Activity 1: population: The goal of this activity is familiarize you with population biology models: In particular: growth models and how they apply to resource management

**Population Biology: Exponential Growth** –

$$\frac{dN}{dt} = rN$$

This is the most basic population growth model. Growth is dependent on two terms: the existing population \(N\) and the intrinsic growth rate \(r\). \(r\) is actually a derived and instantaneous rate defined as birth – death rates.

**Population Biology: Logistic Growth** –

$$\frac{dN}{dt} = rN\left(\frac{K - N}{K}\right)$$

This population growth model has two parts: the left clause is the exponential part and the right clause is a dampening function that introduces density dependence to the model. \(K\) in this model is the carrying capacity of the population.

Below is the logistic curve for:

\(R=1\)

Starting population = 2

\(K=200\)
The logistic equation shown above is written in its derivative form. Recall from calculus that the second derivative of an equation can be used to determine the minimum and maximum rate of change in a population. The maximum rate of change is the point on the graph above where the population grows fastest. It is the maximum instantaneous slope. Why would we want to know this? Because it has been used as a target for management of harvested species, especially in fisheries. The idea is that harvest of populations to a size equal to the population where growth rate is highest maximizes sustainable harvest. This has been called maximum sustainable yield (MSY). For a logistic equation the solution maximizing growth rate is:

\[
\frac{dN}{dt} = \frac{K}{2}
\]

This means that when the population is at half carrying capacity, growth rate is maximized. It also means under MSY that yield is maximized by harvest of stock above this value. The graph of the relationship is shown below:

Clearly the effectiveness of this approach is related to accurate values of N, K and r in the logistic model. In the following exercise assume that r is correct. You will explore consequences if K or N are not estimated accurately. There are two goals: (1) you become familiar with logistic growth, which is foundational for much of Ecology and (2) you understand the sensitivity of models to input parameters and the potential consequences of model use for management.
1) Explore the effect of inaccurate estimation of $K$. Here assume the $r$ and $N$ are accurately estimated but that $K$ may not be. For the purpose of question 1 assume that $K$ is really 150, but that it is inaccurately estimated at 100 or 200. The graph is shown below:

![Population Growth (Logistic)](image)

- Draw a line representing the population size where population growth rate is maximized for the true $K$

- Now assume a survey gets done and the standing stock ($N$) is estimated to be 100. Using MSY modeling
  - i. What would be harvest for $K=200$
  - ii. What would be harvest for $K=150$
  - iii. What would be harvest for $K=100$

- What would be the consequence for scenario (impact of population, yield and future harvest)
  - i. 1bi
  - ii. 1bii
  - iii. 1biii

- Given these results comment on importance of error for $K$ – e.g. over vs underestimates
2) Explore the effect of inaccurate estimation of N. **Here assume the r and K are accurately estimated** but that N may not be. For the purpose of question 2 assume that N (standing stock) is estimated at 175, 100 or 50. **Also assume that N=100 is the truth.** The graph is shown below:

![Population Growth (Logistic)](image)

- a. Draw a line representing the population size where population growth rate is maximized for K = 200
- b. Now assume a survey gets done and the standing stock (N) is estimated. Using MSY modeling
  - i. What would be harvest for N=175
  - ii. What would be harvest for N=100
  - iii. What would be harvest for N=50
- c. What would be the consequence for scenario (impact of population, yield and future harvest)
  - i. 1bi
  - ii. 1bii
  - iii. 1biii
- d. Given these results comment on importance of error for N – e.g. over vs underestimates