



# Introduction to Modeling with Simile

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This is an introduction to using Simile for building and analysing a model.

Simile is a visual modeling tool. It allows you to draw a conceptual model diagram, and if you have quantitative information you can then add this into the conceptual model to produce a quantitative model. Simile also allows the dynamics of a quantitative model to be simulated and the results displayed in graphs and tables.

Extra documentation on Simile can be found in the Simile's help files and on the Simile web site <http://www.simulistics.com/documents>. Links to the relevant web help pages can be found throughout this guide.

The best way to learn about modelling is by practice. So we will look at a simple model which is the Hunter-Gather example from the book "Ecological Modelling: A Common-Sense Approach to Theory and Practice" (Grant and Swannack 2007). We will see how to build and analyse the model with Simile, and then there are some problems which you should try and answer using Simile. At the end I present some additional functionalities of Simile which may be useful for other modelling problems.

## Starting Simile

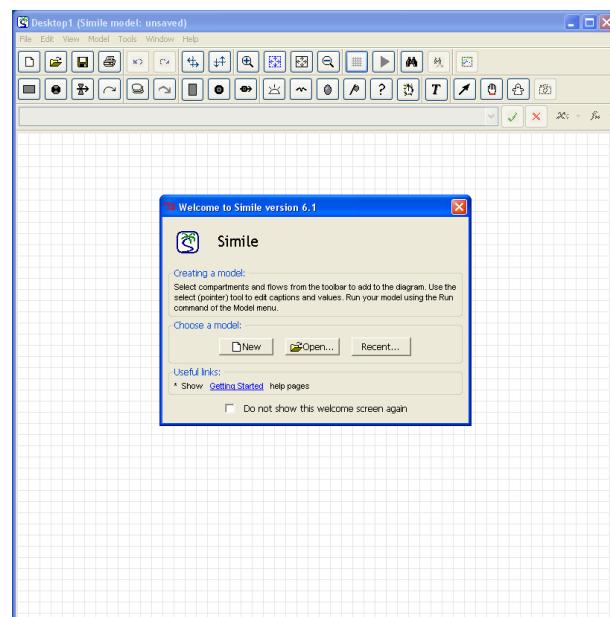


You [start Simile](#) by double-clicking on the desktop icon created during installation, or by clicking on the Simile icon in the Start Menu.

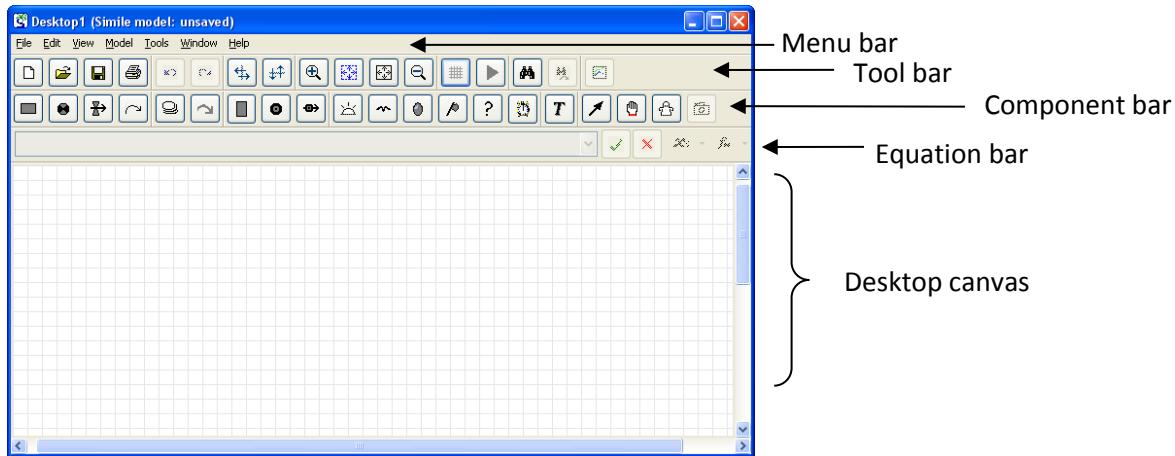
Within a few seconds, the main window will be displayed.

## The Main Window

When Simile starts, you see a single window. If you see a welcome page (shown opposite), click on the "New" button



You should now see the Main Simile window, like this...



The main window contains:

- **The Menu Bar**, containing a standard File menu, some menus specific to Simile, and a Help menu. Hold the mouse over the title for each menu to see the options it contains.
- **The Toolbar**, with standard tools (e.g. for opening and closing files), plus some specific to Simile.
- **The Component Bar**, containing buttons corresponding to each type of model-diagram element: you will use these for building up your model diagram. The right-hand part contains buttons for editing the model diagram. Hold the mouse over each button to get a brief description of its function.
- **The Equation Bar**, for entering equations into the model. At the right-hand end of the equation bar are the tools to accept or reject changes to equations, and to help build equations.
- **The Desktop Canvas**, where you will draw your model diagram. The grid can help you arrange your diagram neatly.



## The ecological system: The question and the data

The ecological system we are going to consider is the first example in the book by Grant and Swannack (Grant and Swannack 2007). It is called the Hunter-Gatherer Model.

**The Question...** Will deforestation have a serious impact on the winter food reserves of a hunter-gather group? The group usually hunts in the savannah until the end of October and then moves to the forest to spend the winter. Can the group collect enough food for the winter despite deforestation?

**The Data...** Severe winter weather, which prevents all food gathering activities, typically arrives by the end of November. Thus the group has the month of November to harvest the food items they need for the winter. There are usually 100 food items in the forest at the beginning of November. For practical purposes, food items are a non-renewable resource during November since plants no longer produce fruits and both birth and death rates of animal populations are essentially zero. Historically, the group has had no trouble harvesting the 75 food items they need for the winter, although the group has told us the rate at which they can harvest food items decreases noticeably as abundance of food items decreases. The group estimates they can harvest about 10% of the available food items per day. As a result of the recent deforestation, we estimate only about 80 food items will remain in the forest when the group arrives this autumn. Although there still appears to be enough food available, we wonder if the group will have enough time to harvest all they need before the severe weather arrives.



