EFFECTS OF SPAYVAC™ ON URBAN WHITE-TAILED DEER AT JOHNSON SPACE CENTER

A Thesis

by

SAUL HERNANDEZ

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

December 2005

Major Subject: Wildlife and Fisheries Sciences

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Approved by:

Chair of Committee,	Roel R. Lopez
Committee Members,	Louis A. Harveson
	Nova J. Silvy
	Donald S. Davis
Head of Department,	Robert D. Brown

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ABSTRACT

Effects of SpayVac™ on Urban White-tailed Deer at Johnson Space Center.

(December 2005)

Saul Hernandez, B.S., New Mexico State University

Chair of Committee: Dr. Roel R. Lopez

White-tailed deer (*Odocoileus virginianus*) populations in the United States have increased in recent years, particularly in urban and suburban landscapes where traditional measures of population control are difficult to implement. As a result of rapid urban development in the last several years, the Lyndon B. Johnson Space Center (JSC) located southeast of the Houston, Texas metroplex has become a refuge for an increasing, isolated urban white-tailed deer population. The use of the immunocontraceptive SpayVac™ has been proposed as a feasible measure in controlling the JSC deer population; however, the potential effects of the vaccine on deer movements are unknown. Furthermore, there is a need to estimate deer densities when using intensive management practices (e.g., contraceptive program) which requires an assessment of methods to estimate urban deer densities. The objectives of my study were to (1) compare female movements and ranges between deer treated with SpayVac™ versus non-treated (control) deer, (2) determine if the timing of SpayVac™ treatment affected efficacy, and (3) compare mark-resight and distance sampling methodologies in estimating urban deer densities. I captured and radio-marked 59 adult female deer at JSC. I found annual ranges between treated (mean 95% kernel = 82 ha, mean 50% kernel = 11 ha) and control (mean 95% kernel = 77 ha, mean 50% kernel = 11 ha) deer were similar ($P > 0.05$). Furthermore, I found daily movements between treated (mean = 430 m) and control (mean = 403 m) deer also were similar ($P > 0.05$). The use of SpayVac™ did not alter movements and ranges of treated deer, and is unlikely to increase deer-vehicle collisions due to increased movements. I found the timing efficacy (i.e., time needed for vaccine to prevent pregnancy) of SpayVac™ was 0% for does treated closer to the breeding season than previously believed. For JSC, this expands the application time for SpayVac™ treatment to a 5–6 month window rather than the 2–3 month window as previously recommended.

I found mark-resight estimates (160–174 deer) were congruent with minimum known alive estimates at JSC (158), whereas distance sampling estimates (83–114) were biased low. The use of non-random road counts likely resulted in the low estimates using distance sampling. I recommend that future efforts to monitor population densities at JSC use mark-resight estimates along with the on-going contraceptive program.

DEDICATION

I dedicate my thesis to my parents who have always supported me in everything I choose to do; also to my older brothers and younger sister who have helped me to become the person I am today. Thank You

ACKNOWLEDGEMENTS

First, I would like to thank Dr. Roel Lopez for all his help and advice along with the other members of my committee: Drs. Louis A. Harveson, Nova J. Silvy, and Donald S. Davis. I also would like to thank the personnel at National Aeronautic Space Administration (NASA) Lyndon B. Johnson Space Center for funding, logistical support, and for allowing me to conduct my research. In particular, I would like to acknowledge Mr. Gary Wessels and the personnel at the Animal Lab Safety committee. Finally, I would like to thank Matt Cook for assisting me in the collection and analysis of data, and all the other brave Texas A&M University students that risked their lives chasing and capturing deer for my project.

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CHAPTER I

INTRODUCTION

White-tailed deer (*Odocoileus virginianus*) populations in the United States have increased in recent years, particularly in urban and suburban landscapes where traditional measures of population control are difficult to implement (McShea et al. 1997). High deer densities typically result in increased deer-human conflicts such as deer-vehicle collisions or damage to ornamental vegetation (e.g., Kuser 1993, Baker and Fritsch 1997, McShea et al. 1997). The white-tailed deer population at the National Aeronautic Space Administration's (NASA) Lyndon B. Johnson Space Center (JSC) is no exception (Figure 1.1). The JSC facility serves as mission control for all manned spaceflights, and is located southeast of the Houston, Texas metro area. As a result of rapid urban development in the last several years, JSC has become a refuge for an increasing, isolated urban white-tailed deer population (Figure 1.2, Whisenant 2003). Recent population studies estimate approximately 150 deer occupy the 552-ha facility surrounded by urban development (Whisenant 2003).

Managing overabundant deer populations in urban landscapes is a challenge for wildlife managers. Population management of urban white-tailed deer can be achieved by either lethal or non-lethal techniques (McShea et al. 1997); however, such measures may have limitations in some urban settings. For example, lethal techniques such as hunting or sharp shooting are effective measures in controlling overabundant deer populations (McShea et al. 1997); however, the use of firearms within the JSC facility is

