# Modeling the Effects of Disasters on a Human Population and Resources

Joshua Yoon
Thomas Jefferson High School for Science and Technology
2008-2009

## Introduction

Recently, over the past decades, numerous disasters such as earthquakes and tsunamis have struck all over the world, and this project is an attempt to not only to model these effects of disasters on humans populations accurately, but also to extrapolate the effects of future disasters on a different sized human population using System Dynamics.

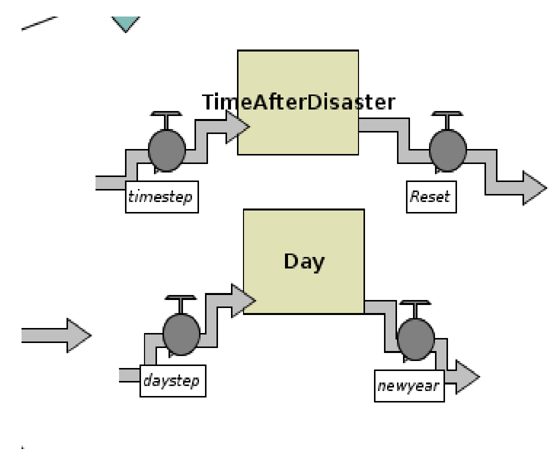



Figure 1.4

$$\text{Growth Rate} = \frac{\text{Growth in Population}}{\text{Population Size}}$$

$$= \frac{dP/dt}{P} = \beta - \delta . P$$

$$\therefore dP/dt = P(\beta - \delta . P)$$

The solution for this is :

$$P(t) = \frac{\beta}{\delta + \left[\left(\beta / P_0\right) - \delta\right] e^{-\beta t}}$$

where

$\beta$ = avg. birth rate

$\delta . P$ = avg death rate

$\delta$ = proportion ality constant for death rate

$\frac{\beta}{\delta}$ = asymptote at t $\to \infty$

Equation 1
(http://prepcalcabc0607.blogspot.com/2007/02/91-modeling-with-differential-equations.html)

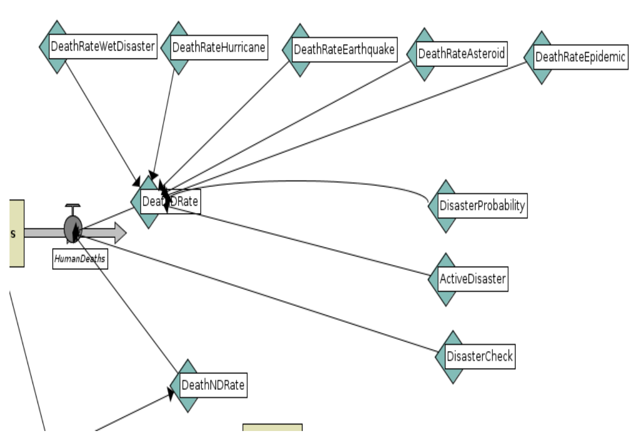


Figure 1.3

## The Main Web

This web can be divided into four components. The first and most important is the human class (Figure 1.1). This class controls the population growth and death of the system's population. The next component is the resource class (Figure 1.2). This works in hand with with the human class to keep the system in check, because otherwise the humans alone would've grown without restraint. The third component is the disaster class (Figure 1.3). The first two components creates a harmonious system, but the disaster class brings chaos into the system and the multiple variables determine which disaster will strike and destroy the population. The last component is the time keepers (Figure 1.4). These two variables make the system more dynamic, because it sets a time frame for the disasters to happen and makes coding much easier.