## The steps taken to model the problem

Two important steps have already been completed.

1. We have a good idea of the **question** we want to ask.
2. We have a good idea of the **data** available to us.

We will continue by

3. Developing a **conceptual model** of the system which is suited to the data and the question
4. Developing a **quantitative model** from the conceptual model by explicitly including the data
5. **Evaluating and analyzing** the model's simulation results
6. Some problems for you to answer about the model system
7. Looking at some additional Simile skills

## Drawing a conceptual model in Simile

Begin by drawing a *conceptual model diagram* for the Hunter-Gatherer model. We are interested in the **Total Harvest** across one season, and this harvest comes from the **Food** in the forest. The **Food** and the **Total Harvest** are linked by the **daily harvest** that removes food from the forest and increases the total harvest. A sketch of the system is shown below.



There are two state variables: **Food** and **Total Harvest**. The solid arrows show the "flow" from forest food into total harvest.

The dashed arrow shows that the daily harvest is influenced by the amount of food in the forest.

Now draw this conceptual model in Simile.

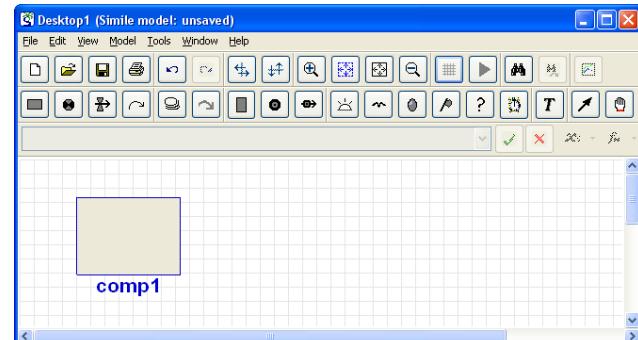
### Adding a compartment to a model

- Click on the  [compartment](#) symbol in the toolbar.
- Move the mouse to the middle of the desktop window, and click again.

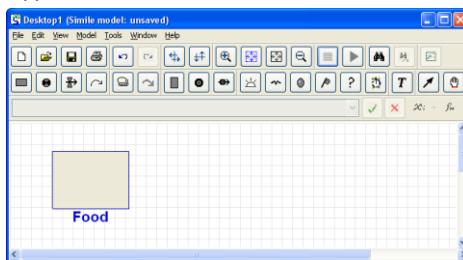
You should see a blue box labelled **comp1**.

**A note on colours in Simile**

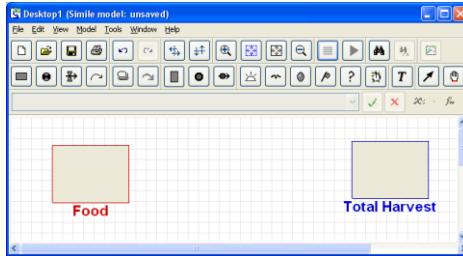
- When you select a compartment it will turn **blue** (a new compartment will automatically be selected).
- When you select a flow it will turn **green** (a new flow will automatically be selected).
- A compartment or flow will be **red** if it is not selected *and* it needs some extra information (like a value or equation).
- When a compartment or flow is complete it will turn **black**.
- When a model diagram is all black the model can be run.



Type in the label **Food**. This box will be the food available in the forest.



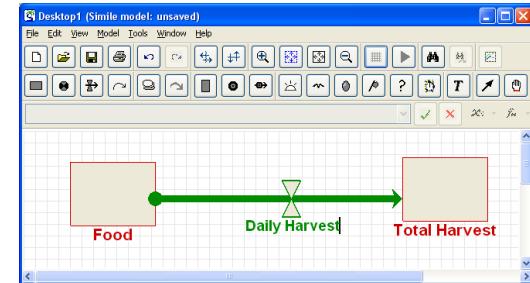
Now repeat this step to create another compartment and label it **Total Harvest**.



### Adding a flow to a model

Add in the [flow](#) from the Food into the Total Harvest.

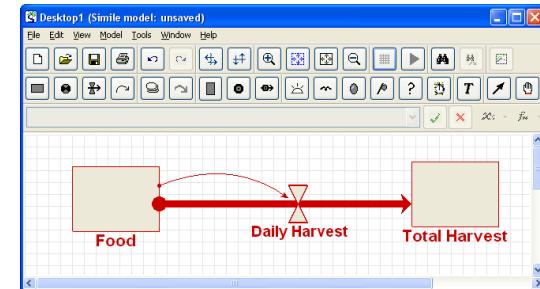
- Click on the flow symbol in the toolbar.
- Move the mouse to the compartment labelled **Food**. Hold the mouse button down and drag the mouse into the centre of the compartment labelled **Total Harvest**. Release the mouse button.
- Type in the label **Daily Harvest**.



### Adding in an influence to a model

The food in the forest influences the daily harvest (the dashed arrow in our sketch). In Simile this is represented by an [influence arrow](#) .

- Click on the influence arrow button in the toolbar.
- Move the mouse to the middle of the compartment labelled **Food**, and drag an influence arrow to the flow labelled **Daily Harvest**.
- Release the mouse button when the flow has turned green.



### Re-arrange the model diagram

- Click on the pointer button in the toolbar.
- Move the mouse to the middle of the compartment labelled **Food**.
- Drag the mouse, and watch the compartment and its associated arrows re-arrange themselves.
- You can move many of the components in Simile, including the flows, the influence arrows, etc.
- The labels of a component can also be moved.



