Wildlife Management: The Case of Bucks Only Hunting

The model in Figure 1 is adapted from an example in Ken Watt's (1968) text on *Ecology and Resource Management*. It distinguishes between bucks and does and between fawns, yearlings and adults. The initial conditions are displayed following the equilibrium diagram format in Chapter 6. But you can see immediately that this population would not be in equilibrium.

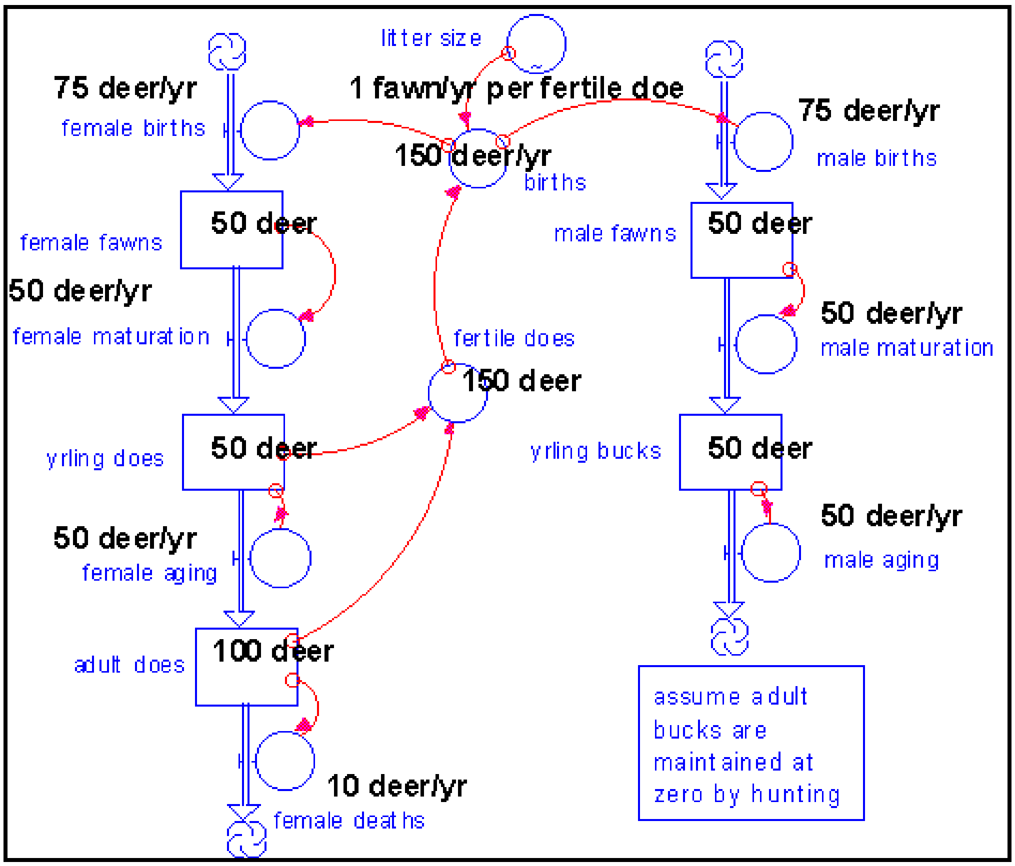

Figure 1. Initial conditions in a simple model of deer hunting.

The diagram assumes that an aggressive hunting policy eliminates the population of adult bucks, but the hunters are not allowed to kill any does. There are 100 adult does and 50 yearling does for a total of 150 fertile does. The fertile does are served by the yearling bucks. The does give birth to one fawn each year. The diagram shows that this population will grow, despite the aggressive hunting of the adult bucks.

This diagram is adapted from Watt's description of a theoretical deer herd (Watt 1968, p. 127). He uses the numerical example to argue against "bucks only" legislation because the hunting would not be sufficient to control the growth of the population. Watt believes that the population would continue growing, eventually reaching starvation levels unless other factors intervene to limit the population. Watt keeps the numerical example simple so the reader can see the growth potential of the deer herd. He then concludes with a call for a more elaborate model (Watt 1968, 130):

Since there is no postulated negative feedback (density dependent regulation)
The model implies that in the absence of hunting there will be no population control,
which is of course impossible.
To obtain real insight into optimum strategy for managing deer,
a systems model is required.

