plants; Proposed Reclassification of Scutellaria Montana (large-flowered skullcap) from Endangered to Threatened." *Federal Register* 65(134). Available: http://www.epa.gov/fedrgstr/EPA-SPECIES/2000/July/Day-12/e17561.htm. Accessed April 10, 2008.

District of Columbia

2001a "2001 Traffic Volumes Map." In *Rock Creek Park and Rock Creek and Potomac Parkway. Final General Management Plan/ Environmental Impact Statement* (2005a). Washington, DC: Department of Transportation.

2001b "2001 Traffic Volumes Map, Downtown Insert." In *Rock Creek Park and Rock Creek and Potomac Parkway. Final General Management Plan / Environmental Impact Statement* (2005a). Washington, DC: Department of Transportation.

2006 *Wildlife Action Plan*. Available at http://ddoe.dc.gov/ddoe/frames.asp?doc=/ddoe/lib/ddoe/DC_WAP_Intro_-_Chp_3.pdf. Accessed August 28, 2007.

District of Columbia Department of Health (DCDOH)

n.d. D.C. Department of Health Environmental Health Administration Animal Disease Prevention Division. Available at: http://doh.dc.gov/doh/cwp/view,a,1374,q,584356,dohNav_GID,1818,.asp.

2004a *District of Columbia Final Total Maximum Daily Loads for Metals in Rock Creek. Department of Health Environmental Health Administration Bureau of Environmental Quality Water Quality Division*. Accessed at: http://www.epa.gov/reg3wapd/tmdl/dc_tmdl/RockCreek/Metals/Final%20DC%20Rock%20Creek%20Metals%20TMDL.pdf.

2004b "District of Columbia Final Total Maximum Daily Loads for Organics and Metals in Broad Branch, Dumbarton Oaks, Fenwick Branch, Klingle Valley Creek, Luzon Branch, Melvin Hazen Valley Branch, Normanstone Creek, Pinehurst Branch, Piney Branch, Portal Branch, and Soapstone Creek." Department of Health Environmental Health Administration Bureau of Environmental Quality Water Quality Division. February 2004.

District Department of the Environment (DDOE)

2006 *Wildlife Action Plan*. Available at: http://ddoe.dc.gov/ddoe/cwp/view,a,1209,q,492187.asp. Accessed October 12, 2007.

Doerr, M.L., J.B. McAnnich, and E.P. Wiggers

2001 "Comparison of Four Methods to Reduce White-tailed Deer Abundance in an Urban Community." *Wildlife Society Bulletin* 29(4):1105–13.

Dumond, Lionel

2000 *All About Decibels Part I: What's Your dB IQ?* Available at: <http://www.prorec.com/prorec/articles.nsf/articles/EA68A9018C905AFB8625675400514576>.

Easyliving Wildflowers

2008 *Deer Resistant Native Plants Wildflowers and Shrubs*. Available at: http://www.easywildflowers.com/quality/deer_resistant_native_plants.htm. Accessed October 13, 2008.

Endpcnoise.com

n.d. *Decibels*. Available at: < http://www.endpcnoise.com/cgi-bin/e/decibels.html>.

Environmental Protection Agency (EPA)
1974 "Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety." Washington, DC.

1981 *Noise Effects Handbook: A Desk Reference to Health and Welfare Effects of Noise*. Office of Noise Abatement and Control, U.S. Environmental Protection Agency. Fort Walton Beach, FL. Accessed at: http://nonoise.org/library/handbook/handbook.htm

Eve, J. H.
1981 "Management Implications of Disease." In *Diseases and Parasites of White- tailed Deer*, edited by W. R. Davidson, 413–23. Miscellaneous publication 7. Tallahassee: Tall Timbers Research Station, U.S. Forest Service.

Fairfax County, Virginia
2003 "Deer Management Report." Wildlife Section, Animal Services Division, Fairfax County Police Department.

Fairfax County Park Authority, Virginia
2004 Natural Resources Management Plan 2004-2008; January 14, 2004.

Favre, C. L., J. L. Sherald, and N. F. Schneeberger
1993 "Gypsy moth management in Rock Creek Park." Washington, D.C. *J. Arboric*. 19:160–167.

Federal Emergency Management Agency (FEMA)
1985 *FIRM maps for D.C*. November 15, 1985. Available at: http://msc.fema.gov/webapp/wcs/stores/servlet/QuickOrderResultView.

Federal Highway Administration (FHWA), U.S. Department of Transportation
2000 *Highway Traffic Noise in the United States, Problem and Response*. Available at <http://www.fhwa.dot/gov/environment/probresp.htm>.

Fleming, Peggy
1978-1995 Unpublished data and reports summarizing treatments and research done on non-native plants in Rock Creek Park, Washington, DC. On file at Rock Creek Park.

Flowerdew, J.R. and S.A. Ellwood
2001 "Impacts of Woodland Deer on Small Mammal Ecology." *Forestry* 74(3):277–287.

Fraker, M.A., R.G. Brown, G.E. Gaunt, J.A. Kerr, and B. Pohajdak
2002 "Long Lasting, Single Dose Immunocontraception of Feral Fallow Deer in British Columbia." *Journal of Wildlife Management* 66(4):1141–47.

Frost, H.C., G.L. Storm, M.J. Batcheller, and M.J. Lovallo
1997 "White-tailed Deer Management at Gettysburg National Military Park and Eisenhower National Historic Site." *Wildlife Society Bulletin* 25(2):462–69.

Galen Carol Audio
n.d. *Decibel (Loudness) Comparison Chart.* Available at <http://www.gcaudio.com/resources/howtos/loudness.html>.

Gardening Guru
2007 *Here's how to protect your garden from deer damage*. Available at: http://www.thegardeningguru.com/Animal%20proofing.doc. Accessed October 13, 2008.

Garrott, Robert A. and Donald B. Siniff
1992 "Limitations of Male-Oriented Contraception for Controlling Feral Horse Populations." *Journal of Wildlife Management* 56:456–64.

Gilman, Edward, and Dennis Watson
1994 *Quercus lyrata*. Fact Sheet FT-550. United States Department of Agriculture, Forest Service, Southern Group of State Foresters. Available: http://hort.ufl.edu/trees/QUELYRA.pdf. Accessed April 10, 2008.

Haight, Robert G. and L. David Mech
1997 "Computer Simulation of Vasectomy for Wolf Control." *Journal of Wildlife Management* 61:1023–31.

Hansen, L. and J. Beringer
1997 "Managed Hunts to Control White-tailed Deer Populations on Urban Public Areas in Missouri." *Wildlife Society Bulletin* 25(2):448–47.

Hatfield, J. S.
2005 "Analysis of long-term vegetation data collected at Rock Creek Park during 1991-2003." Unpublished report. U.S. Department of Interior, National Park Service.

2008 "Analysis of Vegetation Changes in Rock Creek Park, 1991–2007." U.S. Department of Interior, National Park Service. Natural Resource Technical Report NPS/NCR/NCRO/NRTR-2009/001. Washington, D.C.

Hesselton, W.T. and R.M. Hesselton
1982 "White-tailed Deer." In *Wild Mammals of North America*, edited by J.A. Chapman and G.A. Feldhamer, 878–901. Baltimore: The Johns Hopkins University Press.

High Country Gardens
2008 *Rudbeckia fulgida 'Goldsturm' (Black Eyed Susan): High Country Garden*s. Available at: http://www.highcountrygardens.com/catalog/product/82925/. Accessed October 13, 2008.

Hilty, John
2006 *Nodding Ladies' Tresses Orchid (Spiranthes cernua)*. Available at: http://www.illinoiswildflowers.info/prairie/plantx/nodding_orchidx.htm. Accessed April 10, 2008.

Hobbs, N.T., D.C. Bowden, and D.L. Baker
2000 "Effects of Fertility Control on Populations of Ungulates: General, Stage-Structured Models." *Journal of Wildlife Management* 64(2):473–91.

