

Introduction to System Dynamics workforce modelling

December 2016



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Introduction

This pack is designed to introduce elements of systems dynamics modelling and the basics of using the Stella application to develop workforce models.

The pack is part of a resource library created by the HLP Workforce Programme to support the Primary Care, Social Care and Mental Health models that have been developed.

More comprehensive information on how to use Stella, a system dynamics software package referenced in this guide, can be found on the developers' website:

<http://www.iseesystems.com/>

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Workforce Modelling: Context

Aim: To share learning and enable health and social care organisations to benefit from the workforce modelling tools and approach developed by the London HLP Workforce Modelling team

London Workforce Programme

Transforming London's health and care together

Workforce modelling

In order to effectively plan for the future, all organisations need to understand and support the development of their workforce. A key element of this, especially within clinical health care services, is to understand how the evolving needs for services will affect the numbers and types of staff required.

Workforce modelling helps us to quantify how current and future workforces perform in terms of meeting patient needs. It helps investigate if the current channels of recruitment and retention will be sufficient to enable future demand to be met.

Workforce modelling as a tool can be applied in a variety of ways from predicting the supply of GPs over a 5 year period to modelling the optimal usage of various staff types.

This pack gives a brief introduction to the rationale behind developing a workforce model and the stages that are required in model development. More information on this can be found in the 'How to build a model' guide developed by HLP.

The main purpose of this pack is a brief introduction to the Stella tool that can be used for system dynamics modelling.

What does workforce modelling provide?

Workforce modelling is usually applied to support workforce planning to ensure that five key enablers are in place. For instance, workforce modelling can test current and future scenarios including new ways of working, new roles, the adoption of new technology and demographic and societal changes.



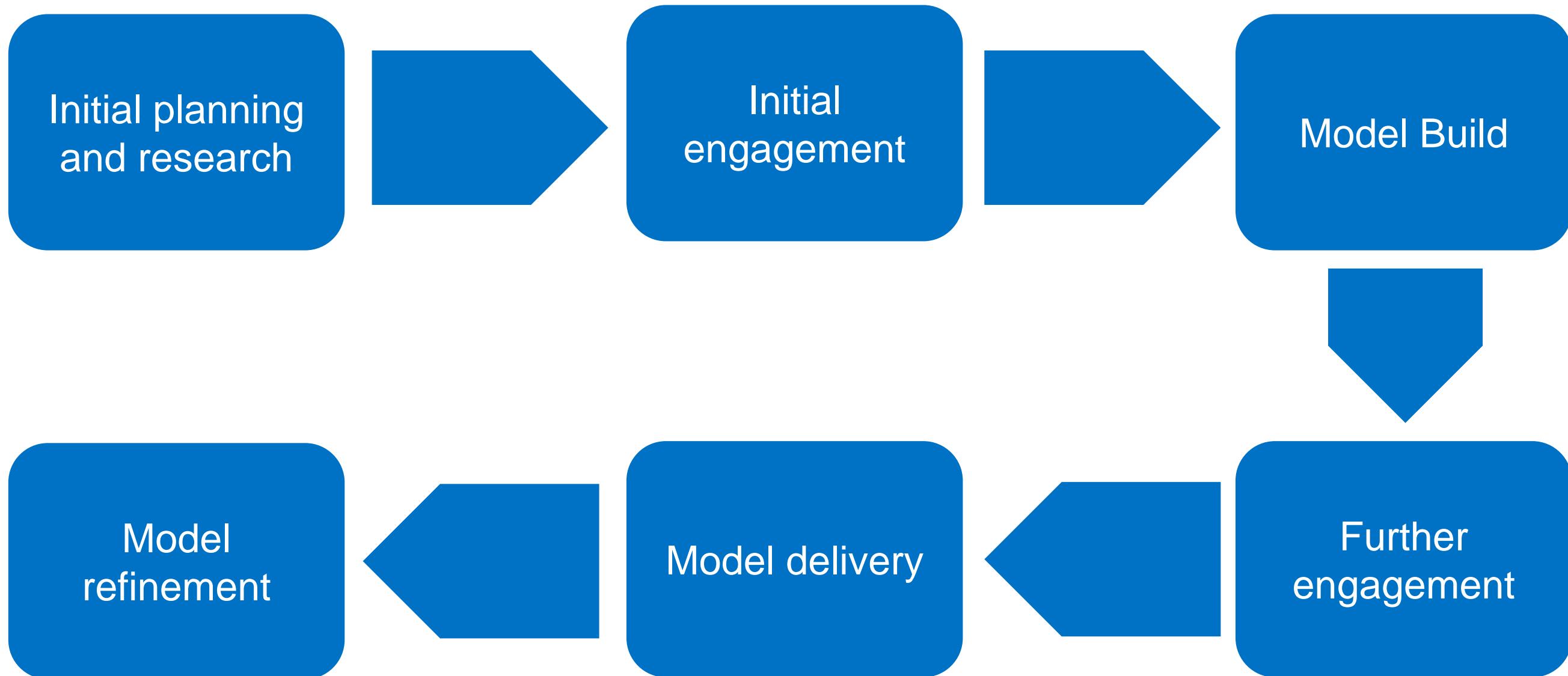
Fundamental principles

Workforce modelling is based on the principles of supply and demand. In simple terms the model compares the current and future supply to expected demand.

- The elements of the supply function will vary and generally depend on the time scale that you are looking to map. Key elements include the number of each staff type, their skills, their availability ('participation rate') and longer term factors such as recruitment, leaver and retirement rates.
- The demand side of the model used by HLP is built by combining the activities that require time from the workforce.
- Depending on the available data and the objective of the piece of work, network flow analysis and optimisation techniques including linear programming can be applied to produce an optimal strategy for using the existing and future workforce.