## Re-sizing the model diagram

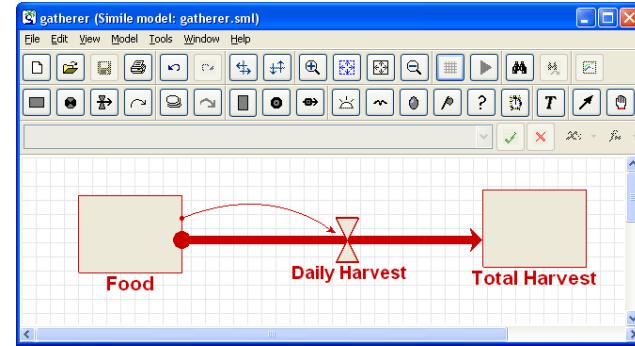
- You can zoom the model diagram to fit the current window by clicking on the button
- You can zoom in to a diagram by clicking on the button
- You can zoom out of a diagram by clicking on the button



## Removing model components

- Click on the pointer button in the toolbar.
- Click on the model component you want to remove (it will turn blue).
- Select the **Edit/Delete** option in the menu bar and the selected component will be deleted.

We now have the conceptual model drawn in Simile, which looks something like this...



Save the model by selecting **File/Save** in the menu bar. Call the model **gatherer.sml**



## Copying a picture of the conceptual model

The diagram of the model can be copied and pasted into another document by selecting **Edit>Select All** in the menu bar, followed by **Edit/Copy**.



## Additional model components

Simile has many other models components, which are described in the [help pages](#). Some other components will be discussed later on.



## Making a quantitative model in Simile

The conceptual model contains no numerical data. But we are given values for the initial amount of food in the forest and the rate at which it can be harvested. So the next step is to include information into our model, and make the model **quantitative**.

We are told that the daily harvest is 10% of the food in the forest, so on Day 1 the harvest is

$$\text{DailyHarvest} = 0.1 \times \text{Food}$$

The daily harvest is calculated from the food available at the start of day (hence the influence arrow in the conceptual model from **Food** to **DailyHarvest**).

Every day the food in the forest is reduced due to harvesting,

$$\text{Food on day 2} = \text{Food on day 1} - \text{DailyHarvest on day 1}$$

and the **Total Harvest** is increased

$$\text{Total Harvest on day 2} = \text{Total Harvest on day 1} + \text{DailyHarvest on day 1}$$

The value of **DailyHarvest** is the rate (per day) at which the forest food is decreasing, and the rate (per day) at which the total harvest is increasing. Simile can use these equations to predict the future Total Harvest and the Food at the end of each day. To do this we have to input this *quantitative information* into the model.



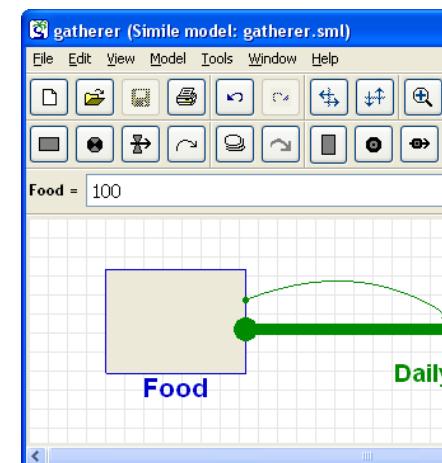
### Prepare to set component properties

Click on the pointer button in the toolbar.



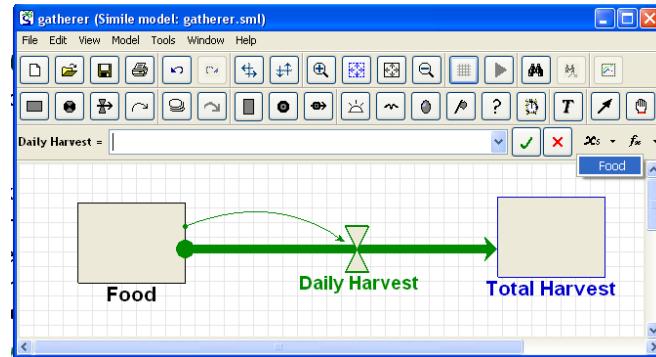
### Assign an initial value for a compartment

- Click on the compartment labelled Food.
- Enter the value 100 into the equation bar.
- Click on the green tick mark or press the Return key.
- Repeat this for the compartment labelled Total Harvest and set its value to 0 in the equation bar.
- As the initial values of the compartments are set they turn black, showing that all the information for this compartment has been specified.



### Add the harvest rate equation

- Click on the flow labelled Daily Harvest.
  - The variable Food is listed as an influence upon Daily Harvest. These influences are visible by clicking on the  $x_s$  button. Selecting an influence from the drop-down list, places the text in the equation bar.
  - Enter the expression **0.1\*Food** into the equation bar.
  - Click on the ✓ green tick mark.
  - A full discussion of defining equations in S



When you have finished, you should notice that every component of the model diagram is now black, rather than red as it was before. This indicates that every component has been mathematically specified, and so the model is ready for running. Simile has enough information to work out the flows, and thus to update the amount of food in the forest and the total harvest forward through time.



## Seeing the equations and data in a model

You can see all the equations in a model by selecting **Model>List equations** from the menu bar, or by typing **Ctrl+L**. This will open a window with all the components in the model, their equations and their values. You can compare the equations with those on the previous page.

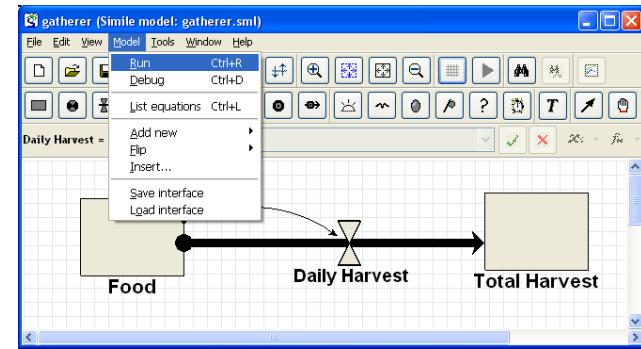


### Running the model

Now all components have been defined we can [run the model](#) to predict the effect of harvesting the forest food.