Horsley, S.B., S.L. Stout, and D.S. deCalesta
2003 "White-tailed Deer Impact on the Vegetation Dynamics of a Northern Hardwood Forest." *Ecological Applications* 13(1): 98–118.

Hough, A.F.
1965 "A Twenty-Year Record of Understory Vegetation Change in a Virgin Pennsylvania Forest." *Ecology* 46(3).

Iowa City, Iowa
2008 *Deer Resistant Landscaping*. Available at: http://www.icgov.org/default/?id=1607. Accessed April 10, 2008.

iVillage Gardenweb
2006 *What Can I Plant that is Deer Resistant?* Available at: http://faq.gardenweb.com/faq/lists/midatl/2002083026012897.html. Accessed October 13, 2008.

Jones, J.M., and J.H. Witham
1990 "Post-translocation Survival and Movements of Metropolitan White-tailed Deer." *Wildlife Society Bulletin*, Vol. 18.

Jull, Laura G.
2001 *Plants Not Favored by Deer*. Available at: http://www.lakeswcd.org/documents/Plants%20not%20favored%20by%20deer.pdf. Accessed April 10, 2008.

Kansas Wildflowers & Grasses
2008 *Desmodium glutinosum*. Available at: http://www.kswildflower.org/details.php?flowerID=92. Accessed October 13, 2008.

Kilpatrick, J.F., I.K. M. Liu, J.W. Turner, R. Naugle, and R. Keiper
1992 "Long term Effects of Porcine Zona Pellucidae Immunocontraception on Ovarian Function in Feral Horses (*Equus caballus*)." *Journal of Reproduction and Fertility* 94: 437–44.

Kilpatrick, H.J., S.M. Spohr, and A.J. DeNicola
1997 "Darting Urban Deer: Techniques and Technology." *Wildlife Society Bulletin* 25(2):542–46.

Kilpatrick, H.J. and W.D. Walter
1999 "A Controlled Archery Deer Hunt in a Residential Community: Cost, Effectiveness, and Deer Recovery Rates." *Wildlife Society Bulletin* 27:115–23.

Komanoff, Charles, and Howard Shaw
2000 *Drowning in Noise: Noise Costs of Jet Skis in America*. A Report for the Noise Pollution Clearinghouse. Available at: <http://www.noise.org/library/drowing>.

Lady Bird Johnson Wildflower Center at the University of Texas at Austin
2008 *NPIN: Passiflora lutea (Yellow passion vine)*. Available at: http://www.wildflower.org/plants/result.php?id_plant=palu2. Accessed October 13, 2008.

Langdon, K.
1985 "White-tailed Deer Action Plan." Supplement to Natural Resources Management Plan, Catoctin Mountain Park. On file at Catoctin Mountain Park, Thurmont, MD.

League for the Hard of Hearing
2003 "Noise Center of The League, 1 888 Noise 88, Noise Levels In Our Environment Fact Sheet." Available at: <http://www.lhh.org/noise/decibel.htm>.

Littlejohn, Margaret
1999 *Rock Creek Park Visitor Study, Report 112*. Moscow, ID: Visitor Services Project Cooperative Park Studies Unit, University of Idaho.

Lopez R.R., N.J. Silvy, J.D. Sebesta, S.D. Higgs, and M.W. Salazar
1998 "A Portable Drop Net for Capturing Urban Deer." In *1998 Proceedings of the Annual Conference of Southeast Association of Fish and Wildlife Agencies* 52:206–9.

Marquis, D.A.
1981 "Effect of Deer Browsing on Timber Production in Allegheny Hardwood Forests of Northwestern Pennsylvania." Northeastern Forest Experiment Station, U.S. Forest Service, Broomall, PA.

Marquis, D.A., R.L. Ernst, and S.L. Stout
1992 *Prescribing Silvicultural Treatments in Hardwood Stands of the Alleghenies. Revised.* General Technical Report NE-96. Northeastern Forest Experiment Station, U.S. Forest Service.

Martha's Bloomers
2008 *Deer-Resistant Plants*. Available at: http://www.marthasbloomers.com/plants/deer-resistant-plants.pdf. Accessed October 13, 2008.

Martin, A.C., H.S. Zim, and A.L. Nelson
1951 *American Wildlife and Plants: A Guide to Wildlife Food Habits — The Use of Trees, Shrubs, Weeds and Herbs by Birds and Mammals of the United States*. New York: Dover Publication, Inc.

Maryland/District of Columbia Audubon Society
2004 "Maryland-District of Columbia Important Bird Areas." In *Rock Creek Park and Rock Creek and Potomac Parkway. Final General Management Plan/ Environmental Impact Statement* (2005a)

Maryland Department of Natural Resources (MD DNR)
1998 *Charting the Course for Deer Management In Maryland: A Management Plan for Whitetailed Deer in Maryland.* Available at: http://www.dnr.state.md.us/wildlife/contents.html.

2005 *Maryland White-tailed Deer Biology*, by Douglas Hotton. Wildlife and Heritage Service. Available at: <http://www.dnr.state.md.us/wildlife/wtdeerbiology.asp>. Site accessed October 12, 2007.

2006–2007 "Maryland Deer Project; 2006-2007 Annual Report." Submitted by Hotton, L. Douglas, George Timko, and Brian Eyler. May 1, 2007.

Maryland Department of Natural Resources, Heritage and Biodiversity Conservation Program
2003 *Current and Historical Rare, Threatened, and Endangered Species of Montgomery County, Maryland*. Available on the Internet athttp://dnrweb.dnr.state.md.us/dowload/rteplants.pdf.

Mathews, N.E. , J. Paul-Murphy, and E. Frank
2005 "Evaluation of a Trap-Sterilize-Release Project for White-tailed Deer Management in Highlands Park, Illinois, 2002-2005." Prepared for the Highlands Park City Council, September 12, 2005.

McCabe, R.E. and T.R. McCabe
1984 "Of Slings and Arrows: An Historical Retrospection." In *White-tailed Deer Ecology and Management*, edited by L.K. Halls.

McCullough, D.E.
1979 *The George Reserve Deer Herd: Population Ecology of a K-Selected Species*. Ann Arbor: University of Michigan Press. McDonald Jr., John E., and Craig S. Hollingsworth

2007 *Preventing Deer Damage*. University of Massachusetts. Available at: http://www.umassvegetable.org/soil_crop_pest_mgt/articles_html/preventing_deer_damage.html.

McDonald, C. and W. McKinley
2009 Mississippi Urban and Suburban Deer: Problems and Solutions.. Available at: http://www.mdwfp.com/level2/Wildlife/Game/Deer/Articles.asp?article=172.

McGregor, Kathryn
2008 *Sylvania Natives*. Available at: http://www.sylvanianatives.com/our_plants-butterfly.php. Accessed April 10, 2008.

McShea, W.J.
2000 "The Influence of Acorn Crops on Annual Variation in Rodent and Bird Populations." *Ecology* 81:228–38.

McShea, W.J. and J.H. Rappole
2000 "Managing the Abundance and Diversity of Breeding Birds Populations through Manipulation of Deer Populations." *Conservation Biology* 14.

McWilliams, W.H., S.L. Stout, T.W.Bowersox, and L.H. McCormick
1995 "Adequacy of Advance Tree-Seedling Regeneration in Pennsylvania's Forests." *Journal of Applied Forestry* 12:187–91.

Mech, D.L.
1990 *The Way of the Wolf. Stillwater*. MN: Voyageur Press, Inc.

Merrifield Garden Center
2008 *Deer Resistant Plants*. Available at: www.merrifieldgardencenter.com/v.php?pg=393. Accessed April 10, 2008.

Metropolitan Washington Airports Authority
2008 *Ronald Reagan Washington National Airport. Monthly Air Traffic Summary Report, July 2008*. Available at: http://www.metwashairports.com/reagan/about_reagan/air_traffic_statistics_2.

Metropolitan Washington Council of Governments
2006 "Deer-Vehicle Collision Report." September 2006.

Miller L.A., K. Crane, S. Gaddis, and G.J. Killian
2000 "Immunocontraception of White-tailed Deer with GnRH Vaccine." *American Journal of Reproductive Immunology* 44:266–74.

