**Homework Set #3 (Points for grabs: 45 – Total HW value: 5% of class grade)**

Email to [khyrenba@gmail.com](mailto:khyrenba@gmail.com) with email subject “MARS6400 – Hw#3” By end of Feb 23rd.

1. The simplest formulation of density-dependent equation does not include a carrying capacity term (K). Rather, the growth of this population responds to the numbers of individuals in the previous time step (this scenario relies on discrete time steps):

N(t+1) = Lambda \* N(t) \* (1 – b N(t))

Where: Mean Lambda = 3.1 and 95% CI Lambda = 2.1 – 4.6

Using b = 0.019 for all the calculations, check out the implications of the variability in the Lambda values (the mean point estimate, the lower 95% CI, and the upper 95% CI) in the expected behavior of the population.

Leaving b fixed at 0.019, do the following three times (for Lambda values of 2.1, 3.1, and 4.6).

First: Calculate the equilibrium population size (where N(t+1) = N(t)). Show me your calculations and the results of the three equilibrium population sizes (Ne). Hint, replace N(t+1) and N(t) with Ne in the equation above and solve the math after plugging in the Lambda and b.

(+2 points each – 6 points total)

Second: Use the excel sheet “question 1” to explore the behavior of this population. For three scenarios (refer to them as Lambda = 2.1, Lambda =3.1, and Lambda = 4.6), start the populations at two initial sizes (10 and 50). Make a plot of the two population trajectories (numbers of y axis, time on x axis) over the first 10 years, showing both initial population sizes (10 and 50) in the same graph. Explain how the population behaves in all three Lambda scenarios (does it reach equilibrium, does it crash, does it cycle?). If the population equilibrates, compare this equilibrium point with the Ne value you calculated above (for the same Lambda scenario).

(+2 points each – 6 points total)

Third: For each Lambda scenario, check out where the 1:1 line (blue line) and the recruitment curve (red line cross): This is the point of equilibrium. However, if the slope of the recruitment curve is too large (curve is too steep) at the equilibrium point, it will become unstable and the population will not stay at equilibrium. To figure out the slope, we take the derivative of the formula with respect to N(t): dN(t+1) / dN(t)= Lambda – (2\* b \* Lambda \* N(t))

Using the b value (0.019), plug in the three lambda scenarios used in the first two parts of this question and calculate the slope at the equilibrium point. Hint, plug in the Ne values you calculated in the first part in the equation, for N(t).

Report the slopes for the three scenarios at the Ne points. Hint: the curves are decreasing, so the slopes should be negative. Interpret your results, by comparing the slopes you calculated with the results of the second part. {Note: equilibrium results when slope > -1; two-point cycles occur when -1 > slope > -2; and chaos occur when -2 > slope).

(+3 points each – 9 points total)

1. Using a more complex formulation of density-dependence (in excel sheet “question 2”), explore the influence of the carrying capacity (K) and the population growth rate (Lambda) on the dynamics of the population. You will use two metrics to describe the stability of this population, as you change Lambda and K: (i) the CV of the population size over 100 years, and (ii) the minimum population size (e.g., did the population go extinct) over 100 years.

First: Starting at an initial population size of 10 and with K\_good = K\_bad = 100, try the following Lambda values: 1.5, 2, 2.5, 3, 3.5, 4. Describe the behavior of the population for each Lambda scenario (Hint: does the population reach equilibrium smoothly, or does it overshoot K and then reach equilibrium?, does the population undergo cycles? If so, how many values are involved in the oscillations?, does the population show chaotic behavior?) (+3 points each – 18 points total)

Second: Finally, start the population at N(t) = 10 and use a varying K (K\_good = 200, K\_bad = 50). Try these Lambda values (1.5 and 2), and report on the behavior of the population. Describe the behavior of the population – in comparison with what you reported in the two answers above (Hint: does the population reach equilibrium smoothly, or does it overshoot K and then reach equilibrium? Does the population undergo cycles? If so, how many values are involved in the oscillations? Does the population show chaotic behavior?)

(+ 3 points each – 6 points total)