WHITE-TAILED DEER POPULATION DYNAMICS AND MANAGEMENT ON THE LYNDON B. JOHNSON SPACE CENTER

A Thesis

by

SHANE WESTON WHISENANT

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

August 2003

Major Subject: Wildlife and Fisheries Sciences

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Approved as to style and content by:

Nova J. Silvy (Co-Chair of Committee)	Roel R. Lopez (Co-Chair of Committee)
Clifton P. Griffin (Member)	Donald S. Davis (Member)
	Robert D. Brown (Head of Department)

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ABSTRACT

White-tailed Deer Population Dynamics and Management

on the Lyndon B. Johnson Space Center. (August 2003)

Shane Weston Whisenant, B.S., Texas A&M University

Co-Chairs of Advisory Committee: Dr. Nova J. Silvy
Dr. Roel R. Lopez

White-tailed deer (*Odocoileus virginianus*) numbers on the National Aeronautics and Space Administration's (NASA) Johnson Space Center (JSC) in Houston, Texas have increased in recent years and are a cause of urban-related accidents (e.g., deer-vehicle collisions, negative interactions with humans). Safety personnel for the JSC are interested in reducing human-deer interactions by a reduction in overall population numbers. My overall study objectives were to (1) estimate population parameters for JSC deer, (2) develop a computer simulation model for the JSC deer, and (3) evaluate 2 management strategies to control JSC deer numbers *a priori* using the JSC deer model.

The 2 management strategies I evaluated were the efficacy of SpayVac™ immunocontraceptive vaccine (sterilization) and trap and translocation (deer removal) efforts in managing white-tailed deer on JSC. In general, single treatments of removals or sterilization (>75% of female deer treated) were not effective in reducing population growth ($R < 1$). Approximately 50% of female deer needed to be removed annually to reduce population growth whereas approximately 25% of female deer needed to be treated annually with SpayVac™ for the same effects. A combination of trap and removals and sterilizations was effective in reducing population growth when applied to approximately 25% of the female population annually.

I recommend the use of sterilization annually (≈25%) or a combination of sterilization and removal (≈25%) to achieve the goals of JSC in maintaining current deer numbers. Removing or sterilizing >50% of the female deer annually caused the JSC deer population to decrease to a level near eradication.

DEDICATION

for Janey Lynn

friend and wife : wife and friend

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The following people have been crucial to my success as an undergraduate and graduate student. I want to thank my parents for their love. The support I have received from my parents is nothing short of amazing. Thank you, Pops and Madre; every child should be so fortunate. I also want to thank my big brother, Brandt, and sister-in-law, Shana, for their support and understanding. I can always count on my brother for a laugh and help; thank you, Brandt. Finally I thank my wife and best friend, Janey Lynn Whisenant. There is so much Janey has done for me and this thesis. Janey spent long nights helping me research, keeping me company while writing, and encouraging me with her smile. I thank her for choosing me.

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INTRODUCTION

White-tailed deer (*Odocoileus virginianus*) have increased to record numbers in recent years. Increasing white-tailed deer populations across North America create problems for both rural and urban communities. Problems arise for human populations in suburban and urban areas due to the suitability of these areas to white-tailed deer (Kuser 1993, Henderson et al. 2000). Deer overabundance is a growing problem in urban areas in many parts of the United States (Henderson et al. 2000).

The white-tailed deer population in Texas is the largest in the United States (>3.6 million deer), with large concentrations found in urban areas (Young and Richards 1996). Urban deer populations have been established in the state since the 1930s; however, recent deer population increases are causing serious economic, political, social, and cultural issues (Conover 1993). The white-tailed deer population on the National Aeronautic Space Administration (NASA) Lyndon B. Johnson Space Center (JSC) in Houston, Texas is no exception. Due to the increase in reported deer problems (e.g., deer-vehicle collisions, attacks on humans, etc.), the JSC Safety Action Team Committee (JSAT) desires to control the deer population within the area (Polly Aucoin, NASA, personal communication). Human-deer interactions are only expected to increase with increasing deer numbers requiring some type of management action by the JSC.

White-tailed deer population management can be achieved by either lethal or -

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This thesis follows the style and format of The Journal of Wildlife Management.

non-lethal techniques. Lethal techniques can be effective, but pose a problem for use within urban areas and are not acceptable for use on the JSC. Use of non-lethal techniques (trap and translocation, sterilizations) are generally more accepted by the public (Ishmael and Rongstad 1984, Lauber and Knuth 2000). Trap and translocation programs have been used to remove deer from overpopulated areas with surplus deer being used for restocking (Beringer et al. 2002). However, a negative result of deer translocations is the high (>25-50%) capture myopathy commonly associated with translocated deer (Jones et al. 1997, Beringer et al. 2002). Sterilization or immunocontraception of deer is gaining public acceptance in urban communities and is viewed as a humane alternative to lethal management of white-tailed deer (Chase et al. 1999). Historically, the efficacy of immunocontraceptive vaccines in controlling urban deer numbers were limited by the need for multiple boosters (DeNicola et al. 1997, Miller et al. 2000, Fraker et al. 2002). Recently, Fraker et al. (2002) documented the efficacy of the immunocontraceptive vaccine SpayVac™ to be 100% for treated does over 3 years without boosters. SpayVac™ may offer wildlife managers a feasible option for sterilization efforts in urban white-tailed deer management.