2001 "Porcine Zona Pellucida Immunocontraception: Long term Health Effects on White-tailed Deer." *Journal of Wildlife Management* 65(4):941–45.

Minnesota Pollution Control Agency
1999 *A Guide to Noise Control in Minnesota: Acoustical Properties, Measurement, Analysis, Regulation*. Available at: <http://www.nonoise.org/library/sndbasic/sndbasic.htm#2.1>.

Miyara, Federico
1998 "Sound Levels." Scientific Interdisciplinary Ecology and Noise Committee.

Montgomery County, Maryland
1994 "Report of the Task Force to Study White-Tailed Deer Management." April.

1995a "Comprehensive Management Plan for White-tailed Deer in Montgomery County Maryland." Updated 2004.

1995b "Inventory of Rare, Threatened, and Endangered Plant Populations and Significant Habitats on Selected Park Lands of M-NCPPC in Montgomery County, Maryland."

2002 "Montgomery County Deer Management Program Annual Report and Recommendations FY2003." June.

2004 "Comprehensive Management Plan for White-tailed Deer in Montgomery County, Maryland." Montgomery County, MD: Deer Management Work Group.

Morton, G.H., and E.L. Cheatum
1946 "Regional Differences in Breeding Potential of White-tailed Deer in New York." *Journal of Wildlife Management* Vol. 10, no. 3.

Murray, C. and D.R. Marmorek
2004 "Adaptive management: A science-based approach to managing ecosystems in the face of uncertainty. In: N.W.P. Munro, T.B. Herman, K. Beazley, and P. Dearden" (eds.). *Making Ecosystem-based Management Work: Proceedings of the Fifth International Conference on Science and Management of Protected Areas*. Victoria, BC: May 2003. Science and Management of Protected Areas Association, Wolfville, Nova Scotia. Cited IN: Williams et al. 2007. *Adaptive Management: The U.S. Department of the Interior Technical Guide*. Washington, DC: Adaptive Management Working Group, U.S. Department of Interior.

Musani, Amin
n.d. *Sound Advice*. Available at: <http://keepandbeararms.com/information/XcIBViewItem.asp?ID=2052>.

Myers, J.A., M. Vellend, S. Gardescu, and P.L. Marks
2004 "Seed Dispersal by White-tailed Deer: Implications for Long-distance Dispersal, Invasion, and Migration of Plants in Eastern North America." *Oecologia* 139:35–44.

National Audubon Society

n.d. "National Audubon Christmas Bird Count Data—Washington, DC Count." Rock Creek Nature Center and Carter Barron Sections. 1980–2002.

National Park Service, U.S. Department of the Interior (NPS)

n.d.a "Rock Creek Park Volunteer Breeding Bird Census Data, 1993–2002." Unpublished.

1991 Director's Order 77. *Natural Resource Protection*. January 1, 1991.

1993 *Tennis Stadium, Rock Creek Park, Washington, DC, Final Environmental Impact Statement*. Denver Service Center.

1995 *Gettysburg National Military Park and Eisenhower National Historic Site, White-tailed Deer Management Plan and Environmental Impact Statement*. Gettysburg, PA.

1996a *Natural Resources Management Plan*, *Rock Creek Park*. Washington, DC.

1996b "The Secretary of the Interior's Standards for the Treatment of Historic Properties, with Guidelines for the Treatment of Cultural Landscapes." Washington, DC.

1997a "An Aquatic Subterranean Macroinvertebrate Survey of Rock Creek and Associated National Parks, Washington, DC." Principal Investigator, Daniel J. Feller. Washington, DC.

1997b Technical Report of Monitoring of Carbon Monoxide Concentrations and Noise Levels in Rock Creek Park, Washington DC, Denver Service Center. April.

1998 "Draft Cultural Landscapes Inventory, Rock Creek Park." On file at the National Park Service Headquarters, Rock Creek Park, Washington, DC.

1999 *Reference Manual #18: Wildland Fire Management*. Washington, DC. Available at: <http://www.nps.gov/fire/fire/fir_wil_pla_reference18.cfm>.

2000a "Cultural Landscape Report: Dumbarton Oaks Park, Rock Creek Park." U.S. Department of the Interior, National Park Service, National Capital Region, Cultural Landscape Program. Washington, DC.

2000b Director's Order 47. *Soundscape Preservation and Noise Management*. December 1, 2000.

2001 Director's Order 12. *Environmental Impact Analysis*. August 1, 2001.

2002a *CWD Translocation Memorandum*. Issued by the Director, NPS, July 6, 2002. Available from NPS Biological Resources Management Division, Fort Collins, CO.

2002b Director's Order 28. *Cultural Resource Management Guideline*. November 6, 2002.

2003a "Cultural Landscapes Inventory, Linnaean Hill, Rock Creek Park." 1998, rev. 2003. National Park Service, Washington, DC.

2003b "Cultural Landscapes Inventory, Peirce Mill, Rock Creek Park." 1998, rev. 2003. National Park Service, Washington, DC.

2003c Director's Order 77-2: *Floodplain Management*. September 8, 2003.

2003d *Rock Creek Park Long-range Interpretive Plan*. Washington, DC.

2003e *Rock Creek Park and Rock Creek and Potomac Parkway Telecommunications Facilities Environmental Assessment*. Washington, DC.

2004a "Draft Invasive Exotic Plant Management Plan." Rock Creek Park, National Park Service, Washington, DC.

2004b *Fort Circle Parks: General Management Plan / Environmental Assessment*. May 2004.

2004c *Rock Creek Park Fire Management Plan*. On file at Rock Creek Park.

2004d "Montrose Park Cultural Landscape Report."

2004e U.S. Department of the Interior. Departmental Manual 516 DM 64.10(A)(5). 2004.

2004f *Environmental Commitment Statement*. Washington, DC. Available at: www.nps.gov/rocr.

2004g "Inventory and Monitoring Program: White-tailed Deer Density Monitoring Protocol Version 1.0: Distance and Pellet Group Surveys." National Capital Region Network, Washington, DC.

2004h *Public Use Statistics for Rock Creek Park*. Available at: http://www2.nature.nps.gov/stats/.

2005a *Rock Creek Park and Rock Creek and Potomac Parkway. Final General Management Plan/ Environmental Impact Statement*.

2005b "Draft Cultural Landscape Inventory, Chevy Chase Circle, Rock Creek Park." Copy on file at National Park Service Headquarters, Rock Creek Park, Washington, DC.

2005c "Rock Creek Park, Unpublished Background Information supplied at Internal Scoping." December 2, 2005.

2005d "Deer Management Plan and Environmental Impact Statement, Final Internal Scoping Report, Rock Creek Park," Washington DC: National Park Service. November 28, 2005.

2005e *Human Consumption of Elk and Deer Meat Gathered from Areas with Endemic Chronic Wasting Disease: A Public Health Perspective*, by George A. Larsen. Dec. 22. Washington, DC: Office of Public Health, Visitor and Resource Protection Directorate.

2006 NPS *Management Policies 2006*. Washington, DC.

2007a *Yearly Visitation Numbers at Rock Creek Park*. NPS Public Use Statistics Office. Available at http://www2.nature.nps.gov/stats/.

2007b *Monthly Recreational versus Non-Recreational Use of Rock Creek Park*. NPS Public Use Statistics Office. Available at http://www2.nature.nps.gov/stats/.

2007c *Coyotes Frequently Asked Questions*. Available at: http://www.nps.gov/rocr/nature/science/coyotefaq.htm.

2007d *Final Report: Science Team Summary; Rock Creek Park Deer Management Plan / Environmental Impact Statement.*

2008a *Visitor Use Statistics*. Available at http://www.nature.nps.gov/stats.

2008b Unpublished Data- NPSpecies Data for Rock Creek Park. Available from NPS Center for Urban Ecology, Washington, DC.

2008c *Rock Creek Park Things To Do*. Available at: http://www.nps.gov/rocr/planyourvisit/things2do.htm.