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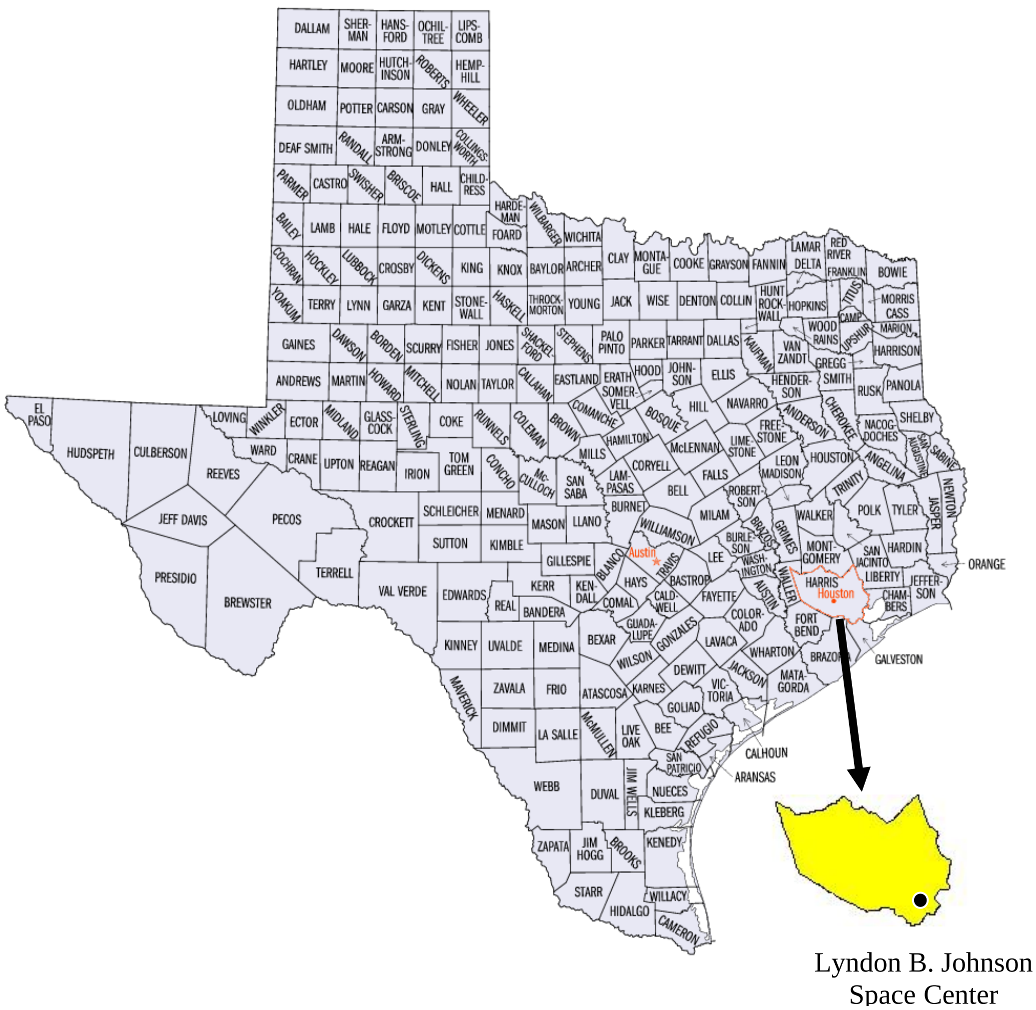

Figure 1.1. Study area location at the Lyndon B. Johnson Space Center, Houston, Texas.

Figure 1.2. Aerial photograph and surrounding area of the Lyndon B. Johnson Space Center, Houston, Texas.

restricted due to surrounding subdivisions and highways, and because of other safety concerns expressed by the JSC administration (Whisenant 2003). Furthermore, lethal control measures also were deemed unfeasible due to the concern of public perceptions regarding controlled hunts at the space center (Whisenant 2003). For JSC managers, initially non-lethal techniques such as trap and relocation programs or contraceptive programs were believed to be more acceptable (Ishmael and Rongstad 1984) in controlling urban deer populations. Trap and relocation programs generally are labor intensive, and result in high capture myopathy (Jones et al. 1997, Beringer et al. 2002); for these reasons, trap and relocation measures were deemed to be inappropriate at JSC. The use of contraceptives for the JSC deer population was viewed as the only feasible alternative in controlling the population (Whisenant 2003).

The use of contraceptives in controlling urban deer numbers has recently gained public acceptance and is viewed as a humane alternative in managing urban deer populations (Chase et al. 1999). Historically, immunocontraceptive vaccine efficacy was limited due to the need for multiple boosters (DeNicola et al. 1997, Miller et al. 2000, Fraker et al. 2002). Recently, Fraker et al. (2002) documented 100% contraceptive efficacy over 3 years for treated does using SpayVac™. SpayVac™ is a unique contraceptive in that it can be administered once and continues to be effective for a number of years (Fraker et al. 2002). Other contraceptives only work for short periods of time, and therefore, require boosters for extended effectiveness. SpayVac™ may offer wildlife managers a feasible option for sterilization efforts in urban white-tailed deer management. For this reason, JSC decided to test the contraceptive drug

SpayVac™ on their deer population. One potential side effect in use of SpayVac™ is the multiple estrous cycles of treated does (Fraker et al. 2002), which likely would extend rutting behavior in deer. The concern for JSC managers with potential increased deer movements related to an extended breeding season was increasing the risk of deer-vehicle collisions. Wildlife managers interested in using SpayVac™ in controlling urban deer numbers need to understand the potential side effects of the vaccine on deer movements and ranges (i.e., potential increased range sizes and movements of treated deer); however, no studies evaluating the effects of SpayVac™ on free-ranging white-tailed deer populations have been conducted. Previous studies of SpayVac™ on white-tailed deer have been conducted in captive settings (M. Fraker, TerraMar Research, personal communication).

Obtaining reliable population estimates is paramount in managing urban deer populations. Population estimates can be used in determining the current deer densities, impacts to habitat, or for making informed decisions in population control (e.g., determining the number of deer to treat in a contraceptive program). Traditional methods in estimating deer densities such as drive, strip, and mark-resight techniques can be expensive and labor intensive (Lancia et al. 1994, Jacobson et al. 1997, Jachmann 2002). A need to evaluate alternative methods of estimating deer densities in urban landscapes is necessary, particularly with methods that are easy to implement, precise, and economical. Furthermore, methods that can provide wildlife managers with annual density estimates rather than population trends are preferred, particularly when intensively managing an overabundant, urban deer population (e.g., implementing a contraceptive program). As previously mentioned, limitations to some methods (e.g, mark-resight) include cost, time requirements, and the need for specialized equipment. The use of distance sampling may overcome some of these limitations (Buckland et al. 1993, Tomas et al. 2001, Forcardi et al. 2002, Koenen et al. 2002); however, few studies (Langdon et al. 2001) have evaluated their utility on urban white-tailed deer populations. The objective of my study is 2-fold. First, I will determine the effects of SpayVac™ on female movements and ranges between treated and non-treated (control) deer, and the timing effectiveness of the vaccine (Chapter II). Second, I will compare 2 methods of estimating deer density at JSC, namely mark-resight and distance sampling (Chapter III). Each of these objectives will be addressed separately and presented as stand-alone, individual chapters; repitition of some material will be inevitable due to this approach. I will summarize findings in my thesis in the last chapter (Chapter IV).