How to build a model

When building a workforce model it is important to follow a well-defined logical approach. The steps below give a suggested approach to building a workforce model that can be applied regardless objectives or sector:



General hints for building a model

When building any model there are a number of useful points to bear in mind. These apply to all software packages and will make the model easier to build, revise and correct as and when this is needed:

- Build the model in sections; if there are errors it will be easier to find them. In Stella these sections can be modules. Each section should have a readout of the numbers at this stage of the model, this is key when checking the results to see if they are correct or not.
- If possible, find previous trends to compare your model's outputs to. If this data doesn't exist make sure that you validate the outputs with stakeholders and/or external experts.
- Continually refer back to the key business question to ensure what you are doing will add value.
- Build in flexibility. Just because a segment or filter is not required in the initial iteration, it doesn't mean that it will never be needed. It is easier to add this flexibility at the start rather than at the end as it can mean making significant changes to the model structure.
- Modelling is an iterative process so make sure you continuously revise the model throughout the project to reflect any new information that you receive.
- In the first instance, build a model that reflects a "no change" scenario. This reduces the number of assumptions around future ways of working that are required, making the model more accurate. It is also easier to understand the results of not changing which makes it easier for your results to be validated by published data sources or your data steering group.

Further Information

A more detailed guide, 'Building Workforce Models', has been published by HLP alongside this introduction to system dynamics. In this guide you will find:

- More information on the types of workforce model that can be built.
- More information on the software that can be used for modelling.
- A step by step guide to the workforce modelling process introduced above.
- Tips on how to carry out the necessary engagement to enable effective workforce modelling.
- Example deliverables, and the system benefits, that can result from using a workforce model.

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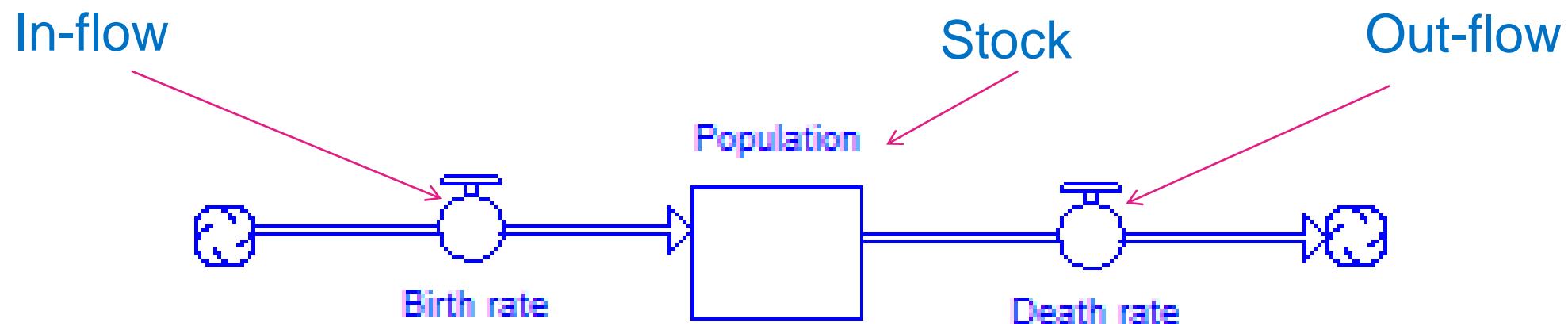
Introduction to Stella & System Dynamics Software

Aim: To share learning and enable health and social care organisations to benefit from the workforce modelling tools and approach developed by the London HLP Workforce Modelling team

London Workforce Programme

What is system dynamics?

- System dynamics (SD) is a way of visually representing complex systems and how the different parts relate to each other, before applying numerical values.
- The approach allows the relationships between different factors (cause, effect, impact, outcomes) to be explored over different time periods and geographical areas. SD has been widely applied as a problem solving tool across a range of disciplines from workforce planning to financial modelling.
- Systems dynamics models are based on a series of “stocks” and “flows” as shown below.
- A “stock” is a quantity that either grows or depletes over time, a “flow” is a connector that drives the increase or decrease.



What are the benefits

By testing different ‘what if’ scenarios, System Dynamics allows users to:

- Understand and analyse risks in different terms (e.g. cost and gaps between supply and demand)
- Design and test new strategies which can lead to improved outcomes
- Develop more effective structures, approaches and project plans
- Accelerate collective learning about potential behaviour and impacts of complex systems
- Model and test policy and program design options
- Analyse and improve business processes
- Understand program performance and sustainability
- Facilitate constructive dialogue among stakeholders
- Lead to strategic decisions that are realistically framed and more likely to accomplish their objectives.

What is required when using System Dynamics?

The key requirement of any system dynamics modelling project is having a clearly defined problem and scope. In most instances, it is not advisable to build 'general' models which look at systems more broadly.

Key considerations include:

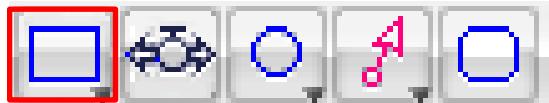
- Define who is/are the target audience or end user? Strategic or tactical purpose.
- What relationships drive system behaviours? Causal loop diagram (CLD).
- Start with a qualitative diagram of relationships in the system. This is an excellent means of building consensus on the structure and function of the current system.
- Quantifying these relationships; build the quantitative SD model.
- Flows control rate of change in the system (e.g. appointments per week) whilst stocks are the accumulations of 'things' that can be counted (e.g. GP headcount or FTE).
- Data collection and validation – using assumptions where necessary.
- Refine, test, validate and iterate – this should be a continuous process.

What is Stella?

- Stella is a systems dynamics software program produced by ISEE systems
- It follows SD principles and uses stocks and flows to enable the modelling of systems
- Further information about the tool can be found on the ISEE website:
<https://www.iseesystems.com/>
- A series of useful example models have been published on the ISEE website and can be accessed at:
- <http://xmile.iseesystems.com/>

What are 'Stocks'?

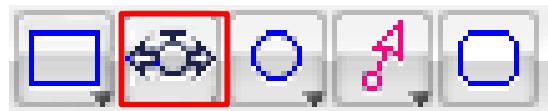
- In Stella, stocks are the primary way for holding the quantities that you want to track. For example, if you wanted to track the population over time you would use a stock to hold the population that you are tracking with flows to manage the people coming in and leaving.
- To insert a stock into Stella use the icon boxed below. This is found in the top left of the Stella window



- When you click on the stock menu you will see a dropdown appear containing stocks with alternative functionality. For the purpose of this introduction we will focus on the standard stocks.
- Three key points to note when using stocks are:
 - 1 - **They have memory.** Stocks will retain all inflows which means that if an inflow is cut off then the size of the stock will not decrease unless there is an additional outflow attached to it.
 - 2 - **Always note their units.** This helps to avoid confusion throughout a model.
 - 3 - **Only flows can be used to modify stocks.** These flows are regulated by converters and connectors.