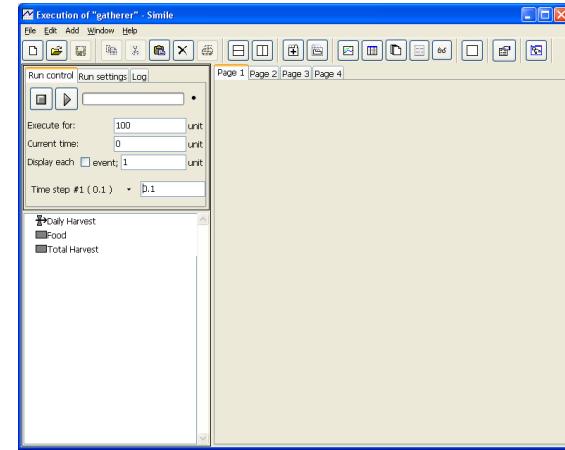
First compile the model:

- Open the **Model** menu
- Select the **Run** item.



Simile creates a new window: [the execution window](#).

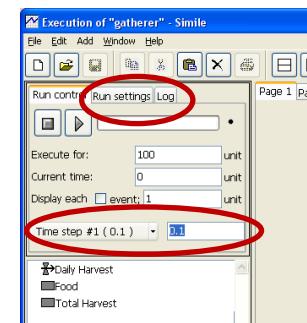
This contains the [controls for running](#) the model; a list of the variables in the model; and an area where any of a variety of tools for showing model results can be displayed.



### Change the time step

Simile uses default time step of 0.1 to update the model (the default method for updating the model is Euler's method). For this model we want a daily time steps, so we will set the time-step to 1.

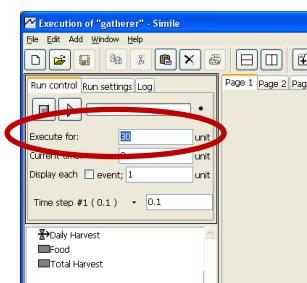
- Change the value for **Time step #1** from 0.1 to 1.
- The **Run Settings** tab contains other options which should not be changed.
- **Note: Leave the time units at their default value (unit)**



### Change the duration of the simulation run

- Change the value for **Execute for** from 100 to 30.

This is because there are 30 days in November.



### Select the graph-plot display

Simile has several [graphical tools](#) to display results. A list of the graphics can be found by clicking on the "[Spectacles](#)" button in the toolbar.

- Click on the "Plotter" display tool on the toolbar; or select it from the list in the Add menu.





## Choose the variable to be displayed

Note the graph window that appears. This is initially scaled with default values on both axes, but will rescale itself as needed. You can re-size the panel containing the graph by dragging on the little boxes on the horizontal and vertical panel separators.

- Click on the **+** "Add a variable" button on the plotter toolbar
- Click on the compartment labelled **Food** in the list of model variables.
- Click on the **+** "Add a variable" button on the plotter toolbar
- Click on the compartment labelled **Total Harvest** in the list of model variables.

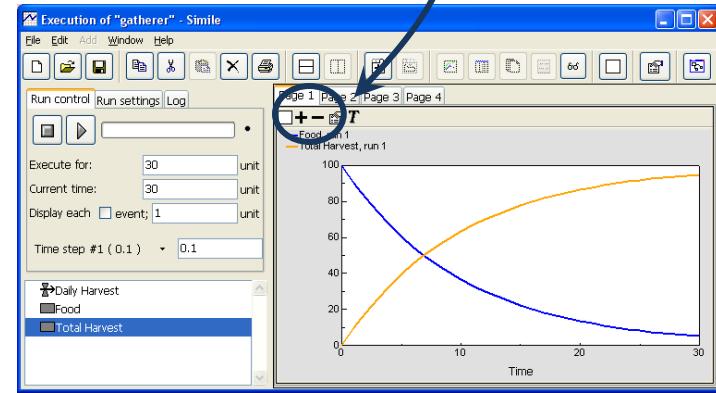


## Start the simulation

- Click on the "Play" button in the Run control dialogue window.

Note the line that appears on the graph.

By placing the mouse over the variable **Food** in the bottom left window shows the value of food after 30 days. The same can be done for Total Harvest and Daily Harvest.



## Continue the simulation

- Click on the "Play" button again.

The simulation carries on for another 30 days.



## Resetting the simulation

The simulation can be reset to time=0, and run again.

- The stop button will stop the simulation and set the current time to zero
- Click on the "Play" button to run the model again



## Resetting the graphics display

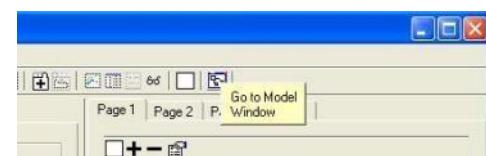
All the graphics can be cleared by clicking the clear button in the toolbar. Individual graphics can be cleared by clicking the same icon in each graphics panel.



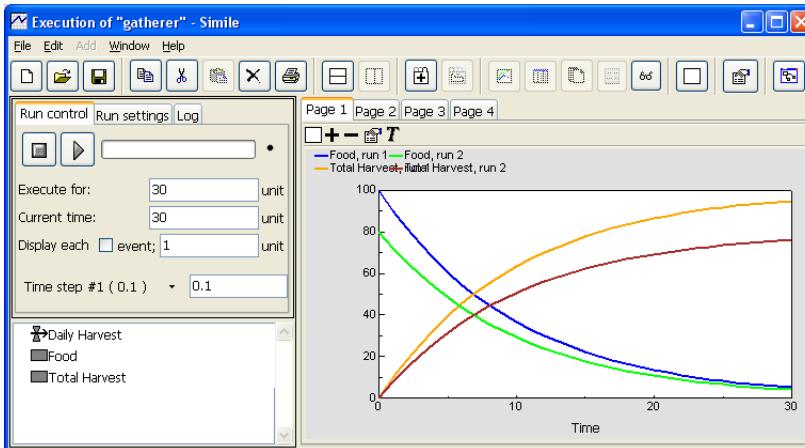
## Changing parameter values and rerunning the model

Now run a simulation where there is less initial food in the forest due to deforestation.