CHAPTER II

EFFECTS OF SPAYVAC™ ON URBAN DEER MOVEMENTS

Introduction

White-tailed deer populations in the United States have increased in recent years, particularly in urban and suburban landscapes where traditional measures of population control are difficult to implement (McShea et al. 1997). High deer densities typically results in increased deer-human conflicts such as deer-vehicle collisions or damage to ornamental vegetation (e.g., Kuser 1993, Baker and Fritsch 1997, McShea et al. 1997). The white-tailed deer population at the National Aeronautic Space Administration's (NASA) Lyndon B. Johnson Space Center (JSC) is no exception. The JSC facility serves as mission control for all manned spaceflights, and is located southeast of the Houston, Texas metro area. As a result of rapid urban development in the last several years, JSC has become a refuge for an increasing, isolated urban white-tailed deer population (Whisenant 2003).

Managing overabundant deer populations in urban landscapes is a challenge for wildlife managers. Population management of urban white-tailed deer can be achieved by either lethal or non-lethal techniques (McShea et al. 1997) but some of these measures may have limitations in urban settings. For example, lethal techniques such as hunting or sharp shooting are effective measures in controlling overabundant deer populations (McShea et al. 1997); however, these measures were deemed impractical at JSC due to safety concerns and potential public outcry (Whisenant 2003). Alternative, non-lethal techniques such as trap and relocation programs or contraceptive programs are generally more acceptable in controlling urban deer populations (Ishmael and Rongstad 1984). Trap and relocation programs generally are labor intensive and result in high capture myopathy (Jones et al. 1997, Beringer et al. 2002); for these reasons trapping and relocating deer was found to be impractical at JSC. Thus, the use of contraceptives was viewed as the only feasible alternative in controlling the JSC deer population (Whisenant 2003).

The use of contraceptives in controlling urban deer numbers has recently gained public acceptance and is viewed as a humane alternative in managing urban deer populations (Chase et al. 1999). Historically, immunocontraceptive vaccine efficacy was limited due to the need for multiple boosters (DeNicola et al. 1997, Miller et al. 2000, Fraker et al. 2002). Recently, Fraker et al. (2002) reported 100% contraceptive efficacy over 3 years for treated does using SpayVac™. SpayVac™ is unique in that it can be administered once, works over a number of years, and does not require boosters for extended use (Fraker et al. 2002). Use of SpayVac™ may offer wildlife managers a feasible option for sterilization efforts in urban white-tailed deer management. In 2003, efforts to control the urban white-tailed deer at JSC began.

SpayVac™ is an immunocontraceptive vaccine used in the treatment of does which prevents the fertilization of an egg during the breeding season (Fraker et al. 2002). One potential side effect in use of SpayVac™ is the multiple estrous cycles of treated does (Fraker et al. 2002), which likely would extend rutting behavior in deer. The potential increased and extended movement patterns of treated female deer are a concern for JSC managers due to the likely increase in deer-vehicle collisions. Wildlife managers interested in using SpayVac™ in controlling urban deer numbers need to understand the potential side effects of the vaccine on deer movements and ranges (i.e., potential increased range sizes and movements of treated deer); however, no studies evaluating the effects of SpayVac™ on free-ranging white-tailed deer populations have been conducted. Previous studies of white-tailed deer treated with SpayVac™ have been conducted in captive settings (M. Fraker, TerraMar Research, personal communication).

SpayVac™ causes treated does to produce antibodies that adhere to the surface of eggs and prevent sperm from binding, thus blocking fertilization (Fraker et al. 2002). Recommendations from the vaccine manufacturer suggests that deer should be inoculated 2 months prior to the breeding season to allow antibody titers to rise to contraceptive levels (M. Fraker, TerraMar Research, personal communication); however, these recommendations are based on limited field experiences. For JSC deer, the treatment period is relatively short (approximately 3 months, June–August) following mean fawning period (May) and prior to the peak breeding season (November). The treatment of deer closer to the peak breeding season could extend the treatment window 2–3 months (i.e., 5–6 months time period to treat deer). A need to evaluate the timing efficacy of SpayVac™ on free-ranging urban white-tailed deer is needed.

The objectives of my study were to (1) determine the effects of SpayVac™ on female movements and ranges between treated and non-treated (control) deer, and (2) determine the timing efficacy of SpayVac™ treatments in preventing pregnancies for the immediate fawning season. Such information would allow wildlife managers to understand the effects of SpayVac™ on treated white-tailed deer.

Study area

Lyndon B. Johnson Space Center is located in Clear Lake, Texas (southeast of the Houston, Texas metro area) in Harris County (Figure 1.1). The 552-ha facility is surrounded by urban development and Galveston Bay (Figure 1.2). The entire space center is surrounded with a 1.8 m chain-link fence with 3 strands of angled out barbed-wire. The space center is characterized by improved pasturelands and scattered park-like areas with oaks (*Quercus* spp.), hickories (*Carya* spp.), and pines (*Pinus* spp.) intermixed with buildings.

Methods

Trapping and treatment

White-tailed deer were trapped at JSC in July–November 2003 and July–November 2004 using drop nets (Lopez et al. 1998) and portable drive nets (Silvy et al. 1975). After initial capture, deer were physically restrained (no drugs were used) for an average time of 10–15 minutes. Sex, age, capture location, body weight, radio frequency, and body condition were recorded for each deer prior to release. Plastic neck collars (6-cm wide) equipped with battery-powered, mortality-sensitive radio transmitter (150–152 MHz, 115 g, Advanced Telemetry Systems, Inc, Isanti, Minnesota) and plastic numbered ear tags for easy identification were fitted to all captured adult females. Prior to release, deer were injected with 200µg of SpayVac™ (treatment) or 200µg of a placebo (control) via intramuscular injection. Finally, all captured deer were permanently marked with an ear tattoo (Lopez et al. 2004).

Radiotelemetry

Radio-marked deer were relocated between July 2003–May 2005 via homing 3–4 times/week using a portable antenna and vehicle (White and Garrott 1990). All deer were relocated within a randomly selected 4-hr segment in each 24-hr period sampled (Lopez et al. 2004). Telemetry locations were entered into a Geographical Information System (GIS) using ArcView (Version 3.2). During the prebreeding season (July–October), radio-marked deer were monitored more intensely using walk-ins to determine the fawning rate of treated versus control deer.