Nature Conservancy

1998 "Vegetation Classification of Rock Creek Park." NBS/NPS Vegetation mapping program. March 1998.

Natureserve

2008 *Juglans nigra*. Available at: http://www.natureserve.org/explorer/servlet/NatureServe?searchName=Juglans+nigra+. Accessed October 13, 2008.

Naugle, R. and A. Rutberg

2007 *Immunocontraception of White-tailed Deer at Fire Island National Seashore. 2007 Progress Report*. Gaithersburg, MD: Humane Society of the United States. 6 p.

Naugle, R.E., A.T. Rutberg, H.B. Underwood, J.W. Turner, Jr., and I.K.M. Liu

2002 "Field Testing Immunocontraception on White-tailed Deer (*Odocoileus virginianus*) on Fire Island National Seashore, New York, USA." *Reproduction Supplement* 60:145–53.

Neighborhood Info DC

2007a *DC Ward Profiles for Wards 1,2,3, and 4*. Accessible at http://www.neighborhoodinfo.org/wards.

2007b "District of Columbia Housing Monitor." Spring 2007.

2007c *Neighborhood Info DC*. Available at: http://www.neighborhoodinfodc.org/index.html. Select "Neighborhood Clusters" for neighborhood-level information. Accessed on October 12, 2007.

New England Wild Flower Society

1997 *Conservation Notes of the New England Wild Flower Society, Volume 1, Number 3*. Available at: http://www.newfs.org/docs/docs/wfn97.pdf. Accessed April 10, 2008.

New York National Heritage Program (NYNHP)

2008 *Conservation Guide – Virginia Snakeroot*. Available at: http://www.acris.nynhp.org/report.php?id=8726. Accessed April 10, 2008.

Nielsen, C. K., W. F. Porter, and H. B. Underwood

1997 "An adaptive management approach to controlling suburban deer." *Wildlife Society Bulletin* 25:470–477.

Niewinski, A.T., T.W. Bowersox, and R.L. Laughlin
2006 *Vegetation Status in Selected Woodlots at Gettysburg National Military Park, Pre and Post White-tailed Deer Management*. Technical Report NPS/NER/NRTR--2006/037. USDI NPS Northeast Region, Philadelphia, PA.

Noise Pollution Clearinghouse
n.d. *Protective Noise Levels—Condensed Version of EPA Levels Document*. Available at: <http://www.nonoise.org/library/levels/levels.htm>.

Northeast Deer Technical Committee
2008 An Evaluation of Deer Management Options. 28 pp.

Nuss, Robert
2000 *Good Landscaping Enhances Home Value*. Available at:. http://www.psu.edu/ur/2000/landvalue.html. Accesessed January 3, 2000.

O'Bryan, M.K. and D.R. McCullough
1985 "Survival of Black-tailed Deer Following Relocation in California." *Journal of Wildlife Management* 49:115–19.

Ohio State University
2008 *Quercus Imbricaria*. Available at: http://hcs.osu.edu/plantlist/description/qu_caria.html. Accessed October 13, 2008.

OPTI Canada Inc..
2000 *Noise Evaluation*. Long Lake Project Application and Environmental Impact Assessment (EIA), December 2000. Volume 2, Section E5.1. Available at: <http://www.longlake.ca/EIA/application.asp>.

Parsons
2004 "June 2004 Traffic Study for Rock Creek Park, Washington, D.C. – Final." By Joseph Springer, Fairfax, VA, prepared for NPS, Denver Service Center In *Rock Creek Park and Rock Creek and Potomac Parkway. Final General Management Plan/ Environmental Impact Statement* (2005a).

Pavek, Diane
2002 "Endemic Amphipods in our Nation's Capital." *Endangered Species Bulletin* 27:1; January/February 2002.

Penn State Cooperative Extension
2008 *Deer-Resistant Plants*. Available at: http://pike.extension.psu.edu/Horticulture/DeerResistantPlants.pdf. Accessed April 10, 2008.

Perry, Leonard
2008 *Deer Resistant Perennials*. University of Vermont Extension, Department of Plant and Soil Science. Available: http://www.uvm.edu/pss/ppp/articles/deerres.htm. Accessed April 10, 2008.

Pfaffko, Mary
2006 "District of Columbia Wildlife Action Plan." Government of the District of Columbia. Department of the Environment, Fisheries and Wildlife Division, 51 North Street, NE, Washington, DC 2002. 127 pp.

Plants for a Future
2008 *Lycopodium clavatum – Plants for a future database report.* Available at: http://www.pfaf.org/database/plants.php?Lycopodium+clavatum. Accessed October 13, 2008.

Porter, W.F.
1991 "White-tailed Deer in Eastern Ecosystems: Implications for Management and Research in National Parks." Natural Resources Report NPS/NRSUNY/NRR-91/05. Washington, DC.

Porter, W.F., H.B. Underwood, and J.L. Woodard
2004 "Movement Behavior, Dispersal, and the Potential for Localized Management of Deer in Suburban Environments." *Journal of Wildlife Management* 68(2):223–34.

Redding, J.
1995 "History of Deer Population Trends and Forest Cutting in the Allegheny National Forest." In *Proceedings of the 10th Central Hardwood Forest Conference*, edited by K. Gottschalk and S.L. Fosbroke, 214–24. General Technical Report NE-197, Forest Service, U.S. Department of Agriculture.

Rooney, T.P.
2001 "Deer Impacts on Forest Ecosystems: A North American Perspective." *Forestry* 74(3).

Rossell, C. Reed, Jr., S. Patch and S. Salmons
2007 "Effects of Deer Browsing on Native and Non-native Vegetation in a Mixed Oak-Beech Forest on the Atlantic Coastal Plain. *Northeastern Naturalist* 14(1):61–72.

Rossman, Bob
2006 "The Science of Sound: Acoustics and Soundscape Management." In Harmon, David (ed.) *People, Places, and Parks: Proceedings of the 2005 George Wright Society*. Conference on Parks, Protected Areas, and Cultural Sites. Hancock, MI.

Rudolph, B.A., W.F. Porter, and H.B Underwood
2000 "Evaluating Immunocontraception for Managing Suburban White-tailed Deer in Irondequoit New York." *Journal of Wildlife Management* 64:463–73.

Russel et al.
2001 "Effects of White-Tailed Deer on Plants, Plant Populations and Communities." *American Midland Naturalist* 146(1).

Sage, R.W., Jr., W.F. Porter, and H.B. Underwood
2003 "Windows of Opportunity: White-tailed Deer and the Dynamics of Northern Hardwood Forests of the Northeastern U.S." *Journal for Nature Conservation* 10:213–20.

Salmons, Sue
2000 "Invasive Non-Native Plant Mitigation Program Final Report." Rock Creek Park. Washington, DC.

Sams, M. G., R. L. Lochmiller, C. W. Qualls, Jr., and D. M. Leslie, Jr.
1998 "Sensitivity of Condition Indices to Changing Density in a White-tailed Deer Population." *Journal of Wildlife Diseases* 34 (1) 110–25.

Schomer, Paul
2001 "A White Paper: Assessment of Noise Annoyance." Champaign, IL: Schomer and Associates. April.

Schultz, T.J.
1978 "Synthesis of Social Surveys on Noise Annoyance." *Journal of the Acoustical Society of America* 64(2):377–405.

Schwartz J.A., R.J. Warren, D.W. Henderson, D.A. Osborn, and D.J. Kesler
1997 "Captive and Field Tests of a Method for Immobilization and Euthanasia of Urban Deer." *Wildlife Society Bulletin* 25(2):532–41.

Sexton, W.T., A. Malk, R.C. Szaro, and N. Johnson (editors)
1999 *Ecological Stewardship: A Common Reference for Ecosystem Management, Volume 3: Values, Social Dimensions, Economic Dimensions, Information Tools*. Oxford, UK: Elsevier Science. Cited in: Williams et al. 2007. *Adaptive Management: The U.S. Department of the Interior Technical Guide*. Washington, DC: Adaptive Management Working Group, U.S. Department of Interior.

