National Park Service
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Northeast Region
Boston, Massachusetts

White-tailed Deer Ecology and Management on Fire Island National Seashore
(Fire Island National Seashore Science Synthesis Paper)

Technical Report NPS/NER/NRTR—2005/022

ON THE COVER
White-tailed Deer at Fire Island National Seashore. Photograph courtesy of the author.

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U.S. Department of the Interior
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PREFACE

FIRE ISLAND NATIONAL SEASHORE
Science Synthesis Papers to Support Preparation of a General Management Plan

BACKGROUND AND PURPOSE

Fire Island National Seashore (FIIS) is scheduled to begin preparation of a new General Management Plan (GMP) in the near future. A GMP outlines how natural and cultural resources, public uses, and park operations should be managed over the next several decades. The GMP addresses significant issues or challenges that are facing the park, proposes management solutions, and establishes management priorities. The Fire Island GMP will be prepared by a team of planners, with input from the park, technical subject matter experts, and with substantial public involvement.

To insure that the GMP team has all relevant natural resource information available to them, a series of scientific synthesis papers has been prepared for a variety of natural resource topics that will be of special relevance to the Fire Island GMP. Based on a 2-day meeting with the FIIS Superintendent, FIIS Chief of Natural Resource Management, Northeast Region planners, and Northeast Region science staff, the following natural resource topic areas were identified;

- Geomorphology of beaches and dunes
- Physical processes of the bay shoreline
- Habitat ecology and water quality of Great South Bay
- Conservation of Living Marine Resources (habitats, finfish and shellfish)
- Vector-borne diseases
- White-tailed Deer ecology and management

For each of these topics, leading scientific experts were invited to prepare papers that synthesize our current state-of-knowledge. There is a wealth of published technical information on these topics. The purpose of these papers was to provide a scientifically credible summary of the available and relevant information and present this information in a succinct manner. The GMP team will receive papers that provide an objective, independent and expert synthesis of an extensive and often complex technical literature. Each paper was subject to the scientific peer review process.

Each synthesis paper is expected to accomplish the following;

- Synthesize and interpret the relevant literature and monitoring data to describe the fundamental processes controlling the natural resource, and describe historic and recent trends or rates of change for relevant processes, habitats, or species.
- Describe current and historic management, regulatory, and other activities that have been relevant to the particular natural resource.
- Identify gaps in our current understanding of the natural resource.

Because the synthesis papers are prepared prior to initiation of the GMP process, if information gaps are considered critical to decision-making for the GMP there may be adequate time to conduct the appropriate required studies or data analysis tasks. Moreover, the papers will serve to identify topics or issues that should be the focus of additional synthesis or review papers in support of the GMP information gathering and synthesis phase.

OVERVIEW OF THE PAPERS

These summaries are derived, with some editing, directly from the individual papers.

The Coastal Geomorphology of Fire Island: a Portrait of Continuity and Change
Technical Report NPS/NER/NRTR—2005/021
Authors: Norbert P. Psuty, Michele Grace, and Jeffrey P. Pace
Rutgers University
Summary: Fire Island has a well-developed beach on the ocean side and is dominated by a variety of dune features, reaching elevations of 11-13m. Much of the island is undeveloped and retains a wide array of coastal dune forms in near natural condition. However, there are a number of residential communities, primarily on the western portion of Fire Island, that have altered the landscape and geomorphological processes. The controlled inlets at either end of the island are a type of interactive feature that have particular roles in the passage of sand along the shore. Thus, the geomorphological characteristics and configuration of the island are products of a suite of natural processes, complemented by human actions. This paper describes the landforms (beaches, dunes, inlets, and barrier island gaps) and basic controls on these landforms, such as tides, wave climate, storm history, the availability and rate of supply of sediment, and sea level rise.

There is insufficient sediment coming to Fire Island from all of the potential sources to maintain the entire system. There is evidence of erosion on all parts of the island, except the artificially-created Democrat Point. The sediment deficits are greatest along the eastern portion of the island, but are buffered in the central and western area because of the contributions from an offshore source. The recent acceleration in sea-level rise, coupled with the general negative sediment budget, will result in continued beach erosion and dune displacement, with greater effects occurring in the eastern portion of the island.

During the peer review process, it was determined that a follow-up synthesis paper should be prepared that specifically focuses on the response of Fire Island beaches and dunes to human activities, including ORV traffic, structures, sand fencing, beach scraping, and other activities. This paper is presently being developed.

Bay Shoreline Physical Processes, Fire Island
Technical Report NPS/NER/NRTR—2005/020
Authors: Karl F. Nordstrom, Rutgers University
Nancy L. Jackson, New Jersey Institute of Technology
Summary: Wave and current energies on the bay side of Fire Island are low, but much of the bay shoreline is eroding. The greatest changes occur near inlets or next to marinas and bulkheads. Inlets, overwash and dune migration deliver sediment from the ocean to the bay

where it forms substrate that evolves into tidal flats, marshes and beaches. These sediment inputs allow barrier islands to maintain themselves as they migrate landward under the influence of sea level rise. The creation and migration of inlets in the past extended their influence well beyond locations of present inlets.

About 17.0 km of the 49.5 km long bay shoreline of Fire Island is marsh; 24.5 km is beach; and 8.0 km is fronted by bulkheads, marina breakwaters and docks. The biggest constraints to allowing Fire Island to undergo natural dynamism are the desire to protect private properties on the island from erosion and overwash and the need to protect the mainland from flooding due to formation of new inlets. Bulkheads are common on the bay shore in developed communities. These structures replace natural formations landward of them and prevent sand from entering the littoral drift system, causing sediment starvation in unprotected areas downdrift. These adverse effects can be reduced by replacing lost sediment by beach nourishment. Use of beach fill on the low tide terrace covers benthic habitat. This problem could be avoided by placing fill above the mean high water mark, creating an eroding feeder upland.

Dune building projects on the oceanside and construction of bulkheads on the bayside restrict the delivery of sediment by inlets, wave overwash and aeolian transport. Temporary inlets would provide some sediment, but artificial closure by human efforts would limit these inputs to a much smaller area than in the past.

Future sea levels are expected to rise at a greater rate, causing increased frequency of overwash and creation of new inlets if not prevented by beach nourishment and dune-building projects on the oceanside. Elimination of the delivery of sediment to the bayside by these natural processes will result in continued retreat of the bay shoreline into the higher portions of the barrier island, resulting in loss of marsh habitat, increase in open water habitat, and truncation of cross-shore environmental gradients.

<u>Water Quality and Ecology of Great South Bay</u>
Technical Report NPS/NER/NRTR—2005/019
Author: Kenneth R. Hinga
University of Rhode Island
Summary: The overall objective of this paper is to present a short synopsis of information on the characteristics of water quality and ecology of the Great South Bay, with particular attention to the waters within the boundaries of Fire Island National Seashore (FIIS), where possible. This report serves as an update and addition to the report *Estuarine Resources of the Fire Island National Seashore and Vicinity* (Bokuniewicz et al., 1993). Great South Bay is approximately 45 km long, with a maximum width of about 11 km. The Bay is shallow, with an average depth at mean low water of just 1.3m.

Regarding water quality, a review of bacterial indicator monitoring data suggests that some bayside beaches and marinas of Fire Island have had fecal coliform concentrations that are at or approaching levels of concern, but in general the levels are quite acceptable. Nutrient enrichment is an issue for all shallow, enclosed, lagoon-type estuaries, like Great South Bay. There is an encouraging trend of decreasing dissolved inorganic nitrogen in Great South Bay over the past quarter century. Coincident with the decline in nitrogen, there appears to be a trend of decreasing primary production, as determined by measuring phytoplankton chlorophyll concentration, over the past 15 years. Historically, portions of Great South Bay (e.g., near and in Moriches Bay) experienced intense phytoplankton blooms, probably attributed to discharges

from duck farms. Since 1985, a brown tide has occurred periodically to disruptive levels in the Bay. Brown tide blooms can cause significant mortalities of hard clams and can damage seagrass beds because the blooms prevent light sufficient to support growth of the seagrass species. The densest seagrass beds in the Bay are found along the shallow shoreline of the Seashore.

