Appendixes

DRAFT ENVIRONMENTAL ASSESSMENT
White-tailed Deer Management
Catoctin Mountain Park

Appendix 11.3: 1985 Summary of impacts on Catoctin's vegetation.

Name	Foliage Damage	Reproductive Impacts	Outlook Given Trend	Remarks
American Elm *Ulmus americana*	Bark eaten, killing entire tree.	Seed production halted, saplings injured as well.	Will probably be eliminated from most of the park.	Moderate injury appears to increase Dutch Elm disease attack.
Slippery Elm *Ulmus rubra*	Bark eaten.	Not severe as yet.	This tree is most common along streams such as Owens Creek where intensive deer foraging is just beginning.	Same as above.
Canadian Hemlock *Tsuga canadensis*	Saplings and lower branches stripped of needles.	Seedlings and saplings killed.	Virtually no reproduction in Whiskey Still watershed, significant to severe elsewhere.	Important shade component for trout streams.
White Pine *Pinus strobus*	Saplings and lower branches stripped of needles.	Seedlings and saplings killed. No recruitment.	Virtually no reproduction parkwide, will be extirpated if browse pressure continues.	A "preferred" browse species.
American Ginseng *Panax quinquefolius*	Leaves commonly eaten, apparently a preferred species.	Flower stalk commonly eaten only 1 stalk produced each year.	Significant. Severe at some populations where number of leaves and fruit produced each spring have been reduced in past 2 years.	Of 4 mature plants monitored in 1984, all 4 had leaves eaten. Only 1 was able to produce berries. Listed as "Highly Rare" by DNR Natural Heritage Program.
Large Purple-Fringed Orchid *Habenaria grandiflora*	Usually only the smaller upper leaves are eaten (Orchids produce only 1 set of flowers per year)	Densely flowered stalk is eaten (Orchids produce only 1 set of flowers per year…….	Significant and increasing less than 35 mature plants in park. In '83 12% eaten.	Very habitat specific, listed as "Highly Rare"

DRAFT ENVIRONMENTAL ASSESSMENT
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Catoctin Mountain Park

Name	Foliage Damage	Reproductive Impacts	Outlook Given Trend	Remarks
Long-Bracted Orchid Habenaria viridis	Moderate, this species is shorter (10-15 cm) than most orchids.	Flower stalk eaten.	Critical. Only a few plants are known in the park and most were eaten in 1984.	Listed as "Highly Rare"
Leatherwood Dirca palustris	Moderate before '83.	Negligible at this time.	Normal since most of this species' few shrubs in the park were included in an exclosure in 1983.	Listed as "Highly Rare"
Mountain Laurel Kalmia latifolia	Severe. Leaves less than 1.5m from the ground are gone from most of this plant's range in the park.	Seedling and most submature shrubs are dead.	Seeds still produced by tallest shrubs but newly sprouted plants eaten. Will eventually be restricted to a few rock outcrops.	Very slow growing, evergreen averaging 2cm hgt growth per year. Tens of thousands of shrubs have been severely browsed. Not a preferred browse species.
Bladdernut Staphlea trifoliata	Significant. Only trees on boulder-strewn water courses have escaped browse damage.	Seedlings absent or severely browsed.	Formerly common in rocky areas but becoming much scarcer.	Apparently a preferred browse species.
Wild Gooseberry Ribes hirtellum	Moderate, 1 stand heavily browsed, 2 others lightly.	Unknown, but probable.	Unknown. Only 3 populations known in park.	Discovered in Maryland (in park) for first time in 1984. Rare.
Round-Leaved Currant Ribes rotundifolium	Severe, low growing woodland shrub is often stripped of all its leaves and twigs.	Reproduction absent from all but the rockiest sites.	Formerly common but disappearing fast, except for the tops of cliffs, and large boulders inaccessible to deer.	Apparently a preferred browse species.
Button bush Cephalanthus occidentalis	Severe, all leaves and twigs eaten up to browse level on these large shrubs.	Some seeds still produced but no seedlings survived.	1 population at mountain top bog. Will eventually be extirpated by deer.	Apparently a preferred browse species.
Spirea Spirea latifolia	Severe. All leaves and twigs eaten.	No flowers have survived browsing.	Will eventually be extirpated by deer only known from 1 site	Unable to ID species for 2 years because of intensive browsing.

DRAFT ENVIRONMENTAL ASSESSMENT
White-tailed Deer Management
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Name	Foliage Damage	Reproductive Impacts	Outlook Given Trend	Remarks
Water Plantain Alisma subcordatum	Entire population of this large aquatic emergent eaten.	No reproduction from park's only population of 50+ plants.	Will eventually be extirpated by deer.	Unable to ID this species for over a year because deer kept entire population eaten to ground.
Christmas Fern Polystichunm acrostichoides	Moderate. Locally intensive along Owens Creek and other wintering sites frequented by deer.	Utilization is mostly in winter and spring, when spores have been released. Plants that have all of their fronds eaten each year probably are declining in vigor.	Probable reduction in numbers and health of population but not critical enough for extirpation at this time.	A long-lived species and our only large evergreen fern.
Downey Arrow-wood Viburnum rafines-queinum	Leaves and twigs eaten up to browse line on this small shrub that grows in dense clumps.	All small shrubs (below 1m tall) killed.	Only a few good-sized populations known in park at present time. Will be greatly reduced.	Uncommon.
Great Rhododendron Rhododendron maximum	Severe. All shrubs less than 1.5m tall are dead. Only 2 tall shrubs remain and they are browsed up 2m.	Critical. Absolutely no seedlings or saplings of this attractive evergreen.	Will be extirpated in a few years.	Known to local people as "Deer Laurel" because of deer's known preference for it. Uncommon in Catoctins.
Wild Pink Azalea Rhododendron periclimenoides	Significant. Over 50% of the shrubs observed have severe browse injury.	Very tall azaleas still producing seed. Sprouts from roots. Very few mid-sized shrubs found.	Eventually will lose most of its range in the park. Currently populations are scattered throughout park.	One of the most attractive native plants. Cultivated azaleas in developed zones.
Smooth Alder Alnus serrulata	Leaves and twigs eaten in summer. Seen for first time in late '84 along headwaters of Owens Creek.	Unknown but recruitment has probably been affected.	Unknown.	Important shade component for headwater trout streams.

DRAFT ENVIRONMENTAL ASSESSMENT
White-tailed Deer Management
Catoctin Mountain Park

Name	Foliage Damage	Reproductive Impacts	Outlook Given Trend	Remarks
Red Canadalily *Lilium canadense* var. *editorum*	Grows to 1.5m tall. By August all known plants in park were eaten to about 0.3m. Only 1 set of leaves and flowers produced per year.	No longer flowers in park due to utilization by deer. Scattered in many small populations in the Owens Creek area.	Eventually survival doubtful. Locations where numbers of flowering plants were found as late as the early to mid-1970s. Now have only a few dwarfed, sterile plants.	Uncommon but still blooms a short distance outside park.
Northern Bush Honeysuckle *Diervilla lonicera*	Only a few shrubs left in park on rock outcrop. All receive heavy loss of leaves and twigs.	Unable to reproduce.	Survival for more than a few years doubtful.	A northern species on the SE limit of its range.
Birch-leaved Spirea *betulifolia*	Should be a shrub to 1m tall. All 15 shrubs found on a cliff in 6/85 were browsed to a height of 10cm.	Unable to reproduce.	Survival for more than a few years is doubtful.	1 location recently discovered in park, believed to be the northeastern most stand of this species.
Bunch Flower *Melanthium spp.*	Foliage and flower spikes eaten.	No flowering. Known to be a preferred food for deer. Most reproduction is by seed.	Population is made up entirely of small sterile plants. These will continue to dwindle.	Park probably has 2 species of *Melanthium*. *M. virginicum* is very uncommon, *M. latifolium* is considered threatened in Maryland.

Appendix B:
Letters of Consultation

#91

COPY

Robert L. Ehrlich, Jr.
Governor

Michael S. Steele
Lt. Governor

Maryland Department of Natural Resources
Tawes State Office Building
580 Taylor Avenue
Annapolis, Maryland 21401

C. Ronald Franks
Secretary

W. P. Jensen
Deputy Secretary

July 13, 2004

Mr. Scott Bell
US Department of the Interior
National Park Service-National Capital Area
Catoctin Mountain Park
6602 Foxville Road
Thurmont, MD 21788

RE: Environmental Review for Catoctin Mountain Park, West of Thurmont, Management of White-tailed Deer Proposal, Frederick County, Maryland.

Dear Mr. Bell:

In response to your inquiry, the Wildlife and Heritage Service's Natural Heritage database does indicate that the following species of interest are known to occur on or within close proximity to the boundaries of the project site:

Scientific Name	Common Name	State Status
Platanthera psycodes	Small Purple Fringed Orchid	Endangered Extirpated
Dirca palustris	Leatherwood	Threatened
Pycnanthemum torrei	Torrey's Mountain-mint	Endangered
Coelglossum viride	Long-bracted Orchis	Endangered
Viola incognita	Large-leaved White Violet	Highly Rare
Geranium robertianum	Herb-robert	Highly Rare
Corvus corax	Common Raven	Rare

TTY via Maryland Relay: 711 (within MD) (800) 735-2258 (Out of State)
Toll Free in MD#: 1-877-620-8DNR ext. _____

Page 2
July 13, 2004

Thank you for providing us the opportunity to review this project. If you should have any further questions regarding this information, please contact me at (410) 260-8573.

Sincerely,

Lori A. Byrne,
Environmental Review Coordinator
Wildlife and Heritage Service
MD Dept. of Natural Resources

ER# 2004.1091.fr
Cc: E.L. Thompson, WHS
R. Wiegand, WHS

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Chesapeake Bay Field Office
177 Admiral Cochrane Drive
Annapolis, MD 21401

August 11, 2004

Mr. Scott Bell
Environmental Protection Specialist
Catoctin Mountain Park
National Park Service
6602 Foxville Road
Thurmont, MD 21788

COPY

RE: Catoctin Mountain Park, a unit of the National Park Service located west of Thurmont Maryland

Dear Mr. Bell:

This responds to your letter, received May 21, 2004, requesting information on the presence of species which are federally listed or proposed for listing as endangered or threatened within the vicinity of the above reference project area. We have reviewed the information you enclosed and are providing comments in accordance with section 7 of the Endangered Species Act (87 Stat. 884, as amended; 16 U.S.C. 1531 *et seq.*).

Except for occasional transient individuals, no federally proposed or listed endangered or threatened species are known to exist within the project impact area. Therefore, no Biological Assessment or further section 7 Consultation with the U.S. Fish and Wildlife Service is required. Should project plans change, or if additional information on the distribution of listed or proposed species becomes available, this determination may be reconsidered.

This response relates only to federally protected threatened or endangered species under our jurisdiction. For information on the presence of other rare species, you should contact Lori Byrne of the Maryland Wildlife and Heritage Division at (410) 260-8573.

An additional concern of the Service is wetlands protection. Federal and state partners of the Chesapeake Bay Program have adopted an interim goal of no overall net loss of the Basin's remaining wetlands, and the long term goal of increasing the quality and quantity of the Basin's wetlands resource base. Because of this policy and the functions and values wetlands perform, the Service recommends avoiding wetland impacts. All wetlands within the project area should be identified, and if construction in wetlands is proposed, the U.S. Army Corps of Engineers,

Baltimore District, should be contacted for permit requirements. They can be reached at (410) 962-3670.

We appreciate the opportunity to provide information relative to fish and wildlife issues, and thank you for your interests in these resources. If you have any questions or need further assistance, please contact Maricela Constantino at (410) 573-4542.