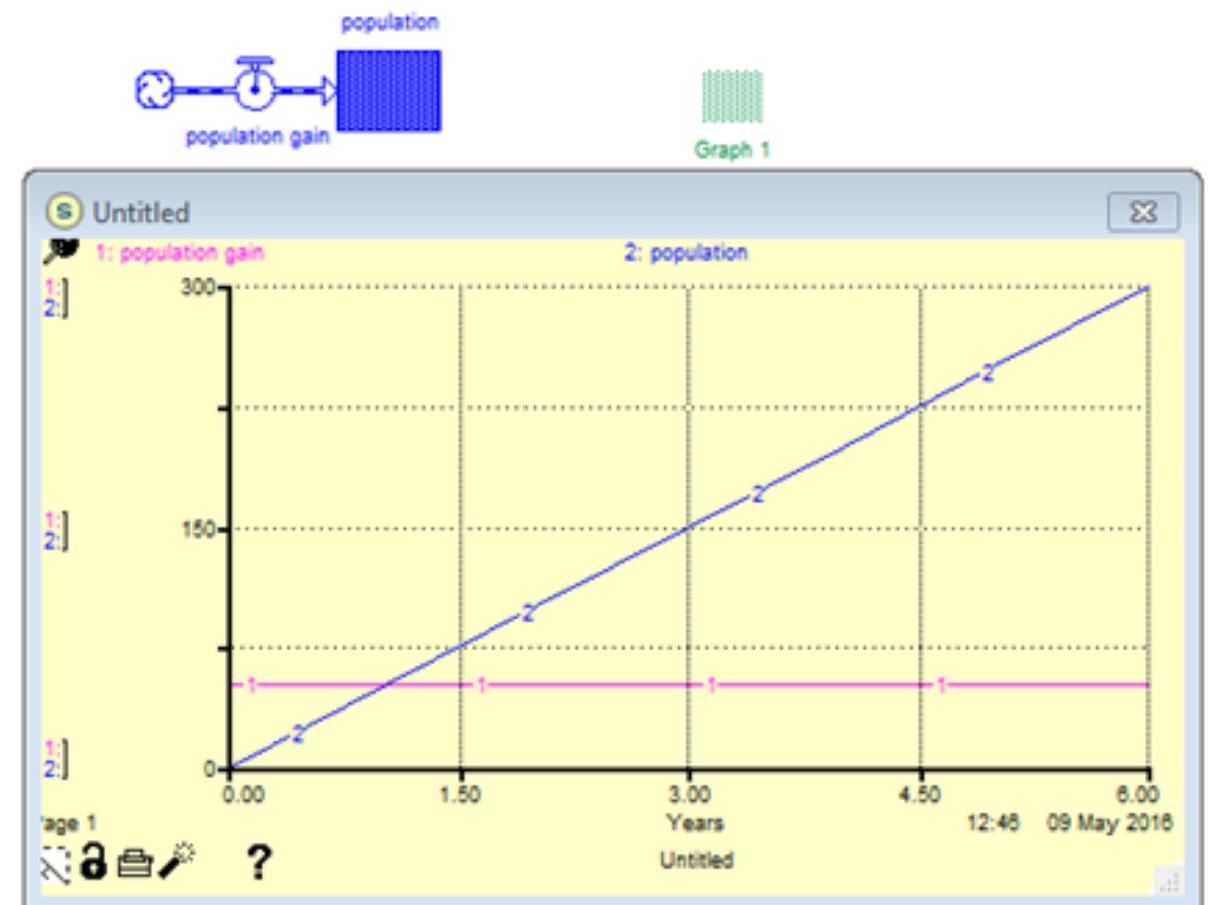
What are 'Flows'?

Flows are the only way to add to and take away from stocks. To insert a flow into Stella use the icon boxed below which can be found in the top left of the Stella window.



When you click on the flow, you will see two boxes drop down: one with 2 arrows, one with a single arrow. The flow with 2 arrows is a bi-flow and is used if population can flow either way between stocks; the single arrow represents a single direction of flow.

- To the right is an example of a simple stock and flow, with the resulting graph. In this example we have set the population to increase by 50 every year.
- In this the flow population gain is set to 50. So over 6 years the population stock increases to 300 (50 every year).
- Note how the population is equal to the integral of the population gain line (combined population gain over time).



What are 'Converters?'

Converters are used to apply changes to stocks throughout a model. Any equations or constants should always be put into a converter for easy model modification. To insert a converter into Stella use the icon highlighted below. This is found in the top left of the window.



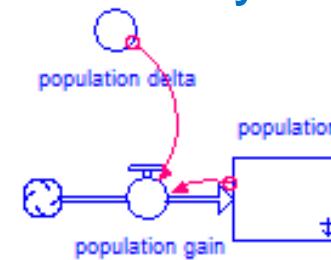
- When using a converter they must always be connected with a connector.
- Converters cannot be directly connected to a stock. They need to be linked to either another converter or a flow.

In this example we have set the population to increase by 20% every year.

This is achieved by setting the population delta converter to 0.2 and the population gain flow to $\text{population} * \text{population delta}$.

Note how population is now connected to population gain as it is included in the equation.

Now in the chart the pink population gain line is increasing with population.



Graph 1



How do I show my outputs in charts?