Objectives

The objectives of my study were to (1) estimate population parameters for JSC deer, (2) develop a computer simulation model for the JSC deer, and (3) evaluate 2 management strategies to control JSC deer numbers *a priori* using the deer model. The 2 management strategies I evaluated were the efficacy of SpayVac™ immunocontraceptive vaccine (sterilization) and trap and translocation (deer removal) efforts in managing white-tailed deer on JSC. Model results were to be used in making final management recommendations to JSC personnel for employment.

METHODS

Study Area

The JSC is located in southeast Harris County, Texas, and provides mission control for all NASA manned spaceflight missions (Fig. 1, Dethloff 1993). The 656 ha facility is located in the Gulf Coastal Plains and Prairies Ecoregion of Texas (Gould 1975). The JSC is surrounded by urban development whereas the facility itself provides refuge for an urban white-tailed deer population. The entire site is enclosed by a 1.8 m chain-link fence with 3 strands of barbed-wire angled out. In addition to numerous buildings, the area is comprised of grasslands with coastal Bermuda grass (*Cynodon dactylon*), bushy bluestem (*Andropogon glomeratus*), dewberry (*Rubus trivialis*), and various other forbs. Two wooded areas comprised of oaks (*Quercus spp.*), sugarberry (*Celtis laevigata*), greenbriar (*Smilax spp.*), yaupon (*Ilex vomitoria*), and Chinese tallow (*Sapium sebiferum*) are also found on the site (Fig. 2).

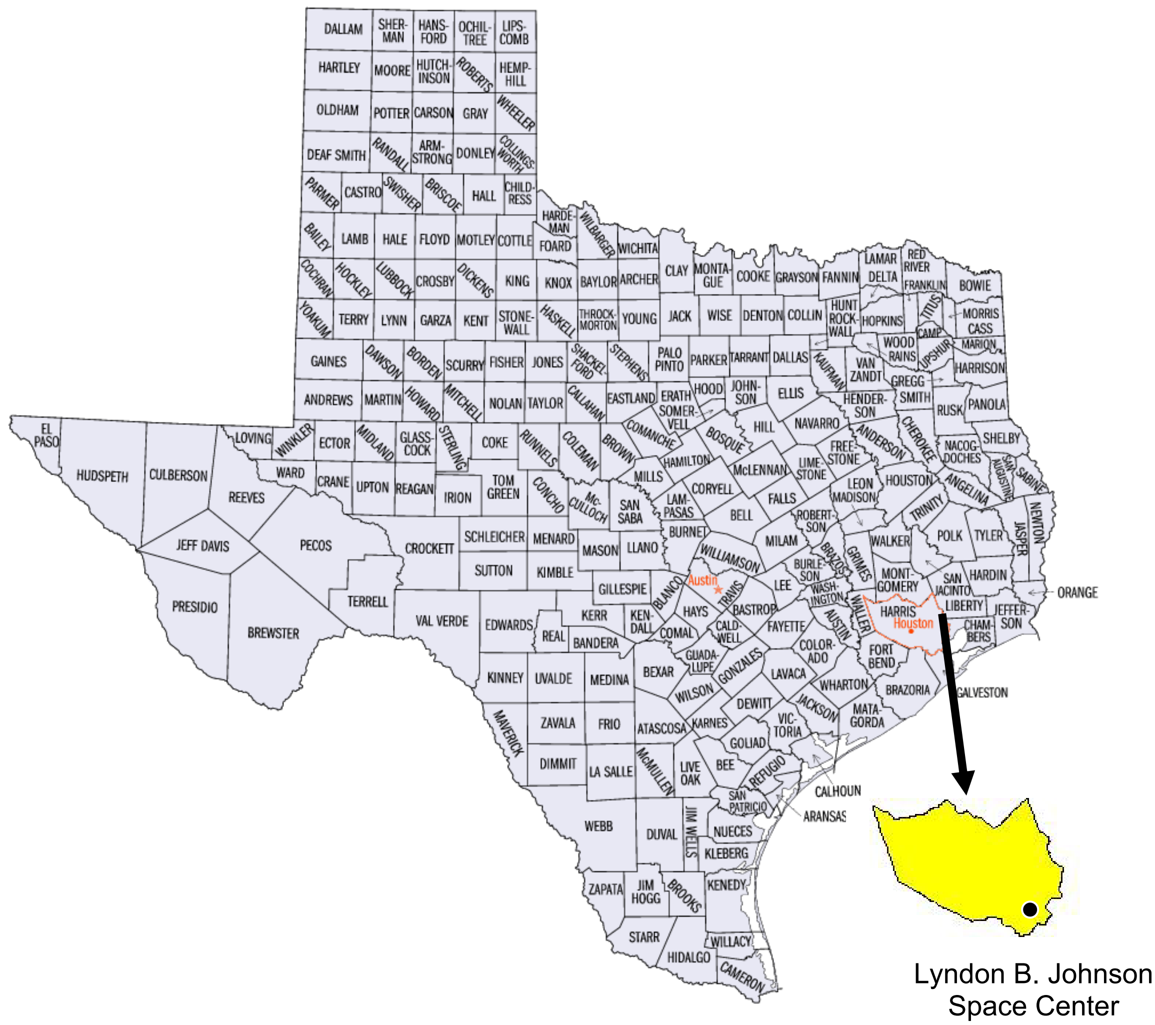

Fig. 1. The Lyndon B. Johnson Space Center in Harris County, Texas.
(Source: United States Census Bureau, 15 July 2003,
A: http://quickfacts.census.gov/qfd/maps/texas_map.html)

