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FINAL REPORT

Chicago Wilderness Grant:

A Model for Managing Overabundant Deer Populations in the Natural Areas of the Chicago Wilderness

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INTRODUCTION:

The rapid growth potential of isolated, unchecked white-tailed deer (*Odocoileus virginianus*) populations is well documented. McCullough (1979) studied population dynamics of deer from the 464 ha enclosed George Reserve in southern Michigan from 1928 to 1971. Six deer (4 females, 2 males) originally introduced into this enclosure, previously devoid of deer, grew to a population of 162 deer in just six years. McCullough (1997), also discussed factors which can contribute to irruptive behavior in ungulate populations. Increasing the carrying-capacity of the habitat either through alteration, artificial feeding, or production of agricultural crops can lead to irruptions. Reducing mortality through the reduction or elimination of predators or human hunting is another factor. Lastly, confinement of populations restricting or eliminating dispersal can lead to population irruptions. All of these factors are present in the urban setting of Northeast Illinois.

A trend to develop open private lands in Northeast Illinois removes available deer habitat, concentrating deer on limited remaining open space. The majority of open space remains as public forest preserves, and a few managed natural areas. This increased concentration of deer threatens the existence of remnant native ecosystems mandated to be protected within these remaining natural areas (Etter et al. 1997, McShea and Rappole 1992, Waller and Alverson 1997). Additionally, overabundant deer pose a threat to human health and safety from deer-vehicle collisions (Conover et al. 1995) and the potential transmission of zoonoses (Acha and Szyfres 1994), and can cause damage to plantings by adjacent property owners.

The traditional method used to control deer populations in Illinois is recreational hunting, but this is not the case in urban Northeast Illinois. Most private landowners are reluctant to grant hunter access and most public lands (e.g. County Forest Preserves and Township Parks) prohibit hunting. Furthermore, the Illinois Department of Natural Resources' restriction to archery only deer hunting in Cook, DuPage, Kane and Lake Counties further limits the control of urban deer populations.

The problem of managing overabundant populations of urban deer is one of the most immediate and frustrating challenges facing managers in the Chicago Region. Managers face new challenges when attempting to model dynamic urban deer populations. Many urban deer populations exist at high-densities, yet most management programs to reduce deer numbers mimic catastrophic population crashes. Such drastic shifts in deer density can greatly alter deer demographic parameters, because both physical and biosocial factors influence reproductive rates, fetal sex ratios, recruitment, dispersal, and survival in deer (Caughly 1980, McCullough 1979, Miller and Ozaga 1997, White and Bartmann 1997). Therefore, managers must include these factors and associated lag times when modeling urban deer populations.

In the urban environment wildlife managers are highly scrutinized and held accountable every day for their management decisions. A model that incorporates the changing urban deer demographic parameters is needed to provide managers a means to predict population trends, and bring credibility to highly publicized management programs. In such an environment the question is not whether to model, but rather how to model effectively given the available information (Starfield 1997). Modeling further insures that managers work through a documentable, problem-oriented solution to managing overabundant deer.

Funding for this study was provided by the Forest Preserve Districts of Cook and DuPage County, Cook County Animal Control, Chicago Wilderness and the Illinois Natural History Survey.

OBJECTIVE:

To develop an empirical "user friendly" urban deer population model for the Chicago Region. We hope this model will provide a credible basis for estimating deer densities in urban habitats and provide a better estimate for establishing harvest strategies as populations are reduced.

METHODS:

During 1993-1998, 2,599 deer (1,573 females, 1,026 males) were culled from Forest Preserves in DuPage County, Illinois as part of an annual program attempting to reduce and then maintain deer populations at goal density of 6 deer per km^2. Sex, age, weight and reproductive status were collected from all harvested deer. Removals included 1,739 deer culled from the 10 km^2 Waterfall Glen forest preserve from southeast DuPage County. Annual removals from Waterfall Glen ranged from 17 to 57 deer per km^2. Winter aerial counts and other data showed a general downward trend in the Waterfall Glen population from 1993 to 1998. We felt that deer removals from Waterfall Glen were representative of the populations structure, because removals were intensive (2-4 days per week over the 4-month period), and all areas of the preserve were accessible through a well maintained network of roads and trails.
Deer removal data was used to determine sex ratio of the population and to develop a density-dependent recruitment curve to predict the addition of fawns in relation to adult doe density.