Data analysis

Female deer ranges (95%-probability area) and core areas (50%-probability area) were calculated using a fixed-kernel home-range estimator (Worton 1989, Seaman et al. 1998, Seaman et al. 1999) with the animal movement extension in ArcView (Hooge and Eichenlaub 1999). Calculation of the smoothing parameter (kernel width) as described by Silverman (1986) was used in generating kernel-range estimates. Seasonal ranges (ha), core areas (ha), and mean daily movements (m) were calculated for radio-marked deer. Seasons were defined as prebreeding (July–October), breeding (November–February), and fawning (March–June). Only deer with >20 locations were used to calculate movement estimates (Seaman et al. 1999). Annual ranges (ha), core areas (ha), and mean daily movements (m) also were calculated. Only deer with >50 locations were used to calculate annual estimates as recommended by Seaman et al. (1999). Differences in ranges, core areas, and mean daily movements were tested using an ANOVA, followed by Tukey's HSD for multiple comparisons to separate means when *F*-values were significant ($P < 0.05$, Ott 1993). Finally, I calculated the fawning rate of treatment does by month to determine the timing efficiency for SpayVac™.

Results

I captured and radio-marked 49 adult females at JSC. Of these captured deer, 38 deer were injected with SpayVac™ (treatment) and 11 deer were injected with a placebo (control). Only 2 deer were censored from my analysis (both treated deer) due to natural mortalities. I observed no differences in JSC annual ranges (mean = 82 and 77 ha, SE = 7 and 14 ha, $P = 0.733$), core areas (mean = 11 and 11 ha, SE = 1 and 3 ha, $P = 0.944$), and mean daily movements (mean = 430 and 403 m, SE = 1.5 and 3.6 m, $P = 0.419$) between treated and control deer (Figures 2.1-2.2). In comparing seasonal ranges between treated and control deer, I found no difference between treatment ($P = 0.733$); however, deer ranges did differ by season ($P = 0.0012$) between the fawning (mean = 64 ha, SE = 9.5 ha) and breeding (mean = 93.5 ha, SE = 14.5 ha) periods but not for the pre-breeding season (mean = 73 ha, SE = 9.5 ha, $P = 0.3328$) (Figure 2.3). Similar results were found in comparing core ranges where treatment did not differ (*P* = 0.944); however, core ranges did differ by season (*P* = 0.0041) between the fawning (mean = 8 ha, SE = 1.5 ha) and breeding (mean = 12 ha, SE = 2 ha) periods but not for the pre-breeding season (mean = 10.5 ha, SE = 1.5 ha, *P* = 0.1229) (Figure 2.4). Finally, in comparing average daily movements I found no difference between treatment (*P* = 0.419); however, daily movements did differ by season (*P* = 0.0014) between the fawning (mean = 352.5 m, SE = 24.5 m) and breeding (mean = 443.5 m, SE = 38 m) periods as well as the fawning and pre-breeding season (mean = 411.5 m, SE = 34 m, *P* = 0.0348) (Figure 2.5).

I found the fawning rate for 26 treated does from July–October 2003 was 0% (July *n* = 7, August *n* = 2, September *n* = 6, October *n* = 8). As expected, deer treated at the beginning of the breeding season (*n* = 3) became pregnant and fawned the following year.

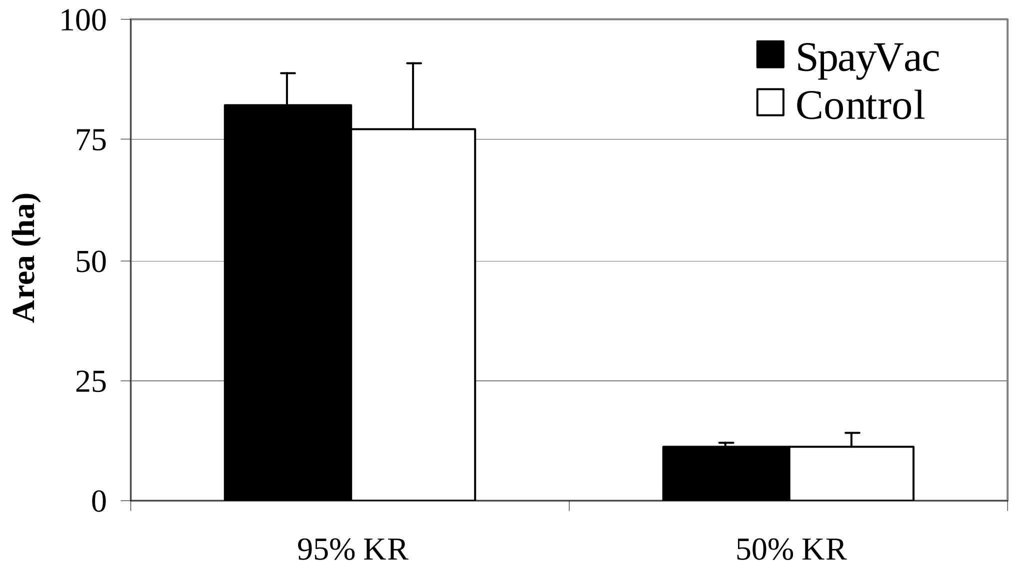

Figure 2.1. Annual ranges (95% range and 50% core areas, ha, 1 SE) for radio-collared white-tailed deer treated with SpayVac™ and placebo (control) at the Lyndon B. Johnson Space Center, Houston, Texas, 2003.