Fig. 2. Aerial photograph of the Lyndon B. Johnson Space Center in Harris County, Texas. (Source: Texas Natural Resource Information System, 9 June 2003,
A: http://www.tnris.state.tx.us/update3.cfm)

Model Overview

A stochastic, sex- and age-structured compartment model was developed based on a time step of 1 year to simulate population trends of JSC deer (Fig. 3). The model was developed using STELLA® Research Version 7.0.3 computer program (High Performance Systems, Inc. 2002). Deer age classes were represented as fawns, yearlings, and adults for both sexes. Within the model, fawns were classified as deer >12-months old, yearlings were deer 12-24 months, and adults were deer >24-months of age. Each age-class was assigned a specific mortality and survival rate (Table 1). Fawn recruitment was added to the yearling age-class at the end of each time step. Yearlings surviving the first year moved into the adult population and all 3 age classes were summed to give the total population size.

Table 1. Model parameter estimates used in the JSC deer simulation model.

Age and sex class	Survival	Mortality	Fecundity	SD
Adult Female	0.842	0.158	0.80	0.294
Yearling Female	0.824	0.176	0.65	0.389
Adult Male	0.597	0.403	---	0.449
Yearling Male	0.569	0.431	---	0.549
Female Fawn	0.50	0.50	---	---
Male Fawn	0.50	0.50	---	---

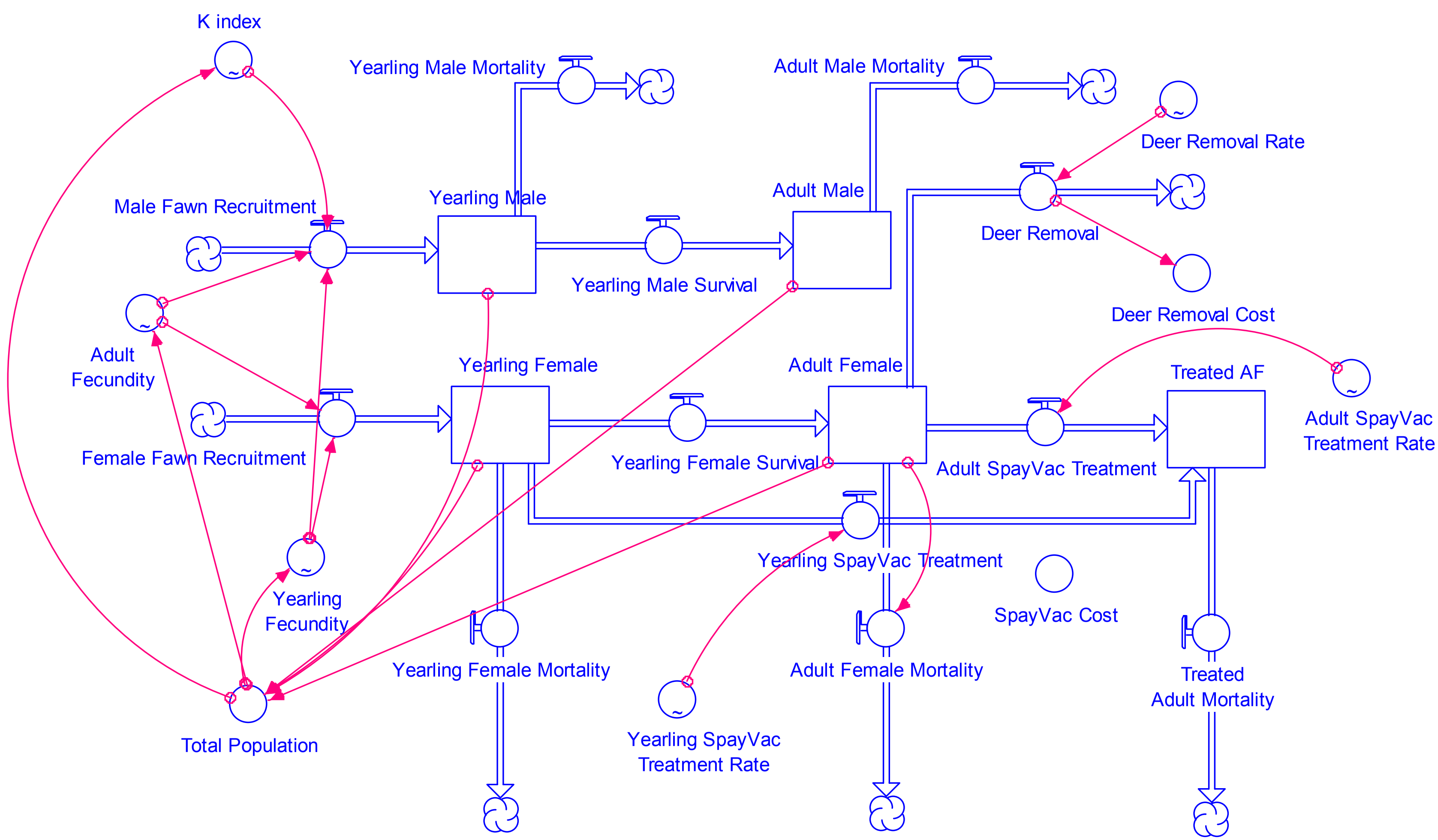

Fig. 3. Conceptual model used to simulate white-tailed deer population on the JSC .