Conservation and Management of Living Marine Resources
Technical Report NPS/NER/NRTR—2005/023
Authors: David O. Conover, Robert Cerrato, and William Wise
Stony Brook University

Summary: The finfish species likely to be landed by commercial harvesters from Fire Island NS or nearby waters are bluefish, winter flounder, summer flounder, weakfish, Atlantic silversides, and menhaden. The recreational species landed within the Bay have not been described in detail since the 1960s, but total recreational landings for New York as a whole suggest that fluke, winter flounder, bluefish, weakfish, tautog, and black sea bass are the main species. Some of the fish species landed in the Seashore region are present only transiently as older juveniles and adults. Such species would include striped bass, menhaden, eels, and weakfish. These species do not use the Bay as a spawning and nursery area. Other species use Fire Island waters as both nursery grounds for young-of-the-year (YOY) stages as well as adults. The value of Seashore estuarine habitats for these species is great (bluefish, winter flounder, fluke, tautog, black sea bass). Ecologically important species, those that are an important forage species for piscivorous fishes, include Atlantic silversides, bay anchovy, sand lance, northern pipefish, and others. Killifishes are a major component of the fish fauna of salt marsh habitats. Shellfish of potential recreational or commercial value found within Seashore boundaries include surfclam, hard clam, blue mussel, soft clam, oyster, bay scallop, razor clam, conch, blue crab, Jonah crab, rock crab, lady crab, spider crab, and horseshoe crab (although not technically classified as shellfish). Generally, there has been a dramatic decline in the commercial harvest of shellfish species from the Bay. For example, since 1976 the harvest of hard clams has declined 100 fold. It is recommended that the Seashore take a leadership role in reaching out cooperatively to government and non-government agencies toward encouraging restoration of Great South Bay living marine resources and increasing public awareness of coastal zone management issues.

Vector-borne Diseases on Fire Island
Technical Report NPS/NER/NRTR—2005/018
Author: Howard S. Ginsberg
USGS-Patuxent Wildlife Research Center

Summary: This paper discusses eleven tick-borne and five mosquito-borne pathogens that are known to occur at FIIS, or could potentially occur. The potential for future occurrence, and ecological factors that influence occurrence, are assessed for each disease. Lyme disease is the most common vector-borne disease on Fire Island. The Lyme spirochete, *Borrelia burgdorferi*, is endemic in local tick and wildlife populations. Public education, personal precautions against tick bite, and prompt treatment of early-stage infections can help manage the risk of Lyme disease on Fire Island. The pathogens that cause Human Monocytic Ehrlichiosis and Tularemia have been isolated from ticks or wildlife on Fire Island, and conditions suggest that other tick-borne diseases (including Babesiosis, Rocky Mountain Spotted Fever, and Human Granulocytic Ehrlichiosis) might also occur, but these are far less common than Lyme disease, if present.

West Nile Virus (WNV) is the primary mosquito-borne human pathogen that is known to occur on Fire Island. Ecological conditions and recent epizootiological events suggest that WNV occurs in foci that can shift from year to year. Therefore, a surveillance program with appropriate responses to increasing epizootic activity can help manage the risk of WNV transmission on Fire Island.

White-tailed Deer Ecology and Management on Fire Island
Technical Report NPS/NER/NRTR—2005/022
Author: H. Brian Underwood
USGS-Patuxent Wildlife Research Center

Summary: Deer populations have grown dramatically on Fire Island National Seashore (FIIS) since 1983. Trend data reveal a dichotomy in deer dynamics. In the eastern half of the island, deer density appears to have stabilized between 25-35 deer/km^2. In the western half of the island, deer densities are 3-4 times as high in residential communities. Concomitant with that increase has been a general decline in physical stature of some animals, visible impacts on island vegetation, especially in the Sunken Forest, and a perceived increase in the frequency of human and deer interactions. Intensive research on FIIS has shown that deer occupy relatively predictable home ranges throughout the year, but can and do move up and down he island. Impacts of deer on vegetation are most dramatic in the Sunken Forest. Most obvious are the effects of browsing on the herb layer of the Sunken Forest. The least obvious, but perhaps more significant impact is the stark lack of regeneration of canopy tree species since about 1970, which coincides with the initiation of the deer population irruption. A number of herbs and shrubs have been greatly reduced in the understory, and their propagules from the soil.

Deer do not readily transmit the bacterium that causes Lyme disease to other organisms, but deer are important hosts for adult ticks which underscores their importance in the transmission pathway of the disease to humans. Deer on FIIS, while occasionally docile, are still wild animals and should be treated as such. Some animals are relatively unafraid of humans due to the absence of predation and a lack of harassment. This in turn has contributed to a long-standing tradition of feeding deer by many residents and visitors, particularly in western portions of the island. Feeding affects both the behavior and population dynamics of deer inhabiting Fire Island. Recent efforts to reduce deer feeding by visitors and residents have been very effective. Ongoing experiments with Porcine Zona Pellucida immunocontraception demonstrate some promise of this technology as a population management tool. Success appears to be linked directly to factors affecting access to deer, which vary considerably among treatment locations. Continued high National Park Service visibility among communities in the form of interpretive programs, extension and outreach activities, and continued support of research and monitoring of deer and their effects on island biota are keys to successful resolution of persistent issues.

Preface prepared by:
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ABSTRACT

Deer populations have grown dramatically on Fire Island National Seashore (FIIS) since 1983. Trend data reveal a dichotomy in deer dynamics. In the eastern half of the island, deer density appears to have stabilized between 25-35 deer/km^2. In the western half of the island, deer densities are 3-4 times as high in residential communities. Concomitant with that increase has been a general decline in physical stature of some animals, visible impacts on island vegetation, especially in the Sunken Forest, and a perceived increase in the frequency of human and deer interactions. Intensive research on FIIS has shown that deer occupy relatively predictable home ranges throughout the year, but can and do move up and down the island. Impacts of deer on vegetation are most dramatic in the Sunken Forest. Most obvious are the effects of browsing on the herb layer of the Sunken Forest. The least obvious, but perhaps more significant impact is the stark lack of regeneration of canopy tree species since about 1970, which coincides with the initiation of the deer population irruption. A number of herbs and shrubs have been greatly reduced in the understory, and their propagules from the soil. Deer do not readily transmit the bacterium that causes Lyme disease to other organisms, but deer are important hosts for adult ticks which underscores their importance in the transmission pathway of the disease to humans. Deer on FIIS, while occasionally docile, are still wild animals and should be treated as such. Some animals are relatively unafraid of humans due to the absence of predation and a lack of harassment. This in turn has contributed to a long-standing tradition of feeding deer by many residents and visitors, particularly in western portions of the island. Feeding affects both the behavior and population dynamics of deer inhabiting Fire Island. Recent efforts to reduce deer feeding by visitors and residents have been very effective. Ongoing experiments with Porcine Zona Pellucida immunocontraception demonstrate some promise of this technology as a population management tool. Success appears to be linked directly to factors affecting access to deer, which vary considerably among treatment locations. Continued high National Park Service visibility among communities in the form of interpretive programs, extension and outreach activities, and continued support of research and monitoring of deer and their effects on island biota are keys to successful resolution of persistent issues.

INTRODUCTION

The management of white-tailed deer (*Odocoileus virginianus*) populations on NPS lands throughout the eastern United States has become the focus of much attention (Underwood and Porter 1991, Warren 1991, Porter and Underwood 1999, Porter et al. 2004). During the 1970's through the 1980's, deer populations along the Eastern Seaboard increased dramatically (Cypher and Cypher 1988). Much to the consternation of biologists, land managers and the public, deer populations have now achieved densities uncommon to our previous experience. While native to Atlantic barrier islands, deer numbers were apparently low at the time FIIS was established in 1964 as sightings were infrequent and uncommon. Deer numbers have increased dramatically since then, however. Issues that have arisen as a result of the increase in deer numbers are primarily those that affect human health and safety, the island's native vegetation and deer population itself. I have been charged with the task of describing the current condition and/or state–of-the-knowledge with regard to ecology and management of deer on Fire Island. I attempt to summarize existing knowledge of white-tailed deer ecology and management gleaned from unpublished data, published papers, final reports and technical correspondence. My aim is for this document to be accurate, but not exhaustive in its scope. To fairly treat the breadth of accomplishment in regard to these issues, I will first describe the affected environment, and provide a brief biological account of the history of deer on the island, record the extent of research conducted by the National Park Service (NPS) and others on deer and related topics, detail the state-of-the-knowledge of the resident deer population with respect to impacts to barrier island vegetation and linkages to Lyme Disease.