- Click on the "Go to Model Window" toolbar button. Or select the model window directly.



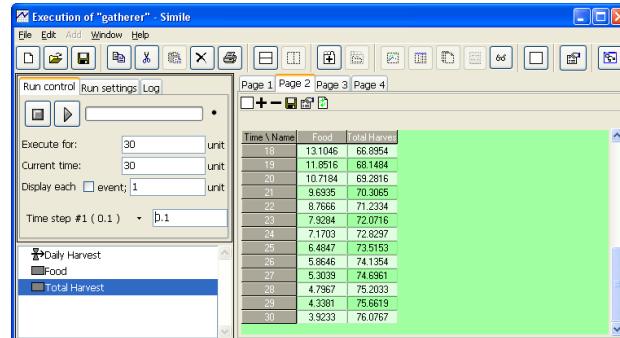
- Now select the **Food** compartment and set its initial value to 80
- Recompile the model, using **Model/Run** in the menu bar.
- Rerun the model for the first 30 days. The new simulation results are shown as run 2.
- Is the harvest at the end of November greater than the 75 units necessary for the hunter-gatherer's survival over the winter?
- At what initial food abundance will the hunter-gathers find it difficult to survive the winter?



### Displaying numerical data

It is often more useful to display the numerical values from a simulation. Displaying data as a table is useful if you want to read the data into Excel. To do this:

- Create a new “Notebook” by clicking on the “Add notebook page” button
- Click on the “Create table” icon
- Click on the “Add a variable” button as you did to add a variable to the plotter
- Then rerun a simulation (output shown on the right)



The online help manual explains all the aspects of customizing a table at <http://www.simulistics.com/help/run/tools/table.htm>.



### Saving the model graphics

The graph of simulation results can be copied and inserted into a Word document. Select the graph and then select **Edit/Copy** in the menu bar to copy the figure onto the clipboard. The figure can then be pasted into a Word document.



## Use your model to answer some problems about the system

Here are some problems which you can use your Simile model to answer (answers can be found on the last page).

-  1. *How long does it take to harvest 75 food items before deforestation took place (i.e. when there are 100 food items at the start of November)?*
  
2. *How long does it take to gather 75 food items now that deforestation has happened (i.e. when there are 80 food items at the start of November)?* 
  
3. *Create a word document which contains a figure showing the model's structure and a figure (with caption) showing the simulation results from one model run.*
  
4. *Include a variable in the model (see additional skills below) that adds together the food in the forest and the total harvest. This variable will keep track of the total amount of food in the system. Does the total amount of food change during the month of November? Explain what you have found.*
  
5. *Food in the harvest can rot. Roughly 0.05% of the food in the harvest is lost each day due to rotting. Modify your conceptual model to include this new information.*

To receive some feedback on your work, you can submit this report or your report from practical 2, via Blackboard **before 6pm Friday**.

## Additional Simile Skills

### Adding a variable to a model

Another component that hasn't been discussed is a [variable](#). A variable in Simile is just a number, but we can give it a name. This will be useful when calculating output results, or defining initial parameter values. We do not need this at the moment, but we will later on. Here is how a variable is added.

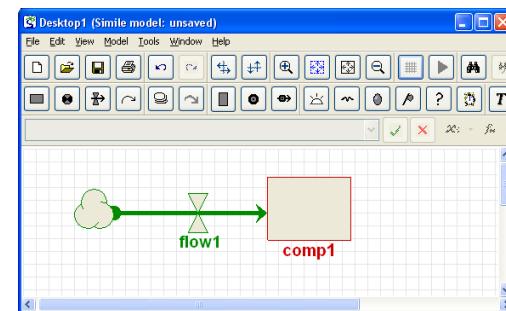
- Click on the  variable symbol in the toolbar.
- Move the mouse to the blank area of the model canvas and click once.
- Type in the label for the variable.

### Adding a source/sink into a model

The final component that hasn't been discussed is a source/sink. A source/sink is represented by three overlapping circles (akin to a cloud), and is very similar to a compartment, which was introduced on page 4. The only difference between a compartment and a source/sink is that the source/sink is inexhaustible.

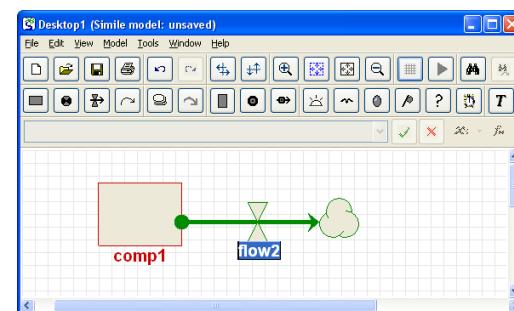
You create a **source** by

- left-clicking on the flow icon, 
- left-clicking on a blank piece of canvas. This will create a source with a flow arrow coming out from the source (pictured on the right).
- By dragging the end of the flow arrow you can link this source to any existing compartment.



You create a **sink** by:

- left-clicking on the flow icon, 
- left-clicking on a compartment that has already been created.
- keep the left button held down and drag the flow arrow to a blank piece of the canvas. This will create a flow arrow from a compartment into a sink (pictured on the right).