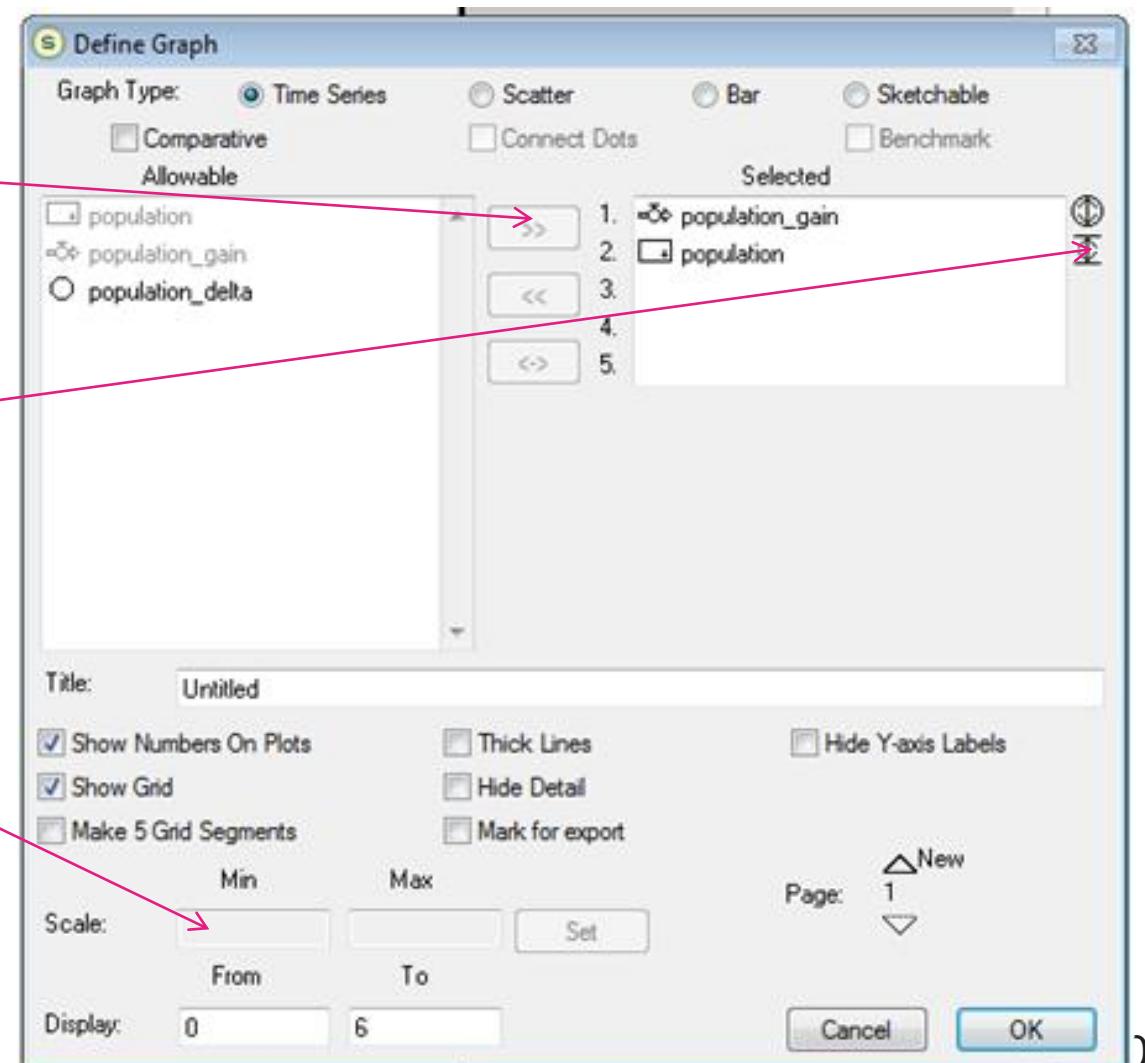
As seen in the examples, you can track the progress of a simulation using charts. Charts are inserted using the toolbar at the top of the page.



Once inserted, a green icon will appear which can be dragged around the page. Double click on the icon to bring up the body of the chart. To edit this double click again to bring up the define graph screen

To select the elements that you would like to show move them to the right hand box.

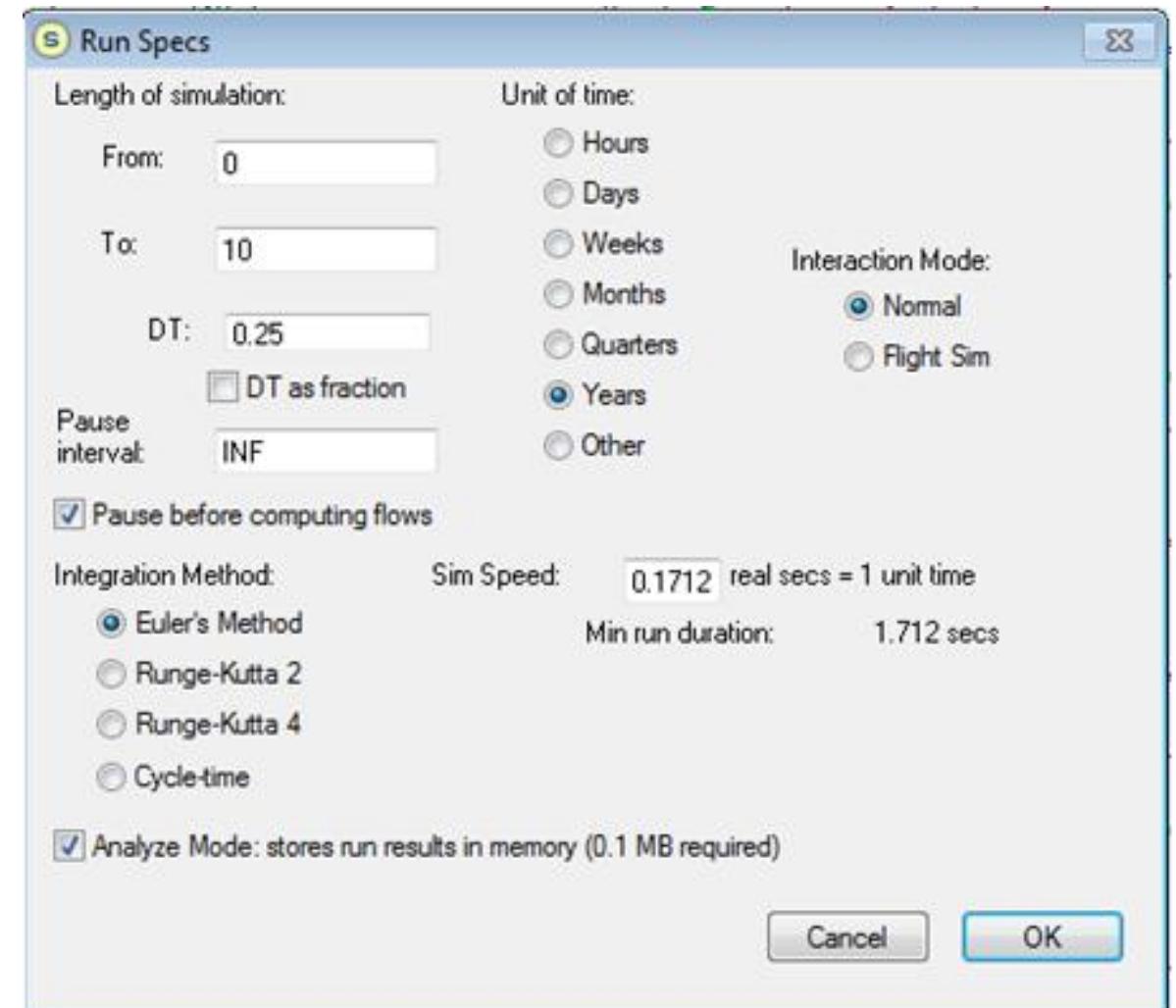
To adjust the scale of the series select them on the right hand side of the selected box and adjust the scale box.