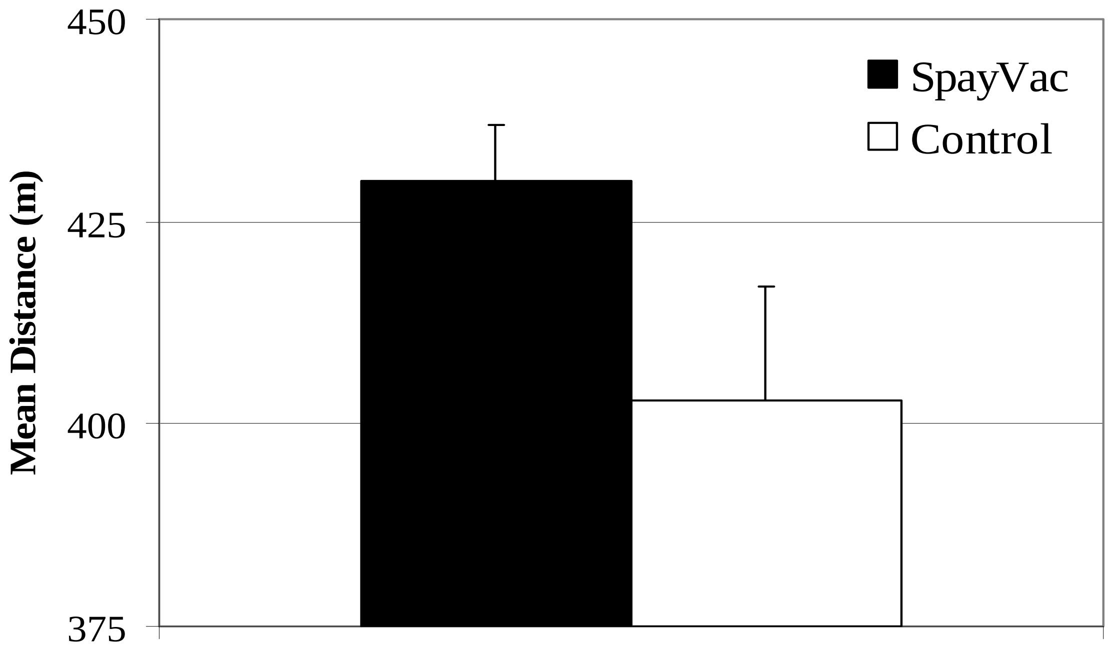

Figure 2.2. Annual daily movements (mean, 1 SE) for radio-collared white-tailed deer treated with SpayVac™ and placebo (control) at the Lyndon B. Johnson Space Center, Houston, Texas, 2003.

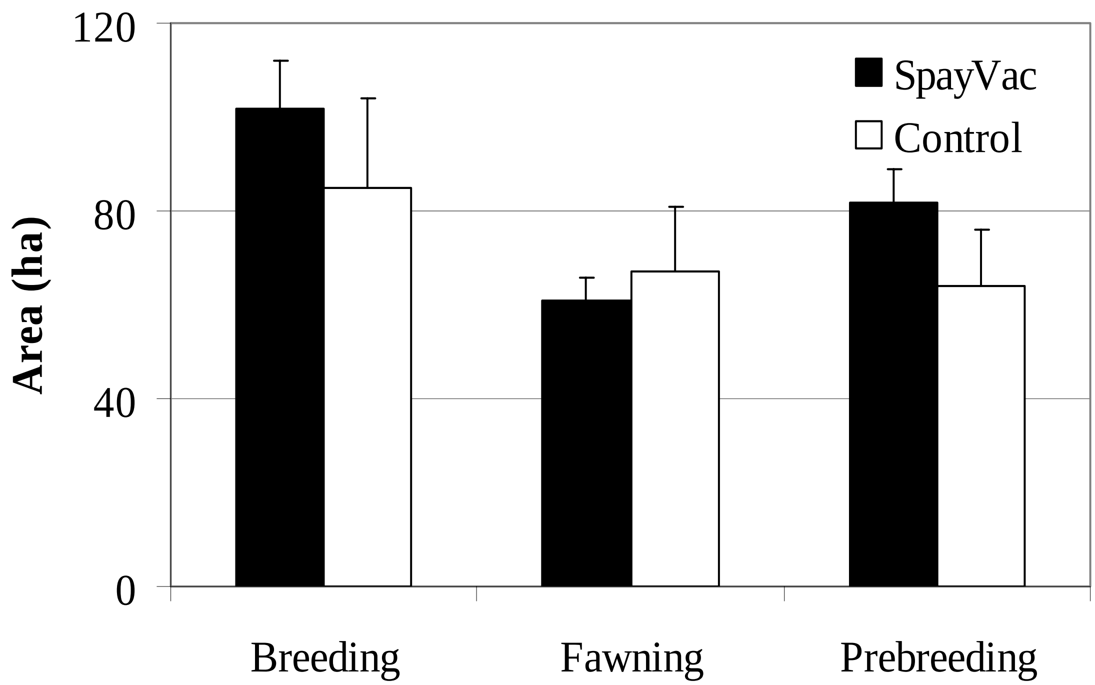

Figure 2.3. Average seasonal ranges (95%, 1 SE) between treated and control deer at Johnson Space Center, Houston, Texas.

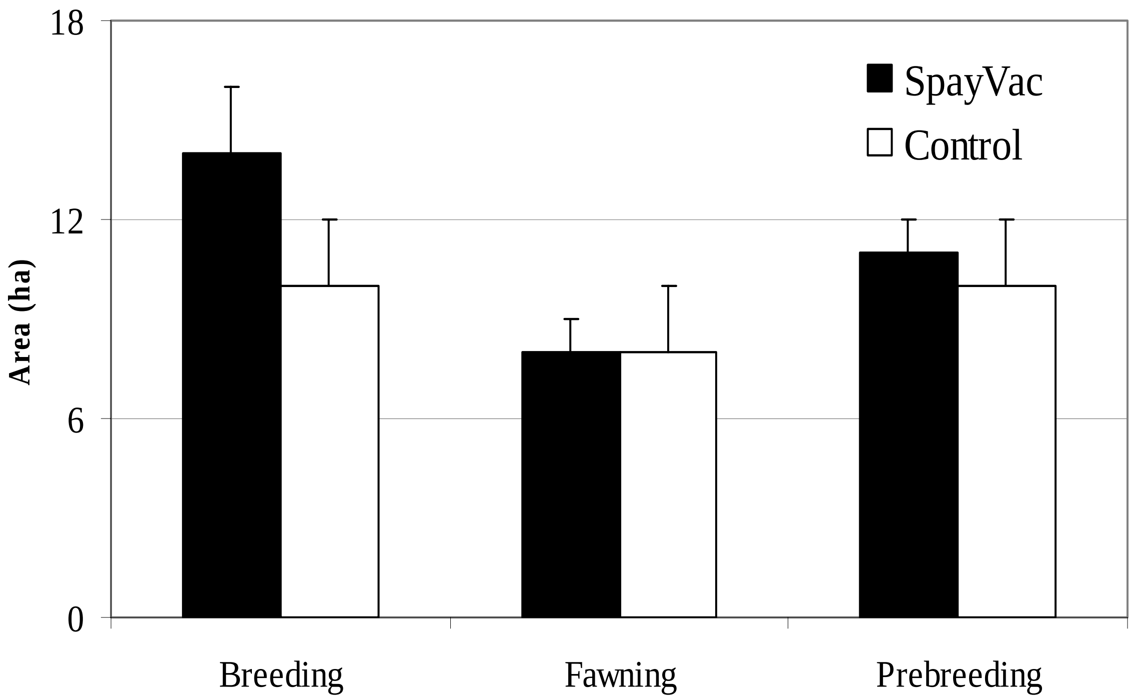

Figure 2.4. Average seasonal ranges (50% core area, 1 SE) between treated and control deer at Johnson Space Center, Houston, Texas.