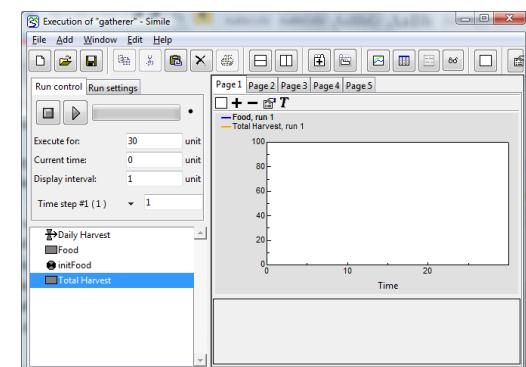
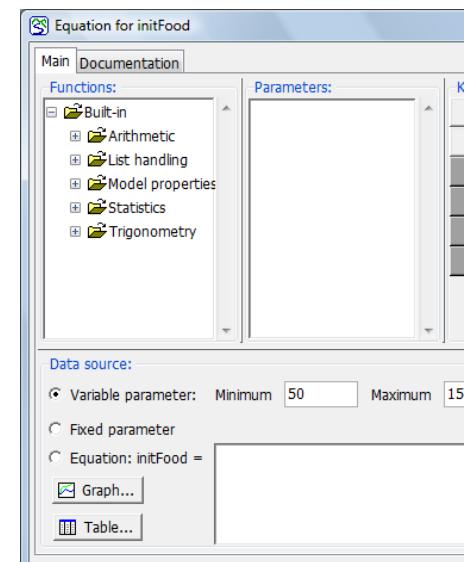
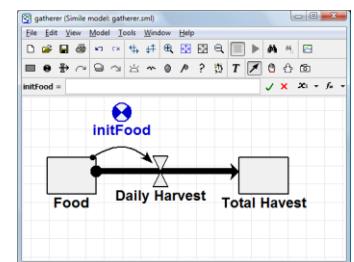
## Defining a variable parameter with the equation dialogue window

The Initial food in the forest can be changed without recompiling the model every time. To do this:

- Return to the Model Window.
- Create a [new variable](#) for the Initial food in the forest and label it **initFood**

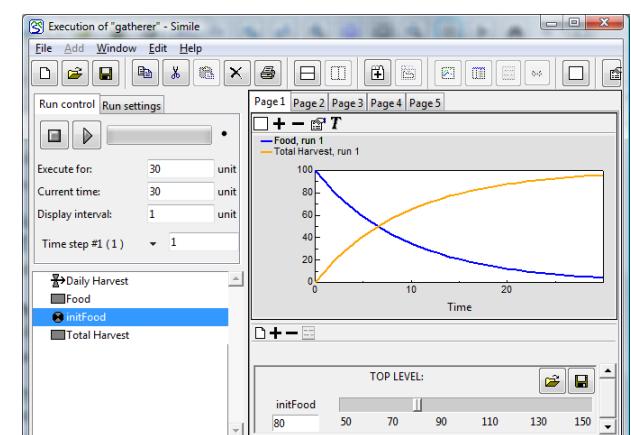
Next define this variable as having a range of possible values rather than one fixed value (this will enable us to set the value when the model is running).

- Under data source click the "[Variable parameter](#)" option and then type in the minimum and maximum values of the efficiency (we'll take the minimum to be 50 and the maximum 150).
- In the window at the bottom type in 100 as a default value for the initial food, and the press the OK button.
- In the model, initFood now has a line through it to show that it is defined with a range of values.
- Draw influence arrows from initFood to the Food compartment.
- Click on the Food compartment and in the equation bar set its initial value to be **initFood** (as shown).
- The initial food is now defined by a new variable (**initFood**) that has a well defined range.
- The model should be ready to compile using **Model/Run** in the menu bar.



This reopens the *execution window*, with the old simulation results. Now we want to be able to change the values of initFood.

- Click on the "Split pane horizontally" button in the toolbar
- Click on the "Create [input sliders](#)" button in the toolbar
- Add the variable initFood by clicking on the "Add a variable" button, and then the variable
- The sliders can be used to set the value for the variable.
- Clear the graph by selecting the "Clear" button
- Reset the simulation with the "Stop" button
- Run the model by clicking on the "Play" button.
- The slider can be used to change parameter values without recompiling. The "Stop" button must be pressed after the slider has been moved to select the initial value.



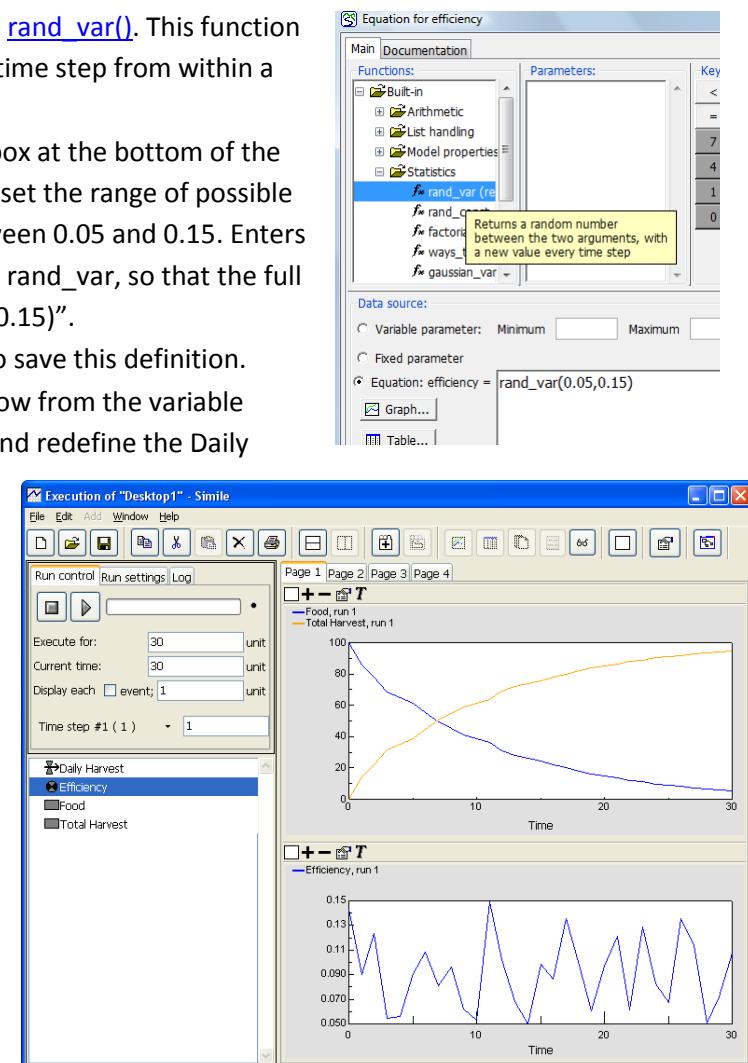


## Random numbers in a simulation

Every variable we have defined up to now has been a well defined number. Simile can also model variables which have [random values](#) (e.g. a random number between 0 and 1). For example, the hunting efficiency may not be constant during a simulation (we have set it to 0.1), but may randomly fluctuate about some mean value.