Sincerely,

G. A. Moser

G. Andrew Moser
Acting Program Supervisor, Threatened and Endangered Species

Appendix C: Overview of Deer Management Activities at Catoctin Mountain Park

Below is a timeline of events related to deer management at Catoctin Mountain Park (NPS 2000e; NPS n.d.).

1981 Catoctin Mountain Park staff visited Pennsylvania State University to develop information on deer population guidelines and vegetation impacts.

1982 First deer exclosure constructed at Thurmont Vista in Catoctin Mountain Park.

First discovery of bark stripping by deer on slippery and American elm trees.

1983 First aerial deer census conducted in winter; 70 deer observed. The aerial deer survey provides a relative indicator, not a density estimate.

Catoctin Mountain Park staff met with National Zoo (Front Royal facility) staff to compare vegetation damage and herd activity.

Daylight deer census begun on Park Central Road.

Two deer pellet transects established and surveyed.

1984 Twelve percent of resident population of purple-fringed orchids reported damaged by deer browse; moderate damage also reported to leatherwoods and mountain laurel from deer browse.

Daylight deer census conducted on Park Central Road.

1985 Three additional exclosures constructed.

Over 250 elm trees reported damaged by bark stripping.

Cubic meter biomass study conducted on two deer exclosures; 49% more vegetative material found inside exclosures compared to outside the exclosures.

1986 Winter aerial deer census conducted; 131 deer observed.

No bark stripping reported, excellent mast year.

1987 The National Park Service entered into a cooperative research agreement with the University of Georgia to collect information concerning herd health.

Park began keeping records of vehicle collisions with deer.

Winter aerial deer census conducted; 117 deer observed.

1988 Winter aerial deer census conducted; no estimate projected due to equipment failure.

Deer immobilization and radio telemetry tracking began.

Six permanent deer pellet transects established.

Five to seven night spotlight survey routes established, and training conducted for staff.

Necropsy activity begun.

Herd health survey conducted by Southeastern Cooperative Wildlife Disease Study; five deer harvested.

Telemetry, spotlight surveys, and deer pellet transect study continued.

Fifteen additional fawns captured for mortality study, and five additional does for supplementing radio telemetry programs.

1989 Winter aerial deer census conducted; observed 324 deer.

The annual survey located 12 purple-fringed orchids in the park.

Receipt of interim research report from the University of Georgia.

Continued radio telemetry program, five to seven night spotlight surveys, pellet group transect surveys, and deer exclosure monitoring.

National Park Service enters into research agreement with West Virginia University on bark stripping of elm trees.

First meeting of Deer Advisory Technical Committee, Catoctin Mountain Park.

1990 Forty-six vegetation plots established by Center for Urban Ecology (CUE) to monitor deer impacts on vegetation.

Necropsies completed on 11 deer.

Bark stripping monitoring and research continued. The greatest concentration was found near Owens Creek campground.

Rare plants (purple-fringed orchids and leatherwood) located and protected from deer browse with wire cages.

Nighttime telemetry surveys initiated for six deer.

Fall spotlight survey, fawn reports, buck observations, and exclosure monitoring continued.

Deer repellents (different types of bar soaps and Ropel®) were applied at the Catoctin Mountain Park Visitor Center; these substances were not effective in repelling deer.

1991 Vegetation plots evaluated.

Fall spotlight survey, fawn reports, buck observations, exclosure monitoring, and nighttime telemetry continued.

Final research report submitted by the University of Georgia: "The Population and Ecological Characteristics of White-tailed Deer on Catoctin Mountain Park."

Initial draft of "Catoctin Mountain Park White-tailed Deer Management Environmental Assessment" completed. Report forwarded to advisory committee.

Thesis on bark stripping completed by Joey Fuller, West Virginia University.

Rare plant protection program continued.

1992 Fall spotlight survey, fawn reports, buck observations, exclosure monitoring, and rare plant protection program continued.

Winter aerial deer census conducted; observed 277 deer.

Small mammal study initiated by the Center for Urban Ecology to examine potential impact of deer on other animals, which compete for the same food sources.

"Draft Deer Management Environmental Assessment" revised by the NPS Washington Office.

Vegetation plots evaluated.

A new deer exclosure was constructed on the Falls Nature Trail.

1993 Rare plant protection program continued.

Fall spotlight survey, fawn reports, buck observations, exclosure monitoring, and rare plant protection program continued.

Winter aerial deer census conducted; observed 127 deer.

Vegetation plots evaluated.

First winter kill deer survey conducted following severe winter weather. Number of deer found was 74.

1994 Deer telemetry project began monitoring five does.

Rare plant protection program continued.

Fall spotlight survey, fawn reports, buck observations, exclosure monitoring, and rare plant protection program continued.

Vegetation plots evaluated.

Winter aerial deer census conducted in January; observed 217 deer.

Winter aerial deer census conducted in March; observed 107 deer.

1995 Deer telemetry program continued.

Rare plant protection program continued.

Fall spotlight survey, fawn reports, buck observations, exc1osure monitoring, and rare plant protection program continued.

Winter aerial deer census conducted; observed 138 deer.

1996 Rare plant protection program continued.

Continued spotlight survey, fawn reports, buck observations, exclosure monitoring, and rare plant protection program.

1997 Rare plant protection program continued.

Hood College, of Frederick, Maryland, exclosure with paired vegetation plot study started.

Fall spotlight survey, fawn reports, buck observations, exclosure monitoring, and rare plant protection program continued.

Winter aerial deer census conducted; observed 264 deer.

1998 Continued monitoring of deer/car motor vehicle incidents; incident locations entered into GIS for previous four years.

Hood College exclosure/vegetation plot study continued; wetland exclosure and two wetland vegetation plots added.

All vegetation plot data sent to regional botanist to be analyzed.

Fall spotlight survey, fawn reports, buck observations, exclosure monitoring, and rare plant protection program continued.

Continued opportunistic collection of necropsy information, which has been done every year.

1999 Winter aerial deer census conducted; observed 300 deer.

Hood College exclosure/vegetation plot monitoring continued.

Fall spotlight survey, fawn reports, buck observations, opportunistic necropsies, and rare plant monitoring and protection continued.

Tracking of dead deer due to motor vehicle accidents continued.

New exclosure built in area damaged by suspected microburst during a severe thunderstorm in June of 1998.

Deer meeting / planning session held by Catoctin Mountain Park and regional CUE staff, December 3.

NPS Servicewide deer management meeting held at Catoctin Mountain Park, December 7.

2000 Catoctin Mountain Park and Center for Urban Ecology (CUE) staff plans for a Deer Advisory Committee Meeting to be held later during the year.

Fawn and buck sighting reports terminated as result of consensus from the 1999 deer management meeting that these reports were not yielding significant data.

Winter aerial deer census; observed 312 deer.

"Summary Report: White-tailed Deer Management in Catoctin Mountain Park" completed on February 15 to document the status of the Catoctin Mountain Park deer herd; based on previous environmental assessments completed in 1995.

Deer Advisory Committee meeting held at Catoctin Mountain Park May 15–17.

Distance sampling training with Dr. Brian Underwood; first distance sampling survey conducted in the fall; park population estimate of 183.99 deer per square mile.

Vegetation plot monitoring continued on a limited basis (15 plots and 5 exclosures); data did not include herbaceous species data, but did include seedling and browse data (includes microburst exclosure and open plot).

Continued tracking of road-killed deer (motor vehicle accidents).

Rare plant monitoring and protection continued.

Diane Pavek analyzed original vegetation plot monitoring data from 1990-1994.

2001 Distance sampling deer spotlight surveys conducted in spring and fall; park population estimates of 147.37 (spring) and 185.83 (fall) deer per square mile.

Vegetation plot monitoring continued on limited basis (16 plots and 5 exclosures); data did not include herbaceous species data, but did include seedling and browse data (including microburst exclosure and open plot).

Continued tracking of road-killed deer (motor vehicle accidents).

Rare plant monitoring and protection continued.

2002 Distance sampling deer spotlight surveys conducted in spring and fall; park population estimates of 112.00 (spring) and 155.43 (fall) deer per square mile.

Deer Technical Committee/Assessment Team meeting at Catoctin Mountain Park May 1. Catoctin Mountain Park White-tailed Deer EIS meeting (Catoctin Mountain Park and CUE staff), May 9.

Meeting to discuss deer management/EIS (Catoctin Mountain Park, CUE, and Washington office personnel) May 22.

Vegetation plot monitoring continued on limited basis (10 plots and 2 exclosures); data did not include herbaceous species data, but did include seedling and browse data (included microburst and fire exclosures and paired open plots).

Deer herd health check by University of Georgia/Southeastern Cooperative Wildlife Disease Study disclosed evidence of significant deterioration of population health problems.

Meeting held with Dr. Susan Stout of the U.S. Forest Service at Kane Experiment Station in the Allegheny National Forest, PA; attended by Diane Pavek (Regional Botanist) and Becky Loncosky (Park Ranger, Catoctin Mountain Park), October 7.

Continued tracking of dead deer from all causes.

Rare plant monitoring and protection continued.

2003 Vegetation plot monitoring continued on limited basis (two plots and two exclosures, including microburst, fire exclosures, and paired open plots).

Received final report from Dr. Russek-Cohen (contracted to analyze vegetation plot data collected during the periods 1990–1995 and 2000–2002).

Distance sampling deer spotlight surveys conducted in spring and fall; population estimates 159.72 (Spring) and 192.95 deer per square mile (Fall).

Received summary report and presentation of distance sampling done in 2000 and 2001 in the National Capital Region from Dr. Brian Underwood.

Continued tracking of road-killed deer (motor vehicle accidents).

Rare plant monitoring and protection continued.

Selected areas for six new exclosures, to be built adjacent to randomly selected pre-existing vegetation monitoring plots. Installed posts for the exclosures, which will be finished after the data is collected in 2004.

Began internal scoping process for the Catoctin's White-Tailed Deer Management Plan / EIS at Catoctin Mountain Park October 28. Two-day meeting held to identify purpose of an need for action, management objectives, issues, and impact topics.

Results of internal scoping meetings produced in "Internal Scoping Report."

2004 Letter dated May 21 initiated informal consultation with USFWS about the presence of federally listed rare, threatened, or endangered species.

Letter dated May 21 initiated informal consultation with the Wildlife and Heritage Service of the Maryland DNR about the presence of state listed rare, threatened, or endangered species in the vicinity of the park.

Notice of Intent to prepare an EIS published in the *Federal Register* on June 23.

Maryland DNR responded to May 21 letter on July 13, listing seven state listed rare, threatened, or endangered species in the vicinity of the park.

USFWS replied to May 21 letter on August 11 stating no federally proposed or listed endangered or threatened species were known to exist within the project impact area, and no biological assessment or further consultation under Section 7 of the Endangered Species Act would be required.

First of five Science Team meetings held October 13 to provide input to the White-Tailed Deer Management Plan / EIS on matters regarding scientific data and analysis. Science Team meetings held over a six-month period.

Newsletter mailed in October to preliminary mailing list of government agencies, organizations, businesses, and individuals.

First public involvement meeting for the White-Tailed Deer Management Plan / EIS held November 9 in Thurmont; park received 64 comments.

Distance sampling deer spotlight survey conducted in fall; population estimate 104.11 deer per square mile.

Continued tracking of road-killed deer.

Started new 3-year rotation of vegetation monitoring. Monitored 6 open plots and corresponding 6 exclosures. The fencing was installed at the 6 exclosures. The microburst and fire open plots and exclosures were also monitored.

Rare plant monitoring and protection continued.

Winter aerial deer census: 128 deer observed.

2005 Second newsletter mailed in March to announce the alternatives development workshop April 20.

Second public involvement meeting (alternatives development workshop) held April 20 in Thurmont. Thirty-six individuals participated and commented. Forty additional comments received.