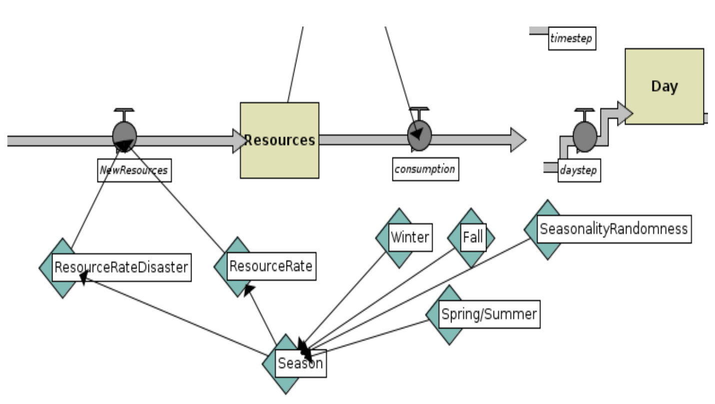



Figure 1.2

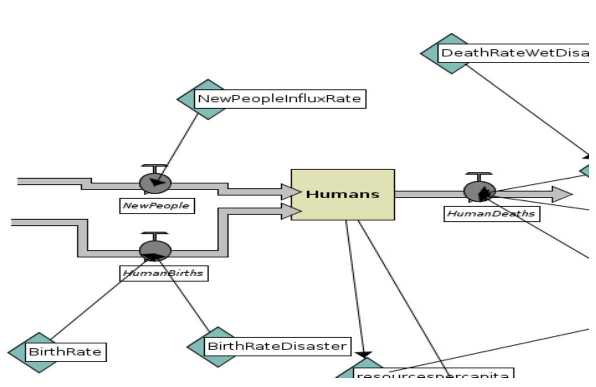
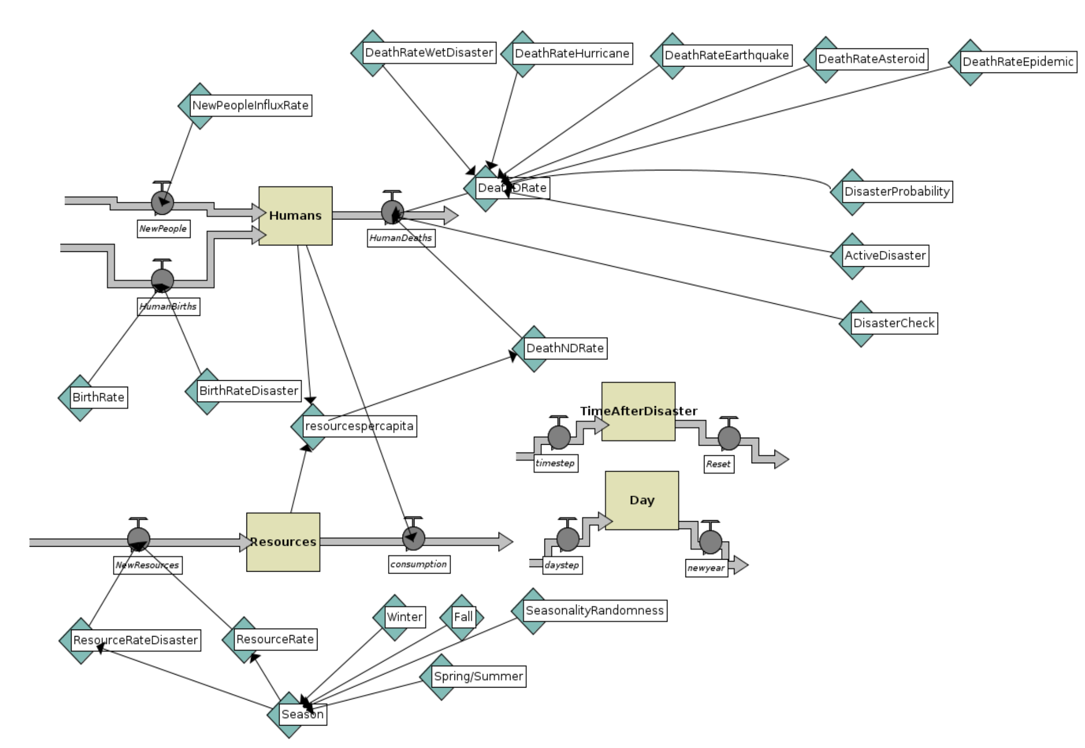



Figure 1.1

## The System Dynamics Approach

System Dynamics is the approach to understanding the behavior of complex systems over time by creating and implementing relationships between multiple variables. The system dynamics approach differs from agent-based modeling, because agent-based modeling is used for random individual interactions, whereas system dynamics is used for entire systems and connections between given factors. Thus, system dynamics can best be shown by a relationship web, as shown on the below.