Model Parameters

Initial Abundances.--Deer were counted weekly on the JSC from 22 January 2001-24 January 2002 using an evening drive census. White-tailed deer are a crepuscular species, which makes late afternoon or early evening ideal to census deer populations (Marchinton and Hirth 1984). The census route was 17.9 km in length and was selected to include all roads within the JSC that allowed deer to be seen in all areas with the least amount of visual overlap. The census route started 2 hours prior to dusk, was driven at 18-36 km/hour, and was usually completed within 1.5 to 2 hours depending on the number of deer observed. When a deer was observed, either binoculars or a spotting scope was used to obtain sex and age data (Silvy 1975).

A mean of 91 (± 8.50, 95% C.I.) deer were observed on JSC from 22 January 2001-24 January 2002. Almost all of the JSC was visible on the census route allowing for a direct count in relation to the entire area. I estimated 16% (105 ha) of JSC was not visible on the census route due to woodland areas and buildings. Using the maximum number of deer seen and accounting for the 16% of the area not surveyed on the JSC, I adjusted my initial abundance estimate to 156 individuals (adult females – 69, yearling females – 34, adult males – 34, and yearling males – 18). The model contained a controlling variable, *K* index, which represented carrying capacity for the white-tailed deer population on JSC (Figure 3). The carrying capacity for JSC (656 ha) was set at 415 deer, or approximately 63 deer per km^2. This carrying capacity was based on the estimated population density of Lakeway, Texas. Density estimates in Lakeway are 1 deer/ 7.6-12.7 ha, or approximately 62 deer per km^2 (Mike Reagan, TPWD, personal communication), and are considered to be at carrying capacity.

Population Trends.--Population trends on JSC were determined by comparing the average number of deer seen for censuses completed during January 2001 with the average number of deer seen for censuses completed during January 2002. A finite rate of increase (R) was calculated by:

$$R = N(t+1)/N(t)$$

where N represents the population at time t. The finite rate of increase (R) for the JSC deer herd was 1.19. The JSC deer herd has the potential for an annual increase of 20% based on the calculation of R from census data.

Survival.--In reviewing the literature, survival and variance estimates for adults and yearlings reported by Lopez et al. (2003) were used in my model. I selected these estimates because these rates represented an unhunted, urban deer population and were the most ecologically comparable. Etter et al. (2002) estimated annual deer survival in suburban Chicago, Illinois, and reported estimates approximately the same as Lopez (2003). Beringer et al. (2002) estimated lower annual survival for an urban deer population in Missouri, but the highest mortality came from hunting. Hunting was illegal or limited in the Lopez et al. (2003) and Etter et al. (2002) studies. Fawn survival estimates in Texas show 50% survival (Carroll and Brown 1977) and 30% survival (Cook et al. 1971) in south Texas. Lopez (2003) estimated fawn survival at 70%, but stated a possibility for an overestimate due to inadequate sample sizes for fawns. In my model, I used an annual fawn survival rate of 50%. Coyotes (*Canis latrans*) and annual shredding of fields could reduce fawn survival to 50% in reference to the urban fawn survival estimate provided by Lopez (2003).

Fecundity.--Adult and yearling fecundity (f) was determined by an index defining the reproductive success of adult and yearling females (Table 1). Adult and yearling fecundity indices were calculated by:

$$f = X_{a,b} * s^{f}$$

where X_a and X_b were reproductive success of adult females and yearling females, respectively, and s^f was fawn survival. Fawn recruitment was divided between male and female recruitment based on a 1:1 fetal sex ratio.

Fecundity plays a crucial role in population dynamics of white-tailed deer. Considerable research shows ranges in adult female white-tailed deer fecundity to be 1.1 to 2.0 fawns/adult doe (Demarais and Krausman 2000). Research on 361 adult white-tailed deer females indicated fecundity rates of 1.59 in south Texas (Barron and Harwell 1973). Teer et al. (1965) reported adult fecundity at 1.52 for the Llano Basin (Edwards Plateau ecoregion) of Texas. Blankenship et al. (1994) found a fecundity rate of 1.68 embryos per adult doe in Texas. Due to the geographic location of the JSC, an average (1.60 fawns/adult doe) of the reported (Teer et al. 1965, Barron and Harwell 1973, Blankenship et al. 1994) fecundity rates in Texas were used to simulate adult female fecundity on the JSC.

As yearlings, female white-tailed deer are able to breed and give birth, usually to 1 fawn (Brothers and Ray 1998). However, research findings suggest higher fecundity based on embryos per yearling doe at >1. Barron and Harwell (1973) reported 1.32

embryos per yearling doe as a fecundity rate from their study in south Texas. Blankenship et al. (1994) found a reproductive rate of 1.28 embryos per yearling female in south Texas on the Welder Wildlife Foundation. Again, since the JSC is located in south Texas, estimates from this region were used for model simulation. An average of yearling fecundity, 1.3 fawns per yearling doe, reported by both Texas studies (Barron and Harwell 1973, Blankenship et al. 1994) was used to simulate yearling fecundity on JSC.

