BIOU9PC: Population and Community Ecology

Lab Practical week 2: Logistic population growth

***22 September 2016***

**Objective**

The purposes of this practical are to

* use the logistic growth model to predict population sizes,
* to explore the population dynamics produced by the model under different parameter estimates and
* to understand the basic use of the logistic growth model to assess and predict sustainable use of natural resources (fisheries, hunting).

**Logistic population growth**

We will predict population growth using the same type coding structure as we used for the discrete-time exponential model last week. Please code up the following logistic growth equation in *R* using a loop structure, just as we used last week:

where *Nt+1* is the population size in the next time step, *Nt* the population in the current time step, *r* the intrinsic population growth rate and *K* the carrying capacity.

We will predict the size of a population that is growing logistically for 100 time-steps into the future.

**Maximum Sustainable Yield**

Maximum sustainable yield (MSY) has been widely used (and widely criticised) as a tool to inform decision-making in fisheries. In a sustainably harvested population, hunters or fishermen remove no more individuals than are generated in a single time step. A question of great management interest, therefore, is under what conditions the harvest can be maximized.

We can use the following equation, which is the derivative of the logistic growth function provided above to calculate the population growth rate.

Tasks:

1. What is the effect of varying the carrying capacity *K*? Use the following values for K: 10, 100, 200, 500, INFINITY. Keep the starting population N0=15 and r=0.1. Note that INFINITY is represented in R as ‘Inf’ (without the quotation marks). Plot the trajectory of the populations over time, putting all curves on one set of axes (hint: use plot(… ylim = c(0, 5000) for the first, then lines() to add subsequent lines. Use different colors for each line). Finally, show your figure to your neighbour, and discuss the interpretation.
2. Vary the value for the intrinsic population growth rates *r* at several steps between 1 and 3, while keeping *K* constant at 500. Plot the varying population trajectories through time. Under which parameter combinations does the model converge smoothly to the carrying capacity, exhibit stable limit cycles, or exhibit chaotic behaviour? Discuss the links between the intrinsic rate growth rate and the resulting population dynamics with your neighbours.
3. Using population\_growth\_rate\_calc(), calculate population growth rates for populations with K = 100, r = 0.1, and size (*N)* between 1 and 100. Plot population growth rate (PGR) versus population size. At what population size is population growth rate maximal? What is the maximal number of individuals that can be harvested per time step?
4. Repeat for *K*=500 and 1000, and r = 1.1 and 2.1. Plot *PGR* versus *N*. How does varying K and r affect the estimation of MSY?
5. What uncertainties affect our estimation of parameters r, N and K in real fisheries?
6. Discuss the challenges of using the MSY concept for setting harvest quotas in fisheries and hunting systems, in relationship to the uncertainties surrounding r, K and N.