AFFECTED ENVIRONMENT

Fire Island is a barrier island located along the southern coast of Long Island, New York (40 41' N, 73 00' W), formed about 10,000 years ago after the retreat of the Pleistocene glaciers. It was designated a National Seashore on September 11, 1964, and is approximately 51 km long and averages about 0.5 km in width. The island is bordered by the inlets of Fire Island to the west and Moriches to the east, and is separated from Long Island by Great South and Moriches Bays (Fig. 1). The physiognomy of Fire Island is typical of Atlantic barrier islands, which grade from a primary dune along the ocean to salt marsh along the bay. The development of vegetation is affected by wind, salt spray, erosion and other environmental factors (Art 1976). The dominant native vegetation on Fire Island includes pitch pine (*Pinus rigida*), eastern red cedar (*Juniperus virginiana*), wax myrtle (*Myrica cerifera*), shadbush (*Amelanchier canadensis*), American beach grass (*Ammophilia breviligulata*), bayberry (*M. pensylvanica*), and common greenbrier (*Smilax rotundifolia*). This particular composition of vegetation is typical of Fire Island except within the various communities where residents have cultivated non-indigenous plant species.

The eastern half of FIIS encompasses the Otis Pike Wilderness Area (OPWA), the only federally designated wilderness in the state of New York. Of the remaining natural zones, most are small, scattered remnants that comprise the interstitial spaces between island communities occupying the western half of Fire Island. As a matter of convenience mostly, I refer to island segments by either proper or political names, which indicate specific geographical entities, or an amalgam of locations that, by virtue of their joint proximity, share certain characteristics.

HISTORY OF DEER ON FIRE ISLAND

White-tailed deer are native to the Atlantic barrier island system. Precisely when deer colonized Fire Island is uncertain, however. O'Connell and Sayre (1988) state that reliable reports of deer on the island date back to the turn of the 20th century. Leopold et al. (1947) documented Suffolk County, Long Island as an area with chronic deer management problems during the Depression. This area of mainland, immediately adjacent to Fire Island, was an important vegetable-trucking region at that time, so tolerance for deer damage to crops was

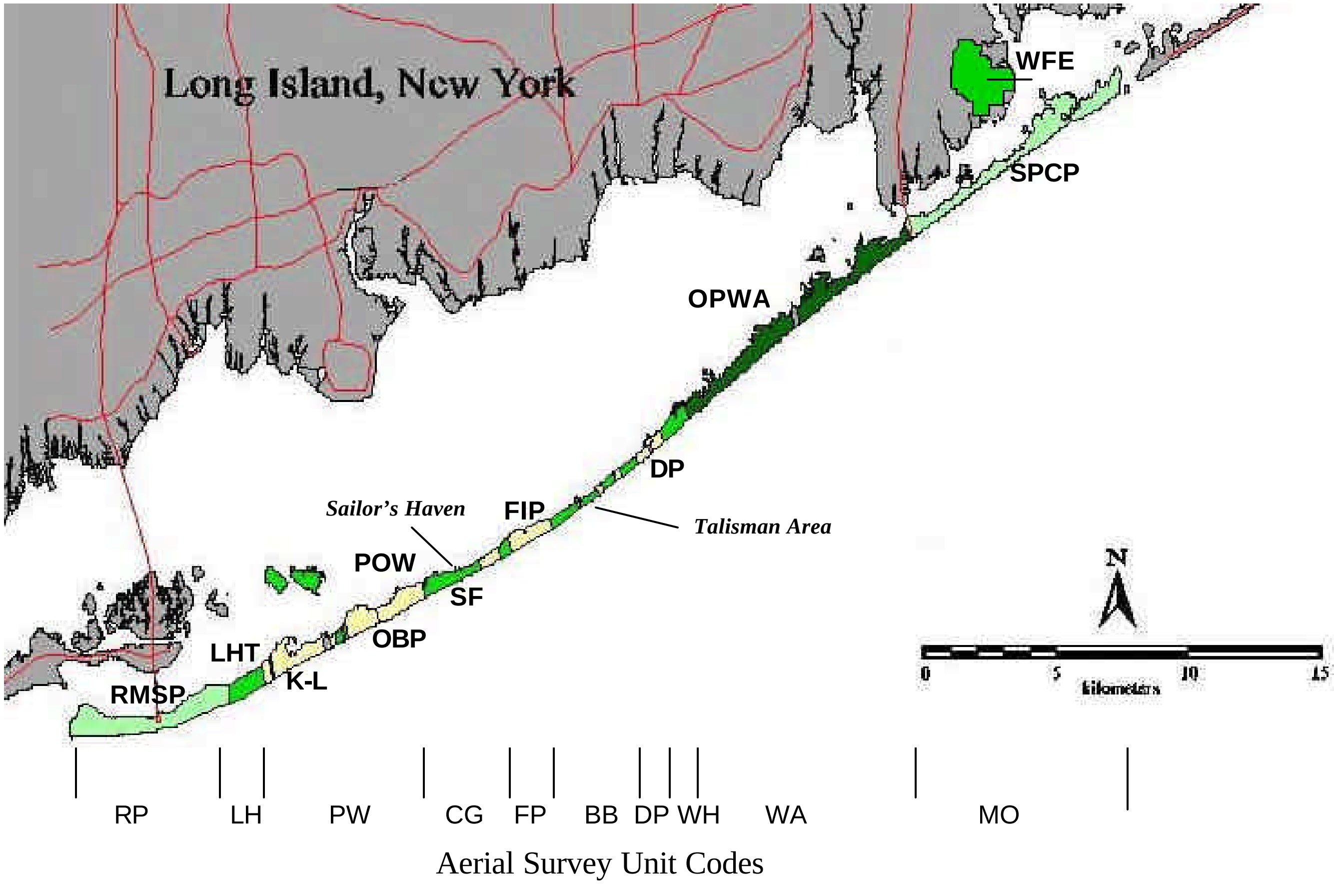

Figure 1. Fire Island and southern Long Island, New York. RMSP = Robert Moses State Park; LHT = Lighthouse Tract; OBP = Ocean Beach-Seaview-Ocean Bay Park; POW = Point 'O Woods; SF = Sunken Forest; FIP = Fire Island Pines; DP = Davis Park; OPWA = Otis Pike Wilderness Area; SPCP = Smith Point County Park; WFE = William Floyd Estate. Aerial survey unit codes and boundaries are shown at figure bottom corresponding with their place names (RM = Robert Moses State Park; LH = Lighthouse Tract; PW = Kismet - Point 'O Woods; CG = Point 'O Woods - Cherry Grove; FP = Cherry Grove - Fire Island Pines; BB = Fire Island Pines - Barrett Beach; DP = Barrett Beach - Davis Park; WH = Watch Hill - Davis Park; WA = Otis Pike Wilderness Area; MO = Smith Point County Park).

probably low. Conner (1971) observed deer on FIIS including in the area of the Sunken Forest. No deer were observed during three years of field research in the Sunken Forest in the mid- to late-1960's (H. Art, personal communication), however. During a field reconnaissance of FIIS, J. McCormick (USDI 1972) wrote:

> *"Browse sign, particularly on sawbrier and catbrier was observed in the Sunken Forest and throughout most of the National Seashore during the present study. It was reported that forty-six deer were sighted between Smith Point and Captree in an aerial census conducted by the National Park Service personnel during Spring, 1971."*

No other evidence could be found to confirm whether a count was ever conducted by or for the NPS, nor can the validity of the number of deer observed be assessed. The most convincing account of a relatively dense population of deer somewhere on FIIS was from a paragraph found in a draft management plan written by FIIS staff in 1970. The authors wrote:

> *"A small scattered number of white-tailed deer live over the entire length of Fire Island. Although they frequent the various zones of the Island, including forays out into the open beach at night, they are primarily dwellers of the brush thickets where edge cover browse is abundant. Although the herd is small their density is quite high...with winter die-offs from malnutrition common..."*

DEER POPULATION TRENDS

In the first study of the island's deer ecology, aerial surveys were conducted twice annually beginning in 1983 and continuing to 1998 (O'Connell and Sayre 1988). Surveys were generally conducted during the spring (before green-up) and autumn (after the first frost), though surveys were not flown in some years due to time and budgetary constraints. A subset of these data was used to examine deer population trends according to geographic location along the island (Underwood 1991). The remaining data are analyzed herein. Two contrasting observations emerged from the 1991 analysis. First, while there was a relatively stable deer population residing in the OPWA, herd segments in the natural zones of western Fire Island were increasing rapidly (Fig. 2). Second, the poor coverage (Table 1) of the residential areas relative to other natural zones on the island left one with the distinct impression that deer were being undercounted within the communities. In addition, the County park on the east end of the island was experiencing a modest increase in deer numbers (10% per year), while the park on the west end was undergoing more rapid increases (30% per year). Correlation of numbers of deer observed among units was high (Table 2) for the 25 counts over a 15 year period. A simple partitioning of the correlation matrix using Lefkovitch's method (Pielou 1984) revealed a strong spatial pattern confirming the east-west dichotomy in deer population trends over time (Fig. 3). From 1994-98, all herd segment counts apparently declined. In the largest units with complete coverage, moderate declines were observed in RMSP and SPCP and a dramatic decline was observed in OPWA (approx. –50%). A cause for the observed island-wide decline in deer abundance remains speculative and will be discussed in a later section of this report.