Quantitative Description of the Model

The model contained 5 state variables (yearling males, adult males, yearling females, adult females, and treated adult females). Material transfers contained equations to calculate mortality, survival, recruitment, deer removal, and age specific female SpayVac™ treatment. Equations found in material transfers and state variables are described below. Equations contain upper case X's to represent state variables, and material transfer variables (mortality, survival, recruitment, deer removal, SpayVac™ treatment) are represented by lower case letters (Peterson 2001). Subscripts represent age-class (yearling and adult) and superscripts represent sex. The basic state variable equation in terms of "f" (females) is described below (the equation is the same for males):

$$X^{f}_{j,t+1} = X^{f}_{j,t} + (\text{input}_{j,t} - \text{output}_{j,t})\ \Delta t \tag{1}$$

Where $X^{f}_{j,t}$ is the number of females in age class j at time t, $\text{input}_{j,t}$ is the sum of material transfers into the state variable X^{f}_{j} during time t to t+1 and represents specific age class recruitment, survival, and treated females, and $\text{output}_{j,t}$ is the sum of material transfers leaving the state variable X^f_j during time t to t+1 and represents specific age class mortality, survival, treated females, and removed adult females. Material transfer equations can be described as (in terms of females; males use the same equations except where not applicable [deer removal and sterilized deer]):

$$m^f_{j,t} = X^f_{j,t} * (1- s^f_{j,t}) \quad (2)$$

$$s^f_{j,t} = X^f_{j,t} - m^f_{j,t} \quad (3)$$

$$r^f_{j,t} = (\sum_j^{f1,f2}(X^f_{j,t} * f_j))/2 * K \quad (4)$$

$$q^f_{j,t} = X^f_{j,t} * \gamma \quad (5)$$

$$t^f_{j,t} = X^f_{j,t} * \gamma \quad (6)$$

where $m^f_{j,t}$ is age class j mortality at time t to t+1, $s^f_{j,t}$ represents survival of individuals of age class j from time t to t+1, $r^f_{j,t}$ represents recruitment of individuals at age class j from time t to t+1, $\sum_j^{f1,f2}$ is the sum of all fawns, males^{f1} and females^{f2}, born to females of age class j at f_j, where f_j represents fecundity rate index at age class j (0.80 for adult females, 0.65 for yearling females), *K* represents carrying capacity index (*K* = 1 if total population is < 300; *K* < 1 with a minimum of 0.42 as total population approaches 415 [carrying capacity] from 300), $q^f_{j,t}$ is females of age class j trapped and translocated from JSC at variable removal percentage γ (0, 25, 37.5, 50, 75), and $t^f_{j,t}$ represents females of age class j treated with SpayVac™ at variable percentages of treatment γ (0, 25, 37.5, 50, 75).

The mortality material transfer equations included standard deviations for survival estimates reported by Lopez (2003). Equations found in driving variables affecting mortality material transfers are described below (in terms of females):

$$m^{f}_{j,t} = X^{f}_{j,t} * \alpha^{f}_{j,t} \quad (7)$$

where $m^{f}_{j,t}$ represents mortality at age class j at time t to t+1 and $\alpha^{f}_{j,t}$ represents the mortality range calculated using standard deviations of survival estimates at age class j and time t to t+1 (Lopez 2003).

Model Use

The JSC deer model simulated the affect of 2 management strategies to control urban deer numbers over a 15 year period: trap and translocation (deer removal) and sterilization (SpayVac™). Each simulation consisted of 1,000 replications. Combinations of 8 management scenarios were evaluated:

1. No Management - 0% removal and 0% sterilization.
2. Various percentages (25%, 50%, 75%) of removal and 0% sterilization applied annually.
3. One time removal treatment of 75%.
4. Zero percent of removal and various percentages (25%, 50%, 75%) of sterilization applied annually.
5. One time sterilization treatment of 75%.
6. Various percentages (25%, 50%, 75%) of removal and 25% sterilization applied annually.
7. Various percentages (25%, 50%, 75%) of sterilization and 25% removal applied annually.
8. Single treatment, 37.5% removal and 37.5% sterilization.

RESULTS AND DISCUSSION

Model Evaluation

Different management scenarios resulted in varying deer population trajectories (Figures 4-8). In general, single treatments of removals or sterilization were not effective in reducing population growth ($R < 1$); annual treatments were more effective. Approximately 50% annual removal treatments were needed to reduce population growth (Figure 4). Conversely, approximately 25% annual sterilization treatments were needed to reduce population growth (Figure 5). The option of using a combination of treatments was modeled (Figures 6-7). In general, combination treatments caused sharp decreases in population at all percentages.

The goals of JSAT are not to eradicate white-tailed deer from JSC, rather, maintain current numbers. I would recommend the use of sterilization annually (≈25). Removing or sterilizing >50% of the female deer annually, or employing a combination treatment, would cause an unnecessary decrease in the JSC deer herd in terms of JSAT goals.

