Lynx vs Hare Cycle (from Northwest Territoies)

Snowshoe hare is the primary food of the lynx. The population cycles of these two species are closely linked.

When hares are plentiful, lynx eat little else and take about two hares every three days.

Lynx prey upon mice, voles, squirrels, grouse, ptarmigan and carrion when hares are scarce. These food sources often do not meet the lynx's nutritional needs. Some lynx cannot maintain their body fat reserves on this type of diet and become more vulnerable to starvation or predation. Other lynx manage to remain healthy by using alternative prey and food sources when the hare population is low. When snowshoe hares are scarce, many lynx leave their home range in search of food.

Hare populations across most of the boreal forest experience dramatic fluctuations in a cycle that lasts 8-11 years. At the peak of the cycle, snowshoe hares can reach a density of up to 1500 animals per km2. The habitat cannot support this many animals. As predation increases and starvation sets in, the population starts to decline. Continued predation due to high populations of lynx and other predators increases the hare population decline.

When the hare population reaches a low level, it stabilizes, for several years. The food plants slowly recover and the hare population starts to increase again. Since hares have several litters each year, the hare population increases rapidly. After a year or two at high densities, the hare cycle repeats itself.

The lynx population decline follows the snowshoe hare population crash after a lag of one to two years. As hare numbers start to decline, lynx continue to eat well because they can easily catch the starving hares.

When hares become scarce, lynx numbers also decline. Their lack of fat reserves makes them less able to live through starvation and cold temperatures. Food shortages also cause behavioural changes such as increased roaming and loss of caution. This increases their vulnerability to predation.

Malnourishment has the most significant effect upon lynx reproduction and population levels. When females are in poor condition, fewer breed and not all of those bred produce litters. Litters are smaller, and most, if not all, of the few kittens born die soon after birth. This means that for a period of three to five years, few or no kittens survive to adulthood. Studies have shown the level of kittens in a lynx population may be zero at the population low and as high as 60 percent when the numbers increase. Low lynx population levels last for three or four years. When hares become plentiful again, the lynx population begins to increase as well.

The rise and fall in numbers of snowshoe hares and Canada lynx was observed more than two hundred years ago by trappers working for Hudsons Bay Company, which was once heavily involved in the fur trade. In the early 20th century, records of the number of lynx and hare pelts traded by Hudsons Bay were analyzed by biologist Charles Gordon Hewitt. In The Conservation of the Wild Life of Canada (1921), Hewitt graphed the data from the records for a period extending from 1820 into the first decades of the 1900s. His graphs emphasized the close relationship in population density between snowshoe hares and Canada lynx.

Predator -Prey Model

We want to model the populations of hares and lynxs in an eco-system with simple mathematical relationships. The Lotka-Volterra Model was created by two mathematicians in 1925 to describe a predator-prey relationship and serves as a first-order method for predicting lynx and hare populations and their interaction.

You will implement this model using python and use it to graph the projected populations of lynx and hare with different starting assumptions:

Lotka-Volterra Model variables

H(t) = Hare population at time t
L(t) = Lynx population at time t
H_b,H_d **= Birth rate , death rate of hares (per time period)**

L_b,L_d = **Birth rate , death rate of lynx (per time period)**

Differnce Equations governing changes in hare and lynx populations:

$H(t+1) - H(t) = H_b * H(t) * dt - H_d * H(t) * L(t) * dt$

$L(t+1) - L(t) = L_b * L(t) * H(t) * dt - L_d * L(t) * dt$

where dt = length of time period

Initial Parameters to use for model:

$H_b = .5$, $H_d = .02$, $L_b = .25 * .02 = .005$, $L_d = .75$

Initial populations: Hare = 500, Lynx = 25

Execution of Predator-Prey Model:

First, get your python code working and run the model with initial parameters and observe graph. What happens? You should get the cycling population levels observed in the wild. Now , try varying some of the initial parameters and observe results:

- **Set initial lynx poulation to zero: What happens to hare population?**
- **Set initial hare poulation to zero: What happens to lynx population?**
- **Introduce "hunting" of lynx by gradually increasing lynx death rate(L_d) from .75 to 1.0. What happens?**
- **Try your own parameters to see if you can get a "stable" model (where populations do not explode or die out completely)**
- **What are some of the assumptions underlying this model?**