To assess population abundance within Fire Island communities, a ground survey method was implemented for monitoring trends in herd abundance and composition (Underwood et al. 1998). Early work focused on the details of implementation, and was conducted in the western-most island communities of Kismet-Lonelyville (K-L). In 1999, a Standard Operating Procedure was written for conducting surveys in all major units of the National Seashore with the exception of Point 'O Woods (POW) and Smith Point County Park (SPCP)[1]. Since 1995, hundreds of individual counts have been conducted throughout the island and in the adjacent Robert Moses State Park (RMSP) and on the mainland at the William Floyd Estate (WFE; Table 3). Initial estimates of deer density indicated about 80 deer/km^2 in most communities during 1995 confirming the inadequacy of the aerial surveys for estimating deer abundance in these areas. Some interpretations of trend can be made, however, since the cessation of aerial surveys over the island. In general, deer abundance appears to have stabilized (i.e., no longer increasing) along western Fire Island, and rebounded from the lows observed in the late 1990s in the OPWA. Though deer density (No./km^2) remains quite high (~80 deer/km^2) in the mid-island communities and adjacent natural zones, it has declined dramatically in throughout K-L (Fig. 4). Deer density on WFE has varied widely with no discernable trend.

DEER MOVEMENTS AND RANGING PATTERNS

Radio-telemetry data collected in the mid-1980's (O'Connell and Sayre 1988) showed that deer home ranges averaged 2.4 km in length. The same home range was used throughout the year with some variation. Movement off FIIS proper was uncommon, occurring only once during the study. Occasional long-range dispersals, made mostly by young males, were also observed as is common in all deer populations. While deer were found along the entire island, it appears that two discrete populations may exist with the FIP/Talisman area serving as a possible dividing line between sub-populations. From casual observations of highly visible and recognizable individuals, deer from the K-L study area were frequently encountered in the adjacent LHT and RMSP units during the late 1990s. Finally, a deer we marked with a semi-permanent dye during the Lyme Disease study conducted in LHT, was subsequently observed in the ball field at Point 'O Woods, a distance of nearly 5 km. It is clear that deer do move along the island and that some of these movements cover substantial distances. Most of the time, however, deer were encountered in well-established home ranges. This is the typical pattern for the species in the Northeast (Cypher and Cypher 1988, Porter et al. 1991).

EXPLORATION OF MANAGEMENT ALTERNATIVES

In December 1988 and January 1989, the park in cooperation with the New York State Department of Environmental Conservation (NYSDEC), conducted a limited hunt on several units of FIIS. The stated goals of the hunt were to assess the physical condition of the deer and the effectiveness of public hunting for reducing deer populations. Archery hunting was implemented for five days in December, primarily in small areas adjacent to communities.

[1] The Point 'O Woods community association declined participation in deer abundance assessment; logistical considerations prevented inclusion of Smith Point County Park.

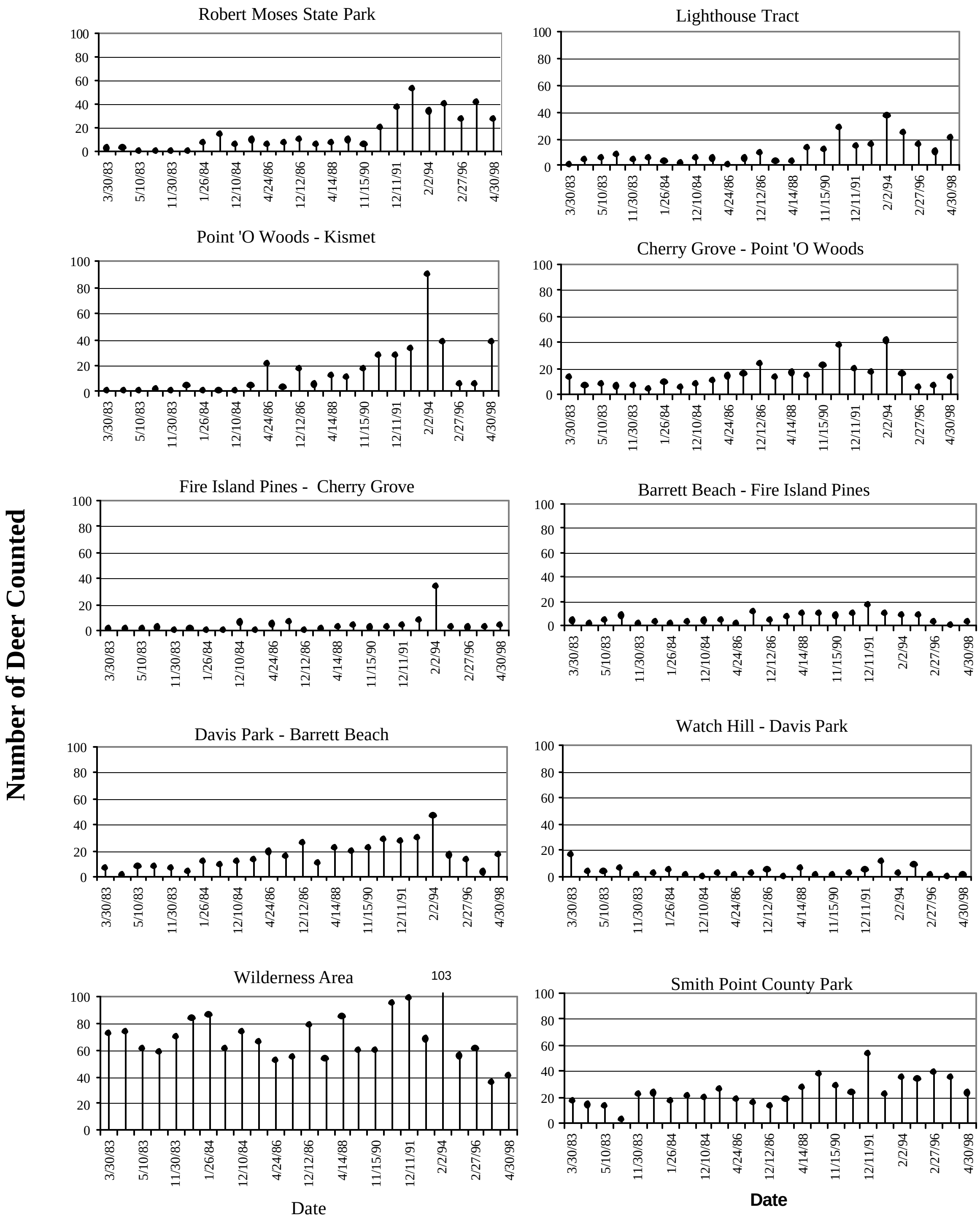

Figure 2. Bi-annual counts of white-tailed deer in select units of Fire Island from low altitude helicopter surveys, Fire Island, 1983-1998. Survey units are in geographical order from west to east, across the page, then down. Points represent the mean tally among 3 or more observers. See Figure 1 for unit codes and boundaries.

Table 1. Rates of population change (%) computed from regressions of ln(Abundance) on time, 1983-1991, Fire Island, New York (adapted from Underwood 1991).