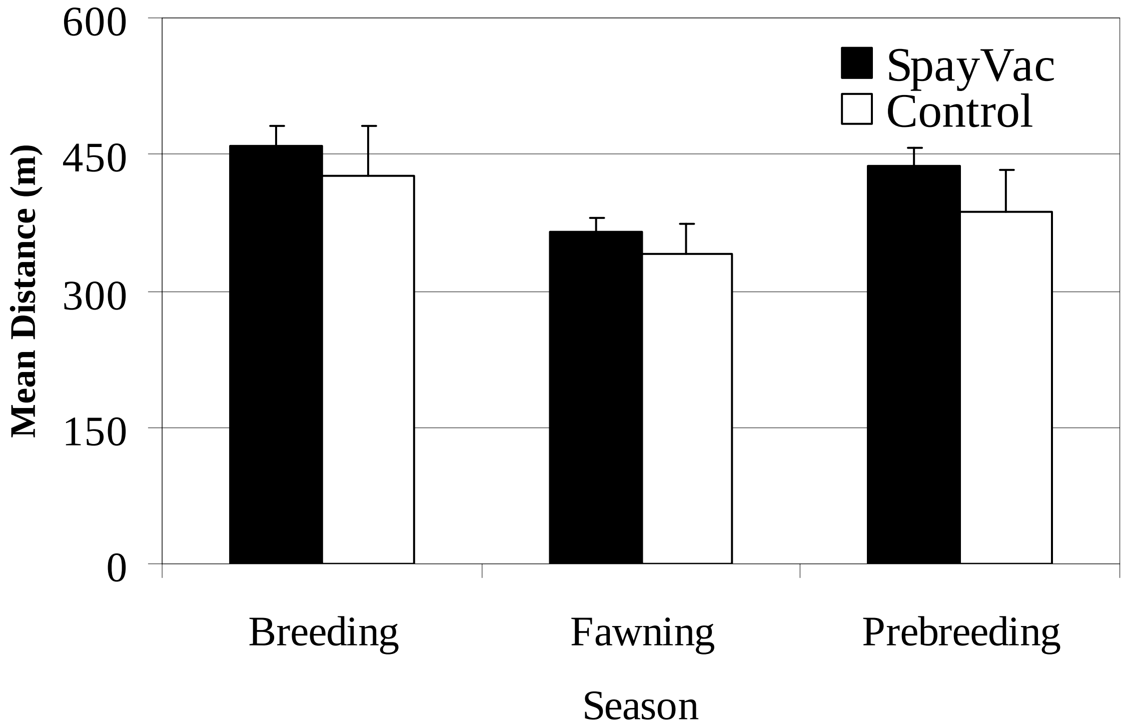

Figure 2.5. Average seasonal movement (1 SE) between treated and control deer at Johnson Space Center, Houston, Texas.

Discussion

I predicted that a potential side effect in use of SpayVac™ in controlling overabundant deer populations was the likely increased rutting behavior due to the multiple estrous cycles of treated does (Fraker et al. 2002). The potential increased and extended movement patterns of treated female deer are a concern for JSC managers due to the likely increase in deer-vehicle collisions. In my study, I found the ranges and average daily movements for does treated with SpayVac™ were greater than control deer, though not significantly different, during the breeding season. One possible explanation for similar movement patterns between treated and control deer at JSC may be the relatively small, enclosed area at JSC (552 ha) restricting the increase in ranges and average daily movements for does treated with SpayVac™. Thus, for the contraceptive program at JSC, the use of SpavVac™ will likely not increase deer-vehicle collisions. This may not be the case in other areas where an expansion of deer movements may not be restrictive as are at JSC.

I found the efficacy of SpayVac™ was 0% for does treated closer to the breeding season (<2–3 months) than previously believed. Manufacturer recommendations suggest a 2–3 month inoculation period prior to the breeding season to allow antibody titers to rise to contraceptive levels (M. Fraker, TerraMar Research, personal communication). My study results suggest an inoculation period of that length was not necessary to successfully prevent pregnancies in treated white-tailed deer. For JSC, this expands the application time in the management of overabundant deer populations to 5–6 months. This is 2–3 months longer than previously thought.

Management implications

SpayVac™ did not alter the ranges and movements of treated deer at JSC. Future applications of SpayVac™, however, should consider the relative size of the area where female deer are being treated. An increase in deer ranges and movements may be observed in larger management areas. Furthermore, future research should evaluate the potential effects of SpayVac™ treatments on male white-tailed deer rutting behaviors. In some instances, the treatment of female deer may result in an increase of male movements/ranges, which may likely increase deer-vehicle collisions.

CHAPTER III

ESTIMATING URBAN DEER DENSITY

Introduction

White-tailed deer populations in the United States have increased in recent years, particularly in urban and suburban landscapes where traditional measures of population control are difficult to implement (McShea et al. 1997). High deer densities typically result in increased deer-human conflicts such as deer-vehicle collisions or damage to ornamental vegetation (e.g., Kuser 1993, Baker and Fritsch 1997, McShea et al. 1997). The white-tailed deer population at the National Aeronautic Space Administration's (NASA) Lyndon B. Johnson Space Center (JSC) is no exception. As a result of rapid urban development in the last several years, JSC has become a refuge for an increasing, isolated urban white-tailed deer population (Whisenant 2003). Recent population studies estimate approximately 150 deer occupy the 552-ha facility surrounded by urban development (Whisenant 2003).

Managing overabundant deer populations in urban landscapes is a challenge for wildlife managers. Obtaining reliable population estimates is paramount in managing these urban deer populations, particularly where intensive management practices (e.g., contraceptive program) are being conducted. Traditional methods in estimating deer densities such as drive, strip, and mark-resight techniques can be expensive and labor intensive (Lancia et al. 1994, Jacobson et al. 1997, Jachmann 2002). A need to evaluate alternative methods of estimating deer densities in urban landscapes is necessary, particularly with methods that are easy to implement, precise, and economical.

