



The number of individuals in a population (N) will grow if individuals reproduce at a rate sufficient to replace themselves, plus some more. As the population grows over time, more and more individuals reproduce at this rate, and the overall population grows faster and faster. This is the basis of the *exponential population growth model*

$\frac{dN}{dt} = rN$, where:

$\frac{dN}{dt}$, is the predicted growth rate of the population of a given size

N , is the current population size

t , is time

r , is the per capita growth rate, which reflects how much a given individual affects the population size

Based on this model, the potential for populations to grow can be extreme (actually infinite). Imagine the bacterium *E. coli*, which has the ability to asexually reproduce by dividing once every twenty minutes. One bacterium is microscopic and invisible to the naked eye, but if one bacterium and its descendants reproduce every 20 minutes, the population will double in size three times an hour. At this rate the mass of the bacteria population will outweigh the Earth within two days! Obviously this doesn't happen, or we all would have drowned in *E. coli* by now. So what limits the growth of bacteria? A student once suggested that a popular brand of spray disinfectant would do the trick. More generally though, population growth is limited because individuals reproduce less, and/or die more as resources (food, water, space, etc.) are depleted, and/or they their environment with their waste products. One of the assumptions of the exponential growth model is that resources are infinite, thus the biologically unrealistic predictions.

The *logistic population growth model* is a simple modification of the exponential model which produces much more realistic predictions. This model factors in *negative feedback*, in which the realized per capita growth rate decreases as the population size increases. It also introduces a theoretical *carrying capacity*, which is the maximum sustainable population size. In this model the population growth rate for a given size is described by the equation

$\frac{dN}{dt} = rN(1 - N/K)$, which adds:

$(1 - N/K)$, the negative feedback term containing

K , the carrying capacity

By inspection, one can see that when N is low, the negative feedback term approaches 1 and the population grows more-or-less exponentially. However, when N approaches K , the negative feedback term approaches 0 causing the overall growth rate to approach 0. It is important to note that $\frac{dN}{dt}$ is the change in the population size over time, that is to say that when $\frac{dN}{dt} = 0$, the population size will remain stable.

Model Details

This model is designed to explore how the various parameters in the logistic growth model affect population dynamics. It is set up with two populations side by side (red and blue), with slider controls for each of the parameters (Figure 1). One can observe individuals in the populations being born and dying over time in the world-view window, and simultaneously follow numeric and graphical representations of the populations. Detailed explanation of the reporters and controls are given in Tables 1 & 2. The most robust way to examine the effect of each parameter is to set each the parameters the same for the red and blue populations, and then raise/lower one parameter at a time in one of the populations to observe the effect.

Figure 1. Screen shot of the Logistic Growth model

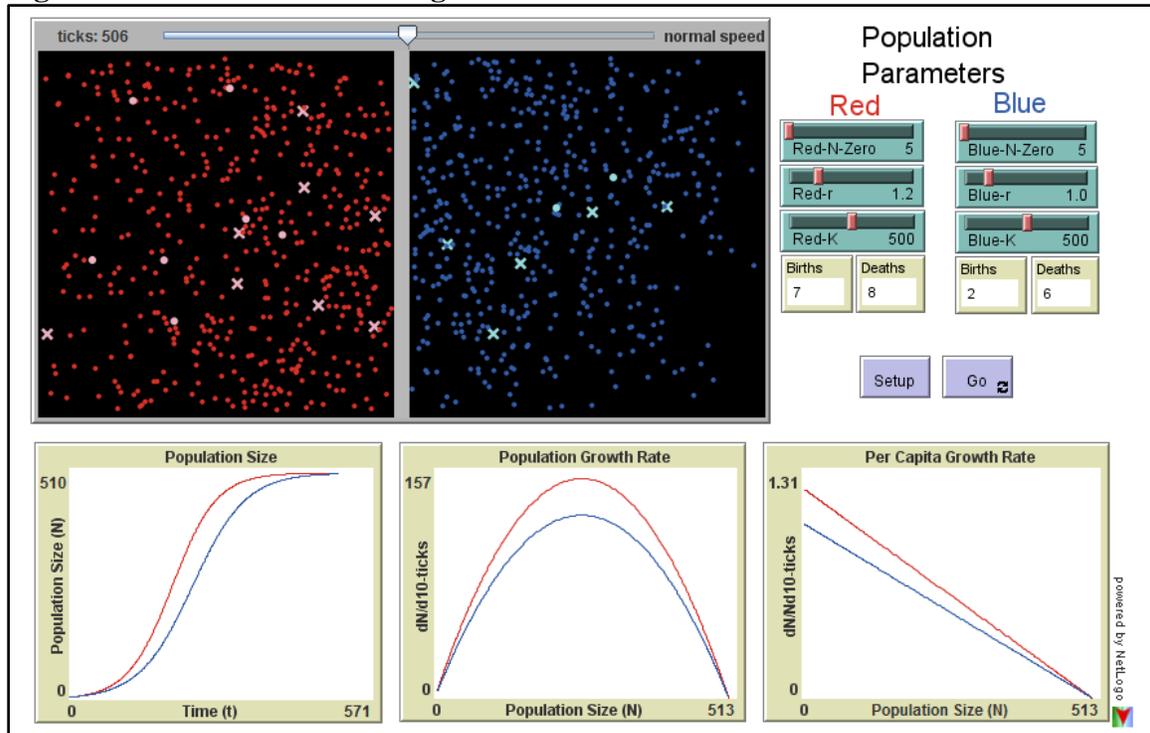


Table 1: Reporters for the Logistic Growth model

Reporter	Description
World-view window	This is an animation of the red and blue populations, each small dot represents an individual, while lighter circles represent a birth, and deaths are represented by an 'x'
Population Size (Graph)	Plot of overall population sizes over time, in all the graphs the red and blue populations are represent by traces of their respective colors
Population Growth Rate (Graph)	The growth rate of the <i>overall population</i> for a given population size
Per Capita Growth Rate (Graph)	The amount by which a <i>particular individual</i> is changing the population for a given population size
Births and Deaths	These numeric reporters give the number of births and deaths in each population at a given time step

Table 2: Controls for the Logistic Growth model

Control	Action
Setup	Clicking clears all values, resets model to current parameter settings
Go	Clicking sets the model in motion (clicking again will stop it)
Red-N-Zero Blue-N-zero	Sets the initial population size (N_0) for each population (0-2000, in increments of 5)
Red-r Blue-r	Sets the per capita growth rate for each population (0-5, in increments of 0.1)
Red-K Blue-K	Sets the carrying capacity for each population (0-1000, in increments of 5)

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