Additionally, 147 deer (129 females and 18 males) were live-captured and radio-marked from 6 DuPage and 2 Cook County forest preserves during 1994-1998. Radio-telemetry data provided estimates of annual mortality and emigration rates.

Detailed results on these urban deer demographic parameters will be made available to Chicago Wilderness partners and other wildlife managers nationwide in peer-reviewed publications that are presently in preparation.

MODEL DEVELOPMENT:

The deer population model followed the simple mathematical equation as expressed by White and Bartmann (1997):

$$N_{t+1} = N_t + B_t - D_t + I_t - E_t$$

where N_{t+1} is the population size in question at time t + 1, N_t, is population size at beginning of interval or time t, B_t is the number of births recruited into the population, D_t, is the number of deaths of deer at time t, I_t, is the number of immigrants into the population, and E_t, is the number of emigrants from the population. I_t and E_t are assumed equal because, during this study 1) there was little emigration of marked breeding aged does (<10%) and 3 of 5 documented movements were annual migrations, 2) yearling age deer emigrated from all preserves, therefore losses from a preserve probably equal gains from other adjacent populations. Therefore, the model could be rewritten as:

$$N_{t+1} = N_t + B_t - D_t$$

Density-dependent reproductive factors and changing population sex structure were considered also in model calculations. Recruits per adult doe increased exponentially as the doe population was reduced at Waterfall Glen from 1993-1998. Also, the sex structure of the population was skewed to a higher proportion of males from 1993-1998. Both of these parameters were added to the model because of their potential to influence population growth under urban deer management scenarios.

The model uses an adaptive management approach so that managers can change model parameters according to site specific information. Otherwise, managers can feel comfortable using the default model parameters because the data used to construct the model was collected from natural areas in the Chicago Region. These data provided the foundation for the development of an empirical urban deer population model using Stella 5.0 software (High Performance Systems, Inc. 1997).

Minimum system requirements: Windows 3.1+, including Windows 95
x486 processor
8 MB RAM
16 MB Hard Disk Space
QuikTime™

The model will provide an estimate of deer population size (number of deer) or density (deer per km^2) at both monthly and annual increments. The sensitivity-analysis function in Stella 5.0 software allows the user to predict annual population shifts in response to harvest of females and males. Some examples of questions the model was designed to answer include, 1) given a known deer population size at time t what would be the population size at time t +1 under different management strategies (e.g., no harvest, harvest of variable numbers deer, etc.), 2) given a population at a selected deer density at time t what will be the predicted outcome of a set harvest at time t +1, t + 2, etc.

The model is preset to run on an annual increment beginning April 1 (time t) and ending April 1 the following year (time t +1). The model requires only an initial population size and size of the area to be managed (in km^2). However, the user must keep in mind that this is an accounting model designed for an adaptive management approach and the more empirical data provided by the user the better the predicted model output. Likewise, the initial population estimate is crucial for accurately depicting population estimates at time t + 1. We recommend the best available data for this input. Initial population estimates might be derived from adjusted aerial or spotlight counts (Beringer et al. 1998, Farfarman and DeYoung 1986) or if marked deer are available a capture-recapture model design could be used (Pollock et al. 1990). The adult deer sex ratio is also an important input, which can be provided by the user.

The proportion of females in the population at time t has a significant influence within the density-dependent recruitment function of the model and controlled management programs tend to target mature females resulting in sexually skewed populations. Previous harvest information or sex ratios collected during deer counts could be applicable for sex ratio input. We will discuss later how to incorporate the previous years sex ratio harvest information into the model.

Manual removals (e.g., translocation or lethal removals) also are input provided by the user. These are the removals required to achieve a certain population size and can be entered as a range of numbers using the sensitivity analysis function in Stella 5.0. We encourage additional data input from managers including survival information, immigration-emigration rates or recruitment curves using the skeletal structure of this model.

MODEL VERIFICATION:

We recommend using an independent variable for verifying model predictions whenever possible. These variables might include deer-vehicle collisions, count data collected independent of model input data or harvest information. Verifying model predictions will provide support for population estimates and help direct possible input data adjustments.