The cost of removing deer on the JSC is estimated at $350/deer. Ishmael and Rongstad (1984) reported an average of approximately $412/deer for live removal and translocation of deer in Wisconsin. Beringer et al. (2002) reported a cost of $356/deer for trap and translocation effort in Missouri. In contrast, the cost of sterilization is estimated at $398/deer. Like most agencies, JSC is interested in the cost of proposed management techniques. Individual costs of removals and sterilization are comparable;

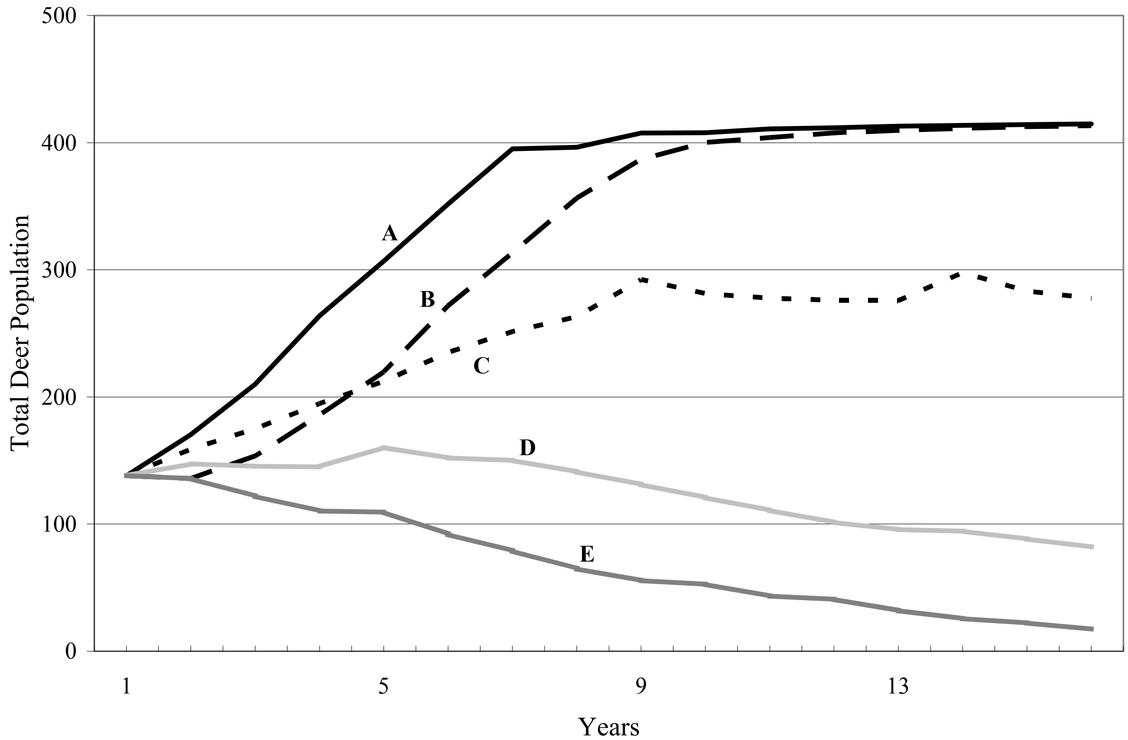

Fig. 4. Graph of simulated population trajectory by management treatments for JSC deer. Treatment A – no management, B – one time, 75% removal, C – 25% removal annually, D – 50% removal annually, E – 75% removal annually.

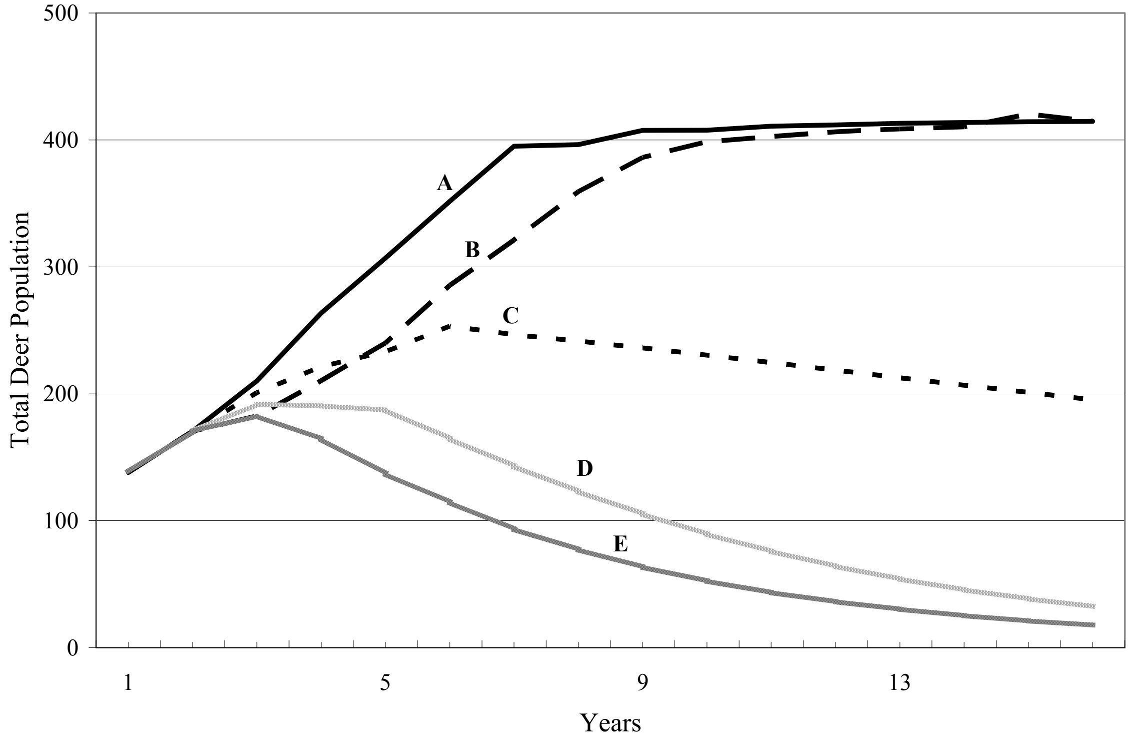

Fig. 5. Graph of simulated population trajectory by management treatments for JSC deer. Treatment A – no management, B – one time, 75% sterilization, C – 25% sterilization annually, D – 50% sterilization annually, E – 75% sterilization annually.