Location	Aerial Survey Unit Code	Relative Area[1] %	%Coverage[2]	Rate[3]
Smith Point County Park	MO	19.9	100	9.6
Wilderness Area[4]	WA	25.3	100	0.3
Watch Hill-Davis Park	WH	3.1	100	-8.6
Davis Park-Barrett Beach	DP	3.0	75	21.9
Barrett Beach-Fire Island Pines	BB	1.3	83	14.0
Fire Island Pines-Cherry Grove	FP	1.4	50	11.1
Cherry Grove-Point 'O Woods [5]	CG	8.5	52	18.5
Point 'O Woods-Kismet[6]	PW	16.3	5	43.8
Lighthouse Tract	LH	3.9	100	17.8
Robert Moses State Park	RM	17.2	100	30.0

[1] proportion of total land area surveyed contained within unit boundary.

[2] approximate percentage of total unit area countable with no altitude restriction.

[3] Rate = $r_{p.a.}$ = percentage rate of change per annum.

[4] composite of four units between Smith Point West Visitor Center and Watch Hill Visitor Center.

[5] includes SF.

[6] unit boundary is western edge of Kismet; includes fertility control treatment area.

Table 2. Pearson correlation coefficients for sequential counts of white-tailed deer among survey units of Fire Island, 1983-1998. Sample size was 25 surveys for each of the 10 survey units. Units are arranged in geographical order from west to east across table columns and from east to west down table rows. **Boldface type** indicates significant correlations at the 0.10 alpha level.

Survey Unit	RM	LH	PW	CG	FP	BB	DP	WH	WA	MO
MO	**0.608**	**0.474**	**0.407**	0.252	0.260	**0.400**	**0.389**	-0.113	0.187	1.000
WA	-0.022	0.274	0.322	**0.512**	**0.348**	**0.357**	**0.504**	0.240	1.000	
WH	0.171	-0.024	0.084	0.077	-0.032	0.233	0.081	1.000		
DP	**0.478**	**0.714**	**0.835**	**0.885**	**0.701**	**0.606**	1.000			
BB	0.303	**0.390**	**0.365**	**0.530**	0.246	1.000				
FP	**0.381**	**0.661**	**0.834**	**0.631**	1.000					
CG	0.321	**0.719**	**0.775**	1.000						
PW	**0.609**	**0.857**	1.000							
LH	**0.664**	1.000								
RM	1.000									

RM = Robert Moses State Park; LH = Lighthouse Tract; PW = Kismet - Point ‘O Woods; CG = Point ‘O Woods - Cherry Grove; FP = Cherry Grove - Fire Island Pines; BB = Fire Island Pines - Barrett Beach; DP = Barrett Beach - Davis Park; WH = Watch Hill - Davis Park; WA = Otis Pike Wilderness Area; MO = Smith Point County Park.

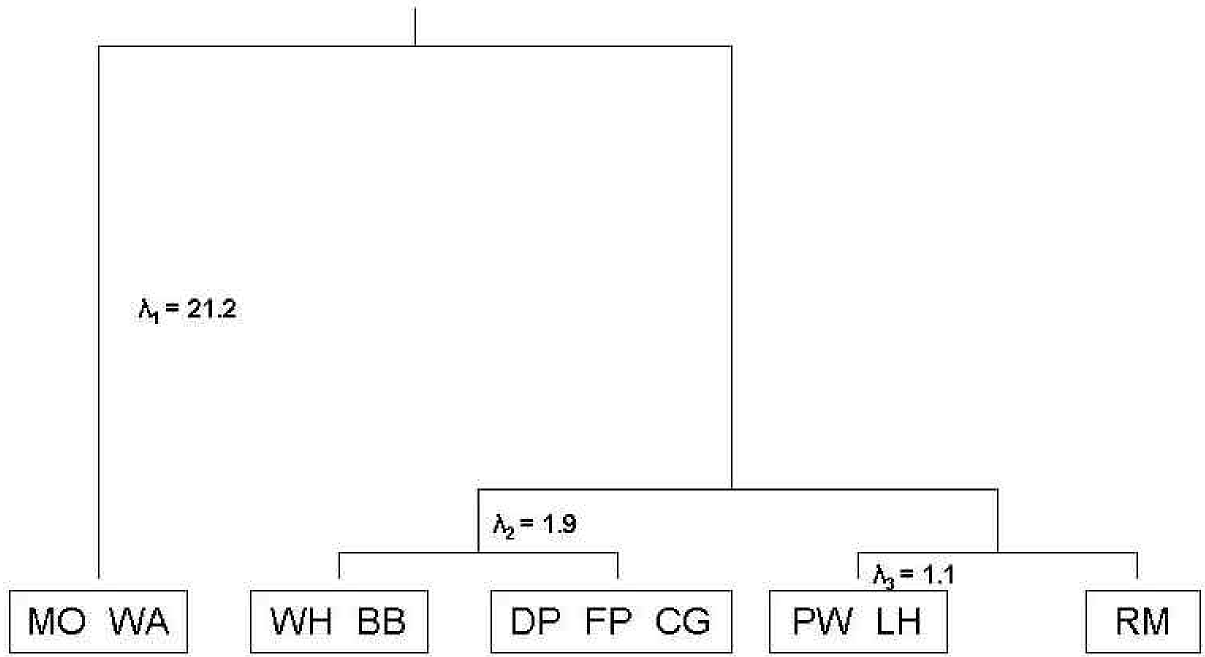

Figure 3. Dendrogram showing the relationship among 10 aerial survey units according to average deer abundance sampled over a fifteen year period, 1983-98. Leftkovitch's method of variance partitioning (Pielou 1984) was used on the correlation matrix of counts by unit. Time trajectories of deer abundance on units sharing a vertical node are similar. Eigenvalues of the first three components (nodes) are shown for reference. RM = Robert Moses State Park; LH = Lighthouse Tract; PW = Kismet - Point 'O Woods; CG = Point 'O Woods - Cherry Grove; FP = Cherry Grove - Fire Island Pines; BB = Fire Island Pines - Barrett Beach; DP = Barrett Beach - Davis Park; WH = Watch Hill - Davis Park; WA = Otis Pike Wilderness Area; MO = Smith Point County Park.

Table 3. Locality descriptions and trends in deer density (No./km^2) as measured by ground surveys employing the distance sampling method, Fire Island National Seashore, 1995-2003.

Locality (West – East)	Description	Extent of Monitoring	General statement regarding trends in white-tailed deer numbers
Robert Moses State Park	Robert Moses State Park (RMSP) is a heavily used area particularly during the summer season. It has numerous public beaches, and is bisected along its length by the Robert Moses Parkway, a two lane divided highway. Feeding deer along the parkway is a perennial problem of which the park is aware and diligent to address.	1995 – present	Deer density has declined to about 7 deer/km^2 after peaking in 1998-99 at nearly 18 deer/km^2.
Lighthouse Tract	A small, vegetated unit of FIIS, the Lighthouse Tract (LHT) is the only point of entry to the Seashore by land. LHT was the focus of an intensive five year investigation of Lyme Disease dynamics in birds, ticks and mammals.	1995 – present	Deer density has fluctuated widely over the years from 32-89 deer/km^2. The LHT does not represent a biological unit.
West End Communities	Access to these communities is provided by boat or by vehicle via the checkpoint in the LHT. The West End Communities are contained within the region defined by the western edge of Kismet to the eastern edge of Loneyville (K-L). Ground survey methods to monitor deer abundance within communities were first implemented here.	1995 – present	Deer density increased from 1995-98 from 79-127 deer/km^2 and has since declined steadily to 44 deer/km^2 in 2003.
Mid-Island Communities	The communities encountered from eastern edge of Lonelyville to the fence at Point 'O Woods are included in the this area, and are referred to as the Ocean Beach-Seaview-Ocean Bay Park Complex (OBP), as those communities comprise most of the land area within.	1999 – present	Average density has varied around 65 deer/km^2, with no discernable trend.
Sunken Forest	The Sunken Forest (SF) is a remnant holly forest of unusual character, and is featured prominently in the Seashore's enabling legislation. It was the focus of an intensive ecosystem study early in the park's history and more recently an ecological study exploring the role of disturbance in shaping the forest community. Sailor's Haven is a prominent ferry port in this area and is a magnet of deer-human interaction.	2002 – present	The most recent (2003) estimate of deer density in the area surrounding Sailor's Haven is 140 deer/km^2. Deer density within the SF is likely between 75-140 deer/km^2.
East End Communities	The villages of Cherry Grove and Fire Island Pines (FIP) are included in this region, though very little deer population monitoring has been conducted in Cherry Grove due to its small size and difficult access.	1999 – present	FIP has exhibited the least variation in abundance with no indication of a trend. The average deer density there is about 75-80 deer/km^2.
Davis Park	The community of Davis Park (DP) serves as a pseudo-control site for the PZP immunocontraception study due to its isolation from communities participating in the research program.	1999 – present	DP deer densities have ranged from 42 deer/km^2 to 94 deer/km^2 with no clear trend.
Otis Pike Wilderness Area	The Otis Pike Wilderness Area (OPWA) is the primary land unit of interest in the eastern part of Fire Island. It extends from the Smith Point County Park on the east, to the NPS's Watch Hill development on the west. The OPWA is a federally designated wilderness area and represents about 11 km of pristine barrier island shoreline.	2000 – present	Deer density in the OPWA has varied around 30 deer/km^2, consistent with helicopter surveys which produced counts between 70-100 deer.
William Floyd Estate	The William Floyd Estate (WFE), is located on the southern shore of Long Island, directly opposite the Smith Point County Park across Narrow Bay. It encompasses approximately 220 ha, which include 163 ha of woodland, 41 ha of salt marsh, and 16 ha of maintained fields. A loop road and several spur roads provide restricted vehicular access to WFE.	1996 – present	Survey of WFE was sporadic but average density fluctuated around 50 deer/km^2.