Because our model was derived from empirical data we felt that it should provide a good estimate of the annual deer population size at Waterfall Glen. To verify the model we used the DuPage County Department of Transportation's annual reported deer-vehicle accidents for all roads surrounding Waterfall Glen as an independent index. A comparison of this trend information with our predicted population estimate shows that our estimate follows a similar trend (Figures 1&2). Additionally, both reported deer-vehicle accidents and the population estimate are influenced by the intensity of the previous years deer removal (Figures 1,2&3). Vegetation monitoring also supported a downward trend in the population after the initiation of deer management in 1992 (Etter et al. 1997, Ludwig et al. 1996).

WEBSITE:

The model and accompanying instructions (Appendix A)can be downloaded from the Illinois Natural History Survey's software archive at:

http://nhsbig.inhs.uiuc.edu/www/deer_model.html

Questions can be directed to the model's authors:

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Figure 1. Number of reported deer-vehicle collisions for all roadways surrounding Waterfall Glen Forest Preserve 1992-1997.

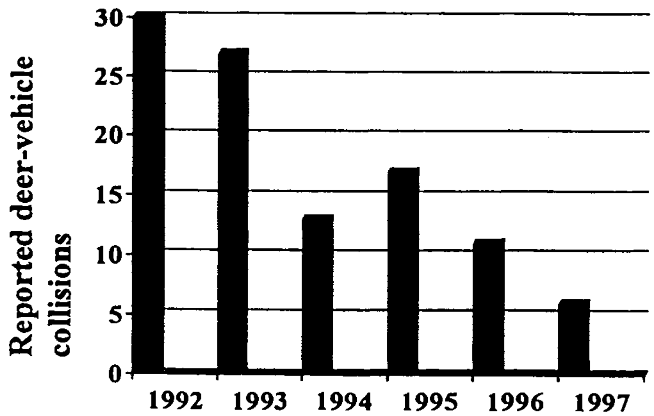


Figure 2. Pre-harvest (December 1) model predictions for the Waterfall Glen deer population 1992-1997.

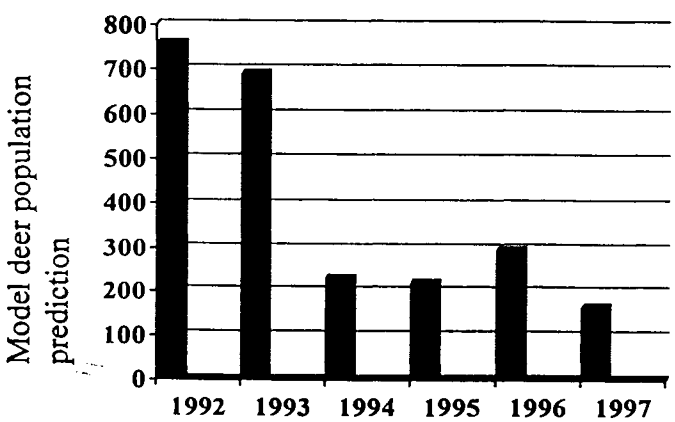
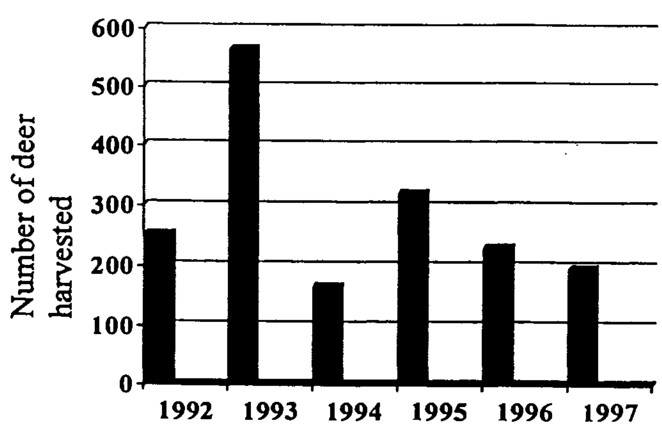


Figure 3. Number of deer harvested fromWaterfall Glen Forest Preserve 1992-1997.



APPENDIX A

Ecology Software Server

An Empirical Model for Predicting Suburban Deer Populations

Management of burgeoning suburban white-tailed deer populations continues to be one of the most immediate and frustrating problems facing wildlife biologists nationwide. In the suburban environment wildlife managers are highly scrutinized and held accountable every day for their management decisions. In such an environment the question is not whether to model, but rather how to model effectively given the available information (Starfield 1997). Modeling insures that managers work through a documentable, problem-oriented solution to managing overabundant deer.