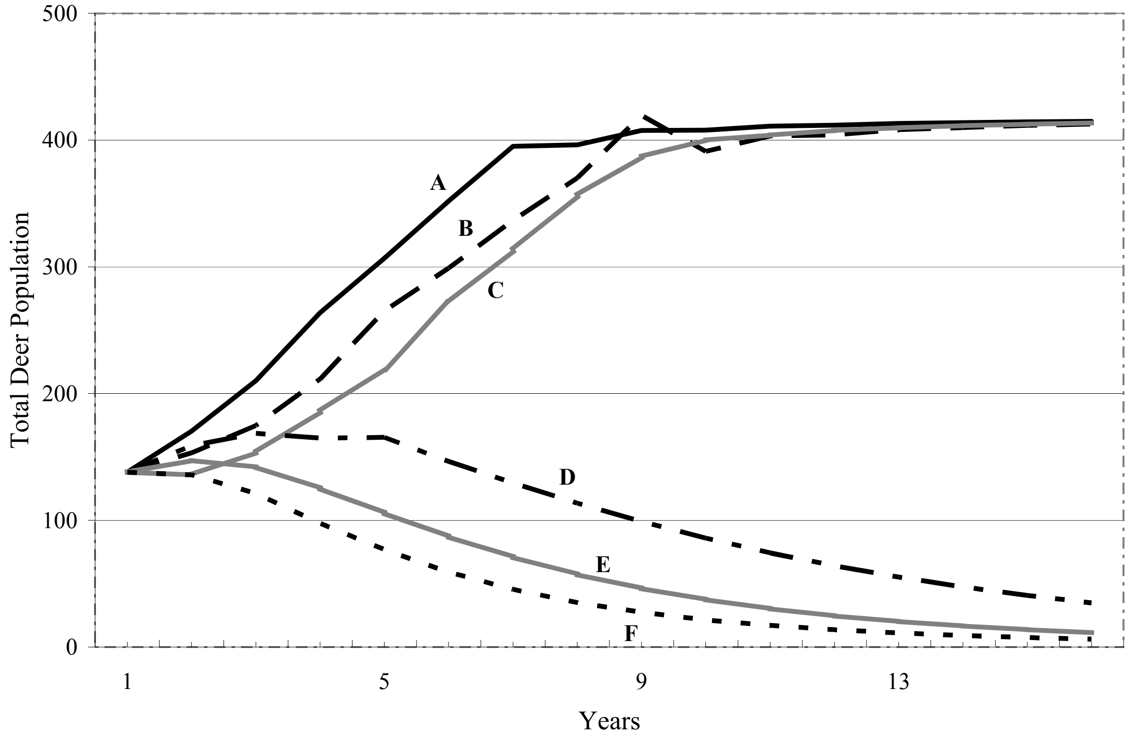

Fig. 6. Graph of simulated population trajectory by management treatments for JSC deer. Treatment A – no management, B – one time, 37.5% removal and 37.5% sterilization, C – one time, 75% removal, D – 25% removal annually, 25% sterilization annually, E – 50% removal annually, 25% sterilization annually, F – 75% removal annually, 25% sterilization annually.

