POPULATION DYNAMICS MODEL

Review the references which describe different implementations of the predator-prey model. There is also a rich set of information about the specific moose-wolf interactions on the Isle Royale website. Some of these findings will be used in the optional additional model components.

The basic model for the populations of moose and wolf are:

dM/dt = Mg * M – Md * M *W

dW/dt = Wg * M * W – Wd * W

Where:

- M = number of moose at beginning of time period
- W = number of wolves at beginning of time period
- Mg = growth rate of moose
- Md = death rate of moose
- Wg = growth rate of wolves
- Wd = death rate of wolves
- dM/dt = change in moose population during current time period
- dW/dt = change in wolf population during current time period
- ts = time step in terms of years. ts = 1/12 to calculate monthly.

This model can also be represented by a set of simple difference equation:

$M_{t+1} = M_t + (M_t$ * births per moose - M_t * moose death fraction * W_t) * ts
$W_{t+1} = W_t + (W_t$ * births per wolf * M_t - W_t * wolf death fraction) * ts

Here are the starting rates for your simple model:

Time period – 50 years
Starting values for Moose/Wolf population dynamics
Moose birth rate 0.2 (proportion of the total population)
Moose death fraction 0.003
Wolf birth rate 0.001
Wolf death fraction 0.5
Starting populations
Moose 500
Wolves 20

Once you have built this model, you should see the cyclic nature of the population growth and decline associated with this system. Test the sensitivity of the model to changes in the moose birth and death rates. For the given birth rate, what does the death rate need to be to provide a more stable population of both species over time (for example a range closer to 250 rather than 600-800). How does this change if the moose birth rate increases by 50%? Explore the sensitivity of the wolf birth and death rates in the same way.

You may also implement one or more of these additional simulation steps:

1. As indicated on the project site, there appear to be some unique circumstances that have altered the population dynamics of the moose population. These include the impacts of ticks and disease on their survival rates. Using the information available, add a component to the model that changes the survival rates in relation to these health conditions. Vary these effects to see if you can more closely match the actual population changes in the moose population.
2. A second confounding factor is the inbreeding of the wolf population and its impact on wolf survival. Add a component to the model to reflect these impacts, guided by the information on the Isle Royale site. Vary these effects to see if you can more closely match the actual population changes in the wolf population
3. The website indicates that the age of the moose population is related to the survival rates. Using the three age groups of moose indicated on the site, change the model to track each group over time and adjust the survival rates to reflect differences in the survival of calves, moose in prime age groups, and senescent moose.
4. If you have finished all of the three above models, combine them and provide simulations to try and match the observed changes in the populations over the 50 year period.

References

PREDATOR-PREY DYNAMICS: LOTKA- VOLTERRA
http://www.tiem.utk.edu/~gross/bioed/bealsmodules/predator-prey.html

Predator-prey model. http://www.scholarpedia.org/article/Predator-prey_model

Isle Royale Research Site. http://www.isleroyalewolf.org/overview/overview/the_setting.html

Lotka–Volterra equations. http://en.wikipedia.org/wiki/Lotka%E2%80%93Volterra_equations