How to run a model: The 'run specs'

Before a model can be run, the run specs need to be adjusted. This is done from Run > Run Specs in the toolbar.

- Choose the appropriate time gaps and from the unit of time column and the number of periods that the model should run for in the From and To boxes. Generally 'From' will always be set to 0, in the example here the model will run for 10 years.
- Sim speed can be adjusted in the Sim speed box, with a higher number slowing the simulation.



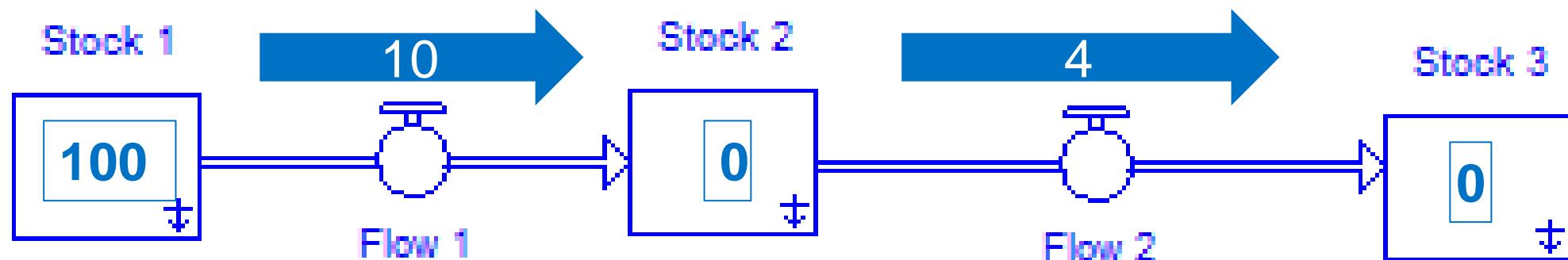
The model is run using the boxes in the bottom left corner of the screen.



Example 1 – Connecting Stocks

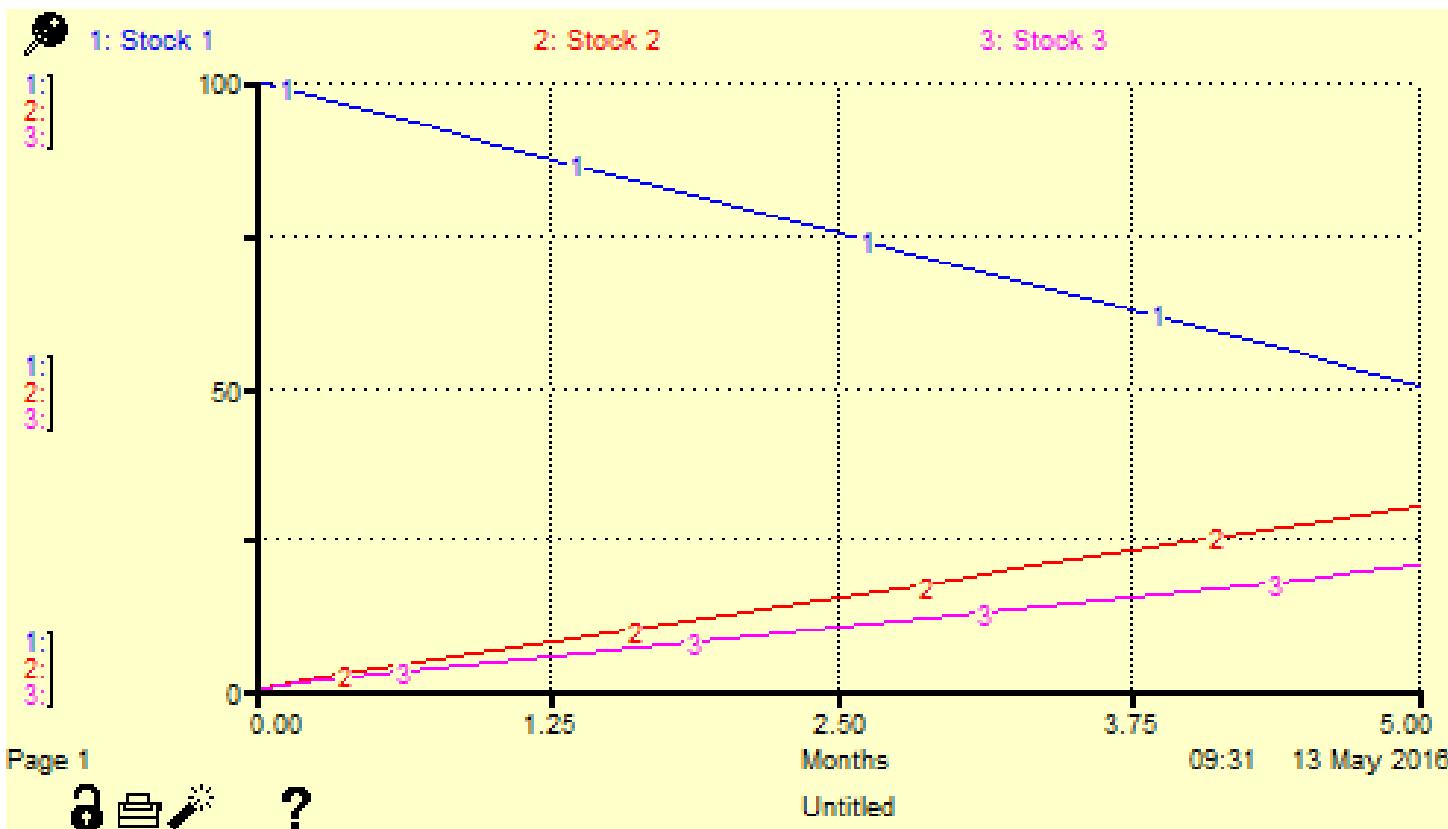
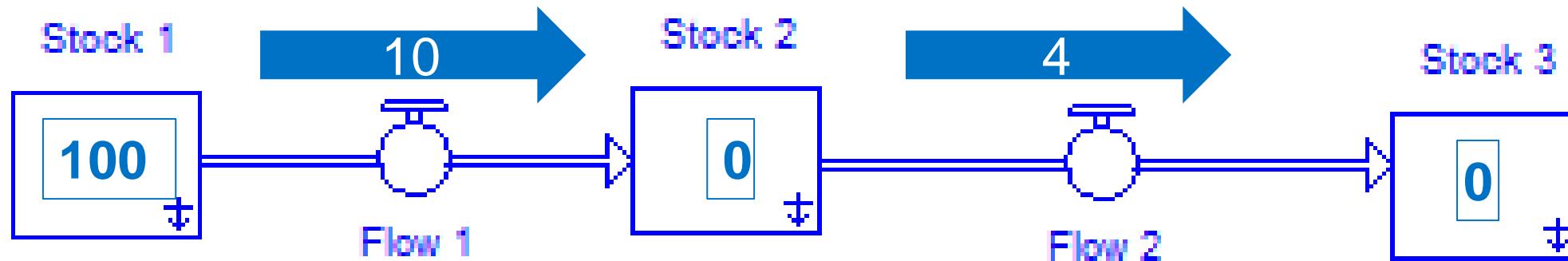
Example of how to build a simple model:

- When building a flow, stocks act as a 'break'.
- This means that when a quantity flowing through the model hits a stock it stops moving and stays there until the next iteration.
- In the Example below stock 1 starts of with 100 units inside; stock 2 and stock 3 are empty.
- Flow1 takes 10 units from stock1 to stock2, flow2 takes 4 units from stock2 to stock3.
- This is shown in the model diagram below.



Example 1 – Connecting Stocks cont'd

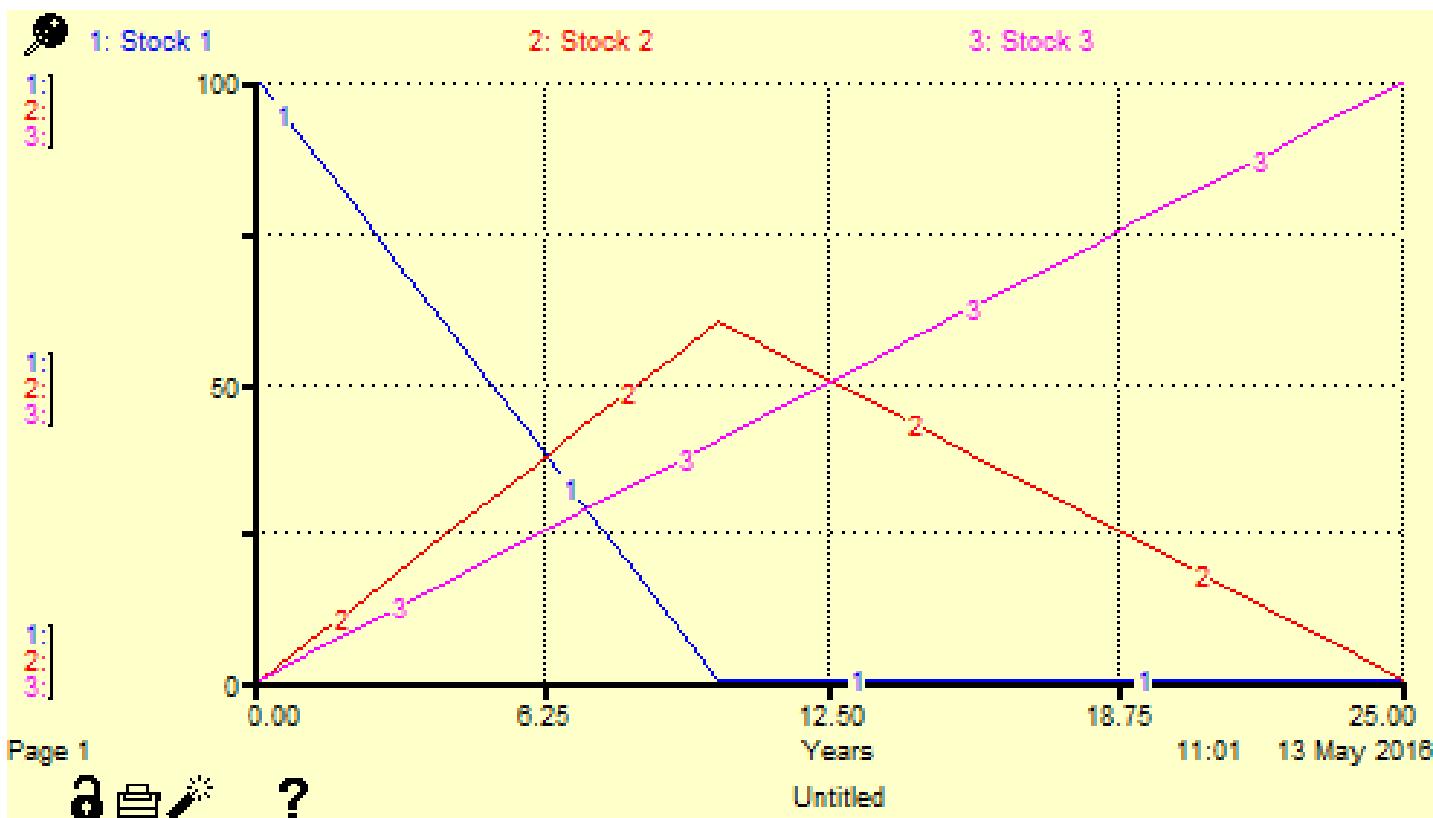
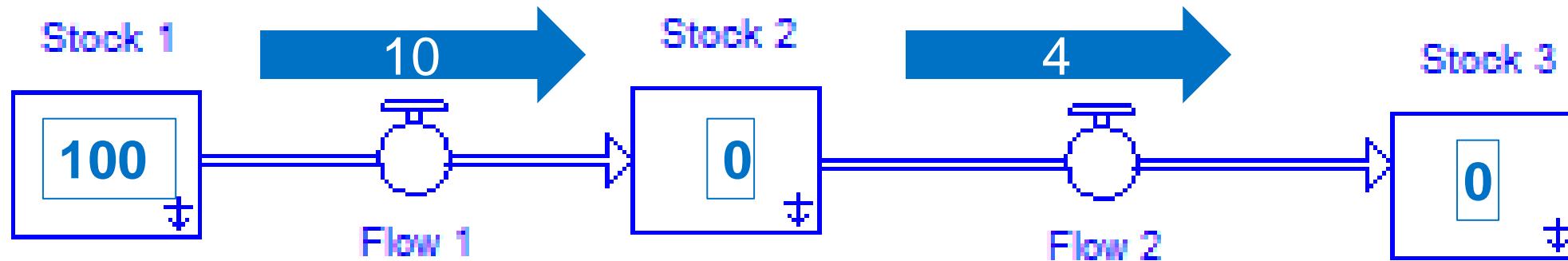
Example of how to build a simple model