Seymour, Randy
1997 *Wildflowers of Mammoth Cave National Park*. Kentucky: University Press of Kentucky.

Shafer, E.L.
1965 *Deer Browsing of Hardwoods in the Northeast*. U.S. Forest Service Research Paper NE-33.

Simons, Patti
2008 *Camouflage Gardening: Deer-Resistant Plants*. Native Plant Society of Texas. Available at: http://www.npsot.org/plant_lists/deer_resistant.htm. Accessed April 10, 2008.

Slattery, B.E., K. Reshetiloff, and S.M. Zwicker
2003 *Native Plants for Wildlife Habitat and Conservation Landscaping: Chesapeake Bay Watershed.* Annapolis, MD: U.S. Fish & Wildlife Service, Chesapeake Bay Field Office. 82 pp.

Smithsonian Migratory Bird Center
2003 Available at: www.nationalzoo.si.edu/ConservationAndScience/migratorybirds/factsheets/default.cfm

Southeastern Cooperative Wildlife Disease Study
2000 "HD Virus Cross-Immunity." *SCWDS Briefs* 16 (1):1–2. Available at: http://www.uga.edu/scwds/topic_index.html.

Storm, G.L and A.S Ross
1992 *A Manual for Monitoring Vegetation on Public Lands in the Mid-Atlantic United States*. University Park, PA: Pennsylvania Cooperative Fish and Wildlife Unit, MANV-00192.

Stott, J.L.
1998 "Bluetongue and Epizootic Hemorrhagic Disease." In *Part IV: Foreign animal Diseases, "The Gray Book."* Richmond, VA: Committee on Foreign Animal Diseases, United States Animal Health Association. Available at: http://www.vet.uga.edu/vpp/gray_book?FAD?BLT.htm.

Stout, S.L.
1999 "Assessing the Adequacy of Tree Regeneration on the Cuyahoga Valley National Recreation Area: A Literature Review and Recommendations." On file at Cuyahoga Valley National Recreation Area.

Sullivan, Janet
1993 "*Quercus lyrata*." In *Fire Effects Information System*. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory. Available at: http://www.fs.fed.us/database/feis/. Accessed April 10, 2008.

Sunlight Gardens
2008 *Sunlight Gardens – Passiflora lutea, Passion Flower, Yellow*. Available at: http://www.sunlightgardens.com/pages/1385.html. Accessed October 13, 2008.

Suter, Alice
1991 *Noise and Its Effects*. Prepared for the Administrative Conference of the United States. Available at: http://www.nonoise.org/library/suter/suter.htm#annoyance.

Swihart, R.K. and M.R. Conover
1991 "Reducing Deer Damage to Yews and Apple Trees: Testing Big Game Repellent®, Ropel®, and Soap as Repellents." *Wildlife Society Bulletin* 18:156–62.

Sylvania Natives
2008 *Sylvania Natives – Our Plants.* Available at: http://www.sylvanianatives.com/our_plants-deer.php. Accessed October 13, 2008.

Taylor, Chris
2003 *Fertile Ground*. March 2003. Smart Money Magazine. http://www.smartmoney.com/mag/index.cfm?story=march03-cover&hpadref=1.

Tilghman, N.G.
1989 "Impacts of White-tailed Deer on Forest Regeneration in Northwestern Pennsylvania." *Journal of Wildlife Management* 53:524–32.

Truax, Barry
1999 *Handbook for Acoustic Ecology*. Second edition. Available at: http://www.sfu.ca/sonic-studio/handbook/index.html.

Turner, John W., Jr., Jay F. Kirkpatrick, and Irwin K.M. Liu
1996 "Effectiveness, Reversibility, and Serum Antibody Titers Associated with Immunocontraception in Captive White-tailed Deer." *Journal of Wildlife Management* 60(1): 45–51.

University of California Cooperative Extension
2008 *Deer-Resistant Plants for the Sierra Foothills (Zone 7)*. Available at: http://ucce.ucdavis.edu/files/filelibrary/1808/11076.pdf. Accessed April 10, 2008.

University of Illinois Extension
2008 *Gardening with Perennials – Deer Resistant Perennials*. Available at: http://www.urbantext.uiuc.edu/perennials/deer.html.; and *UI Plants: Woody Ornamentals*. Available at: http://woodyplants.nres.uiuc.edu/plant/casde50. Both accessed April 10, 2008.

U.S. Census
2007 *Demographic information for the U.S. population*. Available at: www.census.gov.

U.S. Department of Agriculture
1976 *Soil Survey of District of Columbia*. United States Department of Agriculture, Natural Resources Conservation Service.

2000a *Environmental Assessment: Shooting White-tailed Deer to Contribute to Deer Population Reduction Objectives in New Jersey*.

2000b *Pre-Decisional Environmental Assessment, Deer Damage Management in the Commonwealth of Virginia*.

2003 *Environmental Assessment, White-tailed Deer Damage Management in Pennsylvania.*

U.S. Department of the Interior
n.d. *Final Environmental Impact Statement, Miccosukee 3-1 Exploratory Well, Broward County, Florida.* Washington, DC. IN: USDI, NPS, 2005; Final Oil and Gas Management Plan/EIS, December 2005.

U.S. Fish and Wildlife Service, National Wetlands Inventory
2007 *National Wetlands Inventory Wetlands Mapper*. Available at: http://wetlandsfws.er.usgs.gov/NWI/index.html.

U.S. Fish and Wildlife Service, U.S. Department of the Interior
1992 *Migratory Bird Treaty Act of 1918. In Digest of Federal Resource Laws of Interest to the U.S. Fish and Wildlife Service*. Available at: http://laws.fws.gov/lawsdigest/migtrea.html.

2007a *Threatened and Endangered Species List*. Available at http://ecos.fws.gov/tess_public/StateListing.do?state=DC&status=listed.

2007b "Endangered and Threatened Wildlife and Plants – 90 day finding on a petition to list Kenk's amphipod, Virginia well amphipod, and the copepod *Acanthocyclops columbiensis* as Endangered." 72 *Federal Register* 175: 51766–51769, September 11, 2007.

U.S. Fish and Wildlife Service and National Marine Fisheries Service
1998 *Endangered Species Consultation Handbook, Procedures for Conducting Consultation and Conference Activities Under Section 7 of the Endangered Species Act*.

U.S. Fish and Wildlife Service, U.S. Department of the Interior and U.S. Bureau of the Census, U.S. Department of Commerce

2005a *Mason Neck National Wildlife Refuge Potomac River National Wildlife Refuge Complex Fact Sheet*. Available at: http://www.fws.gov/northeast/facts/MasonNeck05.pdf. January.

2005b "Mason Neck National Wildlife Refuge, Woodbridge, Virginia, Annual Big Game Hunting Plan for 2005." November.

2005c "Occoquan Bay National Wildlife Refuge, Woodbridge, Virginia, Annual Big Game Hunting Plan for 2005." November.

U.S. Forest Service (USFS)

2008 *Index of Species Information - Tree List*. Available at: http://www.fs.fed.us/database/feis/plants/tree.

Vellend, M.

2002 "A Pest and an Invader: White-tailed Deer (Odocoileus virginianus Zimm.) as a Seed Dispersal Agent for Honeysuckle Shrubs (Lonicera L.)." *Natural Areas Journal* 22:230–234.Verme, L.J.

Vellend, M., J.A. Myers, S. Gardescu, and P.L. Marks

2004 "Seed dispersal by white-tailed deer: implications for long-distance dispersal, invasion, and migration of plants in eastern North America." *Oecologia* 139:35–44.

Verme,L.J.

1965 "Reproduction Studies on Penned White-tailed Deer." *Journal of Wildlife Management* 29(1).

Verme, L.J., and D.E. Ullrey

1984 "Physiology and Nutrition." In *White-tailed Deer*, edited by L. K. Halls, 91–118. Harrisburg, PA: Stackpole Books.