This exercise follows Watt's advice. We need a "systems model" if we are to gain insight into deer herd management. Let's work with the model in Figure 2. It builds upon Watt's numerical example by adding density dependent regulation. You may use the model to examine hunting policies from a systems perspective. The key "policy variables" in the model are the buck hunt fraction and the doe hunt fraction. You may experiment with these variables in your own search for an "optimum strategy" to manage the deer population.

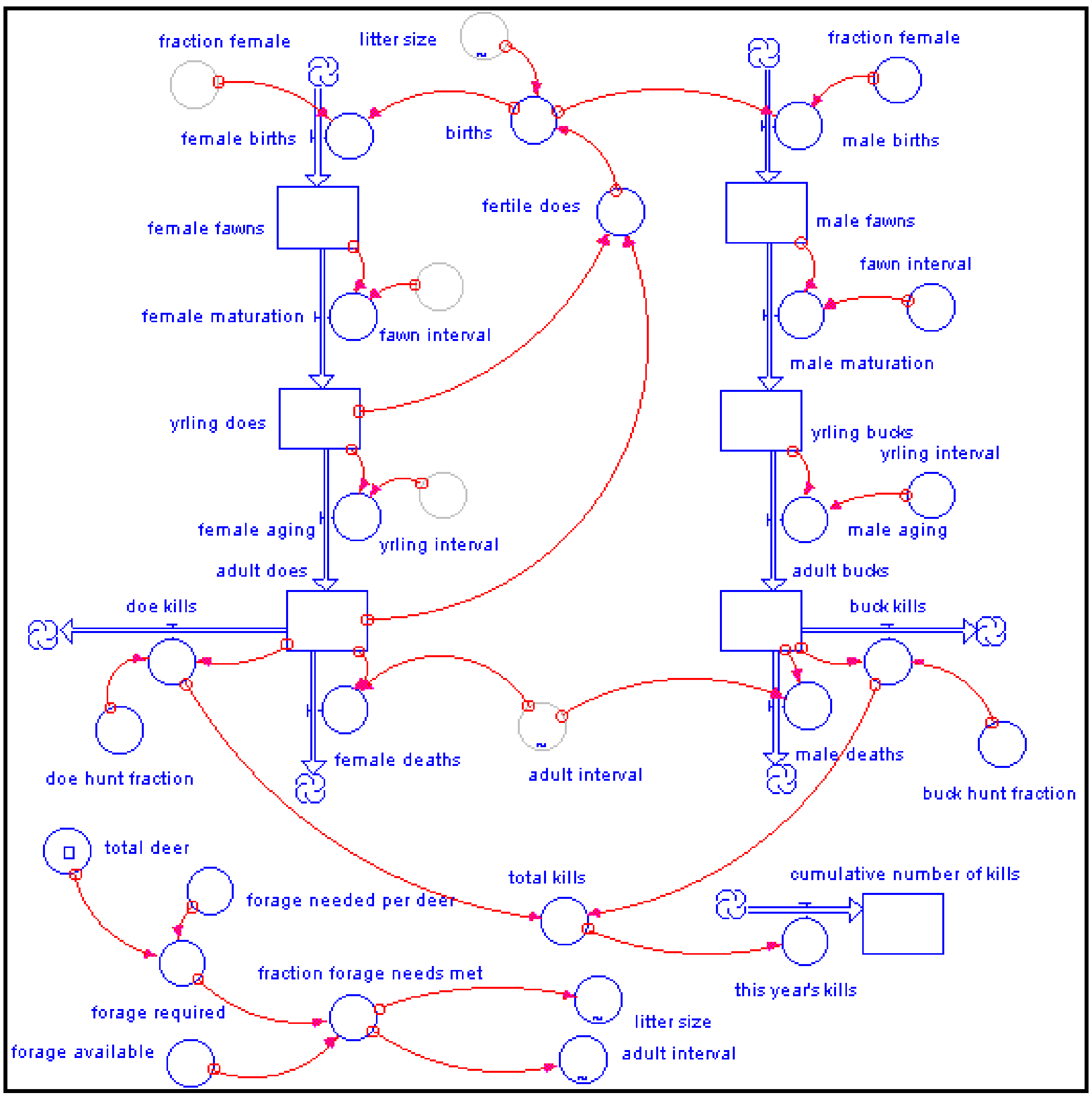

Figure 2. A model to experiment with deer hunting policies.

