

A TABLE FUNCTION EXAMPLE

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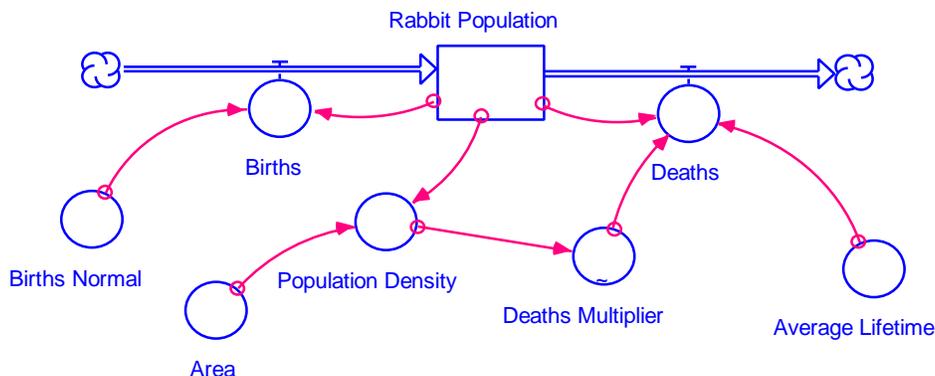
I. Introduction

While building a system dynamics model, the modeler may be faced with a situation where there is a relationship between two variables but no simple algebraic equation to define the relationship. For example, the death rate of a population of rabbits in a fixed area increases rapidly as the area gets more crowded. In cases where the relationship between two variables is not linear, table functions can be used to represent the relationship.

Table functions are used in preference to complicated equations because the modeler can control the shape, slopes and saturation points to accurately represent the non-linear relationship between two variables. Table functions are also easier to interpret and visualize than complex algebraic equations.

II. Using Table Functions in Vensim

The example below, shows how to translate table functions from STELLA to Vensim using the Rabbit Populations model found in “Generic Structures: S-Shaped Growth I” (D-4432-2) in Road Maps 5.



STELLA Version: S-Shaped Growth Structure I

The lookup function for **deaths multiplier** has a dimension in our STELLA example which is not good modeling practice because it violates dimensional consistency

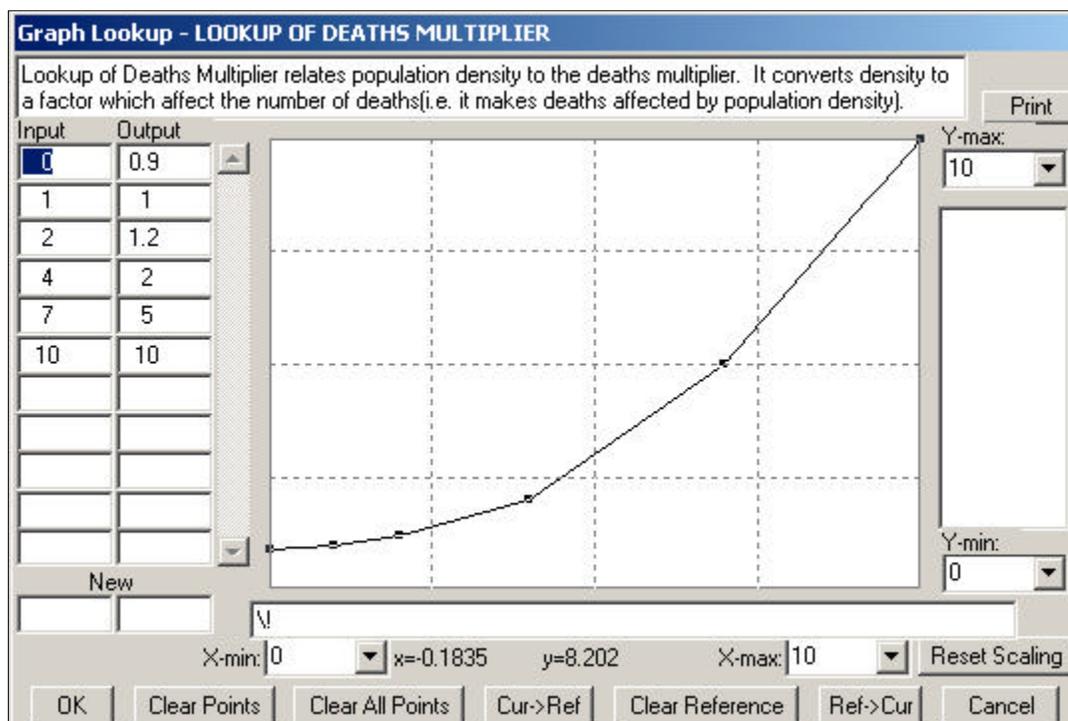
in the model. It is better practice to have dimensionless inputs and outputs to all table functions in system dynamics models.

A variable called “normal” is used to divide the input variable, which in the example is population density, to produce a non-dimensional input to the lookup table. Normals are constants that act as reference points for dynamic behavior e.g. in the example above, the “normal” is the **population density** at which the **deaths multiplier** is 1 and the “deaths” is determined only by the “average lifetime,” “Rabbit Population” and “deaths multiplier.”

In converting the example from STELLA to Vensim, first create two new constants: **NORMAL POPULATION DENSITY** and **lookup of deaths multiplier**. The constant, **NORMAL POPULATION DENSITY** divides **population density** to produce the **relative population density**, a non-dimensional input to the lookup table.