The Complete Web

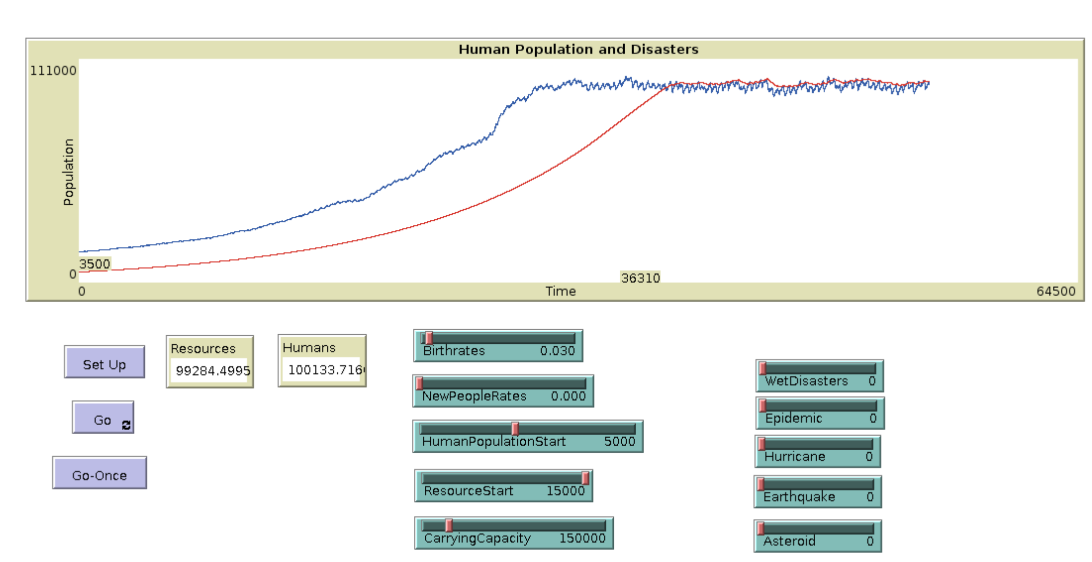



Figure 1.5

## Development / Methodology / NetLogo

The whole basis of this project is in a language called NetLogo. NetLogo offers two coding interfaces: Agent-based modeling, and system dynamics. System dynamics is preferably used here because a disaster is a large event, which affects a a population as a whole, as opposed to individuals like in agent-based modeling. To make a simulation, one builds a relationship web (see The Complete Web) and then the web is reflected in a user contorlled interface (see figure 1.5). To create such things like the logistical population curve (see equation 1 & figure 1.5), and the results (figure 1.6), relationships among variables are created in a flow chart as shown above. The creation of relationships offers the option of creating dynamic behavior without "hard coding" behavior.

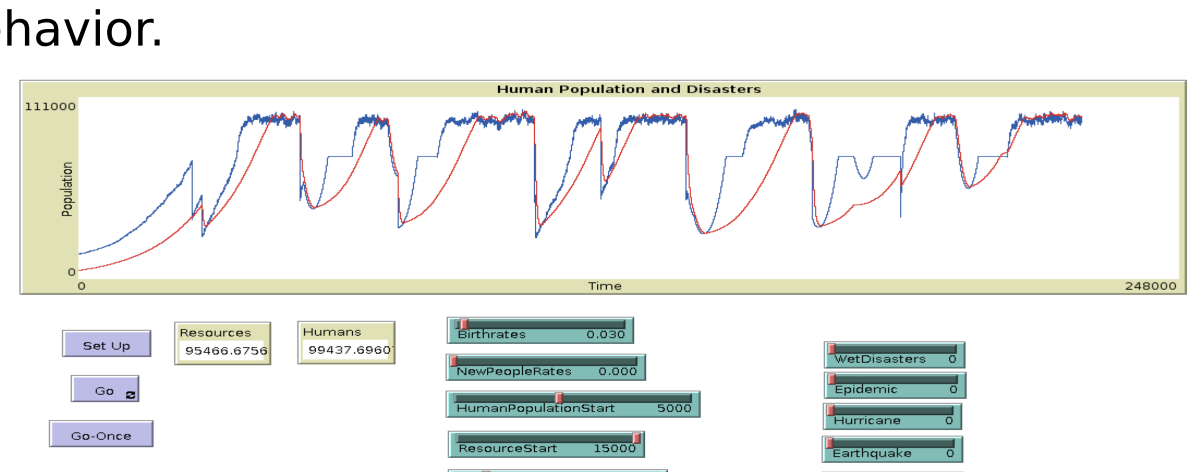



Figure 1.6

## Results

A logisitcal curve, a recovery curve, and realistic data simulations have been created. There is randomness on both microscopic and macroscopic levels. When disasters aren't striking the population (microscopic), the population is fluctuating in small amounts and this accounts for anything from seasonal variations and minor events such as a short drought. When disasters are occuring (macroscopic), the population declines at a rate consistent with real-world data and recover slowly as a real population would.