Deer Herd Hunting Exercises

1. Build and Verify: Build the hunting policy model shown Figure 2. Adopt the following numerical assumptions:

Initial Values of the Stocks	
number of fawns:	50 females, 50 males
number of yearlings	50 females, 50 males
number of adults:	100 females, 100 males
Average Time Intervals	
fawn interval:	1 year
yearling interval:	1 year
adult interval	10 years if well fed; shorter if not
Females and their Litters	
fraction female:	50%
litter size:	1 fawn/yr if well fed; smaller if not
Forage Assumptions	
forage needed per deer	1 metric ton/year (same as chapter 21)
forage available	1,600 metric tons/year

The "summer " is used to add the values of the 6 stocks. to obtain the "total deer." (The "summer" sign will look somewhat different in Stella than it appears on this page.) There would be 400 deer at the start of the simulation, so the forage required would be 400 MT/yr. The 1,600 MT/yr of forage available means that the fraction of forage needs met is 100%. You may specify this fraction as a simple ratio that will not exceed 100%:

fraction_forage_needs_met = Min(1,forage_available/forage_required)

The fraction is used to determine that length of the adult interval and the litter size . To keep the model simple, assume that both the adult interval and the litter size would decline in a linear manner if the fraction forage needs met falls below 100%:

adult_interval = GRAPH(fraction_forage_needs_met)
(0.00, 0.00), (0.5, 5.00), (1.00, 10.0), (1.50, 10.0)

litter_size = GRAPH(fraction_forage_needs_met)
(0.00, 0.00), (0.5, 0.5), (1.00, 1.00), (1.50, 1.00)

Run the model with both hunting fractions set to zero and verify that you get the results in Figure 2.

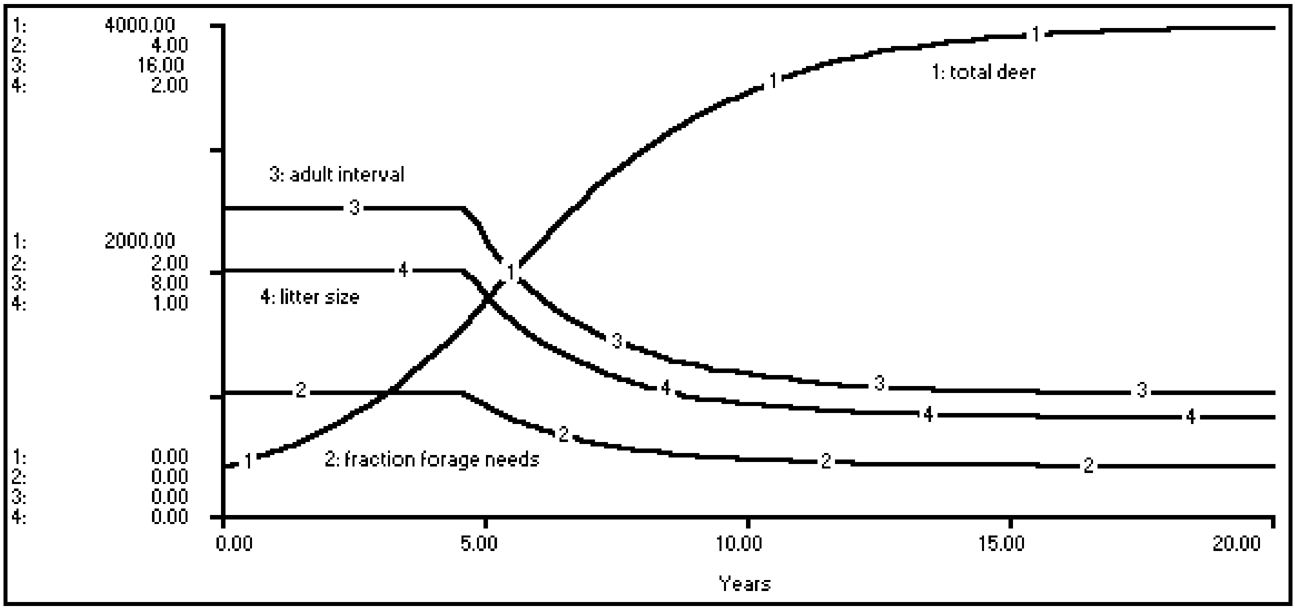

Figure 2. Simulated deer population with no hunting.

