<u>QS2: Population Ecology</u>
Due: start of class on 11/18

Please work with your group to complete the following questions. Turn in one response as a group, along with accompanying R code. Several questions are marked as OPTIONAL – I'd encourage you to think about them, and maybe try a few of your choosing.

In addition to submitting the group assignment, please also send me *as individuals* a short (2-5 sentence?) description of your contributions to the group assignment, and what you learned from it, and how you challenged yourself. Note: there are many important ways to contribute to groups! Learn from each other, challenge each other, try to communicate clearly (follow advice in Shoemaker et al.)

Questions:

In class we considered the logistic growth model. A very similar discrete time model of population size N is known as the Ricker model (it also depends on a growth rate parameter r and carrying capacity K. Values of $r > 0$ lead to population growth). The Ricker model can be further modified to influence the strength of density dependence similar to the 'theta logistic' model mentioned in class and examined in Stacey and Taper. Here's the resulting model, which we will explore:

$$N(t+1) = N(t) \cdot \mathrm{Exp}\left[r \cdot \left(1 - \left(\frac{N(t)}{K}\right)^{\theta}\right)\right]$$

1. Use R & techniques covered in the R Bootcamp to assemble this discrete time model. Make a plot illustrating population dynamics given this model over 20 years (time steps), assuming that starting parameters are: $r = 0.2$, $K = 10$, $\theta = 1$ and $N(t=0) = 1$. Hint: recall what you learned about using for() loops.

2. Modify the above model to demonstrate what happens for several values of θ ranging from 0 to 5. Provide plots and text interpreting the plots, and addressing the effects of θ on the strength of density dependence in this model.

3. OPTIONAL: run your model again for $\theta = 10$ and $\theta = 20$, and plot time series of your population dynamics. What patterns do you observe? What do you think is happening in the model?

An alternative model incorporates the potential for an Allee effect. This model is written a little differently. Instead of modeling the total density of individuals (N), we're going to focus on modeling the density of individuals *relative to carrying capacity K*. Mathematically, we'd say "let $x = N/K$". When the population is at carrying capacity, $N = K$ and $x = K/K = 1$. Here's our model, written in terms of x:

$$x(t+1) = x(t) + \left(1 - x(t)\right) \cdot \left(x(t) - A\right)$$

The additional parameter 'A' can range in value from 0 to 1, and will define the threshold of the Allee effect.

4. Implement this model in R. Model population dynamics over 10 time steps, assuming that A = 0.2, and explore what happens to the population when you vary the initial population size (i.e., the value of x(t=0)) between 0 and 1. Under what conditions does the population grow? Go extinct?

5. What happens if you change the value of A?

6. OPTIONAL: Consider what would happen if you add immigration to this model. Can you contrive a scenario where a population that would otherwise go extinct due to the Allee effect is able to persist due to immigration?

Consult the provided R script, examine the simulation model of Stacey & Taper 1992

7. Can you replicate their assessment of the effects of variability? (in particular, what happens if you remove the variability? pg. 21). Take the model above, and replace the random draws of s.A, s.J, and fecundity with their mean values. Run the simulation again. How does the distribution of extinction times change?

8. Pick out one of the assumptions of the paper, change it, and describe/illustrate what happens.

9. Is the basic simulation model actually completely density independent? hint: try calculating how many individuals are lost from the population each year (mortality + emigration), and produce a plot of this rate of loss against population density.

OPTIONAL:

10. What would happen if the sex-ratio of the population was not assumed to be 50:50? What are some different ways that this might occur? Can respond in writing, or supplement with quantitative results.

11. Can you figure out how Stacey & Taper calculated an overall population growth rate of lambda = 0.95 (on pg. 21)?

12. Did we actually reproduce the original model accurately? Fig. 2 suggests that the maximum time to extinction in their set of 1000 runs was 49 years. How often in sets of 1000 runs do we observe maximum extinction times longer than 49 years?