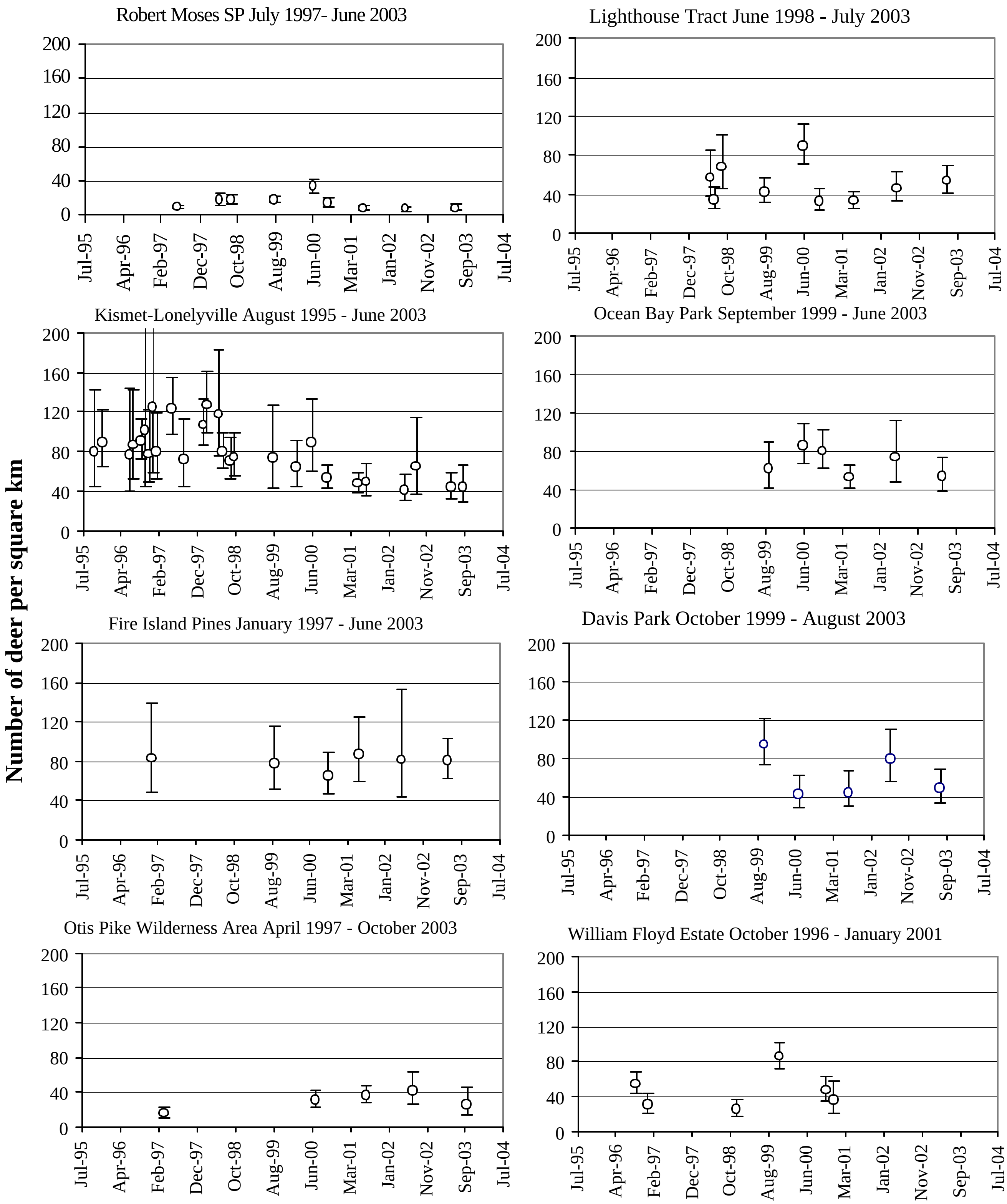

Figure 4. Estimates of white-tailed deer density (No. deer/ unit area) in select units of Fire Island, 1995-2003. Also shown are 90% confidence intervals around mean densities. Localities are shown in geographical order from west to east across the page, then down.

Firearms were permitted in portions of the OPWA, Talisman and Sailor's Haven areas during eight days in January. Sixty deer in total were collected as a result of these hunts. Six deer were harvested during the archery hunt and 54 were harvested during the firearms hunt. From the biological specimens recovered, a series of comparisons was made between deer removed from sites adjacent to communities verses those from the OPWA (O'Connell and Sayre 1989).

Compared to hunted populations on Long Island, fawns collected during the experimental hunt had lower body weights (average = 22.2 kg). This reflected general differences in density between the Long Island populations and those on Fire Island. Fat reserves from kidneys and femurs varied considerably among animals collected on Fire Island. Pregnancy rates based on ovary examinations were 0% for fawns (n = 8) and 12% for yearlings (n = 12). Adult females had a 62% pregnancy rate (n = 21). All females on the western half of the island were pregnant (n = 6), while only 50% were pregnant (n = 16) within the OPWA. These characteristics were interpreted as indicating differences in deer density and food quality from one part of the island to another, though the sample sizes were quite small. The hunt garnered much controversy, and ultimately resulted in litigation. The court upheld the NPS's authority to continue with the hunts as planned. The firearms season was voluntarily terminated, however, as park officials determined that a sufficient sample of deer had already been collected. No additional hunts for any purpose have been conducted on Fire Island.

In response to the high visibility created by the hunt controversy, a research project funded largely though private donations to the Humane Society of the United States (HSUS) was initiated in 1993 on Fire Island to explore the use of emerging immunological contraception technology on a free-ranging population of deer (Turner et al. 1992, Kirkpatrick et al. 1997). As its principal aims, the project sought to determine if the current technology could be employed to an unconfined population of wild animals, and if the vaccine could produce a measurable reduction in fertility among treated females. The vaccine contains three substances: (1) Porcine Zona Pellucida (PZP), a protein mass of cells derived from pig ovaries and (2), an adjuvant for accentuating immune response in deer, emulsified in (3) a buffered saline solution. Because zona pellucida (ZP) cells are non-specific in most mammals, the female deer essentially creates antibodies toward its own eggs. Eggs released from the ovary are attacked by ZP antibodies which block potential fertilization sites for sperm. Both objectives were substantially affirmed during the first five years of study (Naugle et al. 2002).

Phase II (1998-2002) of this study sought to determine if a population of deer can be managed to lower abundance through PZP immunocontraception. This was an important next step because it introduces an additional problem encountering and treating enough females to offset the number of fawns being born by untreated or unresponsive females. Based on density and fawning rates estimated in the treatment areas, the ability to treat "enough" females has varied. In areas where with the longest treatment history, the longest record of monitoring and the best access to breeding-aged females, the deer population has declined by almost 50% since 1998 (Naugle et al. 2002). In other treatment areas, population responses have been much less dramatic. One conclusion is perfectly clear, however; management horizons of at least a decade are not unreasonable when attempting to evaluate fertility control for managing free-ranging deer.