Distance sampling deer spotlight survey conducted in fall; population estimate 74.5 deer per square mile.

Continued tracking of road-killed deer.

Second year of 3-year rotation of vegetation monitoring. Twenty open plots monitored. The microburst and fire open plots and exclosures were monitored. A new exclosure was built in a blow-down exclosure and an existing open plot located in that same area were monitored.

Rare plant monitoring continued.

2006 Draft White-Tailed Deer Management Plan / EIS released for public review and input.

Appendix D: Chronic Wasting Disease

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

As of November 2005 chronic wasting disease has been diagnosed in two national parks — Rocky Mountain and Wind Cave national parks. Several National Park System units are at high risk because of their proximity to areas where CWD has been diagnosed in either captive or free-ranging cervids. In addition, there is a high likelihood that the disease will be detected in other areas of the country following spread of the disease and increases in surveillance for the disease. Therefore, chronic wasting disease 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 the NPS response to chronic wasting disease 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 the translocation of deer and elk into or out of National Park System units. Like any policy, deviation from the guidance memo would require a waiver approved by the director.

A National Park Service Manager's Reference Notebook to Understanding Chronic Wasting Disease (November 15, 2005)

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. Chronic wasting disease 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 National Park Service.

Human Consumption of Elk and Deer Meat Gathered from Areas with Endemic Chronic Wasting Disease (December 22, 2005)

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

Description and Distribution

Chronic wasting disease 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).

Chronic wasting disease 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 November 2005, chronic wasting disease had been found in captive/farmed cervids in 10 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 chronic wasting disease 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

Chronic wasting disease 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 chronic wasting disease. Each has various advantages and disadvantages. Only certified laboratories can perform immunohistochemistry or the rapid CWD tests.

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

TRANSMISSION

There is strong evidence that chronic wasting disease is infectious and is spread by direct lateral (animal to animal) or indirect transmission (M. W. 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; M.W. Miller et al. 2000; Miller and Williams 2003; Miller and Wild 2004).

Like other contagious diseases, CWD transmission increases when animals are 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 and reduce prevalence. Increasing mortality slows transmission by two mechanisms:

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 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 or Incineration* — 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.

  Incineration is another disposal method used by veterinary diagnostic laboratories. This method burns the carcass at intense temperatures.

Alkaline digestion and incineration are two of the most effective ways of destroying contaminated organic material. These are usually only available at veterinary diagnostic laboratories or universities. Arrangements can often be made with laboratories to test and then dispose of animals.

- *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 parts.

MANAGEMENT

Chronic wasting disease has occurred in a limited geographic area of northeastern Colorado and southeastern Wyoming for over 20 years. 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, and New York.

The National Park Service does not currently have a single 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 chronic wasting disease 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 chronic wasting disease 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 chronic wasting disease 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., opportunistic and 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 chronic wasting disease 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, 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 chronic wasting disease. 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 chronic wasting disease without changing management of the deer population. This is a good option for park units where chronic wasting disease 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 chronic wasting disease. 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 (M.W. 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 chronic wasting disease 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 chronic wasting disease 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 chronic wasting disease. 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 spreading out across the landscape, deer and elk stay in high-density herds in tight 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 chronic wasting disease in park units, working within the park's management policies. Chronic wasting disease 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).

Appendix E: A Review of White-tailed Deer Reproductive 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 alternatives management methods.

The use of reproductive control in wildlife management has been assessed for the last 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). Oftentimes, 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 et al. 1997).

The following appendix describes the current state of reproductive control (2006) as it relates to white-tailed deer management. In addition to describing the current technology available, it also covers population management challenges, regulatory issues, logistics, and consumption issues. It should be noted that since technology is changing rapidly in this field of research, this appendix is meant to be a description of the types of technology available and is not all-inclusive.

CURRENT TECHNOLOGY

The area of wildlife reproductive control 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 (i.e., 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).

PORCINE ZONA PELLUCIDA (PZP). The majority of immunocontraceptive research in wildlife has been conducted using PZP vaccines, which in 1992, Turner et al. successfully used on white-tailed deer (Turner et al. 1992). Due to its mechanism of action this type of vaccine is only effective in female deer. Until recently there were only two PZP vaccine products being developed- one is simply called PZP, and the other SpayVac™, however the company producing SpayVac™ has stated that it will no longer begin new research projects involving SpayVac™. The other PZP vaccine has been used extensively in white-tailed deer in the course of investigating its effectiveness (Kirkpatrick et al. 1997; Turner et al. 1992, 1996; Walter et al. 2002a, 2002b).

The currently available PZP vaccine formulation is effective for one year, though multi-year applications are also being studied. There are several limitations to the PZP based vaccines. First, at this time, PZP vaccines require annual boosters in order to maintain infertility, resulting in the need to mark treated animals and re-treat the same individuals each year. Second, the Food and Drug Administration (FDA) has not determined whether vaccine components pose a human health risk. While the antibodies generated by the host's immune system should not pose a risk to human health, the possibility of accidental consumption of the vaccine depot by non-target animals or humans has not been investigated. Finally, the PZP based vaccines may cause abnormal out of season breeding behavior in treated deer populations (Fraker et al. 2002; McShea et al. 1997) as treatment with PZP causes repeated estrous cycling in females, which can result in late pregnancies and behavioral changes.

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 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 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.

The use of GnRH vaccines has been used in a variety of both wild and domestic ungulates (hoofed mammals). And, in recent years, a great deal of research has been done on their effectiveness. One such GnRH vaccine being researched and developed is GonaCon™. In addition to developing an adjuvant with fewer unwanted side effects, researchers are also studying ways to develop a multi-year dose of the vaccine (USDA/APHIS 2004). Potential benefits of this vaccine include the longer-lasting contraceptive effect and the lack of repeated estrous cycling. However, at this stage there are many uncertainties about this vaccine. First, like PZP vaccines, there is little information regarding the theoretical human and non-target species health risks. Second, there is very little information regarding vaccination of pregnant animals. Third, the vaccine can cause antibody development to not only the GnRH antigen but also a component of the adjuvant. This may cause difficulties when determining the Johne's disease status of a population of treated deer. Finally, there is limited published data using this vaccine in free-ranging animals. More work is necessary to establish population and herd level effects.

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 similar in structure to GnRH and act in a similar way – by attaching to receptors in the pituitary gland. In attaching to the receptors, these agonists reduce the number of binding sites available and thereby suppress the effect of the GnRH. As a result of this suppression, reproductive hormones are not released (Aspden et al. 1996; D'Occhio et al. 1996). However, 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. That being said, it is important to fully understand the effects of a product on a given species. GnRH agonists have been tested in white-tailed deer and shown to suppress a specific reproductive hormone (luteinizing hormone). Researchers believe this may be a useful tool for preventing ovulation and pregnancy; however, this hypothesis has not yet been tested in white-tailed deer. This has been shown to be the case in female mule deer and elk, and will likely hold true for white-tailed deer as well.

Leuprolide acetate—Leuprolide is one such GnRH agonist that is being 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. 2004; Baker et al. 2002). 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.). This means that, should a female be treated in one year, before the breeding season, it will not be come pregnant in that year, but if the female is not re-treated the following year, then it has the same chances of becoming pregnant as an animal that was never treated. Treatment using leuprolide differs from GnRH vaccines in that it does not require an adjuvant, however, it does require a slow release implant that remains under the skin or in the muscle for the duration of the treatment effectiveness.

An added benefit to the use of leuprolide is that it requires only one treatment for the first year of use, whereas some immunocontraceptive vaccines require retreating the same individual several times with boosters to develop and maintain infertility. Additionally, leuprolide is not likely to pose a threat to the environment or non-target species (including humans; Baker et al. 2004). In contrast with some of the immunocontraceptive vaccines, leuprolide does not result in physiological side effects, and short term behavioral effects are minimal.

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, in testing it 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 remote delivery system 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 analogue. The toxin is then carried to the receptors in the pituitary gland and is internalized. Once absorbed, the toxin disrupts cellular function and can lead to cellular death. When this occurs the production of reproductive hormones is affected. This process has been studied in female mule deer (Baker et al. 1999), and the technology is still being developed.

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. 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 non-target species, including humans.

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 prostaglandin $F_{2\alpha}$ analogue (Becker and Katz 1994; DeNicola et al. 1997; Waddell et al. 2001). Lutalyse® is a commercially available form of prostaglandin $F_{2\alpha}$ analogue. Unlike many of the other alternatives, there are no issues related to consumption of the meat when it has previously treated with this product. Difficulties with contragestives include; timing of administration, efficacy, potential to re-breed 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. Surgical sterilization is an invasive procedure that requires a veterinarian and is common in managing domestic animal fertility. Chemical sterilization is typically performed on males as a reproductive control measure. Both types of sterilizations are typically permanent.

REGULATORY ISSUES

The application of reproductive control agents in free-ranging wildlife is fairly new and is currently (December 2005) regulated by the United States Food and Drug Administration (FDA). None of the agents discussed here have been licensed or labeled for use as reproductive control agents in wildlife species. However, some can be used in a research setting under an Investigational New Animal Drug (INAD) exemption. This exemption is granted by the FDA for the purpose of allowing research to facilitate the gathering of information pertaining to the agent prior to the FDA granting full approval for its use.

Some of the agents discussed above, specifically several of the pharmaceuticals, have FDA approval for therapeutic use in humans (e.g., leuprolide) or other non-wildlife species (e.g., prostaglandin $F_{2\alpha}$). As a safety precaution each approved agent is labeled indicating how it is to be used. In order to use the agent in a manner other than that indicated on the label, a licensed veterinarian must prescribe the agent and it must be used in accordance with the *Animal Medicinal Drug Use Clarification Act of 1994*. The prescribing veterinarian is accountable for prescribing and labeling a product when it is to be used in an extra-label manner. However, the owner (in this case, the NPS unit manager) is responsible for using the agent in the prescribed manner. In addition, the veterinarian must establish a meat residue withdrawal period – the time it takes for the animal to fully metabolize and clear the drug from its tissue – for any animals that may enter the human food chain. A treated animal may not be killed and enter the human food chain before the meat residue withdrawal period is over. Treated animals for which a meat residue withdrawal period has been established need to be marked accordingly. If, however, there is no meat residue withdrawal period the animals do not need to be marked.

POPULATION MANAGEMENT CHALLENGES

Managing local populations of wildlife using reproductive control can be difficult. The level of difficulty relates to the number of animals that need to be treated, their behavior (i.e., solitary, herd, diurnal, nocturnal, etc.), the topography of the habitat in which they are found, as well as treatment protocol logistics. In species like elk, animal roundups can occur making treatment easier than in cases where the populations are more dispersed (e.g., deer).

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 to effectively reduce or halt population growth (Rudolph et al. 2000). Additionally, a significant amount of population data is necessary to effectively monitor the effects of long term population changes due to the use of reproductive controls (Rudolph et al. 2000; Hobbs et al. 2000; Porter et al. 2004).

Reproductive control agents generally decrease population levels slowly. At best, with 90% of the female deer treated, a 5% decline in the population would likely be expected after several years of treatment. Hobbs et al. described a model that suggests deer density will remain constant if 90% of the initial females are treated with a long term reproductive control agent. Subsequently, 90% of female fawns would require treatment. This would stabilize the population if the average mortality rate is 10%. However, this result does not hold for short-duration agents (1 year duration). In this case, the 90% of reproductively mature females would require treatment each year in order to maintain constant herd numbers (Hobbs et. al. 2000). Reproductive control techniques are best suited to localized populations where the number of breeding females to be treated is small (e.g., less than 100 deer) and managers are trying to maintain the population between 30% and 70% of carrying capacity (Rudolph et al. 2000).