Furthermore, methods that can provide wildlife managers with annual density estimates rather than population trends are preferred, particularly when intensively managing an overabundant, urban deer population. As previously mentioned, limitations to some methods (e.g, mark-resight) include cost, time requirements, and the need for specialized equipment. The use of distance sampling may overcome some of these limitations (Buckland et al. 1993, Tomas et al. 2001, Forcardi et al. 2002, Koenen et al. 2002); however, few studies (Langdon et al. 2001) have evaluated their utility on urban white-tailed deer populations. The objective of my study was to compare 2 methods of estimating deer density at JSC, namely mark-resight and distance sampling. Such information can be used by urban wildlife managers in addressing overabundant deer populations in urban landscapes.

Study area

Lyndon B. Johnson Space Center is located in Clear Lake, Texas (southeast of the Houston, Texas metro area) in Harris County. The 552-ha facility is surrounded by urban development and Galveston Bay. The entire space center is surrounded with a 1.8 m chain-link fence with 3 strands of angled out barbed-wire. The space center is characterized by improved pasturelands and scattered park-like areas with oaks (*Quercus* spp.), hickories (*Carya* spp.), and pines (*Pinus* spp.) intermixed with buildings.

Methods

Trapping and marking

Female white-tailed deer were trapped at JSC between July 2003–December 2004 using drop nets (Lopez et al. 1998) and portable drive nets (Silvy et al. 1975). An on-going contraceptive program was being implemented during my study, thus, only female deer were captured and marked. After initial capture, deer were physically restrained (no capture drugs were used) for an average time of 10–15 minutes. Sex, age, capture location, body weight, radio frequency (if applicable), and body condition were recorded for each deer prior to release. Furthermore, female deer were treated with the immunocontraceptive SpavVac™ (Fraker et al. 2002) or placebo. Plastic neck collars (6-cm wide) equipped with battery-powered, mortality-sensitive radio transmitter (150–152 MHz, 115 g, Advanced Telemetry Systems, Inc, Isanti, Minnesota) and plastic numbered ear tags for easy identification were fitted to all captured adult females. Finally, all captured deer were permanently marked with an ear tattoo (Lopez et al. 2004).

Deer surveys

Weekly road counts were conducted along a standardized 10-km route at sunset from September 2003–December 2004 (Figure 3.1). Start and finish points were the same for each route and started 2 hours before official sunset. Two observers in a vehicle traveled along the survey route (average travel speed 18–36 km/hr) and recorded the observed number of deer (marked/unmarked), sex, and age (fawn, yearling, adult). The perpendicular distance to each deer also was measured for deer observed using a rangefinder (Bushnell Yardage Pro 1000, Overland Park, Kansas), and all deer locations were marked on a map and entered into a database. The number of available marked deer each week was determined from telemetry data or survey data observations.

Data analysis

Annual population estimates using weekly survey data was determined using the computer programs NOREMARK (White 1996) and Program DISTANCE 4.1 (Buckland et. al. 1993, Focardi et. al. 2002) Version 2. Program NOREMARK was used in estimating population density using a mark-resight framework (White 1996), whereas Program DISTANCE used perpendicular distances of observed deer in obtaining a density estimate (Buckland et. al. 1993, Focardi et. al. 2002). Deer density estimates for the 2 methods were compared using confidence limit estimates.

Results

I conducted 89 weekly surveys from July 2003–December 2004. A total of 59 adult females was captured and marked at JSC during my study. From these data, I estimated the JSC deer population to be 167 deer (160–174) using Program NOREMARK. Conversely, I found the distance sampling estimates to be significantly lower ($P < 0.05$) with an estimated 97 deer (83–114) (Figure 3.2).