In the autumn of 1998, FIIS, the HSUS and USGS undertook a joint project whose primary goal was to aggressively discourage deer feeding by residents and visitors to Fire Island in an effort to minimize conflicts. The deer feeding issue was tackled through a number of outreach activities including the use of bumper stickers, informative brochures, speaking engagements to end-user groups, voluntary pledge drives for island service personnel and contractors, daily education/enforcement patrols and activities for primary school-aged children. In FY2001, for example, nearly 2000 person-contacts were made in outreach activities. The programs were received enthusiastically with dramatic results such that by the end of the project (September, 2003), the number of deer-related resource complaints plummeted (personal communication, Michael Bilecki, Chief, Resources Management, Fire Island National Seashore). Park staff continues to maintain several outreach components that can be incorporated into daily routine, though the level and intensity of activity is diminished.

IMPACTS OF DEER ON BARRIER ISLAND VEGETATION

In 1966, vegetation studies were initiated in the SF to examine how maritime forests develop and maintain themselves (Art 1976). Plant communities, like the SF, act as anchors for wind-blown sand, and are essential to the stability of barrier island systems. Most of what we know about impacts of deer on FIIS vegetation was derived from this early study and several follow-up studies.

In 1985, additional studies were begun to assess the impacts of deer browsing and Hurricanes Gloria on the island's vegetation. Some of the permanent vegetation monitoring plots established in 1966 were re-located and measured. In addition, deer exclosures and-control plots were established in three locations on the island: two each in LHT, three each in SF, and two each in OPWA. The results of these surveys were inconclusive due to the small number of exclosures sampled. In some areas, there was compelling evidence of impacts by deer browsing and grazing, while in others, evidence was weak or equivocal (Art 1987).

The most compelling results were from the SF plots, which documented a significant decline in the dominance of perennial plants in the herb and liana layers. Once common herbaceous species have become very rare in unfenced plots. By the second growing season, herb cover inside the deer exclosures increased by about 50%. It is probable that the decline of shrub species, such as huckleberry (*Gaylussacia baccata*) and inkberry (*Ilex glabra*), in unfenced plots are also a result of deer browsing. Since 1985, density of dominant shrubs has increased dramatically inside fenced plots.

To address the larger question of the role of disturbance, in all its manifestations, on the character and maintenance of the island's vegetation, another study of the SF was initiated in 1999. The goal of this study was to examine multiple factors affecting the establishment, growth and development of plants within the SF. With the assistance of Dr. Henry Art, the permanent plots were again relocated and resurveyed. Main questions and preliminary results are provided as follows (Forrester 2004).

(1) *Assess the change in the structure and composition of the SF from 1967 to 2003*. The composition and structure of the major forest canopy constituents have changed minimally over the past 35 years. As typical of an aging forest, stem densities decreased while basal area increased over the time period. *Ilex opaca*, *Amelanchier canadensis* and *Sassafras albidum* remain the three dominant canopy species. Diameter distributions of the main canopy species indicate that while *I. opaca*, *S. albidum* and *Nyssa sylvatica* stems are increasing in size and entering larger size classes, these species are not replacing the smaller stems.

Although the density of the shrub layer increased from 4922 stems per ha to 4960 stems per ha, the basal area has decreased from 2.3 to 1.5 stems per m^2. *Vaccinium corymbosum* remains the most common species in the understory but species such as *Aronia arbutifolia*, *Gaylussacia baccata*, *Ilex glabra* and *Toxicodendron radicans* have decreased in importance within study plots. The percent cover of the herbaceous layer has decreased significantly since 1967 from a mean 44% cover of all species to 6% in 2002. *Prunus serotina* and *Polygonum* sp. have increased within the plots while the majority of all other species have decreased significantly.

(2) *Describe the age structure of the SF.* Several *I. opaca* individuals are older than any other species aged in the forest. The present *I. opaca* population began establishing in 1790 and experienced pulses of recruitment in 1850, 1910 and again in 1960. *Nyssa sylvatica* has established sporadically within the forest since the 1820s. *Sassafras albidum* and *A. canadensis* first established in the 1860s and 1900s respectively, and both populations have undergone the most recruitment in the mid 1900s. Very few individuals have established since the 1970s indicating an overall lack of recruitment within the forest. The *I. opaca* individuals >150 yrs are well distributed spatially throughout the forest indicating a significant, stand-wide disturbance has not occurred since the early 1800s.

(3) *Analyze the vegetation-environment relationship of the SF.* The cover, density and composition of herbaceous and woody vegetation were characterized under canopy gaps and within the closed canopy portion of the SF. Tree-fall canopy gaps composed 11.3% of the land area within the SF. While density and cover were higher in gaps than under closed canopy forest, there was high disparity between the extant species composition and the potential species composition as measured in the seed bank. The measured dissimilarity in dominant species within canopy gaps, closed canopy forest and the seed bank indicates a disruption of the regeneration cycle of the SF.

(4) *Measure the availability of seed source within the SF.* Seed bank samples were collected from several locations (including within and outside the deer exclosures and from 26 additional locations within the forest) and placed in cold storage. The samples were placed in the greenhouses and subjected to two period of cold stratification. *Rhus copallina, Smilax rotundifolia* and *Digitaria sanguinalis* (all herbs) were the most abundant species in the seed bank. *I. opaca* did not germinate until after the second cold stratification period, but was the fourth most abundant germinant in the seed bank samples. The remaining important canopy constituents (*S. albidum, A. canadensis* and *N. sylvatica)* exhibited very low germination rates, and several herbs were absent from the seed bank sample. More germination occurred within the samples taken from the exclosures than from samples taken from unfenced areas. *Trientalis*

borealis and *Polygonum* sp. germinated exclusively in samples from plots protected from herbivory.

The maritime holly forest is a unique assemblage of species dominated by the broadleaf evergreen, *Ilex opaca*. The maritime holly forest has been classified as critically imperiled due to its highly restricted occurrence: the SF on FIIS and on Sandy Hook, Gateway National Recreation Area. The maritime holly forest of the SF is considered to be in an old growth state, which accentuates its uniqueness. The forest of Sandy Hook is mature, but not considered to be old growth. Remarkably, despite a long history of intense grazing pressure in the SF, there have been no recorded extirpations of any native plant species.

LINKAGES TO LYME DISEASE

Research on ticks and Lyme disease on Fire Island has dealt with the distribution of infected ticks, and with techniques to manage tick populations and Lyme disease (Ginsberg 1992). Adult black-legged ticks (*Ixodes scapularis*), active in spring and autumn, are most common in high shrub thickets, in the woods and along trails. About half of all adult ticks are infected with the Lyme disease bacterium. Immature ticks are most common in leaf litter and ground-level vegetation in the woods. About one-fifth to one-third of the nymphs (active late spring through midsummer) is infected. Larvae (midsummer into the fall) are rarely infected.

The relationship between population levels of white-tailed deer and abundance of black-legged ticks remains unclear (Ginsberg et al. 2004). Because deer are not competent reservoirs for the disease organism, they play no direct role in the transmission cycle. Deer are, however, the primary host for adult black-legged ticks and thus indirectly affect the distribution and abundance of immature ticks as adult females become engorged, drop-off and lay eggs. Ginsberg et al. (2004) documented dramatic declines in juvenile ticks inside fenced enclosures for three years following exclusion of deer, lending credence to this supposition. Juvenile ticks increased inside one of the fenced areas in the fourth year, however, suggesting other potential factors affecting their distribution. An obvious candidate is the presence of other suitable hosts for adult ticks. Thus, lowering deer population abundance does not guarantee a permanent reduction in tick populations or reduced risk of contracting Lyme Disease. Ginsberg (1992) clearly demonstrated that the risk of contracting Lyme Disease was manageable through simple precautions that limit exposure.