- Create a [new variable](#) and label it **efficiency**
- Double click on the **efficiency** variable to open up the *equation dialogue window*
- In the top left of the window is a section called “Functions:”. Click on the “[Statistics](#)” folder and double click on the top entry, which is [rand\\_var\(\)](#). This function creates a new random number every time step from within a range of possible values.
- `rand_var()` will have appeared in the box at the bottom of the equation dialogue box. We must now set the range of possible values, which we'll take as being between 0.05 and 0.15. Enters these values between the brackets on `rand_var`, so that the full expression looks like “`rand_var(0.05, 0.15)`”.
- You can then click on the OK button to save this definition.
- Finally we must draw an influence arrow from the variable **efficiency** to the flow **Daily Harvest**, and redefine the Daily Harvest flow to be **efficiency\*Food** (instead of `0.1*Food`).

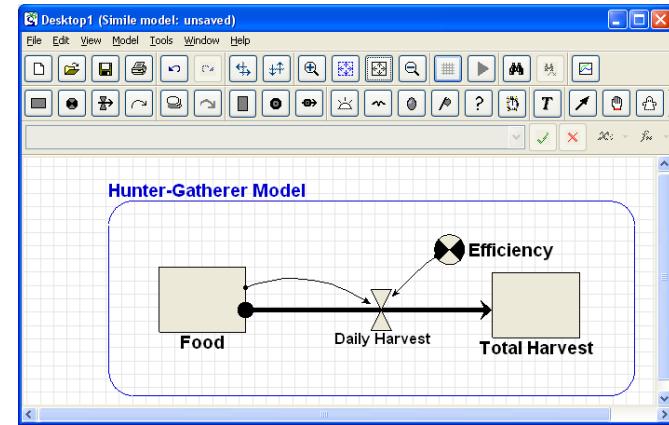
The harvesting efficiency is now a random variable which fluctuates daily between 0.05 and 0.15. Running the model and plotting the output gives the following result. We can see that the efficiency is randomly jumping around from one day to the next, but always within our defined range. The effect of this random variation can be seen in the graph of Total Harvest and Food.



### Submodels

We can enclose all or part of a model within a rectangle, which will define the contents as a [submodel](#). Submodels are useful to make the model diagram easier to read. They are also useful for creating several copies of the same model diagram (e.g. in a spatial population model the same population dynamics could describe populations at different spatial locations, we can use the submodel to create multiple copies of a model, one for each spatial location).

- We want to define our entire model as a submodel. Click on the  submodel button in the component bar.
- Use the mouse to draw a box around all the model components, and enter the label as “Hunter-Gatherer Model”.

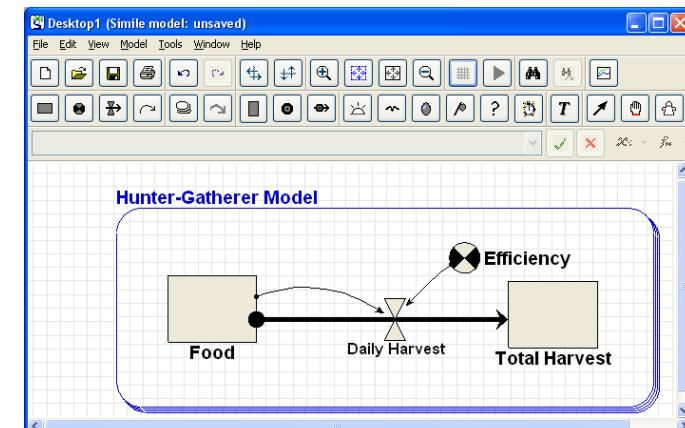
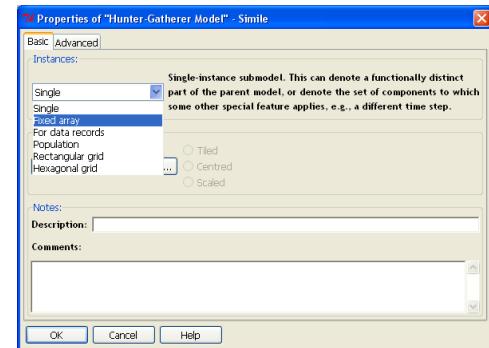


### Vectors and matrices

So far all the variables in our model have been single numbers. Simile can define variables which are vectors or matrices (e.g the variable  $x=[9, 10, 11, 12, 13]$  is a vector with five elements which happen to be the numbers from 9 to 13). Simile calls a vector a one-dimensional [array](#), and a matrix a two-dimensional array. Arrays are explained in the [Simile's help](#).

We could define 5 copies of the whole model by defining the “Forest Model” [submodel into an array](#). To do this we

- Select the submodel, so that it turns blue.
- Double click in the interior of the submodel to bring up the *Properties window*.
- Select “Fixed array” from the list (shown above right)
- To create five copies of the submodel enter 5 in the text box that appears.
- Click OK.
- Multiple copies of the submodel are shown in the model diagram by the boundary of the submodel having several lines (shown opposite).





## Exporting results from Simile into Excel

Once you have created a table and run the model so that the table contains some data you can save this data in a format that can be read by Excel. You do this by clicking on the Save button in the table's notebook and then typing in the name of the file where you want the data to be saved. By default this will be a “Comma Separated Variable” file ( a CSV file) which is a text file that can be read by Excel.



## Changing the look of the model diagram

Sometimes the default “look” of the model diagram will be unclear. For instance you may want to make the compartment boxes larger, or change the size of text, thickness of lines, etc. The look of a Simile model diagram can be changed under the menu item “View/Customise”. For example, if you want to change the way compartments are displayed select “View/Customise/Compartments...” which will open up a window called “Customise compartment appearance” where you can change the look of all the compartments in your model.