Walter, W.D., P.J. Perkins, A.T. Rutberg, and H.J. Kilpatrick

2002a "Evaluation of Immunocontraception in a Free-ranging Suburban White-tailed Deer Herd." *Wildlife Society Bulletin* 30:186–2.

Warren, R.J.

1991 "Ecological Justification for Controlling Deer Populations in Eastern National Parks." *Transactions of the 56th North American Wildlife and Natural Resources Conference*.

1997 "Deer Population Management through Hunting and Alternative Means of Control." In *Proceedings of the Conference on Deer as Public Goods and Public Nuisance*, edited by B. L. Gardner, 81–88. University of Maryland, College Park. Available at <http://www.arec.umd.edu/Policycenter/Deer-Management-in-Maryland/warren.htm>.

West Virginia University

1985 "Deer and Agriculture in West Virginia." Publication 820. Center for Extension and Continuing Education, Cooperative Extension Service. Available at <http://www.wvu.edu/~exten/infores/pubs/pest/deer820.pdf>. Accessed July 17, 2005.

West Virginia University Extension Service
2008 *Resistance of Ornamentals to Deer Damage*. Available at: http://www.wvu.edu/~Agexten/hortcult/treeshru/resistan.htm. Accessed April 10, 2008.

WHITE BUFFALO, Inc.
2005 *Review of Available Techniques*. Available at <http://www.whitebuffaloinc.org/techniques.htm>. Accessed Jan. 24, 2006.

Williams, E.S, J.K. Kirkwood, and M.W. Miller
2008. "Transmissible Spongiform Encephalopathies." In *Infectious Diseases of Wild Mammals*. Third Ed. Online. Edited by E.S. Williams and I.K. Barker 292–301. Blackwell Publishing.

Williams, B.K, R. C. Szaro, and C.D. Shapiro
2007 *Adaptive Management: The U.S. Department of the Interior Technical Guide*. Washington, DC: Adaptive Management Working Group, U.S. Department of Interior.

Williams, S.C. and J.S. Ward
2006 "Exotic Seed Dispersal by White-tailed Deer in Southern Connecticut." *Natural Areas Journal* 26:383–390.

Willson, M.F.
1993 "Mammals as Seed-dispersal Mutualists in North America." *Oikos* 67:159–167.

PERSONAL COMMUNICATIONS

Armstead, Tawana. Secretary to the Superintendent, Rock Creek Park

2007 Personal communication with Ashley Cobb, The Louis Berger Group, regarding the amount and type of complaints filed by neighboring citizens about deer incidents. October 25, 2007.

Bates, Scott. NPS Center for Urban Ecology

2008a Personal communication with Nancy Van Dyke, The Louis Berger Group, regarding Maryland state ranking of state listed species in Rock Creek Park. June 27, 2008.

2008b Personal communication with Nancy Van Dyke, The Louis Berger Group, regarding K. Sullivan presentation at Wildlife Society meeting. September 5, 2008.

2008c Personal communication with Nancy Van Dyke, The Louis Berger Group, regarding K. Sullivan presentation, USDA deer removal, references, current status and role of deer. June 27, 2008.

2008d Personal communication with Nancy Van Dyke, The Louis Berger Group, regarding Highland Park Study, distance surveys, Cornell bird data. September 5, 2008.

2008e Personal communication with Nancy Van Dyke, The Louis Berger Group, regarding Distance Sampling results from 2000 to 2007. January 6, 2009.

Bowersox, Todd, Department of Forestry, Pennsylvania State University

2005 Personal communication with Beth Kunkel, Science Team facilitator, White-tailed Deer Management Plan/Environmental Impact Statement, Catoctin Mountain Park, National Park Service, as confirmed by Beth Kunkel, email to N. Van Dyke and Kristina Heister , May 14, 2008.

Champagne, Jennifer. Administrative Officer, Rock Creek Park

2007 Personal communication with Rebecca Byron, The Louis Berger Group, regarding human health and safety at the park. October 18, 2007.

Ferebee, Ken, Natural Resource Manager Rock Creek Park

2005 Personal Communication at Internal Scoping Meeting RE: deer history in ROCR. July 13-14, 2005.

2006 Personal communication with Beth Kunkel, URS Corporation, regarding roadkill data for Rock Creek Park (1996 – 2006). September 18, 2006.

2007a Personal communication with Beth Kunkel, URS, Corporation, regarding 2006 roadkill data. January 29, 2007.

2007b Personal communication with Beth Kunkel, URS Corporation, regarding deer density data. January 29, 2007.

2007c Personal communication with Lori (Gutman) Fox, the Louis Berger Group, Inc., regarding the socioeconomic impacts of deer on the park and neighboring communities. October 16, 2007.

2007d Personal communication with Nancy Van Dyke, the Louis Berger Group, Inc., regarding rare plants, vegetation, park management and operations. October 29, 2007.

2007e Personal communication with Ashley Cobb, the Louis Berger Group, Inc., regarding deer disease, forest conditions, fishing, community gardens, safety. October 25, 2007.

2007f Personal communication with Ashley Cobb, the Louis Berger Group, Inc., regarding complaints about deer damage. October 25, 2007.

2007g Personal communication with Nancy Van Dyke, the Louis Berger Group, Inc., regarding ground nesting birds in Rock Creek Park. November 1, 2007.

2007h Personal communication (email) with Beth Kunkel, Kimley-Horn Associates, regarding deer telemetry data. December 17, 2007.

2008a Personal communication with Nancy Van Dyke, the Louis Berger Group, Inc., regarding latest deer density and other monitoring information, visitation trends, turbidity/water/tributaries, browse impacts, deer health observations, golf course noise levels. March 11, 2008.

2008b Personal communication with Nancy Van Dyke, the Louis Berger Group, Inc., regarding cumulative impact scenario. March 24, 2008.

2008c Personal communication with Nancy Van Dyke, the Louis Berger Group, Inc., regarding Spotlight survey accuracy, MOU, Montgomery County deer program. January 10, 2008.

2008d Personal communication with Nancy Van Dyke, the Louis Berger Group, Inc., comments on home range/deer usage of park and surrounding areas in Chapter 3 draft comments and at roundtable meeting. June 24, 2008.

2008e Personal communication with Nancy Van Dyke, the Louis Berger Group, Inc., regarding erodible soils, vegetation cover types, cost of invasive species control, spotlight route distance, hiking/biking trails, USPP function. August 20, 2008.

2008f Personal communication with Nancy Van Dyke, the Louis Berger Group, Inc., regarding spotlight count data and standard error for 2007. April 9, 2008.

2008g Personal communication with Nancy Van Dyke, the Louis Berger Group, Inc., regarding deer herd composition, cost of fencing, 2007 staffing levels, consultation letters, October 17, 2008.

2008h Personal communication with Nancy Van Dyke, the Louis Berger Group, Inc., regarding M-NCPPC cooperation, October 26, 2008.

2008i Personal communication with Nancy Van Dyke, the Louis Berger Group, Inc., reconfirming distance deer typically move outside the park, December 18, 2008.

Gunther, R. Rock Creek Park

2007 Personal communication with Lori (Gutman) Fox, the Louis Berger Group, Inc., regarding park visitation numbers and visitor safety. August 16 2007.

2008 Personal communication with Nancy Van Dyke, the Louis Berger Group, Inc., regarding recent accident statistics. April 8, 2008.

Hamilton, William

2008 Personal communication with Nancy Van Dyke, the Louis Berger Group, Inc., regarding Montgomery County managed deer hunts. January 11, 2008.

Illige, Laura. National Park Service, Rock Creek Park

2005 Personal communication with Lori (Gutman) Fox, the Louis Berger Group, Inc., August 25, 2007.

Newman, Alberta. Employee Relations Specialist, Rock Creek Park

2007 Personal communication with Rebecca Byron, The Louis Berger Group, regarding employee safety information for Rock Creek Park. October 24, 2007.

Pavek, Diane

2008 Personal communication with Nancy Van Dyke, The Louis Berger Group, and Melissa Behrent, NPS EQD., regarding Palisades neighborhood airplane flyovers. September 12, 2008.