ADMINISTERING THE TREATMENT

There are two basic approaches to administering reproductive control agents: capture and treat and remotely treat. Capture and treat requires physically and/or chemically restraining the animal and using a syringe or other delivery device to treat the animal. One benefit of this approach is that it allows for marking the deer which facilitates subsequent treatments. This method also is helpful in collecting valuable biological data, and it provides notice of meat residue withdrawal times. However, this approach is often more time intensive and can be more expensive than using a remote delivery system, especially as treated animals tend to be more difficult to recapture. In addition, capture-related mortality can also be a concern.

A remote delivery system uses an adapted firearm (i.e., dart gun) and some form of projectile that contains the reproductive control agent. These projectiles can be darts or another form of delivery system (e.g., biobullet) that can be used at a distance without needing to capture the animal first. One shortcoming of remote treatment is that it does not allow for permanently marking the treated animals. In addition, previously treated animals can be more difficult to re-treat.

POTENTIAL IMPACTS TO DEER BEHAVIOR AND HEALTH

There have been few studies designed to intensively assess the effects of reproductive control on deer behavior and health. For many agents, additional research is needed to

fully understand the behavioral and social consequences of reproductive control use. Because each group of reproductive control agents operates differently, the effects to the individual deer or population can vary widely. Porcine zona pellucida (PZP) immunocontraceptive agents have been documented to cause the continued cycling of females, which can extend the breeding season or rut (Fraker et al. 2002; McShea et al. 1999). This can result in increased levels of testosterone in males leading to aggressive behavior for an extended period. In addition, if the female gets pregnant later in the year, there are changes to fawning dates and survival rates, as they are born later in the season (DeNicola et al. 1997). Other immunocontraceptives such as the gonadotropin releasing hormone (GnRH) vaccine, when applied to males, have resulted in depressed antler development and lack of interest in breeding. When this vaccine is applied to females, they appear as if they are in anestrus and not estrous cycling during the breeding season. If enough females in the population are treated, it may result in a disruption to natural male/female social as well as reproductive interactions.

The group of reproductive control agents categorized as non-immunocontraceptive methods can also have varying effects to deer behavior and health. For example, GnRH agonists have not been documented as causing behavioral changes when applied to female deer (Baker et al. 2004). GnRH agonists have had variable behavioral effects when applied to male elk. Steroids like progestegin can result in females being unreceptive to males resulting in breeding behavioral changes (Matschke 1977). Contragestives pose a different kind of problem depending on when the treatment is applied. If applied too early in the breeding season, then the female could potentially breed again later in the year extending the rut and resulting fawn-related health issues such as those described for some immunocontraceptive agents above. If applied too late in the season contragestives can result in health implications for the female (DeNicola et al. 1997).

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.

As described above, any effect that could extend the rut has the potential for secondary effects to the individual deer. Increase attempts to breed, especially if unwelcomed, can result in increased aggression and movements. This can be problematic in areas with high vehicle use, as there could be increases in deer/vehicle collisions or other negative interactions with the public. However, as stated above, the effects of reproductive control agents still need more research in order to more fully understand the variations in deer behavior and health.

Potential Impacts to Consumption

As described above, some of the reproductive control agents can result in issues related to human consumption of meat. These issues can be avoided by: (1) using an agent that does not pose a risk to humans, (2) marking treated animals and providing meat residue withdrawal times (if possible), (3) providing educational materials to the local public that may consume hunted animals in the general area of treated animals, and (4) increasing research efforts to determine true human consumption risks.

TABLE E-1. A SUMMARY OF THE PERCEIVED ADVANTAGES AND DISADVANTAGES OF DIFFERENT REPRODUCTIVE CONTROL AGENTS FOR DEER

Reproductive Control Agent	Mechanism	Advantages	Disadvantages
PZP Vaccine	Immunization – antibodies directed at the ovum (egg).	• No hormonal residues • Effective for at least 1 year • Antibodies not harmful to humans • Apply any time of year • Remote delivery possible • No apparent adverse health effects • Reversible • Available for use as an INAD	• Requires booster vaccinations • Only useful in females • Females continue to cycle out of natural breeding season • Not 100% effective • Potential adjuvant problems • Animals must be permanently marked in hunted populations
GnRH Vaccine	Immunization – antibodies directed at a protein hormone that is needed for reproduction.	Same as above plus: • Stops hormonal cycling • Applicable to both males and females • Adjuvant may be FDA approved in future • Used as an INAD	• Can remove primary and secondary sexual characteristics • May affect behaviors • Animals must be permanently marked • Incompletely tested in free-ranging populations
GnRH Agonists Leuprolide Historelin	Overwhelming GnRH receptors on anterior pituitary suppressing release of reproductive hormones.	• No hormonal meat residues • No affect on reproductive behaviors • FDA approved for therapeutic use in humans • Slow-release formula available • Remote delivery possible • Continuous release micro-pump (surgically implanted) available	• Annual treatment prior to breeding season • Meat withdrawal period not well established
GnRH Toxin	Linking a GnRH analog to a cellular toxin which targets and kills GnRH receptors preventing release of reproductive hormones.	• May cause permanent sterility	• More research is needed before using this product in free-ranging populations
Steroid Hormones Progestins Estrogens	Controlling the reproductive cycle by administering steroid hormones or their analogues.	• Variable efficacy • Variable duration	• Some formulations can be accumulated in tissues and may pose a health risk to scavengers or humans • Some steroids can be harmful to the target species • Animals must be marked • Administered by slow release implants or repeated feeding
Contragestion Prostaglandin $F_{2\alpha}$	Pre-term pregnancy termination.	• Administered by biobullet or hand injection • FDA approved for use in domestic large animals • No meat withdrawal period in domestic cattle	• Administered when the animal is pregnant • Re-breeding may occur if given early • Increased health complications if given late

Appendix F: Deer Population and Vegetation / Regeneration Monitoring Methods

Deer Population Monitoring Methods

Park staff would continue using the distance sampling method to annually estimate the deer population density within the park (NPS 2004f). 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 objects of interest are. The method allows for a proportion of objects within a certain distance of the line to be missed. Unbiased estimates of density can be obtained from the distance data if three assumptions are met: (1) objects on the line or point are detected with certainty; (2) objects are detected at their initial location; and (3) distance measurements are exact (Buckland et al. 2001; Thompson et al. 1998; Underwood et al. 1998). A problem with distance sampling in past surveys has been the use of roads and trails as the transect. Recent research and discussion concerning a curved line transect has alleviated many of the conflicts; however, the use of roads and trails still carries the risk of bias from unrepresentative sampling of available habitats (Buckland et al. 2001; Hiby and Krishna 2001). However, Buckland et al. (2001) state that few studies have attempted to verify whether the resulting density estimates are unbiased for the wider study area. After five years of distance sampling (from 2001 to 2005), NPS staff at Catoctin were able to detect a 1% change in the deer population (Bates, pers. comm. 2005; NPS 2004f).

Surveys would typically be conducted at night when deer are most active and would be conducted in late October when leaf drop allows easy viewing and deer behavior is not radically influenced by the breeding season. Deer surveys at Catoctin have been conducted in late October since 1989.

Distance sampling surveys would be conducted for three consecutive nights unless ambient conditions or personal safety reasons (e.g., heavy traffic) required a postponement. Additional surveys would be added when variability in the data exceeded certain statistical standards; specifically, when the coefficient of variation associated with the number of deer groups encountered after three nights of sampling exceeded 20% or if the detection probability variation exceeded 25%. The coefficient of variation and the detection probability variation would not be calculated until the third survey had been completed. The coefficients would be recalculated after each subsequent survey until the above-mentioned criteria were satisfied.

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

Ambient conditions should meet minimum standards (wind — less than 19 mph; rain — less than heavy; visibility — greater than 2 miles; temperature — higher than 35°F), as reported from the nearest official National Oceanographic and Atmospheric Administration weather data site (<www.weatherunderground.com>) before each survey. Surveys would be postponed if ambient conditions could exceed minimum standards during the survey.

Surveys would begin no earlier than 30 minutes after sunset. A minimum three-person crew, consisting of a driver (data recorder) and two observers, would be required to execute each survey. Survey routes would be driven at speeds ranging from 6 to 10 mph. Observers would use handheld spotlights to illuminate the survey area on both sides of the transect; each observer would focus attention on one side of the transect. Upon

detection of a deer, the observer would direct the driver to position the vehicle such that the perpendicular distance (90° angle to the transect) could be measured. Because 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 was not possible, a radial distance could be measured. When measuring a radial distance, the bearing of the transect and the white-tailed deer location would be obtained using a handheld compass. The radial distance would then be 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 would be measured using a laser rangefinder and should be 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 would be required to observe groups of deer on the transect line and record the distance of the deer or group, if any, from the transect line.

Deer would be categorized by group size (e.g., an individual deer would be a group of one, and five deer would be a group of five). Deer would be partitioned into groups by using behavioral cues and the nearest neighbor criterion (LaGory 1986). For instance, deer that repeatedly looked back at other deer could be 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 would be counted as part of a group. When large groups of deer were are seen in open fields, group classification would be attempted before positioning the vehicle for a distance measurement so as to minimize a flight response. In cases where the deer fled, the observer would note the initial location of the group and obtain a distance measurement to the location of first detection.

Data would be recorded on a standard deer distance sampling datasheet. Demographic classification would be collected only when bucks, does, and fawns could be clearly identified; “unknown” would be the demographic classification default.

Data would be analyzed using the distance model (Thomas et al. 2003; Underwood et al. 1998). This model provides estimates of population density (deer per square mile) with well-defined confidence intervals. The minimum amount of data required would include the survey dates, park area, transect length, number in group, and distance.

VEGETATION / REGENERATION MONITORING METHODS

If the deer population is to be managed based on the success of forest regeneration, then tree seedlings would be monitored to determine at what point browsing impacts would warrant the implementation of the possible additional actions.

Since 1990 various vegetation monitoring projects have been conducted at Catoctin. In 1990, 45 open plots, each approximately 66 feet square (20 meters square), were established and monitored for five years. In 1997 the vegetation in six open plots was compared with the vegetation in three existing exclosures to document differences. These paired plots and exclosures were monitored from 1997 to 1999 and from 2000 to 2002. In 2004, based on data previously collected and work with Dr. Susan Stout, the park adopted a monitoring protocol to document forest regeneration (NPS 2004i; Marquis et al. 1992; Stout 1999; Pavek 2000; McWilliams et al. 1995). The original 45 plots established in 1990 are the baseline for regeneration monitoring.

Other paired plots (one open, one closed) have been added recently in disturbed areas (blowdowns). Six new exclosures adjacent to randomly chosen open plots from the original 45 were added in 2004 to gather additional information on deer browsing impacts. The original plots would be monitored on a three-year cycle, so that at the end of

each cycle all 45 plots would have been monitored. Within each of the plot areas, four subplots would be surveyed, each of which would be approximately 6.6 feet by 6.6 feet or 44 square feet (4 square meters), for a total monitoring area of approximately 176 square feet (16 square meters). Within the subplots the number of seedlings between height class 3 and 7 (approximately 10–60 inches [or 26–150 cm]) would be counted and species documented. Successful regeneration would be defined as having 51 seedlings or more per open plot in 67% or more of the original 45 open monitoring plots (Stout 1999).

References

REFERENCES

Alverson, W.S.
1988 "Forests too Deer: Edge Effects in Northern Wisconsin." *Conservation Biology* 2:348–58.

Animal Veterinary Medical Association
2001 "2000 Report of AVMA Panel of Euthanasia." *Journal of Animal Veterinary Medical Association* 218 (5): 669–96.

Anderson, R.R., D. McFaden, and G.C. Jones
1976 "Resources Basic Inventory Catoctin Mountain Park: Vegetation Community Structure." Final report. Department of Biology, The American University, Washington, DC.

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, 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 Jan. 12, 2006.