Many suburban deer populations exist at high-densities, yet most management programs to reduce deer numbers mimic catastrophic population crashes. Such drastic shifts in deer density can greatly alter deer population parameters, because both physical and biosocial factors influence reproductive rates, fetal sex ratios, recruitment, dispersal, and survival in deer. Therefore, managers must include these factors when modeling suburban deer populations. During 1992-1998, 2,599 deer were culled from Forest Preserves in DuPage County Illinois in an attempt to reduce and then maintain deer populations at goal density of 6 deer/km^2 (post-harvest). Additionally, 181 deer were live-captured and marked (147 were radio-marked) from these Forest Preserves and preserves in adjacent Cook County during 1994-1998 to determine population dynamics for suburban deer. These data provided the foundation for the development of an empirical suburban deer population model using Stella 5.0 software. The model treats male and female populations as discrete, because of their different survival, emigration, and reproductive potential. Density-dependent recruitment rates were incorporated to account for changes associated with fluctuating deer-densities. Sensitivity analysis was used to test the ability of different male and female removal strategies to achieve desired deer densities on an annual culling schedule.

Our hope is that this model will form a conceptual framework based on empirical data for managers attempting to predict deer population trends in the Chicago region and nationwide.

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Ecology Software Server

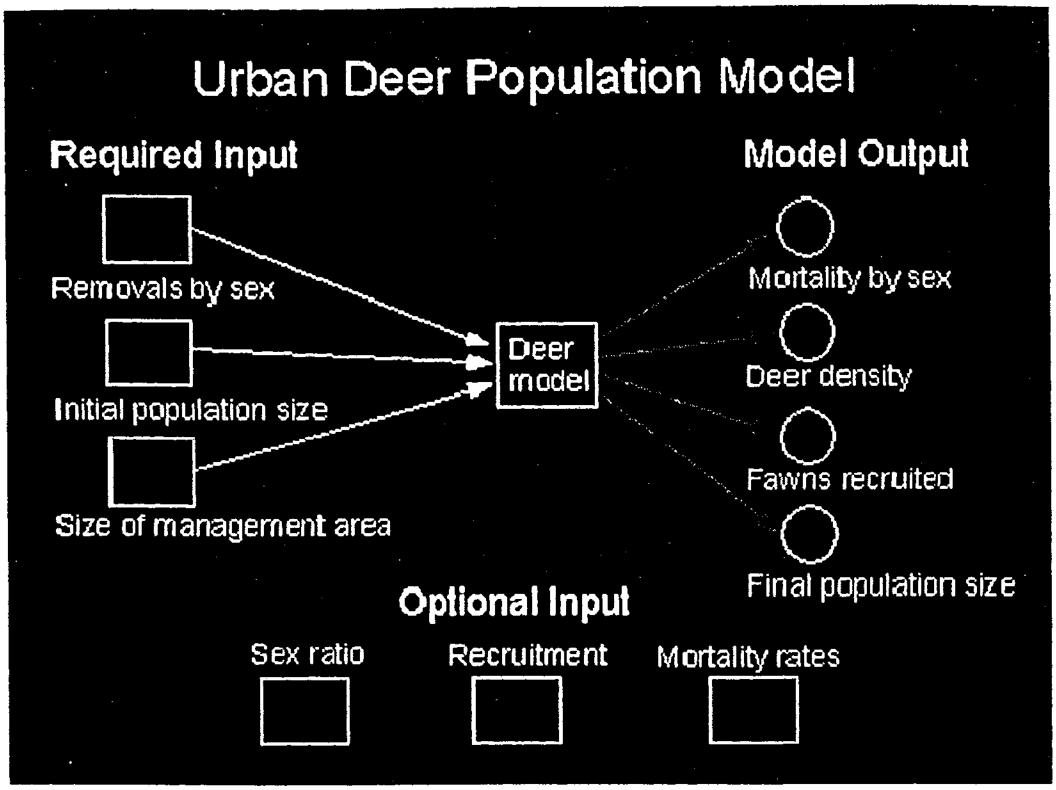
Suburban Deer Population Model

Model development: This model is the result of an adaptive management approach to estimating deer population densities in suburban Chicago, Illinois. Empirical data was combined in Stella 5.0 software (HPS 1997) to produce deer population estimates in semi-isolated suburban landscape. Empirical data was collected from a 1,500 km^2 study area encompassing Cook and DuPage Counties in northeastern Illinois from winter 1992 through summer 1998. This data includes survival and movement information from 147 radio-collared white-tailed deer (129 females, 18 males) and sex ratio and recruitment information collected from 2,599 lethally removed deer (1,573 females, 1,026 males). Capture and culling techniques were reviewed and approved by the University of Illinois' Lab Animal Care Committee.