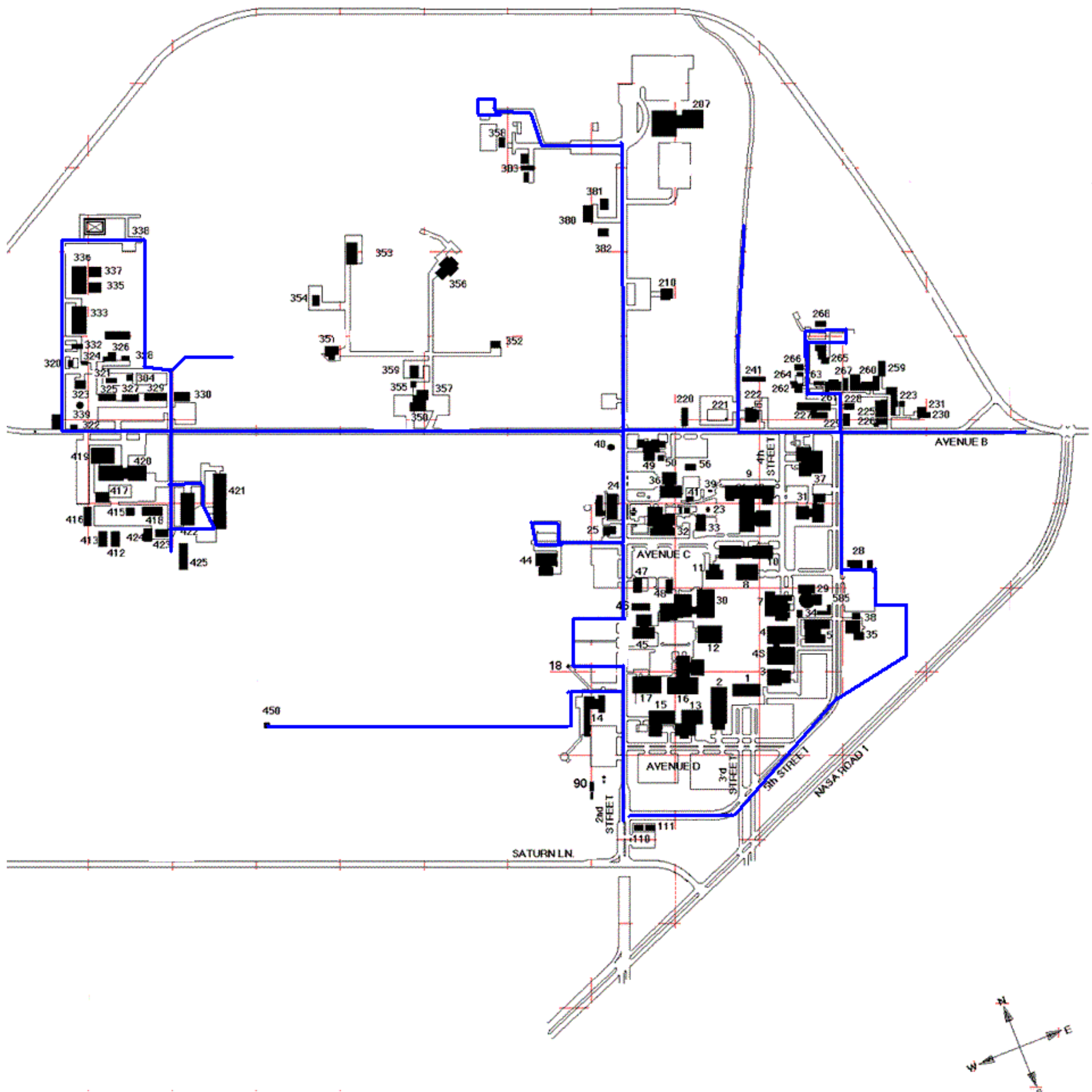

Figure 3.1. Road-survey route used to estimate deer densities at the Lyndon B. Johnson Space Center, Houston, Texas.

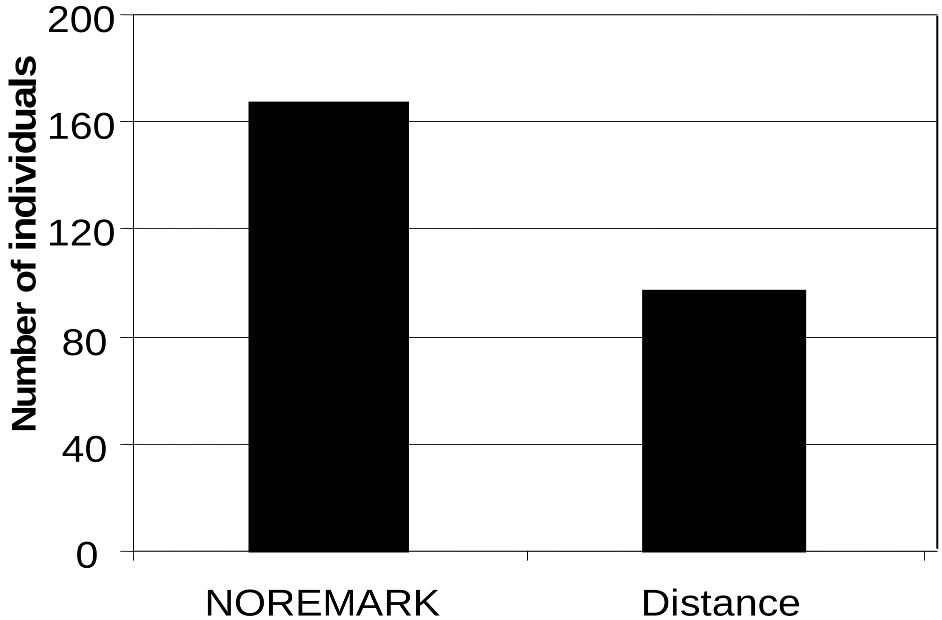

Figure 3.2. Comparison of 2 population estimates for white-tailed deer at the Lyndon B. Johnson Space Center, Houston, Texas.

Discussion

I found the density estimates for the JSC deer population using a mark-resight framework to be different from those obtained using distance sampling methodologies. Estimates from mark-resight methods were nearly double compared to distance sampling. The distance sampling methods were biased low in my study based on the minimum known alive estimates. The minimum known alive estimate (i.e., 158) approaches the confidence limits (160–174) of the mark-resight estimates. Whisenant (2003) reported approximately 90% of the area at JSC was observed from the survey route due to the relatively small study area and the high road density (i.e., adequate road coverage of area surveyed). The low estimate obtained from distance sampling may be due to the use of road counts in estimating deer density. Buckland et al. (1993) stated transect lines used in collecting distance data should be positioned randomly within the study area. In my case, the use of road counts likely violated this assumption due to the non-random placement of roads. Based on my study results, I would recommend the use of mark-resight estimates for deer at JSC.

Management implications

I found that mark-resight estimates appeared to be more accurate than distance sampling at JSC and would recommend the former in future efforts to monitor the deer population. In controlling the deer population at JSC with the use of SpayVac™, federal law requires the marking of treated animals (M. Fraker, TerraMar Research, personal communication). This requirement can easily be incorporated into a population-monitoring program using a mark-resight framework.

CHAPTER IV

CONCLUSIONS AND IMPLICATIONS

Managing overabundant deer populations in urban landscapes is a challenge for wildlife managers. As a result of rapid urban development in the last several years, the Lyndon B. Johnson Space Center has become a refuge for an increasing, isolated urban white-tailed deer population (Figure 1.1, Whisenant 2003). The use of the immunocontraceptive SpayVac™ has been proposed as a feasible measure in controlling the JSC deer population. One potential side effect in the use of SpayVac™ with JSC deer was the likely increased rutting behavior due to the multiple estrous cycles of treated does (Fraker et al. 2002). This was a concern for JSC managers due to potential increased deer movements resulting in a likely increase in deer-vehicle collisions. I found this was not the case at JSC where treated and control deer ranges and movements were similar ($P > 0.05$, Chapter II). I also found the timing efficacy of SpayVac™ was 0% for does treated closer to the breeding season than previously believed. I found the suggested 2–3 month inoculation period prior to the breeding season was not needed to prevent pregnancy in deer the following fawning season (Chapter II). For JSC, this expands the application time in the management of overabundant deer populations to a 5–6 month window rather than the 2–3 month window previously recommended.

Obtaining reliable population estimates is paramount in managing urban deer populations, particularly when intensive management practices (e.g., contraceptive program) are being implemented. I compared mark-resight estimates to those obtained using distance sampling, and found estimates from mark-resight methods were more accurate (Chapter III). In my study, distance sampling estimates were biased low, whereas mark-resight estimates were congruent with minimum number of deer seen at JSC (Chapter III). I recommend that JSC personnel continue to monitor population densities at the space center using mark-resight estimates incorporated with the on-going contraceptive program.

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