2004 "GnRH: Deer Population Control." Wildlife Services. Available at <http://www.aphis.usda.gov/ws/nwrc/ research/reproductive_control>. Accessed Dec. 7, 2005.

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.

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.

Backer, Dana M., and Douglas Boucher
1997 "The Impact of White-tailed Deer *(Odocoileus virginianus)* Browsing on Plant Biodiversity at Catoctin Mountain Park, Maryland." Department of Biology, Hood College, Frederick, MD.

Baker, D.L., T.M. Nett, N.T. Hobbs, R.B. Gill, and M.M. Miller
1999 "Evaluation of GnRH-Toxin Coagulate As an Irreversible Contraceptive in Female Mule Deer." The Wildlife Society 6th Annual Conference, Austin, TX.

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

Becker, S.E. and L.S. Katz
1995 "Effects of Gonadotropin-Releasing Hormone Agonist on Serum Luteinizing Hormone Concentrations in Female White-tailed Deer." *Small Ruminant Research* 18:145–150.

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.

Boone, D.D. and B.A. Dowell
1986 "Catoctin Mountain Park Bird Study 1985–1986." Final report. Prepared for the National Park Service. On file at Catoctin Mountain Park, Thurmont, MD.

Boucher, Douglas H. and Kerrie L. Kyde
1999 "Effects of Deer Enclosures on Plant Abundance and Diversity in Catoctin Mountain Park, Maryland: 1999 Results." Department of Biology, Hood College, Frederick, MD.

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.

Bramble, W.C. and M.K. Goddard
1953 "Seasonal Browsing of Woody Plants by White-tailed Deer in the Ridge and Valley Section of Central Pennsylvania." *Journal of Forestry* 51:815–19.

Braun, E.L.
1950 *Deciduous Forests of Eastern North America.* New York: Hafner Publishing Company.

Brown, R.G. and M.L. Brown
1972 *Woody Plants of Maryland*. Baltimore: Port City Press.

1984 *Herbaceous Plants of Maryland*. Baltimore: Port City Press.

Brown, T.L., D.J. Decker, and P. Curtis
2004 "Farmers' Estimates of Economic Damage from White-tailed Deer in New York State." HDRU Series No. 04-3. Human Dimensions Research Unit, Cornell University, Ithaca, NY.

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 Biological Populations*. New York: Oxford University Press.

Caughley, C.G.
1974 "Bias in Aerial Survey." *Journal of Wildlife Management* 38(4): 921–33.

1976 "Wildlife Management and the Dynamics of Ungulate Populations." In *Applied Biology*, vol. I, edited by T.H. Coaker. London: Academic Press.

1981 "Overpopulation." In *Problems in Management of Locally Abundant Wild Mammals*, edited by P.A. Jewell and S. Holt. New York: Academic Press.

Cheatum, E.L.
1949 "Bone Marrow as an Index of Malnutrition in Deer." *New York State Conservation* 3(5).

Chesapeake Bay Program
2005 "Sediment Related Criteria for Surface Water Quality." Available at <http://www.chesapeakebay. net/pubs/subcommittee/wqsc/wqsctg/doc-StatesSedimentWaterClarityRelatedWQSSummary.pdf>. Accessed July 25, 2005.

Chronic Wasting Disease Alliance
n.d. Information available at <http://www.cwd-info.org/index.php/fuseaction/about.main>.

Coffey, M.A.
1999 "White-tailed Deer in National Parks." NPS Natural Resource Information Division Fact Sheet. Available at <www.nature.nps.gov/facts/fdeer2.htm>.

Conner, Mark C., Edward C. Soutiere, and Richard A. Lancia
1987 "Drop-netting Deer: Costs and Incidence of Capture Myopathy." *Wildlife Society Bulletin* 15 (3): 434–38.

Council on Environmental Quality
1978 "Regulations for Implementing the Procedural Provisions of the National Environmental Policy Act." *Federal Register* 43: 55978–56007.

1981 "Forty Most Asked Questions Concerning CEQ's National Environmental Policy Act Regulations." *Federal Register* 46 (55): 18026–38.

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.

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

Cypher, B.L. and E.A. Cypher
1988 "Ecology and Management of White-tailed Deer in Northeastern Coastal Habitats: A Synthesis of the Literature Pertinent to National Wildlife Refuges from Maine to Virginia." Biological Report 88(15). U.S. Fish and Wildlife. Service.

Dassman, R.
1971 *If Deer Are to Survive.* Harrisburg: Stackpole Books.

Davidson, William R.
1988 "Report on Deer Herd Health Check, November 30." College of Veterinary Medicine (Parasitology), University or Georgia.

2002 "Report on Deer Herd Health Check, October 21." College of Veterinary Medicine, University of Georgia.

deCalesta, D.S.
1992 "Impact of Deer on Species Diversity of Allegheny Hardwood Stands." In *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,* edited by William J. McShea, H. Brian Underwood, and John H. Rappole, 267–79. Washington, DC: Smithsonian Institution Press.

Decker, D.J. and T.L. Brown
1982 Fruit Growers' vs. Other Farmers' Attitudes Toward Deer in New York. The Wildlife Society Bulletin 10:150-155.

Deer-Resistant Landscape Nursery
2004 "Deer-resistant Plants." Available at <http://www.deerxlandscape.com/cgi-bin/webc.cgi/st_main.html?p_catid=9>. Accessed July 25, 2005.

DeNicola, Anthony J. and Robert K. Swihart
1997 "Capture-induced Stress in White-tailed Deer." *Wildlife Society Bulletin* 25 (2): 500–503.

DeNicola, A.J., D.J. Kesler, and R.K. Swihart
1997 "Remotely Delivered Prostaglandin $F_{2\alpha}$ Implants Terminate Pregnancy in White-tailed Deer." *Wildlife Society Bulletin* 25:527–31

DeNicola, A.J., K.C. VerCauteren, P.D. Curtis, and S.E. Hygnstrom
1999 *Managing White-tailed Deer in Suburban Environments: A Technical Guide.* Cornell Cooperative Extension, Ithaca, NY.

D'Occhio, M.J., W.J. Aspden, and T.R. Whyte
1996 "Controlled, Reversible Suppression of Oestrous Cycles in Beef Heifers and Cows Using Agonist of Luteinizing Hormone-Releasing Hormone." *Journal of Animal Science* 74: 218–25.

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

Ellingwood, M.R. and S.L. Caturano
1988 *An Evaluation of Deer Management Options*. Wildlife Bureau, Connecticut Department of Environmental Protection.

Environmental Protection Agency
2005 "National Management Measures to Control Nonpoint Source Pollution from Forestry." Report EPA-841-B-05-001, April. Office of Water.

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.

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.

Fairfax County, Virginia
2003 "Deer Management Report." Wildlife Section, Animal Services Division, Fairfax County Police Department.

2005 "Deer Management in Fairfax County." Available at <http://www.co.fairfax.va.us/comm/deer/deermgt.htm>. Accessed Aug. 11, 2005.

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* 15:119–26.

Flyger, V. MS.
1956 "The Status of White-tailed Deer in Maryland." Natural Resources Division, Maryland Department of Research and Education.

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

Frederick County, Maryland
n.d.a "Zoning Atlas." Available at <http://www.co.frederick.md.us/planning/zoneatls.html>. Accessed April 2005.

n.d.b *Thurmont Region Plan.* Available at <http://www.co.frederick.md.us/planning/thurmont.htm>. Accessed April 2005.

n.d.c *Walkersville Region Plan*. Available at <http://www.co.frederick.md.us/planning/walkersville/WARegionPlan.htm>. Accessed March 2006.

1995 *Frederick County Comprehensive Plan, Volume I.* Available at <http://www.co.frederick.md.us/ planning/CompPlan/>.

1998 *Frederick County Comprehensive Plan. Volume I: Countywide Plan*. Available at <http://www.co.frederick.md.us/planning/CompPlan/>.

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.

Fuller, J.C.
1991 "Bark-stripping of Slippery Elm by White-tailed Deer." M.S. Thesis. West Virginia University.

Garrot, Robert A.
1994 "Effective Management of Free-Ranging Ungulate Populations Using Contraception." *Wildlife Society Bulletin* 23 (3): 445–52.

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.

Gibbs, D.
1995 *Deer Resistant Plants for the Home Landscape*. Chevy Chase, MD. National Capital Park and Planning Commission. Referenced in *Fact Sheet 655*. Maryland Cooperative Extension, University of Maryland. Available at <http://www.agnr.umd.edu/CES/Pubs/PDF/FS655.pdf>. Accessed July 25, 2005.

Goodman, David, and Richard S. Sojda
2004 "Applying Advanced Technologies for Adaptive Management and Decision Support in Natural Resources." Available at <http://www.esg.montana.edu/esg/adaptive_mgmt_1.html>. Accessed Aug. 11, 2005.

Hadidian, John
1994 "Data Collection, Catoctin Mountain Park." On file at Catoctin Mountain Park, Thurmont MD.

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.

Hazum, E. and P.M. Conn
1998 "Molecular Mechanisms of Gonadotropin Releasing Hormone (GnRH) Action: I. The GnRH Receptor." *Endocrine Review* 9: 379–86.

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.

Hiby, L. and M.B. Krishna
2001 "Line Transect Sampling from a Curving Path." *Biometrics* 57:727–731.

Hickey, C. J.
1975 "The Vascular Flora of Catoctin Mountain Park in Frederick County, Maryland." M.S. thesis, Towson State College.

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.

Holling, C.S., ed.
1978 *Adaptive Environmental Assessment and Management.* New York: John Wiley & Sons.

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

Hosley, N.W. and R. K. Ziebarth
1935 "Some Winter Relations of the White-tailed Deer to Forests in North Central Massachusetts." *Ecology* vol. 16, no. 4.

Hough, A.F.
1965 "A Twenty-Year Record of Understory Vegetation Change in a Virgin Pennsylvania Forest." *Ecology*, vol. 46, no. 3.

Iowa Department of Natural Resources
2005 "White-tailed Deer." Des Moines, IA. Available at <http://www.iowadnr.com/wildlife/>. Accessed Feb. 1, 2006.

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 Free-ranging Wisconsin White-tailed Deer." *Emerging Infectious Diseases* 9:599–601.

Jones, J.M., and J.H. Witham
1990 "Post-translocation Survival and Movements of Metropolitan White-tailed Deer." *Wildlife Society Bulletin,* vol. 18.

Kilpatrick, H.J. and W.D. Walter
1997 "Urban Deer Management: A Community Vote." *Wildlife Society Bulletin* 25: 388–91.

1999 "A Controlled Archery Deer Hunt in a Residential Community: Cost, Effectiveness, and Deer Recovery Rates." *Wildlife Society Bulletin* 27:115–23.

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 ,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.

Kirkpatrick, J.F., J.W. Turner, Jr., I.K. M. Liu, 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* 9:105–10.

Knox, W.M., K.V. Miller, and R.L. Marchinton
1988 "Recurrent Estrous Cycles in White-tailed Deer." *Journal of Mammalogy* 69:384–86.

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* 41:503–11.

LaGory, K.E.
1986 "Habitat, Group Size, and the Behavior of White-tailed Deer." *Behavior* 98:168–79.

Langdon, K.
1985 "White-tailed Deer Action Plan." Supplement to *Natural Resource Management Plan, Catoctin Mountain Park.* On file at Catoctin Mountain Park, Thurmont, MD.

2001 "A Comparison of White-tailed Deer Population Estimation Methods in West Virginia." Thesis submitted to the College of Agriculture, Forestry, and Consumer Sciences at West Virginia University.

Leopold, A., L.K. Sowls, and D.L. Spencer
1947 "A Survey of Over-populated Deer Ranges in the U.S." *Journal of Wildlife Management* vol. 11, no. 2.