What makes this model unique is that it was constructed from an extensive radio-telemetry data set for suburban deer life histories used in combination with reproductive data collected from continuous intensive annual deer culling programs (1992 through 1997). This allowed us to build important density-dependent factors directly into the model. Furthermore, this model provides a tool for managers attempting to estimate variable populations of suburban deer and provides credibility founded in scientific research to highly scrutinized suburban deer management programs. We thank the Forest Preserve Districts of Cook and DuPage Counties, Cook County Animal Control and Chicago Wilderness for funding this project.

Minimum system requirements:
Windows 3.1+, including Windows 95:
x486 processor
8 MB RAM
16 MB Hard Disk Space
QuikTime™
Stella modelling software

Model input: The model is preset to run on an annual increment beginning April 1 (time t) and ending April 1 the following year (time t +1). The model requires only an initial population size and size of the area to be managed (in km^2). However, the user must keep in mind that this is an accounting model designed for an adaptive management approach and the more empirical data provided by the user the better the predicted model output. Likewise, the initial population estimate is crucial for accurately depicting population estimates at time t + 1. We recommend the best available data for this input. Initial population estimates might be derived from adjusted aerial or spotlight counts (Beringer et al. 1998, Farfarman and DeYoung 1986) or if marked deer are available a capture-recapture model design could be used (Pollock et al. 1990). The adult deer sex ratio is also an important input, which can be provided by the user. The proportion of females in the population at time t has a significant influence within the density dependent recruitment function of the model and controlled management programs tend to target mature females resulting in sexually skewed populations. Previous harvest information or sex ratios collected during deer counts could be applicable for sex ratio input. We will discuss later how to incorporate the previous years sex ratio harvest information into the model. Manual removals (e.g., translocation or lethal removals) also are input provided by the user. These are the removals required to achieve a certain population size and can be entered as a range of numbers using the sensitivity analysis function in Stella 5.0. We encourage additional data input from managers including survival information, immigration emigration rates or recruitment curves using the skeletal structure of this model.



Model output: The model will provide an estimate of deer population size (number of deer) or density (deer per km^2) at both monthly and annual increments. The sensitivity-analysis function in Stella 5.0 software allows the user to predict annual population shifts in response to harvest of females and males. Some examples of questions the model was designed to answer include, 1) given a known suburban deer population size at time t what would be the population size at time t + 1 under different management strategies (e.g., no harvest, harvest of variable numbers deer, etc.), 2) given a population at a selected deer density at time t what will be the predicted outcome of a set harvest at time t +1, t + 2, etc.

Running the model: To run the model you first need to enter the size of the area you intend to manage and the initial population size. Double click on the AREA symbol located in the bottom left corner of the model. Enter the area (Km^2) and click OK. Now double click the INT POP box and type in a beginning population number at time t (model preset at April 1) and click OK. To run the model click RUN from the RUN drop down menu. To review output double click on TABLE 1 (upper left hand corner of model). The output displays a final population size and deer density at time t +1 (April 1 of the following year). To review output for a different month, let's assume December 1, the model must be adjusted. There are numerous ways to achieve this, but the simplest is to stop the FINAL POP and DEER DENSITY accounting functions at November 30. Remember that the model is preset to run from time t (April 1, month 1) to time t + 1 (April 1, month 13), so in this time schedule December is month number 9. Therefore, all additions and subtractions from the population must be included through November 30th, but must cease after this time. To achieve this first click the X in the upper right corner of the screen to return to the model and then double click on FINAL POP (bottom center of model).

Within the IF TIME statement change the month (TIME) from 13 to 9 and select OK. Re-run the model and view the output in TABLE 1 for FINAL POP and DEER DENSITY. Observe how these numbers have changed and appear next to month 8 accounting for all additions and subtractions through November 30th. These results are the December 1 (month 9) population estimate. Now exit from the table and repeat this process changing the month back to 13 in FINAL POP.