You also have some flexibility to change the way the model “look” under the menu item “Edit/Preferences...”. This opens up a window called “Preferences”. Under the “Edit” tab you can change several aspects of model look. Perhaps the most useful is the “Rectilinear Flow Routing” option.



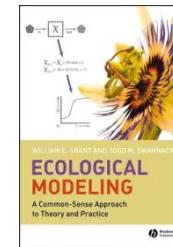
## Final Note

This has been a very quick look at Simile. Simile allows you to create and analyse quite sophisticated models, and generate a range of output interfaces. Now to properly understand how to use all these components you're going to have to get stuck in to a modeling project and use Simile.



## References

Grant, W. E. and T. M. Swannack (2007). Ecological Modelling: A common-sense approach to theory and practice. New York, Wiley-Blackwell.



**Question 1. *How long does it take to harvest 75 food items before deforestation took place (i.e. when there are 100 food items at the start of November)?***

On the end of day 13 the model predicts that the total harvest will be 74.6 food items, and at the end of day 14 it will be 77.1 food items (this is quoting food items to 1 decimal place accuracy). So 75 food items will take 14 days to collect (if you round up to a whole number of food items then 13 days could also be correct, showing that model results are dependent upon the accuracy, and your interpretation of the results to a certain extent). Since the model only considers whole days, we cannot say when on day 14 the harvest will hit 75 food items. Besides, this would be tending to make a precise prediction which is not consistent with the simplicity of the model.

**Question 2. *How long does it take to gather 75 food items now that deforestation has happened (i.e. when there are 80 food items at the start of November)?***

On the end of day 26 the model predicts that the total harvest will be 74.8 food items, and at the end of day 27 it will be 75.3 food items. So 75 food items will take 27 days to collect.

**Question 3.** Create a word document which contains a figure showing the model's structure and a figure (with caption) showing the simulation results from one model run.



Figure 1: A diagram of the hunter-gatherer model, showing the movement of food from the forest (Food compartment) into the yearly harvest (compartment Total Harvest).

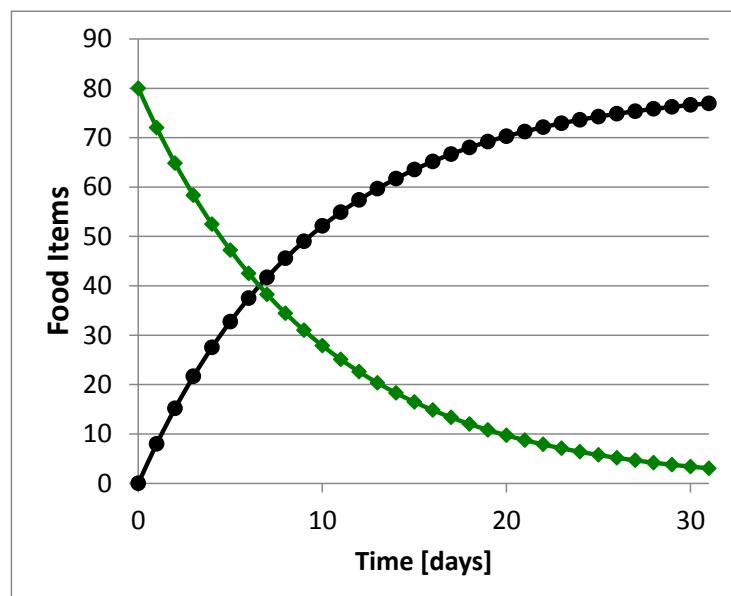
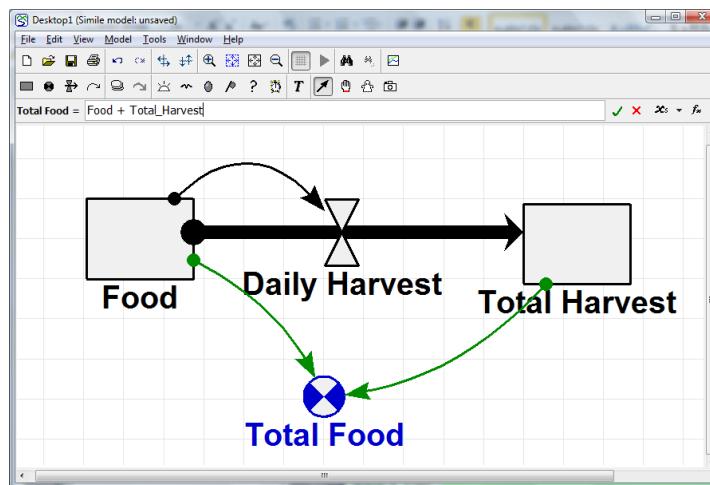


Figure 2: The food items in the forest (green line) and the total harvest (black line) as a function of days in November. At day 0 the total harvest was zero and there were 80 food items in the forest.

To answer this question I have used Excel to produce the graph because Simile does not produce graphs of sufficient quality for reports. The axes are clearly labeled, the text is readable and the units of the axes are included. The caption explains the two lines and other details about the simulation used to produce these results (in this case the initial conditions).

**Question 4.** Include a variable in the model (see additional skills below) that adds together the food in the forest and the total harvest. This variable will keep track of the total amount of food in the system. Does the total amount of food change during the month of November?

Below is the model with a variable added that calculates the sum of Food and Total Harvest



Running this model shows that the total amount of food in the model does not change. This is because the model represents a **closed system**. There are **no sources** of new food and **no sinks** for the food, food can only move between the forest (food compartment) and the Total Harvest.

**Question 5. Food in the harvest can rot. Roughly 0.05% of the food in the harvest is lost each day due to rotting. Modify your conceptual model to include this new information.**

Below is the conceptual model which includes the rotting of the harvest. The quantitative information has also been included. Notice that 0.05% gives a daily rotting rate of

$$0.05/100 * \text{Total\_Harvest} = 0.0005 * \text{Total\_Harvest}$$

in units of food items per day