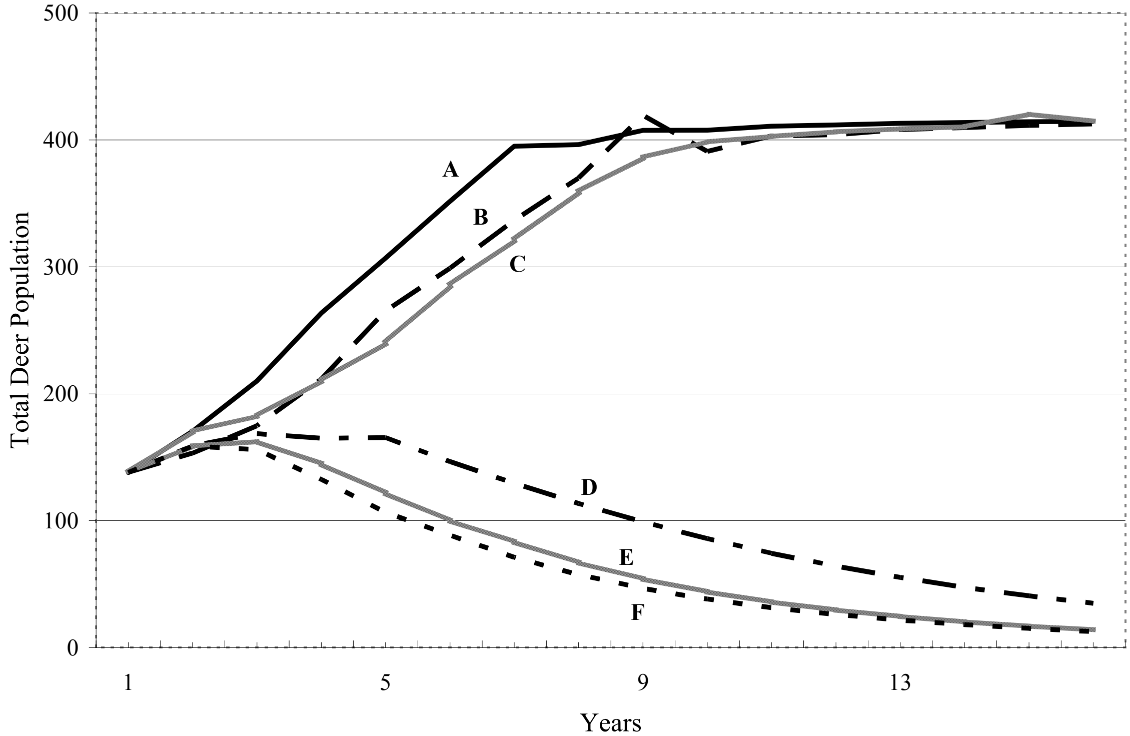

Fig. 7. Graph of simulated population trajectory by management treatments for JSC deer. Treatment A – no management, B – one time, 37.5% removal and 37.5% sterilization, C – one time, 75% removal, D – 25% removal annually, 25% sterilization annually, E – 25% removal annually, 50% sterilization annually, F – 25% removal annually, 75% sterilization annually.

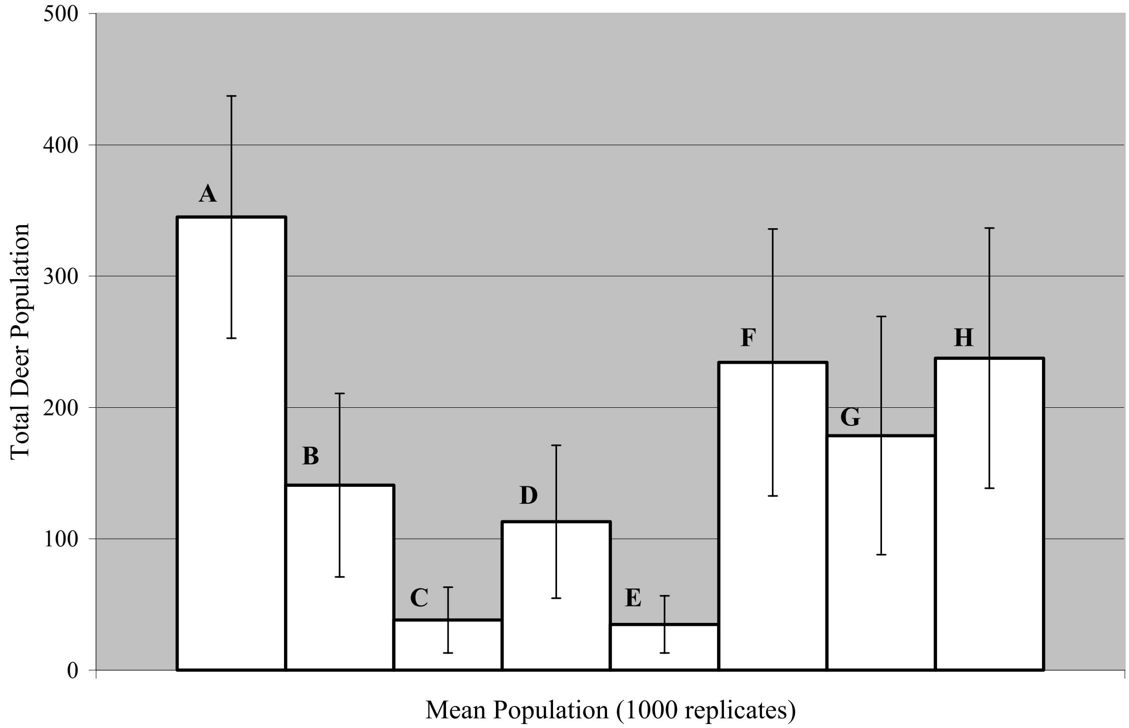

Fig. 8. Graph of simulated population means by management treatments for JSC deer. Treatment A – No Management, B – 25% removal annually, C – 50% removal annually, D – 25% sterilization annually, E – 50% sterilization annually, F – one time, 75% removal, G – one time, 75% sterilization, H – one time, 37.5% removal and 37.5% sterilization.

however, the efficacy of sterilization is greater than deer removals. Deer removals can differ in costs. For example, removal costs can be decreased if euthanasia is used rather than translocation; however, euthanasia would probably be unacceptable in some urban communities (Chase et al. 1999). Sterilization with SpayVac™ offers a management technique limiting handling time and capture events, while eliminating lethal management in urban white-tailed deer. For these reasons, I would recommend the use of SpayVac™ in controlling urban white-tailed deer numbers.

CONCLUSION

Model simulations suggest immunocontraception in white-tailed deer could be more efficient than deer removal at maintaining lower population numbers on JSC. Non-lethal management techniques are the best choice for JSC. The urban environment prohibits the safe use of lethal techniques like hunting and sharpshooting. JSAT officials feel the use of non-lethal techniques, in particular immunocontraception, is the most acceptable management technique.

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