LeReusche, R.E. and R.A. Rausch
1974 "Accuracy and Precision of Aerial Moose Censusing." *Journal of Wildlife Management*, vol. 38.

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.

Lowe's Greenhouse
2003 "Deer Resistant Plants." Available at <http://www.lowesgreenhouse.com/ deer%20resistant%202003.pdf>. Accessed July 27, 2005.

Lynch, Lori
1997 "Maryland Deer Valued for Social, Recreational and Commercial Reasons." In *Deer Management and Policy Options in Maryland – Conference Proceedings*. Center for Agricultural and Natural Resource Policy, University of Maryland. Available at <http://www.arec.umd.edu/Policycenter/ Deer-management-in-Maryland/lunch1.htm>. Accessed July 15, 2005.

Management Considerations
n.d. "Species: *Bromus ciliatus*." Available at <www.fs.fed.us/database/feis/plants/graminoid/brocil/ management_considerations.html>. Accessed July 27, 2005.

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.

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 Agricultural Statistics Service
2002 "2001 Wildlife Damage Survey." Available at <http://www.nass.usda.gov/md/2001%20Wildlife%20Damage.pdf>. Accessed July 15, 2005.

2004 "Maryland Agrifacts." AF-05-04. Mar. 9. Available at <http://www.nass.usda.gov/md/ag0504.pdf>. Accessed July 13, 2005.

Maryland Department of Natural Resources
n.d. "Maryland State Hunting Regulations." Available at <http://www.dnr.state.md.us/outdooradventures/hunt2cfalls.html>.

1998 *Charting the Course for Deer Management in Maryland: A Management Plan for White-tailed Deer in Maryland*. Available at <http://www.dnr.state.md.us/wildlife/contents.html>.

2000 "Frederick City Watershed CWMA." Available at <http://www.dnr.state.md.us/publiclands/ western/fcw.html>

2004a "Deer Damage Permit Information." Wildlife and Heritage Service. Available at <http://www.dnr.maryland.gov/wildlife/ddpermit.asp>. Accessed July 18, 2005.

2004b "Questions and Answers about MD's Proposed Black Bear Management Plan." Maryland Wildlife and Heritage Service. Available at <http://www.dnr.state.md.us/dnrnews/infocus/blackbear_faq.html>.

2004c "Guide to Hunting and Trapping. Region B: Deer Seasons and Bag Limits." Available at <http://www.dnr.state.md.us/huntersguide/regionb.asp>.

2005a "2005–2006 Forest Game Seasons and Bag Limits." Available at <http://www.dnr.state.md.us/huntersguide/2005_2006fg.asp>. Last updated Feb. 11.

2005b "Deer Crop Damage Statistics for Catoctin Mountain Park Area, 2000 through 2004." Baltimore, MD. On file at Catoctin Mountain Park, Thurmont, MD.

2005c "Deer Management Options." Wildlife and Heritage Service. Available at <http://www.dnr.state.md.us/wildlife/options/html>. Accessed Aug. 13, 2005.

2005d "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 Jan. 31, 2006.

Maryland Historical Trust
2005 "National Register Listings in Maryland." Available at <http://www.marylandhistorictrust.net/nr>. Accessed July 21, 2005.

Maryland State Archives
2003 "Historical List, Governors of Maryland, 1896–." Available at <www.mdarchives.state.md.us/msa/ speccol/sc2600/sc2685/html/gov05.html>. Site visited Nov. 19, 2003.

Matschke, G.H.
1977 "Antifertility Action of Two Synthetic Progestins in Female White-tailed Deer." *Journal of Wildlife Management* 41: 194–96.

McCabe, R.E. and T.R. McCabe
1984 "Of Slings and Arrows: An Historical Retrospection." *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.

McIntyre, E.B.
1972 "Bark Stripping — A Natural Phenomenon." *Journal of the Royal Scottish Forestry Society* 26:43–50.

McNew, Kevin and John Curtis
1997 "Maryland Farmers Lose Bucks on Deer-Damaged Crops." In *Deer Management and Policy Options in Maryland — Conference Proceedings*. Center for Agricultural and Natural Resource Policy, University of Maryland. Available at <http://www.arec.umd.edu/Policycenter/Deer-management-in-Maryland/lunch1.htm>. Accessed July 15, 2005.

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 C.O'Brien
2003 "Small Mammal Survey of National Capital Region Parks." Prepared for the National Park Service by the Smithsonian Institution, Washington, DC.

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.

McShea, William J., Steven L. Monfort, Salah Hakim, Jay Kirkpatrick, Irwin Liu, John W. Turner, Jr., Lisa Chassy, and Linda Munson
1997 "The Effect of Immunocontraception on the Behavior and Reproduction of White-tailed Deer." *Journal of Wildlife Management* vol. 61, no. 2.

McWilliams, W.H., S.L. Stout, T.W. Bowersox, 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.

Michael, E.D.
1987 "Bark Stripping by White-tailed Deer in West Virginia." Northern Journal of Applied Forestry 4:96–97.

Mielke, M., and K. Langdon
1986 "Dogwood Anthracnose Fungus Threatens Catoctin Mountain Park." *Park Science* vol. 6, no. 2.

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.

Miller, M.W. and M.A. Wild
2004 "Epidemiology of Chronic Wasting Disease in Captive White-tailed and Mule Deer." *Journal of Wildlife Diseases* 40:320–27.

Miller, M.W. and E.S. Williams
2003 "Prion Disease: Horizontal Prion Transmission in Mule Deer." *Nature* 425:35–36.

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* 34:532–38.

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* 10:1003–6.

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* 36:676–90.

Miquelle, D.G. and V. van Ballenberghe
1989 "Impact of Bark Stripping by Moose on Aspen-Spruce Communities." *Journal of Wildlife Management* 53:577–86.

Montgomery County, Maryland
2004 "Montgomery County Deer Management Program: Annual Report and Recommendations." Deer Management Work Group, Montgomery County, MD.

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.

Muller, Lisa I., Robert J. Warrnen, and Donald L. Evans
1997 "Theory and Practice of Immunocontraception in Wild Animals." *Journal of Wildlife Management* vol. 25 (2): 504–14.

National Agricultural Statistics Service
1999 "Fruit Wildlife Damage." May 26. Agricultural Statistics Board, U.S. Department of Agriculture, Washington, DC. Available at <www.nass.usda.gov>.

2004 "New England Agricultural Statistics for 2004: Apples." Available at <www.nass.usda.gov>.

National Park Service, U.S. Department of the Interior
n.d. "Revised Timeline for Deer EIS and TAC." Provided by park staff. Catoctin Mountain Park, Thurmont, MD.

1990a "Catoctin Mountain Park Administrative History." On file at park headquarters, Thurmont, MD.

1990b "Catoctin Mountain Park White-tailed Deer Research, January 1988-January 1990." Thurmont, MD.

1991a *Fire Management Plan, Catoctin Mountain Park.* Thurmont, MD.

1991b *NPS 77: Natural Resource Management Guideline.* Washington, DC.

1993 "Catoctin Mountain Park Deer Mortality Survey." Thurmont, MD.

1994a *Protecting Cultural Landscapes: Planning, Treatment and Management of Historic Landscapes.* Preservation Brief 36. Washington, DC.

1994b *Resources Management Plan, Catoctin Mountain Park.* Thurmont, MD.

1995a "Catoctin Mountain Park Deer Telemetry Project 1994-1995 Summary Report." Thurmont, MD.

1995b *Environmental Assessment, White-tailed Deer Management in Catoctin Mountain Park*, and "Finding of No Significant Impact," January 31. Thurmont, MD.

1995c *Gettysburg National Military Park and Eisenhower National Historic Site, White-tailed Deer Management Plan and Environmental Impact Statement.* Gettysburg, PA

1996a "Nomination Forms for the National Register of Historic Places, Camp Misty Mount Historic District and Camp Greentop Historic District, Catoctin Mountain Park." On file at Catoctin Mountain Park, Thurmont, MD.

1996b *Statement for Management, Catoctin Mountain Park.* Thurmont, MD.

1996c *The Secretary of the Interior's Standards for the Treatment of Historic Properties, with Guidelines for the Treatment of Cultural Landscapes.* Washington, DC.

1997a *Comprehensive Interpretive Plan, Catoctin Mountain Park*. Thurmont, MD.

1997b *NPS-28: Cultural Resource Management Guideline.* Release 5. Washington, DC.

1998a *Director's Order 28: Cultural Resources Management*. Washington, DC.

1998b *Resource Management Plan Catoctin Mountain Park 1998 Update*. Thurmont, MD.

1998c "Water Resources Scoping Report, Catoctin Mountain Park," by Wayne Rose, Matthew Sherald, and James Voigt. Thurmont, MD.

1999a "Catoctin Mountain Park Spotlight Survey Results." Thurmont, MD.

1999b "Catoctin Mountain Park Aerial Deer Census." Thurmont, MD.

2000a "Cultural Landscapes Inventory, Catoctin Mountain Park." Thurmont, MD.

2000b "Forest Stand Structure — Regrowth." Catoctin Mountain Park, Thurmont, MD.

2000c *Management Policies 2001*. Washington, DC. Available at <http://www.nps.gov>.

2000d *Strategic Plan, Catoctin Mountain Park.* Thurmont, MD.

2000e "Summary Report: White-tailed Deer Management in Catoctin Mountain Park, Frederick County, Maryland," by Dr. John Hadidian. Thurmont, MD.

2000f "Vegetation Baseline Data Sampling Design and Analyses." Catoctin Mountain Park, Thurmont, MD.

2001a "Desired Visitor Outcomes for Catoctin Mountain Park. August." Catoctin Mountain Park, Thurmont, MD.

2001b *Director's Order #12: Conservation Planning, Environmental Impact Analysis, and Decision-making,* and *Handbook.* Washington, DC. Available at <http://www.nps.gov/policy/DOrders/ DOrder12.html> and <http://www.nps.gov/policy/DOrders/RM12.pdf>.

2001c "Interpretive Themes for Catoctin Mountain Park." Catoctin Mountain Park, Thurmont, MD.

2001d "Statements of Significance for Catoctin Mountain Park." Thurmont, MD.

2002a "Catoctin Mountain Park Visitor Study." Report 138. University of Idaho Park Studies Unit.

2002b "Director's CWD Guidance Memorandum." July 26. Washington, DC.

2002c *How to Apply the National Register Criteria for Evaluation.* National Register Bulletin #15. Revised for the Internet. National Register, History and Education. Available at <http://www.cr.nps.gov/nr/publications/bulletins/nrb15/>. Accessed Dec. 20, 2004.

2003a "Deer 2003 Scoping Meeting." PowerPoint presentation. On file at Environmental Quality Division, Denver, CO.

2003b *Gypsy Moth Suppression Program Environmental Assessment.* Catoctin Mountain Park. Thurmont, MD.

2003c *Hemlock Woolly Adelgid Suppression, Environmental Assessment.* Catoctin Mountain Park. Thurmont, MD.

2003d "Internal Scoping Meeting and Field Trip Report, Catoctin Mountain Park, October 28–30." On file at Environmental Quality Division, Denver, CO.

2004a "Annual Performance Plan for Catoctin Mountain Park." April 9. Available at <http://www.nps.gov/cato/docs/perfplan/2004perf.htm>.

2004b "Deer Management: Deer Spotlight Survey Data." PowerPoint presentation at Nov. 2004 Alternatives Meeting. On file at Catoctin Mountain Park, Thurmont, MD.

2004c *Fire Management Plan, Catoctin Mountain Park*. Thurmont, MD.

2004d *Integrated Pest Management Plan, Catoctin Mountain Park.* Updated. Thurmont, MD.

2004e "Internal Scoping Report, Deer Management Plan, Catoctin Mountain Park." On file at Catoctin Mountain Park, Thurmont, MD.