- This graph shows 5 iterations of the model (months 0 to 5).
- This chart shows stock 1 losing 10 units per iteration, going from 100 to 50.
- Stock2 has a net gain of 6 per iteration, input of 10 from flow 1 but losing 4 through flow2.
- Stock3 has a gain of 4 from flow2.

Example 1 – Connecting Stocks cont'd

Example of how to build a simple model



- This chart shows what happens as the model progresses to 25 iterations.
- Stock 1 gets drained after 10 iterations and stops filling stock 2.
- Stock 2 then begins to be emptied by flow 2 until it is empty and all of the units are in stock 3 after 25 iterations.

03

Building a simple population model

Building a simple model

This section gives a step by step guide to building a simple population model in Stella

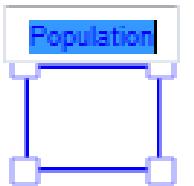
Step 1 – click the stock icon in the top right corner.



Step 2 – click on the worksheet to place a stock and the following will appear:

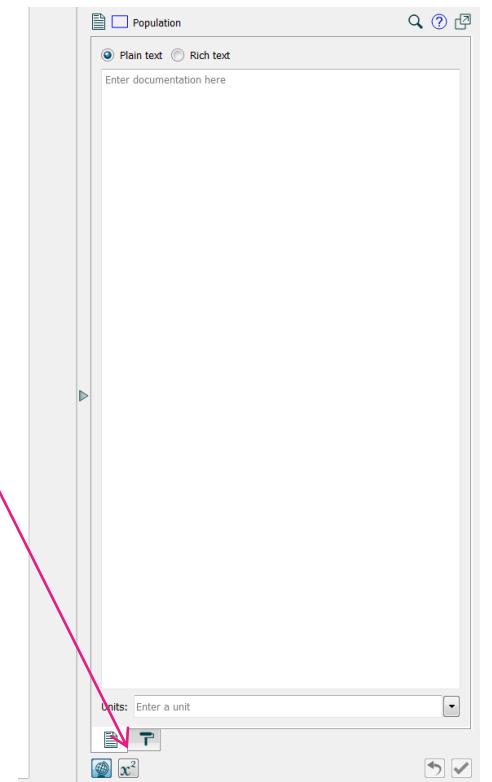


Step 3 – Rename the stock by clicking on the text above the stock.



Step 4 – Double click on the stock to bring up the data entry panel.

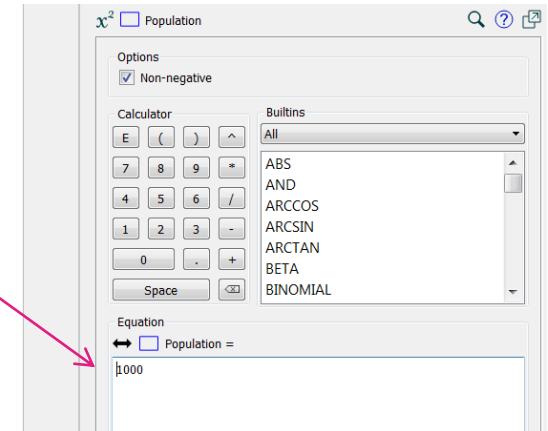
Step 5 – Select the numeric entry option on the data entry panel.



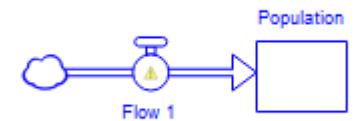
Building a simple model cont'd

Step 6 – enter the current population into the equation box.

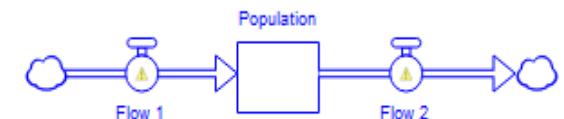
Step 7 – add flows to the diagram.



Step 8 - Do this by clicking to the left of the stock, holding the mouse button and dragging the arrow into the stock. This creates an inflow.

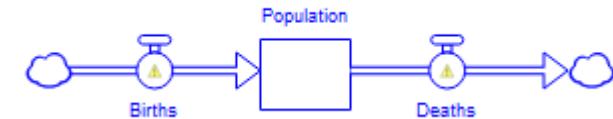


Step 9 – Repeat the step above except this time click do not click on the sheet but instead click on the stock and drag to the right. This creates an outflow.