Sherald, Jim

2008 Personal communication with Ken Ferebeee, NPS Rock Creek Park., regarding Watershed Condition Assessments. July 9, 2008

GLOSSARY

Action Alternative — An alternative that proposes a different management action or actions to address the purpose, need, and objectives of the plan; one that proposes changes to the current management. Alternatives B, C, and D are the action alternatives in this planning process. See also: "No-Action Alternative."

Adaptive Management — The rigorous application of management, research, and monitoring to gain information and experience necessary to assess and modify management activities. A process that uses feedback from research and the period evaluation of management actions and the conditions they produce to either reinforce the viability of objectives, strategies, and actions prescribed in a plan or to modify strategies and actions in order to more effectively accomplish management objectives.

Affected Environment — A description of the existing environment that may be affected by the proposed action (40 CFR 1502.15).

Antibody — An immunoprotein that is produced by lymphoid cells in response to a foreign substance (antigen), with which it specifically reacts.

Antigen — A foreign substance, usually a protein or polysaccharide, which stimulates an immune response upon introduction into a vertebrate animal.

Anthracnose — Any of several plant diseases caused by certain fungi and characterized by dead spots on the leaves, twigs, or fruits.

Biobullet — A single dose, biodegradable projectile comprised of an outer methylcellulose casing containing a solid, semi-solid, or liquid product (usually a vaccine or chemical contraceptive), propelled by a compressed-air gun.

Blight — Any of numerous plant diseases that result in sudden and conspicuous wilting and dying of affected parts, especially young growing tissues.

Bluetongue Virus — An insect-transmitted, viral disease of ruminant animals, including white-tailed deer, which causes inflammation, swelling, and hemorrhage of the mucous membranes of the mouth, nose, and tongue.

Browse Line — A visible delineation at approximately six feet below which most or all vegetation has been uniformly browsed.

Caging — Small scale fencing that is placed around individual plants to protect them from deer browsing; caging is common to all alternatives in this document.

Carrying Capacity — The maximum number of organisms that can be supported in a given area or habitat.

Cervid — A member of the deer family, such as white-tailed deer, mule deer, elk, moose, and caribou.

Chronic Wasting Disease (CWD) — A slowly progressive, infectious, self-propagating neurological disease of captive and free-ranging deer, elk, and moose. CWD belongs to the transmissible spongiform encephalopathy (TSE) group of diseases and is characterized by accumulations of abnormal prion proteins in neural and lymphoid tissue.

Contragestive — A product that terminates pregnancy.

Cultural Landscape — A geographic area (including both cultural and natural resources and the wildlife or domestic animals therein) associated with a historic event, activity, or person or exhibiting other cultural or aesthetic values.

Cumulative Impacts — Those impacts on the environment that result from the incremental effect of the action when added to the past, present, and reasonable foreseeable future actions regardless of what agency (federal or nonfederal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time (40 CFR 1508.7).

Deer Herd — The group of deer that have common characteristics and interbreed among themselves. For the purposes of this plan, this term is synonymous with deer population.

Deer Population — See Deer Herd, above.

Demographic — Referring to the intrinsic factors that contribute to a population's growth or decline: birth, death, immigration, and emigration. The sex ratio of the breeding population and the age structure (the proportion of the population found in each age class) are also considered demographic factors because they contribute to birth and death rates.

Depredation — Damage or loss.

Direct Reduction — Lethal removal of deer; includes both sharpshooting and capture/euthanasia.

Distance Sampling — An analytical method to estimate population density that involves an observer traveling along a transect and recording how far away objects of interest are.

Endemic — Native to or confined to a particular region.

Ecosystem — An ecological system; the interaction of living organisms and the nonliving environment producing an exchange of materials and energy between the living and nonliving.

Epizootic Hemorrhagic Disease (EHD) — An insect-borne viral disease of ruminants that causes widespread hemorrhages in mucous membranes, skin, and visceral organs.

Environment — The sum total of all biological, chemical, and physical factors to which organisms are exposed; the surroundings of a plant or animal.

Environmental Assessment (EA) — A concise public document, prepared in compliance with NEPA, that briefly discusses the purposes and need for an action, and provides sufficient evidence and analysis of impacts to determine whether to prepare an environmental impact statement or finding of no significant impact (40 CFR 1508.9).

Environmental Consequences — Environmental effects of project alternatives, including the proposed action, any adverse environmental effects which cannot be avoided, the relationship between short term uses of the human environment, and any irreversible or irretrievable commitments of resources which would be involved if the proposal should be implemented (40 CFR 1502.16).

Environmental Impact Statement (EIS) — A detailed written statement required by Section 102(2)(C) of NEPA, analyzing the environmental impacts of a proposed action, adverse effects of the project that cannot be avoided, alternative courses of action, short term uses of the environment versus the maintenance and enhancement of long term productivity, and any irreversible and irretrievable commitment of resources (40 CFR 1508.11).

Ethnographic Resource — Any site, structure, object, landscape, or natural resource feature assigned traditional legendary, religious, subsistence, or other significance in the cultural system of a group traditionally associated with it.

Euthanasia — Ending the life of an animal by humane means.

Exclosure — A large area enclosed by fencing to keep out deer and allow vegetation to regenerate.

Exotic Species — Any introduced plant, animal or protist species that is not native to the area and may be considered a nuisance; also called non-native or alien species.

Extirpated Species — A species that is no longer present in an area where it once lived.

Exsanguination — The action or process of draining blood.

Fenced Plot — An area enclosed by a fence to keep deer out so vegetation can grow without the influence of deer browsing.

Folliculogenesis — the maturation of the ovarian follicle (see below)

Follicle — one of the small ovarian sacs containing an immature egg

Follicle Stimulating Hormone — a hormone synthesized and secreted by the pituitary gland that (in females) stimulates the growth of immature follicles to maturation.

Forest Regeneration — For the purposes of this plan, the regrowth of forest species and renewal of forest tree cover such that the natural forest sustains itself without human intervention.

Genetic Variability — The amount of genetic difference among individuals in a population.

Habitat — The environment in which a plant or animal lives (includes vegetation, soil, water, and other factors).

Hectare — A metric unit of area equal to 2.471 acres.

Herbaceous Plants — Non-woody plants; includes grasses, wildflowers, and sedges and rushes (grass-like plants).

Herbivore — An animal that eats a diet consisting primarily of plant material.

Histopathology — The study of the microscopic anatomical changes in diseased tissue.

Home Range — The geographic area in which an animal normally lives.

Hypothesis — A tentative explanation for an observation or phenomenon that can be tested by further investigation.

Immunocontraception — The induction of contraception by injecting an animal with a compound that produces an immune response that precludes pregnancy.

Immunocontraceptive — A contraceptive agent that causes an animal to produce antibodies against some protein or peptide involved in reproduction. The antibodies hinder or prevent some aspect of the reproductive process.

Impairment (NPS Policy) — As used in NPS Management Policies, "impairment" means an adverse impact on one or more park resources or values that interferes with the integrity of the park's resources or values, or the opportunities that otherwise would exist for the enjoyment of them, by the present or a future generation. Impairment may occur from visitor activities, NPS activities in managing a park, or activities undertaken by concessioners, contractors, and others operating in a park. As used here, the impairment of park resources and values has the same meaning as the phrase "derogation of the values and purposes for which these various areas have been established," as used in the General Authorities Act.

Impairment (Clean Water Act) — As used in conjunction with the Clean Water Act and associated state water quality programs, a water body is “impaired” if it does not meet one or more of the water quality standards established for it. This places the water body on the “impaired waters list”, also known as the “303(d) list” for those pollutants that exceed the water quality standard.

Infrared — The range of invisible radiation wavelength just longer than the red in the visible spectrum.

Irretrievable — A term that applies to the loss of production, harvest, and consumptive or nonconsumptive use of natural resources. For example, recreation experiences are lost irretrievably when

an area is closed to human use. The loss is irretrievable, but the action is not irreversible. Reopening the area would allow a resumption of the experience.