We discussed earlier the importance of adult deer sex ratio in calculating the number of recruits into the population. Sex ratio information is difficult to collect in the field, but if deer are harvested in an unbiased manner, it is acceptable to use the previous years harvest ratio in an adaptive management approach. The present sex ratio is set at 60:40 females to males, but this can be changed if a different ratio is desired. This is easily done by first double clicking on MALE RATE located under INT POP in the center of the model. Then simply enter the new rate and select OK. Repeat this process for the FEMALE RATE so that the two combined equal one-hundred percent. Also, a function built into the model will automatically calculate the new sex ratio after deer have been harvested from the population. To calculate this first double click on FEMALES REMOVED located in the upper right hand corner of the model. Then enter the number of females harvested or estimated to be harvested and select OK. Now do the same for MALES REMOVED. Now double click on TABLE 1 and then double click on the table again to reveal a selection menu. Then, under the ALLOWABLE menu scroll down and select NEW FEMALE RATIO by clicking to highlight and then clicking the >> sign to the right and selecting OK. Now run the model to review the output under NEW FEMALE RATIO. This new ratio can then be inserted into FEMALE RATE as described above. Also, be sure to edit MALE RATE so that the two combined equal one-hundred percent. Now when the model is run this new sex ratio will be used in all calculations.

The strength of this model for management decisions lies within the Sensitivity Analysis function of Stella 5.0, which allows for input of multiple simultaneous deer removal scenarios. Exit from the table and select SENSI-SPECS under the Run menu. Then click in the box under # OF RUNS. Within the box enter the number of different removal strategies you are proposing (e.g. 5 runs). Then, under the ALLOWABLE menu scroll down and select first FEMALES REMOVED and then MALES REMOVED by highlighting each and then clicking the >> sign to the right. Then click on FEMLAES REMOVED under SELECTED (VALUE) so that it is highlighted. Now click on AD HOC under VARIATION TYPE and in the box to the right of the AD HOC VALUES type the first number of female deer you are predicting to remove from the population (e.g., 0), and click set. This selected value will appear in the box to the right under RUN #1. Now type in the next value (e.g. 10) and select SET. Continue to enter numbers until all RUNS #s have a corresponding VALUE. Now click on MALES REMOVED from the SELECTED (VALUE) menu and repeat the process. Once you have set your runs for females and males click OK to return to the model. Move the hand to TABLE 1 and double click. Double click again on the table to get a selection screen. Select COMPARATIVE under TABLE TYPE. Now select only one (1) of the fields (usually FINAL POP or DEER DENSITY) within the ALLOWABLE box by double clicking. This setup will produce a comparison of the multiple model runs for the selected variable. Make sure the ORIENTATION (Vertical) and REPORT INTERVAL (Every DT) are checked. Also, check ENDING BALANCES and INSTANTANEOUS under REPORT and REPORT FLOW VALUES. When this is complete click OK. Now select RUN from the drop down menu and click S-RUN. TABLE 1 now displays the results of various runs. Compare the runs and select a few which produced desired population estimates or densities. Then go back to SENSI-SPECS from the RUN drop down menu and click FEMALES REMOVED. Scroll down the RUN # VALUE box to see which numbers corresponded to the runs you selected as good. Now do the same for MALES REMOVED. To refine these numbers re-run SENSI-SPECS using values within the range of good values chosen. To exit from S-RUN and return the model to a standard RUN mode, double click on the table and uncheck COMPARATIVE under TABLE TYPE. Then reselect the variables you wish to view in the table. Also, go back to SENSI-SPECS under the RUN drop down menu and remove MALES and FEMALES REMOVED from the SELECTED VALUE.

Most other model variables such as natural removal rates (mortality rates) and the density-dependent recruitment can be adjusted within their respective control variables (see Stella 5.0 Technical Documentation).

Model verification: We recommend using an independent variable for verifying model predictions whenever possible. These variables might include deer-vehicle collisions, count data collected independent of model input data or harvest information. Verifying model predictions will provide support for population estimates and help direct possible input data adjustments.

Download the model (6 KB 'zip' archive)

Literature cited:

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Farfarman, K.R. and C.A. DeYoung. 1986. Evaluation of spotlight counts of deer in South Texas. Wildl. Soc. Bull. 14:180-185.

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Pollock, K.H., J.D. Nichols, C. Brownie and J.E. Hines. 1990. Statistical inference for capture-recapture experiments. Wildl. Mono. 107:97pp

Questions or comments are welcome and should be directed to the models authors:

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