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

2004g "Summary: 2003–2004 NRPP Exotic Plant Project at Catoctin Mountain Park." Thurmont, MD.

2004h "Superintendent's Compendium, Catoctin Mountain Park." Available at <http://www.nps.gov/cato/ docs/compend/comp2004.htm>.

2004i "Vegetation Monitoring Protocol, 2004, Catoctin Mountain Park." On file at Catoctin Mountain Park, Thurmont, MD.

2004j *Visitor Brochure, Catoctin Mountain Park.* Harpers Ferry, WV.

2004k "Visitor Use Statistics, Catoctin Mountain Park." Available at <http://www2.nature.nps.gov/stats/>. Accessed Nov. 2.

2005a "Alternatives Development, Internal Meeting held at Catoctin Mountain Park." Feb. 23–25. Report on file at Catoctin Mountain Park, Thurmont, MD.

2005b "Alternatives Development Public Workshop, Draft White-tailed Deer Management Plan / Environmental Impact Statement, Catoctin Mountain Park." April 20. Report on file at Catoctin Mountain Park, Thurmont, MD.

2005c *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. Office of Public Health, Visitor and Resource Protection Directorate. Washington, DC.

2005d Information on the Catoctin Mountain Park website. Available at <http://www.nps.gov/cato/pphtml/nature.html>. Accessed 2005.

2005e *A National Park Service Manager's Reference Notebook to Understanding Chronic Wasting Disease,* by Jenny Powers and Margaret Wild. Nov. 15. Biological Resource Management Division, Fort Collins, CO.

2005f *Natural Resource Reference Manual 77.* Washington, DC. Available at <http://www.nature.gov/rm77/>. Accessed Aug. 3, 2005.

2005g *Soundscape Preservation and Noise Management Plan, Catoctin Mountain Park.* Catoctin Mountain Park, Thurmont, MD.

2005h "Vegetation Characteristics and Breeding Bird Densities at Catoctin Mountain Park and the Frederick City Watershed." National Capital Region Center for Urban Ecology. On file at Catoctin Mountain Park, Thurmont, MD.

2005i "Visitor Spending and Economic Impacts for National Park Units." Available at <http://www.prr.msu.edu/yayen/NPS/NPSSelect.cfm>. Updated March 17.

2005j "Water Quality, Catoctin Mountain Park." Available at <http://www.nps.gov/cato/pphtml/subenvironmentalfactors22.html>. Accessed July 7, 2005.

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.

Nielsen, C.K., W.F. Porter, and H.B. Underwood
1997 "An Adaptive Management Approach to Controlling Suburban Deer." *Wildlife Society Bulletin* 25:470–77.

Nyberg, J.B.
1998 "Statistics and the Practice of Adaptive Management." *Statistical Methods for Adaptive Management Studies.* Land Management Handbook for the British Columbia Ministry of Forests Research Program. Victoria, BC.

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.

Oldfield, B. and J. Moriarty
1994 *Amphibians and Reptiles Native to Minnesota.* University of Minnesota Press.

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* 36:1750–55.

Pavek, D.
2000 "Vegetation Baseline Data, Sampling Design and Analyses." On file at Catoctin Mountain Park, Thurmont, MD.

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* 12:579–82.

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.

1992 "Burgeoning Ungulate Populations in National Parks: Is Intervention Necessary?" In *Wildlife 2001: Populations,* edited by D. R. McCullough and R. H. Barret, 304–12.

Porter, W.F., and H.B. Underwood
1999 "Of Elephants and Blind Men: Deer Management in the U.S. National Parks." *Ecological Applications* 9:3–9.

2001 "Contraception and Deer: The Irondequoit Report." The Roosevelt Wild Life Station, College of Environmental Science and Forestry, State University of New York, Syracuse.

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.

Prusiner, S.B.
1982 "Research on Scrapie." *Lancet* 2:494–95.

1991 "Molecular Biology of Prion Diseases." *Science* (Washington) 252:1515–22.

1997 "Prion Diseases and the BSE Crisis." *Science* (Washington) 278:245–51.

Redding, J.
1995 "History of Deer Population Trends and Forest Cutting on 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.

Robbins, C., B. Bruun, H. Zim, and A. Singer
1983 *A Guide to Field Identification: Birds of North America.* Rev. ed. New York: Golden Press. Western Publishing Company, Racine, WI.

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.

Russek-Cohen, Estelle
2003 "A Statistical Analysis of Vegetation Data Collected during 1990–1995 and 2000–2002. Possible Impacts of White-tailed Deer on Vegetation within Catoctin Mountain Park." Biometrics Program, University of Maryland.

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." *Biological Conservation* 116:243–50.

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.

Salman, M.D.
2003 "Chronic Wasting Disease in Deer and Elk: Scientific Facts and Findings." *Journal of Veterinary Medical Science* 65:761–68.

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.

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, WI.

Sayre, R.W., and D.J. Decker
1990 *Deer Damage to the Ornamental Horticulture Industry in Suburban New York: Extent, Nature and Economic Impact.* Human Dimensions Research Unit Publication 90-1, Cornell University, Ithaca, NY.

Schneeberger, N.F. and W. Jackson
1988 "Impact of Dogwood Anthracnose on Flowering Dogwood at Catoctin Mountain Park." Office of Natural Resources, Catoctin Mountain Park, Thurmont, MD.

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.

Shafer, E.L.
1965 "Deer Browsing of Hardwoods in the Northeast." U.S. Forest Service Research Paper NE-33.

Shrauder, P.A.
1984 "Appalachian Mountains." In *White-tailed Deer*, edited by L. K. Halls. Harrisburg, PA: Stackpole Books.

Shelford, V.E.
1972 "Vascular Plants of the Catoctin Mountain Park Area." Office of Resource Management, Catoctin Mountain Park.

1974 *The Ecology of North America*. Urbana: University of Illinois Press.

Short, H.L.
1986 "Habitat Suitability Index Model: White-tailed Deer in the Gulf of Mexico and South Atlantic Coastal Plain." Biological Report 82 (10.123). U.S. Fish and Wildlife Service.

Sinclair, J.A.
2002 "National Capital Network Bird Inventory Program." 2001 Annual Report. National Capital Parks, National Park Service, Washington, DC.

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>.

2004 "2003 HD Final Report." *SCWDS Briefs* 20 (2): 6–7. Available at <http://www.uga.edu/scwds/topic_index.html>.

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.

Stills, H.F. Jr., and M.Q. Bailey
1991 "The Use of Freund's Complete Adjuvant." *Laboratory Animal* 20: 25–30.

Stockle, A.W., W.R. Davidson, and G.L. Doster
1978 "Endogenous Fat As an Indicator of Physical Condition of Southeastern White-tailed Deer." *Proceedings of the Southeast Association of Fish and Wildlife Agencies* 32:269–79.

Storm, G.L., R.H. Yanner, D.F. Cottam, and G.M. Vecellio
1989 "Population Status, Movements, Habitat Use, and Impact of White-tailed Deer at Gettysburg National Military Park and Eisenhower National Historic Site, Pennsylvania." Technical Report NPS/MAR/NRTR-89/043.

Stott, J.L.
1998 "Bluetongue and Epizootic Hemorrhagic Disease." In *Part IV: Foreign animal Diseases, "The Gray Book."* Committee on Foreign Animal Diseases, United States Animal Health Association. Richmond, VA. 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.

Strickland, B. and S. Demarais.
2003 "Buck Movements and Mortality: Limitations in QDM Programs" Available at <http://www.qdma.com/articles/details.asp?id=7>.

Strider, P.
1983 "Aerial Deer Census of Catoctin Mountain Park." Office of Resource Management, Catoctin Mountain Park, Thurmont, MD.

Stynes, D.J. and Ya-Yen Sun
2003 *Economic Impacts of National Park Visitor Spending on Gateway Communities, Systemwide Estimates for 2001.* Department of Park, Recreation, and Tourism Resources, Michigan State University, East Lansing, MI. Available at <http://www.prr.msu.edu/mgm2/NPSSystem2001.pdf>.

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.

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, and J.R.B. Bishop
2003 "Distance 4.1. Release 2." Research Unit for Wildlife Population Assessment, University of St. Andrews, UK. Available at <http://www.ruwpa.st-and.ac.uk/distance/>. Accessed Aug. 12, 2005.

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

Tilghman, N.G.
1989 "Impacts of White-tailed Deer on Forest Regeneration in Northwestern Pennsylvania." *Journal of Wildlife Management* 53:524–32.

Thurmont, Maryland
n.d. *Zoning Ordinance*. Available at <http://www.thurmont.com/Thurmont_Zoning_Ordinance.doc>. Accessed April 2005.

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
2001 "Parasites and Host Population Dynamics." In *The Ecology of Wildlife Diseases*, edited by P.J. Hudson, A. Rizzoli, B.T. Grenfell, H. Heesterbeek, and A.P. Dobson, 45–62. New York: Oxford University Press.

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 GnRH Analogue Implant to Produce Reversible Long term Suppression of Reproductive Function in Male and Female Domestic Dogs." *Journal of Reproduction and Fertility* (Suppl.) 57: 255–62.

Truax, Barry
1999 *Handbook for Acoustic Ecology*. 2nd ed. Originally published by the World Soundscape Project, Simon Fraser University, and ARC Publications, 1978. N.p.: Cambridge Street Publishing. Available at <http://www.sfu.ca/ sonic-studio/handbook/index.html>. Accessed Jan. 31, 2006.

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.

Turner, John W., Jr., Irwin K.M. Liu, and Jay F. Kirkpatrick
1992 "Remotely Delivered Immunocontraception in Captive White-tailed Deer." *Journal of Wildlife Management* 56 (1): 154–57.

Underwood, H. Brian, Frank D. Verret, and James P. Fischer
1998 "Density and Herd Composition of White-tailed Deer Populations on Fire Island National Seashore." On file at Fire Island National Seashore, Patchogue, NY.

U.S. Bureau of the Census, U.S. Department of Commerce
2005 "Maryland QuickFacts." Available at <http://quickfacts.census.gov/qfd/states/24/24021.html>. Last updated February 1.

U.S. Centers for Disease Control and Prevention
2003 "CDC Lyme Disease Home Page." Available at <http://www.cdc.gov/ncidod/dvbid/lyme/ index.htm>.

U.S. Department of Agriculture
1997 "Soil Survey Report, Catoctin Mountain Park, Maryland."

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. Fish and Wildlife Service, U.S. Department of the Interior, and U.S. Bureau of the Census, U.S. Department of Commerce
2001 *National Survey of Fishing, Hunting, and Wildlife-Associated Recreation.* Available at <http://www.census.gov/prod/2003pubs/01fhw/fhw01-md.pdf>.

2005a Mason Neck National Wildlife Refuge Potomac River National Wildlife Refuge ComplexFact 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.

Verme, L.J.
1965 "Reproduction Studies on Penned White-tailed Deer." *Journal of Wildlife Management* vol. 29, no. 1.

1969 "Reproductive Patterns of White-tailed Deer Related to Nutritional Plane." *Journal of Wildlife Management* 33 (4): 881–87.

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.

Virginia Department of Game and Inland Fisheries
2004 "Hemorrhagic Disease (HD)." Available at <http://www.dgif.state.va.us/hunting/va_game_wildlife/hd.html>. Accessed Aug. 16, 2005.

Waddell, R.D., 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: 1067–74.

Wall, R.
2004 Watching the river run: the science of sustainable flow. The Academy of Natural Sciences. Available at http://www.acnatsci.org/education/kye/pp/kye112003.html. Last visited 6/14/06.

Walter W.D., H.J. Kilpatrick, and M.A. Gregonis
2002 "Does Immunocontraception Improve Condition of Free-ranging Female White-tailed Deer?" *Journal of Wildlife Management* 67 (4): 762–66.

