

3.4 Build your own complex system simulator

One way of working on our systems thinking skills is by using simulation software. Thinking about how a system behaves and then simulating it using software to explore how interactions, feedback loops, accumulations and nonlinear relationships all contribute to the system's dynamics helps build our systems thinking skills. It's a little like working out at an online systems thinking gym!

There are a number of software programs that allow us to simulate systems behavior. The most commonly used programs in system dynamics are Stella and Vensim. We will be using a free, online browser based program called Insight Maker. The advantage is that there is nothing to install and it is easy to share your models.

First you need to create an account at insightmaker.com. Once you login, click on "create new insight" in the top right hand corner and then "click me to clear this demo model" to show a blank worksheet. You are now ready to create your first model.

We will build the model following the same steps as when we drew it. Let's first draw the stocks and the corresponding flows.

To create a stock, click on the "Add Primitive" menu and select "Add Stock". Double-click on the text "New Stock" and change the name of the stock to "Fish population". Click on the "=" icon that appears when you move your cursor over the stock to show the equation window of the stock. Key in "1000" for the initial value. Click on the "Unitless" icon and change the primitive units to "Fish". Click twice on "Apply". You now need to draw the flows. Click on the arrow icon that appears when you move your cursor over the stock and pull it out 3cm or so to the left of the stock. Click on the "reverse connection direction" icon on the top menu. Change the name of the flow to "births per year" and the units to "Fish per year". Now add two outflows and call them "deaths per year" and "catch per year".

To create a link between the fish population and the births per year, you need to first activate the links function by clicking on the "Links" button in the menu bar. Click on the arrow icon on the fish stock and drag it out to the births per year flow until the arrow becomes green. This means that the two variables are connected. We can round the links by selecting them, holding down the shift button and clicking on the middle of the link. A new circle appears that you can then pull on to bend the arrow. Add a link from the fish population to deaths per year.

We now need to add the variables that influence the flows. To create a variable, click on the "Add Primitive" menu and select "Add Variable". Double-click on the text "New variable" and change the name to "hatch rate". Change the value to 6 as we are going to assume that six fish are born each year per fish in the population. Change the units to "1/year" which simply means per year. We can now write the equation for the inflow as "fish population" times the "hatch rate". We do this in the equation window by selecting the appropriate variables that are connected to the "births per year flow" from those with a green cross next to it in the right hand column. Add the variable "carrying capacity" with an initial value of 1200 and units of "Fish". The variable "saturation" is the ratio of fish population to carrying capacity. Its units are fish per fish, so we leave the variable "unitless".

Now it's time to add a nonlinear relationship to reflect the change in the death rate depending on the saturation level. We use a special kind of variable called a "converter" to do this. Click on the "Add Primitive" menu and select "Add Converter". Change the name to "death rate" and open the equation window. The window is divided into two parts: above you have the chart of the relationship

between the two variables, and below you have a table to key in the data points. The “input” is the cause, which in our case is the saturation variable, and the “output” is the effect, which here is the death rate. Delete the three existing data points by clicking on the minus sign, and key in 0 for the input value and 5 for the output value. This means that when there are few fish compared to the carrying capacity, the saturation value is zero or close to zero and the death rate will be 5 fish per year. Now key in 0.2 for the input value and 5.2 for the output value. You can see that the death rate increases as the saturation ratio increases. Key in all of the coordinates and complete the model with the information from the additional materials below.

Once the model is complete, we can simulate it. Click on the “settings” icon and change “simulation length” to “20” and time to “years”. Click on the “simulate” icon to run the simulation. The value of the stock is plotted over time. You can change the output options from the “configure” menu.

When we run the simulation the catch per year increases linearly until the twelfth year when it levels off and then collapses. We can add some extra bells and whistles to our model to test different policy decisions. Open the right hand window and click on the “fraction invested” variable. All of the variable’s properties should now show on the right hand side of the screen. We are going to make a “slider” to make it easier to test the impact of different actions in our model. Change “Show value slider” to “Yes”. Change the “Slider Max” to 1; the “Slider Min” to 0 and the “Slider Step” to 0.05. Click back on a blank part of the screen to show the slider. You can now make changes to the “fraction invested” variable by changing the slider value and then re-running the simulation. Here for example, I have reduced the fraction invested by 0.05, or 5% to 0.15 which results in the fish population collapsing in year 16, rather than year 12.

Feel free to add some more sliders and explore the other features of the software. You can’t break anything and you will gain a better understanding of how the systemic structure works.