The deer herd would grow from 400 to 4,000 eventually reaching a state of equilibrium that resembles Watt's expectations. The average adult (that would normally live for ten years) is simulated to live for only 4 years. To see the relationship between the longevity of the adults and the eventual size of the deer herd, ask for a scatter graph of the adult interval relative to the size of the deer herd. Your scatter graph should match the results in Figure 3.

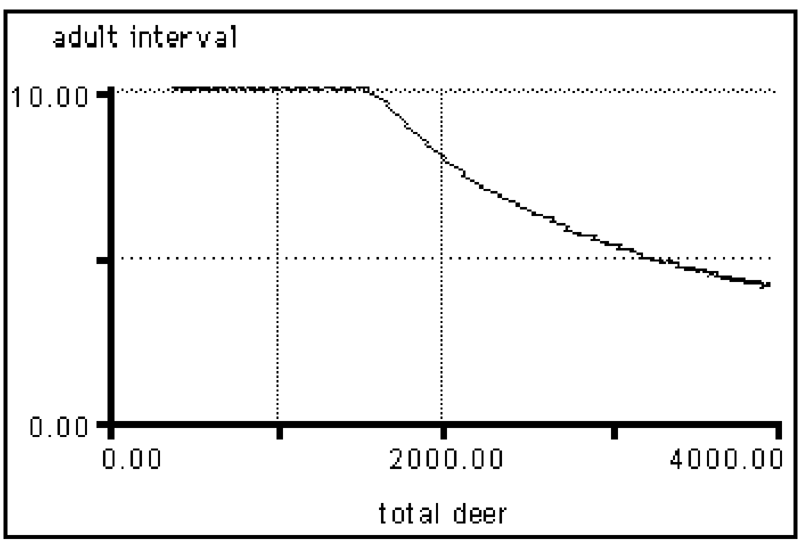

Figure 3. Scatter graph of the simulation with no hunting.

<u>2. "Bucks Only" Hunting</u>: Experiment with different values of the buck hunt fraction to learn if the size of the deer herd can be controlled to avoid the starvation conditions. Assume that your goal is to limit the size of the herd so that the adults enjoy longevity of ten years. Are Watt's concerns about "Bucks Only Hunting" justified?

3. Sensitivity of the "Bucks Only" Results: Set the bucks hunt fraction to 100%/yr or even higher. (Note: 200%/yr would correspond to a policy to kill 100% in a 6 month interval.) Experiment with changes in some of the numerical assumptions such as fraction of fawns that are female or the average litter size when the deer are well nourished. Is it possible that a reasonable change in numerical assumptions would reverse your "bucks only" finding in the previous exercise?

4. Search for a Satisfactory Control Policy: Experiment with both the doe hunt fraction and the buck hunt fraction to learn the extent of hunting required to control the size of the deer population. Assume that your goal is to maintain the longevity of the adult deer at ten years. Document your policy simulation by turning in a time graph of the total deer population and a scatter graph of the adult interval versus total deer population. Also, turn in a time graph showing the two hunting fractions, this year's kills and the cumulative number of kills.

5. Random Variations in Litter Size: Review how a random number can be selected and held for a specified interval of time (chapter 14). Use a similar approach to introduce variability in the litter size in the deer herd model. Change the name "litter size" in the current model to "indicated litter size" (that is, the litter size indicated by the fraction of forage needs met.) Then define the actual litter size as the indicated litter size multiplied by a random factor to account for "good years" and "bad years" for the does. Assume that the random factor will lower the litter size by as much as 50% at one extreme and raise it by as much as 50% at the other extreme. (Be sure that the random factor varies on a year by year basis, not every DT.) Run the new model with the hunt fractions set to zero. How does the simulated population compare with the results in the 1st exercise?

6. Test the Control Policy with Random Variations: Test the control policy (from the 4th exercise) with the random variations in litter size. Does the policy still deliver satisfactory results?

7. Search for a New Control Policy: If you don't like the results from the 6th exercise, think of a new control policy that will deliver satisfactory results in the presence of random variations in litter size. For example, you may decide to change the hunt fractions from an exogenous input to an endogenous variable that is linked to one of the other variables in the model. If you experiment in this direction, be sure to ask yourself whether the manager would have access to the information you are using to determine the hunt fraction.