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.

2002b "Evaluation of Immunocontraceptive Adjuvants, Titers, and Fecal Pregnancy Indicators in Free-ranging White-tailed Deer." *Wildlife Society Bulletin* 30:908–14.

Warner, J.R.
1972 "Vascular Plants of the Catoctin Mountain Park Area." Office of Resource Management, Catoctin Mountain Park, Thurmont, MD.

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>.

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.

Warren, Robert J. and Charles R. Ford
1990 "Population and Ecological Characteristics of White-tailed Deer on Catoctin Mountain Park." Final report. U.S. Department of Agriculture and School of Forest Resources, University of Georgia, Athens.

Warren, Robert J., and Daniel B. Warnell
2000 "Overview of Fertility Control in Urban Deer Management." In *Proceedings of the 2000 Annual Conference of the Society for Theriogenology, 2 December, San Antonio, Texas.* Society for Theriogenology, Nashville, Tennessee. Available at <http://coryi.org/Florida_panther/deerfertilitycontrol.pdf>.

Watry M.K., L.L. Wolfe, J.G. Powers, M.A. Wild
2004 "Comparing Implementation of a Live Test and Cull Program for Chronic Wasting Disease in Wildland and Urban Settings." In *Proceedings of AAZV, AAWV, WDA Joint Conference.*

Webb, W.L., R.T. King, and E.F. Patrick
1956 "Effect of White-tailed Deer on a Mature Northern Hardwood Forest." *Journal of Forestry* vol. 54, no. 6.

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.

Wehrle, Edmund
2000 "Catoctin Mountain Park: A Historic Resource Study." Available at <http://www.nps.gov/cato/hrs/hrs.htm>. Accessed July 20, 2005.

WHITE BUFFALO, Inc.
2005 "Review of Available Techniques." Available at <http://www.whitebuffaloinc.org/techniques.htm>. Accessed Jan. 24, 2006.

Whittington, R.W.
1984 "Piedmont Plateau." In *White-tailed Deer*, edited by L.K. Halls. Harrisburg, PA: Stackpole Books.

Williams, B.K.
1997 "Approaches to the Management of Waterfowl under Uncertainty. *Wildlife Society Bulletin* 25:714–20.

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* 21:305–16.

2003 "Transmissible Spongiform Encephalopathies in Non-domestic Animals: Origin, Transmission and Risk Factors." *Revue Scientifique et Technique - Office International des Epizooties* 22:145–56.

Williams, E.S. and S. Young
1992 "Spongiform Encephalopathies in Cervidae." *Revue Scientifique et Technique - Office International des Epizooties* 11:551–67.

1993 "Neuropathology of Chronic Wasting Disease of Mule Deer (*Odocoileus hemionus*) and Elk (*Cervus elaphus nelsoni*)." *Veterinary Pathology* 30:36–45.

Williams, E.S., M.W. Miller, and E.T. Thorne
2002a "Chronic Wasting Disease: Implications and Challenges for Wildlife Managers." *Transactions of the North American Wildlife and Natural Resources Conference 67*. In press.

Williams, E.S., M.W. Miller, T.J. Kreeger, R.H. Kahn, and E.T. Thorne
2002b "Chronic Wasting Disease of Deer and Elk: A Review with Recommendations for Management." *Journal of Wildlife Management* 66:551–63.

PERSONAL COMMUNICATION

Bates, Scott, Wildlife Biologist, Center for Urban Ecology, National Park Service
2005 E-mail correspondence with Beth Kunkel, URS Corporation. Mar. 4.

Bell, P. Scott, Environmental Protection Specialist, Catoctin Mountain Park, National Park Service
2003a E-mail correspondence. Nov. 26.

2003b E-mail correspondence with P. Steinholtz, URS Corporation, regarding low income or minority populations. Dec. 5.

2003c E-mail correspondence. Dec. 8.

2004 Telephone communication. Feb. 24.

Bowersox, Todd, Department of Forestry, Pennsylvania State University
2005 Telephone communication with Beth Kunkel, URS Corporation. May 14.

Crampton, Mark, Assistant District Engineer for Project Development. Maryland Department of Transportation, District Office at Frederick
2003 Telephone communication. Dec. 1.

Davidson, William R., College of Veterinary Medicine, University of Georgia
2002 Letter to Becky Loncosky, NPS. Oct. 21.

DeNicola, Anthony J., President, WHITE BUFFALO, Inc.
2004a Personal communication with Rusty Schmidt regarding direct deer reduction details. Apr. 13.

2004b Telephone conversation with Rusty Schmidt, URS Corporation, regarding SpayVac, GNRH, and PZP. Apr. 16.

Eyler, B., Maryland Department of Natural Resources
2005 Personal communication with M. Mayer, NPS. July 21.

Gould, A., Maryland Department of Natural Resources
1998 Personal communication with J. Voigt, NPS, regarding plant species of concern in Catoctin Mountain Park. Jan. 29.

Jacobson, Daryl, Natural Resource Technician, City of Burnsville, Minnesota
2004 Telephone conversation with Rusty Schmidt, URS Corporation. April 26.

Langdon, Keith, Supervisory Natural Resource Specialist, Catoctin Mountain Park
1990 Memorandum to Carroll Schell, Branch Chief, Natural Resources, regarding effects of deer browsing on vegetation. Oct. 1.

Loncosky, B. and Swauger, D., National Park Service
2005 Personal communication with D. Otto and S. Cauley, The Louis Berger Group, Inc. July 22.

Maryland Department of Health
2003 Telephone communication. Dec. 1.

Maryland Department of Transportation, State Highway Administration
2002 Letter to Scott Bell, Catoctin Mountain Park. Nov. 19.

Moser, G.A., U.S. Fish and Wildlife Service
2004 Personal communication with P. S. Bell, NPS, regarding threatened and endangered species. Aug. 11.

Nicholson, Sandy, Farm Service Agency, U.S. Department of Agriculture
2005 Personal communication with K. Lusby, the Louis Berger Group, regarding agriculture in Frederick County, Maryland. July 18.

Sullivan, Kevin, Animal and Plant Health Inspection Service, U.S. Department of Agriculture
2005 Letter to B. Kunkel, URS Corporation, regarding direct reduction implementation experience. Mar. 18.

Swauger, Donna. Environmental Protection Specialist, Catoctin Mountain Park, National Park Service
2005a Telephone communication with P. Steinholtz, URS Corporation, regarding safety. July 6.

2005b Personal communication with N Van Dyke, URS Corporation, regarding logging adjacent to the park, ozone effect on plants, nearby hog farm, and cell towers. July 12.

2005c Personal communication with S. Smith and D. Otto, The Louis Berger Group, Inc., regarding water quality and vegetation. July 21.

2005d Personal communication with P. Steinholtz, URS Corporation, regarding nonnative plants. Oct. 24.

2005e Personal communication with P. Steinholtz, URS Corporation, regarding gypsy moth control and hemlock woolly adelgid. Nov. 16.

2005f Personal communication with B. Kunkel, URS Corporation, regarding plant abundance and trout. Dec. 20.

Underwood, Brian, Wildlife Biologist, USGS Patuxent Wildlife Research Center, Syracuse, NY
2005 Telephone conversation with Beth Kunkel, URS Corporation. March.

Voigt, Jim, Catoctin Mountain Park, National Park Service
2005a Telephone conversation with Beth Kunkel, URS Corporation. Mar. 15.

2005b E-mail correspondence with P. Steinholtz, URS Corporation, regarding noise. Mar. 30.

2005c Personal communication with P. Steinholtz, URS Corporation, regarding park budgeting. Apr. 21.

2005d Personal communication with P. Steinholtz, URS Corporation, regarding park operations. Apr. 26.

2005e Personal communication with P. Steinholtz, URS Corporation, regarding surface water, May 6.

2005f Personal communication with J. Gorder, the Louis Berger Group, regarding park staffing and operations. July 27.

2005g Personal communication regarding alternative cost estimates. October.

Welsh, Terry, Natural Resources Conservation Service, U.S. Department of Agriculture
2005 Personal communication, K. Lusby, the Louis Berger Group, regarding agriculture in Frederick County, Maryland. July 26,

Glossary, Acronyms, and Index

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.

Carnivore — An animal that eats a diet consisting solely or mostly of meat.

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.

Contractor — For the purposes of this plan, a contractor is a fully-insured business entity, nonprofit group, or other governmental agency engaged in wildlife management activities that include trapping, immobilization, and lethal removal through sharpshooting and chemical euthanasia. The contractor must possess all necessary permits and be able to pass any needed security clearances.

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 living within Catoctin Mountain park that have common characteristics and interbreed among themselves. For the purposes of this plan, this term is synonomous 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 — 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 the National Environmental Policy Act, 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 — An area enclosed by a barrier, such as a fence, to protect vegetation and prevent browsing by animals.

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.

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).

Habitat Fragmentation — The breaking up of large, contiguous blocks of habitat into small, discontinuous areas that are surrounded by altered or disturbed lands.

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.

Immunohistochemistry — Identification of specific antigens in tissues by staining them with antibodies that are labeled with fluorescent or colored material.

Impairment — 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.

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.

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 E for additional details).

Lithic — Of or relating to stone.

Lumbar — Of, near, or situated in the part of the back and sides between the lowest ribs and the pelvis.

Macroinvertebrate — A relatively large, generally soft-bodied organism that lacks a backbone.

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 (NEPA) — 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.

Nephelometric Turbidity Unit (NTU) — A unit of measure for turbidity.

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.

Omentum — One of the folds of the peritoneum that connect the stomach with other abdominal organs.

Opportunistic Surveillance — Taking diagnostic samples for CWD testing from deer found dead or harvested through a management activity within a national park unit.

Palatability — The property of being acceptable to the taste or sufficiently agreeable in flavor to be eaten.

Paleontological Resources — A resource related to the forms of life existing in prehistoric or geologic times, such as fossils of plants, animals, and other organisms.

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.

Pericardial — Around or surrounding the heart.

Pheromone — A chemical secreted by an animal that influences the behavior or development of others of the same species, often functioning as an attractant of the opposite sex.

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.

Radial Distance — A straight-line distance measured along a radius.

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.

Rhyolite — A fine-grained extrusive volcanic rock used by Native Americans.

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).

Secondary Succession — A gradual change from one community to another, characterized by a progressive change in species structure, an increase in biomass and organic matter, and a gradual balance between community production and community respiration.

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.

Subcutaneous — Under the skin.

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.

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, U.S. Department of Agriculture
AVMA	American Veterinary Medical Association
Bt	*Bacillus thuringienis*
CEQ	Council on Environmental Quality
CWD	chronic wasting disease
EPA	Environmental Protection Agency
FDA	Food and Drug Administration
GCIV	GonaConTM immunocontraceptive vaccine
GnRH	gonadotropin releasing hormone (reproductive control hormone)
HSUS	Humane Society of the United States
INAD	Investigational New Animal Drug (classification by the Food and Drug Administration)
MASS	Maryland Agriculture Statistics Service
MD DNR	Maryland Department of Natural Resources
NASS	National Agricultural Statistics Service
NEPA	National Environmental Policy Act
NIST	National Institute of Standards and Technology
NPS	National Park Service, U.S. Department of the Interior
NWR	National Wildlife Refuge
PZP	porcine zona pellucida
SCWDS	Southeastern Cooperative Wildlife Disease Study
USDA	U.S. Department of Agriculture

INDEX

As the nation's principal conservation agency, the Department of the Interior has responsibilities 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 American Indian reservation communities and for people who live in island territories under U.S. administration.

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Catoctin Mountain Park
Thurmont, Maryland

UNITED STATES DEPARTMENT OF THE INTERIOR

NATIONAL PARK SERVICE