The relationship **lookup of deaths multiplier** will contain all the data points representing the non-linear relationship between the two variables: **relative population density** and **deaths multiplier**.

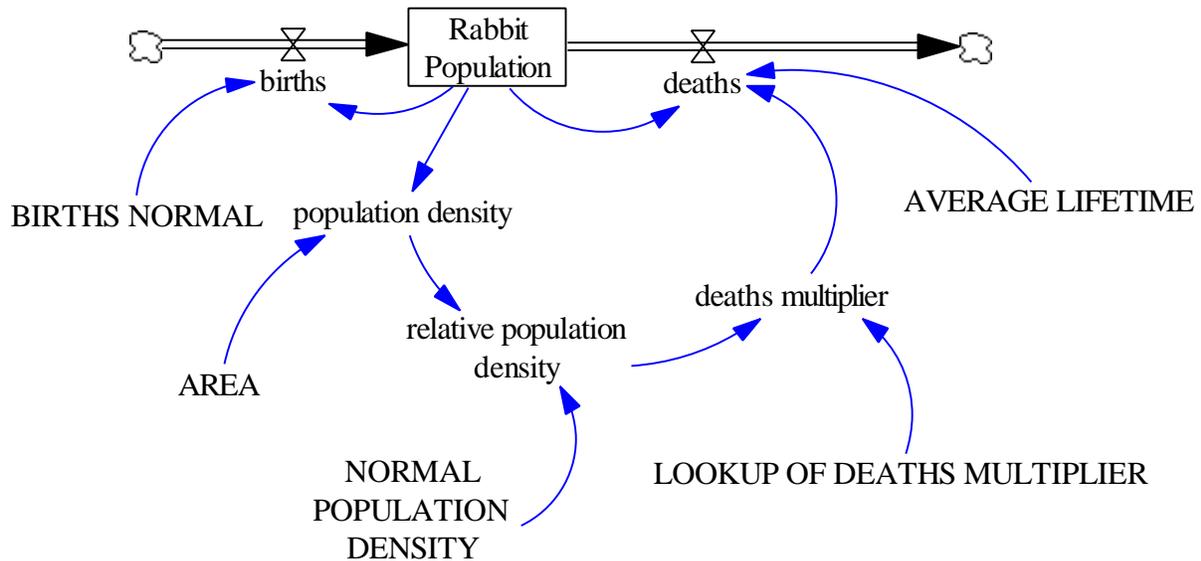
To input data points for the lookup of deaths multiplier, go to the equation editor and under “type,” select “Lookup,” then “As Graph” and you will be taken to a screen where you can enter the data points in the form of a graph:



The equation that relates the table function, normal and multiplier is:

$$\text{deaths multiplier} = \text{lookup of deaths multiplier (relative population density)}$$

The complete Vensim version of the example is shown below:



Vensim Version: S-Shaped Growth Structure I

Documentation for Rabbit Population Model

- (01) AREA = 1
Units: acre
The amount of land the rabbit population is living on.
- (02) AVERAGE LIFETIME = 4
Units: year
The number of rabbits that die per rabbit in the population per year.
- (03) births = Rabbit Population*BIRTHS NORMAL
Units: Rabbits/year
The number of rabbits being born each year.
- (04) BIRTHS NORMAL = 1.5
Units: 1/year
The number of rabbits born into the population per rabbit in the population each year.
- (05) deaths = (Rabbit Population/AVERAGE LIFETIME)*deaths multiplier
Units: Rabbits/year
The number of rabbits that die each year.

- (06) deaths multiplier = LOOKUP OF DEATHS MULTIPLIER (relative population density)
Units: dmnl
deaths multiplier gives the effect of population density on the rate of deaths of rabbits.
- (07) FINAL TIME = 12
Units: year
The final time for the simulation.
- (08) INITIAL TIME = 0
Units: year
The initial time for the simulation.
- (09) LOOKUP OF DEATHS MULTIPLIER([(0,0)-0,10]),(0,0.9),(1,1),(2,1.2),(4,2),(7,5),(10,10))
Units: dmnl
Lookup of Deaths Multiplier relates population density to the deaths multiplier. It converts density to a factor which affect the number of deaths(i.e. it makes deaths affected by population density).
- (10) NORMAL POPULATION DENSITY = 1
Units: Rabbits/acre
- (11) population density = Rabbit Population/AREA
Units: Rabbits/acre
The number of rabbits per unit of area.
- (12) Rabbit Population= INTEG (births-deaths,1)
Units: Rabbits
The number of rabbits in the rabbit population.
- (13) relative population density = population density/NORMAL POPULATION DENSITY
Units: dmnl
relative population density gives the ratio of population density to NORMAL POPULATION DENSITY to provide a dimensionless input to the lookup table.
- (14) SAVEPER = TIME STEP
Units: year
The frequency with which output is stored.
- (15) TIME STEP = 0.0625
Units: year
The time step for the simulation.

To see the complete STELLA version of the example refer to “Generic Structures: S-Shaped Growth I” (D-4432-2) in Chapter 5 of Road Maps. A detailed discussion of table functions, normals and multipliers can be found in “Mistakes and Misunderstandings: Table Functions” (D-4653) in Chapter 9 of Road Maps.