Irreversible — A term that describes the loss of future options. Applies primarily to the effects of use of nonrenewable resources, such as minerals or cultural resources, or to those factors, such as soil productivity that are renewable only over long periods of time.

Landscape/Habitat Fragmentation — The breaking up of large, contiguous blocks of habitat or landscape into small, discontinuous areas that are surrounded by altered or disturbed lands.

Leuprolide — A reproductive control agent that prevents secondary hormone secretion, which stops the formation of eggs and ovulation. Leuprolide is a GnRH agonist (see appendix C for additional details).

Luteinizing Hormone — a hormone which triggers ovulation in females.

Monitoring — A process of collecting information to evaluate if an objective and/or anticipated or assumed results of a management plan are being realized (effectiveness monitoring) or if implementation is proceeding as planned (implementation monitoring).

National Environmental Policy Act of 1969 — A law that requires all Federal agencies to examine the environmental impacts of their actions, incorporate environmental information, and utilize public participation in the planning and implementation of all actions. Federal agencies must integrate NEPA with other planning requirements and prepare appropriate NEPA documents to facilitate better environmental decision making. NEPA requires Federal agencies to review and comment on Federal agency environmental plans/documents when the agency has jurisdiction by law or special expertise with respect to any environmental impacts involved (42 U.S.C. 4321-4327) (40 CFR 1500-1508).

Naturally Regenerating and Sustainable Forest — A forest community that has the ability to maintain plant and animal diversity and density by natural (non-human facilitated) tree replacement.

No-Action Alternative — The alternative in which baseline conditions and trends are projected into the future without any substantive changes in management (40 CFR 1502.14(d)). Alternative A is the no-action alternative in this planning process.

Opportunistic Surveillance — Taking diagnostic samples for CWD testing from deer found dead or harvested through a management activity within a national park unit.

Paired Plot — Two plots used for monitoring that include a fenced and an unfenced plot.

Palatability — The property of being acceptable to the taste or sufficiently agreeable in flavor to be eaten.

Parasitism — A symbiotic relationship in which one species, the parasite, benefits at the expense of the other, the host.

Penetrating Captive Bolt Gun — A gun with a steel bolt that is powered by either compressed air or a blank cartridge. When fired, the bolt is driven into the animal's brain and renders it instantly unconscious without causing pain.

Population (or Species Population) — A group of individual plants or animals that have common characteristics and interbreed among themselves and not with other similar groups.

Prion — Protinaceous infectious particle; a microscopic particle similar to a virus but lacking nucleic acid, thought to be the infectious agent for certain degenerative diseases of the nervous system such as CWD.

Record of Decision (ROD) — A concise public record of decision prepared by a federal agency, pursuant to NEPA, that contains a statement of the decision, identification of all alternatives, a statement

as to whether all practical means to avoid or minimize environmental harm from the alternative selected have been adopted (and if not, why they were not), and a summary of monitoring and enforcement where applicable for any mitigation (40 CFR 1505.2).

Recruitment — Number of organisms surviving and being added to a population at a certain point in time.

Reproductive Control — A method or methods used to limit the numbers of animals in a population by decreasing the reproductive success of the animals, such as contraception or sterilization.

Rut — An annually recurring condition or period of sexual excitement and reproductive activity in deer; the breeding season.

Sapling — A young tree, generally not over 4 inches in diameter at breast height.

Scoping — An early and open process for determining the extent and variety of issues to be addressed and for identifying the significant issues related to a proposed action (40 CFR 1501.7).

Seedling — A young plant grown from seed; a young tree before it becomes a sapling.

Seral — A phase in the sequential development of a climax community.

Sex Ratio — The proportion of males to females (or vice versa), in a population. A sex ratio of 50:50 would mean an equal number of does and bucks in a deer population.

Sharpshooting — The authorized shooting of animals by specially trained professionals using appropriate weapons for means of effective and efficient lethal control.

Species Diversity — The variety of different species present in a given area; species diversity takes into account both species richness and the relative abundance of species.

Species Richness — The number of species present in a community.

Spotlight Survey — A method used to estimate deer numbers in an area by shining spotlights at night and counting the number of deer observed. This technique provides an estimate of deer numbers but not density.

Sterilization — a surgical technique leaving a male or female unable to reproduce.

Targeted Surveillance — Lethal removal of deer that exhibit clinical signs of CWD, such as changes in behavior and body condition, and testing to determine if CWD is present.

Transect — A line along which sampling is performed.

Transmissible Spongiform Encephalopathies (TSEs) — A group of diseases characterized by accumulations of abnormal prion proteins in neural and lymphoid tissues, which cause distinctive lesions in the brain and result in death.

Turbidity — Visible undissolved solid material suspended in water.

Unfenced Plot — A specific unfenced area that allows effects on deer browsing to be seen and to be measured.

Ungulate — A hoofed, typically herbivorous, animal; includes horses, cows, deer, elk, and bison.

Vaccine — A suspension of killed or attenuated microorganisms that, when introduced into the body, stimulates an immune response against that microorganism.

Vascular Plant — A plant that contains a specialized conducting system consisting of phloem (food-conducting tissue) and xylem (water-conducting tissue). Ferns, trees, and flowering plants are all vascular plants.

Viable White-tailed Deer Population — A population of deer that allows the forest to naturally regenerate, while maintaining a healthy deer population in the park.

Woody Plants — Plants containing wood fibers, such as tress and shrubs (see "Herbaceous Plant").

ACRONYMS

APHIS	Animal and Plant Health Inspection Service
ATF	Alcohol, Tobacco, and Firearms
AVMA	American Veterinary Medical Association
BSE	bovine spongiform encephalopathy (mad cow disease)
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CJD	Creutzfeldt-Jakob disease
CLI	cultural landscape inventory
CLR	cultural landscape report
CSO	combined sewer overflow
CWD	chronic wasting disease
dB	decibel
dBa	A-weighted decibel scale
DC	District of Columbia
DCDOH	District of Columbia Department of Health
DM	Departmental Manual
DO	Director's Order
EA	Environmental Assessment
EHD	Epizootic Hemorrhagic Disease
EIS	Environmental Impact Statement
EO	Executive Order
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
FDA	U.S. Food and Drug Administration
FEMA	Federal Emergency Management Agency
FLIR	Forward Looking Infrared Surveys
FMP	Fire Management Plan
FSH	follicle stimulating hormone
GCIV	GonaCon® immunocontraceptive vaccine
GIS	Geographic Information System
GMP	general management plan
GnRH	gonadotropin releasing hormone
IHC	immunohistochemistry

K	soil erodibility factor
Ldn	day-night average sound level
LH	luteinizing hormone
LTCP	long-term control plan
M-NCPPC	Maryland National Capital Park and Planning Commission
NBS	National Biological Survey
NCPC	National Capital Planning Commission
NCR	National Capital Region
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
NIST	National Institute of Standards and Technology
NPS	National Park Service
NWI	National Wetland Inventory
NWR	National Wildlife Refuge
PEPC	Planning, Environment, and Public Comment
PFO1	palustrine forested broad-leaved deciduous
plan/EIS	Draft White-tailed Deer Management Plan and Environmental Impact Statement
PZP	porcine zona pellucida
SOF	Statement of Findings
TMDL	Total Maximum Daily Load
TSE	transmissible spongiform encephalopathy
USC	United States Code
USDA	U.S. Department of Agriculture
USDI	U.S. Department of the Interior
USFWS	U.S. Fish and Wildlife Service
USPP	U.S. Park Police
WASA	D.C. Water and Sewer Authority

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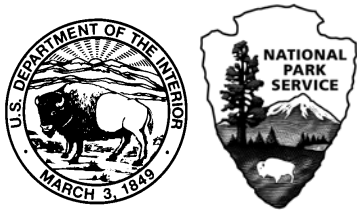

As the nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering wise use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historic places, and providing for the enjoyment of life through outdoor recreation. The department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people. The department also promotes the goals of the Take Pride in America campaign by encouraging stewardship and citizen responsibility for the public lands and promoting citizen participation in their care. The department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

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