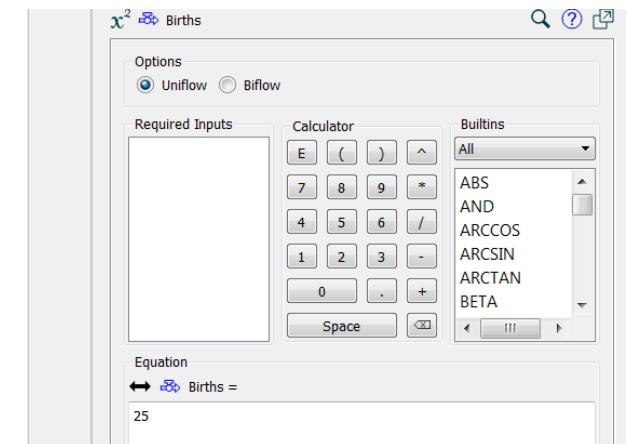


Building a simple model cont'd

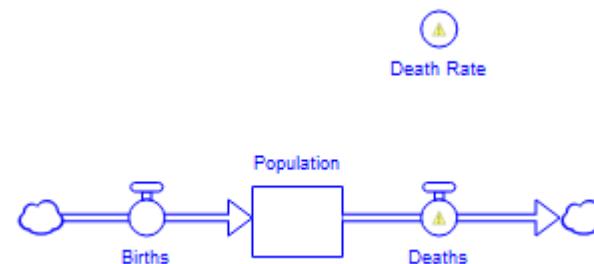
Step 10 – name the flows in the same way as the stock.



Step 11 – click on the 'births' inflow and add the estimated number of births in a time period.



Step 12 – add a converter to the model above the deaths flow and name it death rate.

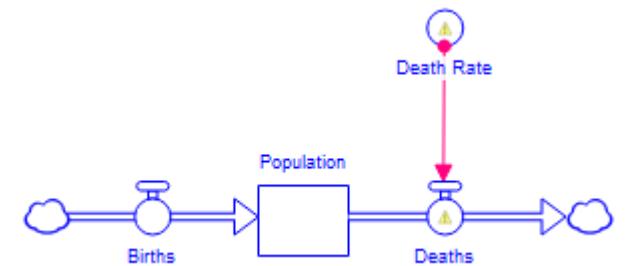


Building a simple model cont'd

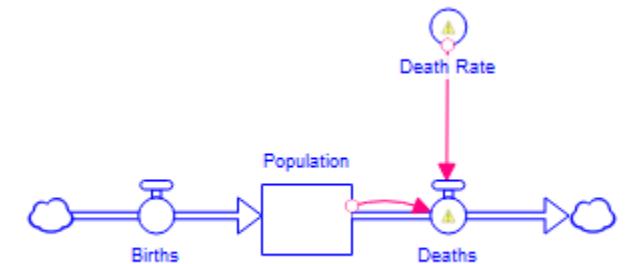
Step 13 – add connectors to the model. These will connect the 'Deaths' flow with the Population stock and the Death rate connector.



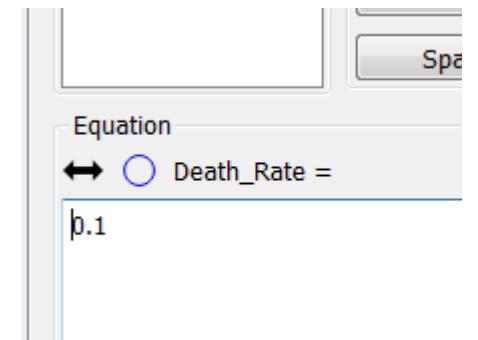
Step 14 - to connect the connector with the flow, click the connector icon, then click and hold on the converter and drag down to the flow.



Step 15 - to connect the flow with the stock, click the connector icon, then click and hold on the stock and drag down to the flow.

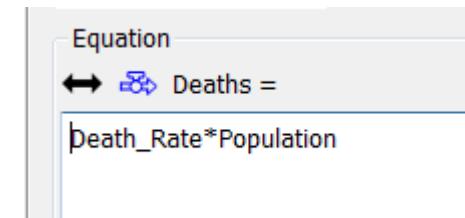


Step 16 – click on the converter and add the death rate into the equation box, in this case 0.1.



Building a simple model cont'd

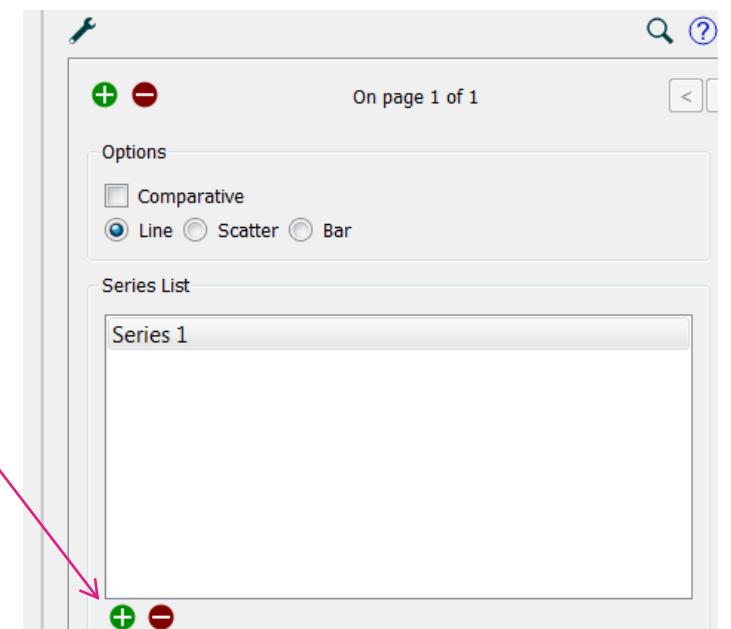
Step 17 – set the Deaths flow to equal the death rate multiplied by the population. Do this by clicking on the flow and setting the equation box to $\text{Death_Rate} * \text{Population}$.



Step 18 – add a chart to the model by clicking on the chart icon and then on the workbook.



Step 19 – double click on the chart to bring up the chart panel on the right hand side.



Step 20 – add data series to the chart by clicking the green + arrow. Add population births and deaths to the chart.

Building a simple model cont'd

Step 21 – now the “run specs” of the model need to be set. To do this, click ‘model’ in the top toolbar and select the “Run Specs” option from the dropdown. The Run Specs tile should appear to the right of the screen.

Step 22 – set the model to run for 5 time periods by changing stop time to 5.

Step 23 – run the model by clicking the arrow in the bottom left corner of the screen.



This will update the corresponding charts and tables you have created.