REFLECTIONS, CAVEATS AND UNCERTAINTIES

Although there are scant data, it is apparent that prior to the establishment of the National Seashore, the number of deer island-wide was much lower than today, though anecdotes suggest that deer density (i.e., number per unit area) in some areas of the island was sufficiently high that winter mortality was common. The only formal winter mortality survey revealing widespread mortality, however, was conducted in the spring following the landfall of Hurricane Gloria. I contend that the eastern half of Fire Island, which is now federally designated wilderness, was the source of deer that ultimately led to a population irruption that took the better part of three decades to complete. That very few deer were counted in aerial surveys on the extreme western end of Fire Island until the late 1980s (Fig. 2), supports the notion that the dispersal front proceeded from east to west. Deer abundance on the eastern half of Fire Island had already stabilized while on the western end abundance was increasing rapidly. To my knowledge, the deer population residing throughout eastern Fire Island is the first documented case of a contemporary, unmanaged herd fluctuating around its carrying capacity (Caughley 1979).

The aerial survey data indicated declines in abundance in most of the larger survey units from about 1994-98. The winter of 1997-98 was particularly "severe" for Fire Island deer, having a substantial number of days with persistent, accumulated snow. These conditions force deer to browse dormant, woody material for sustenance and can induce significant mortality among younger and weaker animals. Other contributing factors may include a delayed demographic response to the removal of approximately 100 deer from the island population due to Hurricane Gloria, which made landfall in 1985, and the hunt that took place in the late 1980s. Because the statistical uncertainty around the aerial survey counts is high in some units, many of the counts may not reflect real differences in deer abundance. While there appears to have been a decline in deer abundance from 1994-98, it cannot be conclusively established from the data.

Implementing a ground-based method for assessing deer abundance, particularly within Fire Island communities, increased our confidence and ability to interpret population changes. Still, some areas remain problematic. I am not particularly comfortable with the interpretations of deer population trends for Fire Island Pines (FIP), for example. Having gained a substantial intuitive familiarity with the distance sampling method over the years, my students and I have come to appreciate subtle indications when estimates don't seem quite "right". For instance, we know that encounter rate (i.e., a variance component of density) should be positively correlated with abundance (Gormezano 2004). We have tested the robustness of this conclusion with dozens of data sets from all over the world with very good results.

In FIP, density has remained relatively unchanged despite some compelling observations to the contrary. Encounter rate in FIP has demonstrated a significant decline (-54%) since the winter of 1997, which is consistent with reports from biologists and monitors who administer the PZP vaccine to deer in these same communities. FIP is unique in a number of characteristics, and we have long suspected that several factors would interfere with our method of density estimation. For example, there is significant topographic relief with which to contend, and perhaps most importantly, a great many households are fenced right up to the boardwalks to protect cultivated vegetation from deer. The consequence of the presence of fencing is that most observations of deer are recorded on the boardwalks and those that are recorded at some distance are constrained to locations where deer movement is not obstructed. This phenomenon represents a significant violation of an important assumption of the method, which is that animals are distributed in the environment by some stochastic process (Buckland et al. 1993). We are currently seeking a remedy for this problem, though for most of the other communities, fencing is not as significant an issue.

There is a dearth of information about the movements of deer up and down the island. With the exception of O'Connell and Sayre (1988), there have been no serious attempts to uniquely identify deer for this purpose. A better understanding of deer movements, especially in and around Fire Island communities, would help us resolve the difficulties encountered with ground-based surveys of abundance, and help us to better allocate resources associated with the fertility control research program. For example, models of PZP fertility control treatment show that even modest errors in identification of individual females can lead to serious inefficiencies (Underwood and Verret 1998). Encounter histories from known individuals would also facilitate a more quantitative treatment of population demography.

Finally, documentation of impacts of deer grazing and browsing on island vegetation has focused primarily on the SF, and rightly so. The fact that most of the important canopy tree species are not regenerating raises a number of questions about what needs to be done and when. Because the SF is in an old growth state, any severe disturbance and loss to the canopy in the near future could jeopardize the persistence of the community. What we do not yet know is how many recruitment events are needed to satisfactorily restock the losses of canopy trees to old age mortality? Is it better to have a continuous recruitment, or is punctuated recruitment viable? How long can we wait before taking action to reduce the intensity of browsing within the SF? The data to explore many of these questions are available. More support is needed to fully address them.

RECOMMENDATIONS

Population trends clearly indicate that deer abundance in the eastern half of FIIS has not changed appreciably in decades. The issues of grazing and browsing effects on native vegetation notwithstanding, the deer population in OPWA appears to be at ecological carrying capacity. This does not imply that this population is static, however. Annual fluctuations on the order of about 20% are indicated in the survey data. Fluctuations of greater magnitude might be expected after a significant hurricane or particularly severe winter, for example. Current management within this area of FIIS, which represents approximately 70% of all natural-zoned areas within the Seashore, is consistent with NPS natural resources policy regarding animal populations (Appendix I). A similar conclusion cannot be as easily reached for the remaining natural areas (approximately 30%) restricted to western FIIS. These areas are represented by the interstitial green spaces between island communities, the SF and LHT. The acknowledgment of a well-documented human influence on deer numbers in western FIIS and the recent success in altering that human influence, underscore the importance of a more direct involvement of the NPS in community planning and visitor experience efforts. NPS policies regarding native species management are very clear in cases where human influences or activities are implicated in wildlife overabundance. Significant progress toward the elimination of deer feeding by island residents and visitors addresses the spirit if not the intent of current policy guidance. These efforts should not only be continued, but also expanded to include other areas of community development and planning. For the SF, however, the mitigation of human activity may not be enough to reverse impacts already incurred, and further intervention may be justified. The successful resolution of deer management issues island-wide will depend on a creative, sensitive approach that elevates the awareness of residents and visitors as to the consequences of living in a natural environment and the responsibilities that go along with that privilege. From this analysis, it is recommended that FIIS:

(1) Create a permanent, dedicated liaison between FIIS and the island communities for dealing with natural resource issues related to wildlife and vegetation. This person(s), working closely among park divisions, would provide direct assistance to Fire Island communities in the areas of policy interpretation, planning, and coordination of activities designed to reduce human impacts to native wildlife populations.

(2) Revive and reinvigorate the community and visitor relations plan crafted and implemented during the recent Natural Resources Preservation Program (NRPP) project. Subjects should include NPS policy interpretation, awareness of Federal regulations applicable to the feeding of wildlife (especially deer), dissemination of factual information about the biology of FIIS deer, and all issues surrounding Lyme disease.

(3) Establish a science and management advisory team that includes representation from FIIS, RMSP and SPCP. Law enforcement entities from all jurisdictions should also be represented.

(4) Support existing deer monitoring activities throughout Fire Island, and work with cooperators to expand research into specific areas of uncertainty identified in this document. Those questions pertaining to the SF should be addressed immediately.

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APPENDIX I. 2001 NPS MANAGEMENT POLICIES

4.4.2 Management of Native Plants and Animals

Whenever possible, natural processes will be relied upon to maintain native plant and animal species, and to influence natural fluctuations in populations of these species. The Service may intervene to manage individuals or populations of native species only when such intervention will not cause unacceptable impacts to the populations of the species or to other components and processes of the ecosystems that support them, and when at least one of the following conditions exists:

- Management is necessary
    - because a population occurs in an unnaturally high or low concentration as a result of human influences (such as loss of seasonal habitat, the extirpation of predators, the creation of highly productive habitat through agriculture or urban landscapes) and it is not possible to mitigate the effects of the human influences;
    - to protect specific cultural resources of parks;
    - to accommodate intensive development in portions of parks appropriate for, and dedicated to, such development;
    - to protect rare, threatened, or endangered species;
    - to protect human health as advised by the U. S. Public Health Service (which includes the Centers for Disease Control and the NPS Public Health Service Program);
    - to protect property in cases in which it is not possible to change the pattern of human activities; or
    - to maintain human safety in cases in which it is not possible to change the pattern of human activities.
- Or, removal of individuals or parts thereof
    - is part of an NPS research project described in an approved management plan, or is part of research being conducted by others who have been issued a scientific research and collecting permit;
    - is done to provide plants or animals for restoring native populations in parks or cooperating areas without diminishing the viability of the park populations from which the individuals are taken; or
    - meets specific park management objectives.

The Service will assess the results of managing plant and animal populations by conducting follow- up monitoring or other studies to determine the impacts of the management methods on non- targeted, as well as targeted, components of the ecosystem.

As the nation's primary conservation agency, the Department of the Interior has responsibility for most of our nationally owned public land and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical 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 by encouraging stewardship and citizen participation in their care. The department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

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National Park Service
U.S. Department of the Interior

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