POPULATION MODELS

Deterministic: Roc Basic

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In this exercise, we're going to start building a spreadsheet model of Roc population dynamics.

And, remember, population dynamics is just a way of formalizing how populations will change over time. And they do that by increasing their numbers through birth or immigration, and they decrease their numbers through death or emigration. In the case of the rocs, they reproduce, and they have a clutch size, and so births are the way that they grow. There's no immigration into the population. The way that rocs die is they get shot by silver bullets. Other than that, they all die after they've reproduced, and so mortality doesn't enter into the equation.

We're going to basically build this model - and what we want to do is have a population size that is projected from the year 1000 to the year 2000. And we're going to have those numbers run down one of our columns. And so our model is going to be built on a time step, and we've talked about how that time step will be 1000 years.

Let's actually start our model, by just setting up what the model's going to look like, as far as years go. Click on cell A4, and enter the word ‘Year’. In cell B4, enter the word ‘Rocs’. And we said that our starting year was the year 1000, and we're going to project the population size through the year 2000. And there's a couple of ways we can do that, in terms of setting up the series.

And the first way is just to simply enter the next time step, 1100, in cell A6. And then we've started that series so take your mouse and highlight both of those cells. Put your cursor on the Fill Handle button, and then press your mouse down, and drag it down to cell A15, and release. And those numbers are automatically filled in.

The second way you can do that is to use a formula. In that case, you would - let's go ahead and delete these. And you can just increment your time step with the formula. So in this case, we'd enter equals [=] the time step before plus 100, to add 100 years. And now cell A6 has a formula in it. And, if we copy that formula down to cell A15, we generate our time series, with a time step of 100 from the year 1000 to the year 2000.

Now our goal is to calculate how many rocs will be present in each of those years, and so we're going to develop a model that will calculate that for us. What we said in the exercise (that Tony talked about), was that rocs grow through births and they die by being shot by bullets. Those are two key parameters of this particular model. Let's set up a place on our spreadsheet where we can signify what those parameter values are.

So in cell A1, enter the word “Clutch Size”, and in cell A2 enter the word “Bullets.” You can see how the word Clutch Size spills over into column B. We can change that, or fix that, by making the column width be larger by just grabbing the right side of that and then dragging over until we get the size we want. Now these are two inputs into the model, and so by convention we're going to color those green because they are numbers that will go - green for go - into the model. Select those two cells, and then go up to the Fill Color option box and choose a color green, and that will alert you to the fact that these are going to be model inputs that you can change.

We said in the lecture that the clutch size, on average, was 1.06 offspring per breeding roc. And we said that there were 20 silver bullets out there that are able to kill rocs that are trying to reproduce. Now our goal is to use this information in cells B1 and B2 in a formula that will allow us to project the population dynamics through time.

We'll start with the number of rocs in the year 1000 (and Tony said that there were 700). Now instead of us entering the number 700 here, we're going to turn that into another model input by writing the word ‘Initial Population Size’ in cell D1. We're going to again - let's stretch that out - and we're going to enter the number 700 in that cell and color it green, once again.

Instead of entering a number in cell B5, we're simply going to replace that with a formula that references what's in cell E1. And that's a really important thing to do because then, by changing this particular number, we can change and see quickly how the dynamics play out by changing our Initial Population Size. That is, we can see how sensitive the model is - the result, the final result - when we change of these input parameters. Let's put that back to 700.

And, of course, what we're most interested from this model is to know (because the caliph told us he wants to know is what the population size will be like in the year 2000), we're going to write the words ‘Ending Population.’ This is our key model output, and we're going to reference whatever the value is going to be in cell B15 as our answer. And right now, since there are no dynamics, the spreadsheet returns a 0 in that particular cell. This is a model output, and so I want to shade that differently than the model inputs, and I'm going to choose to shade it as a

color blue. Remember green are cells that go into the model - they're model inputs. And then blue is a model output. That's something that's calculated by the model, and it's a result that we're most interested in finding.

What we need to do right here now is to say, We know that there were 700 rocs in the year 1000. How many rocs will there be in the year 1100?

We're going to need to enter an equation that computes that number for us. And then, once we have that equation written, we can take the handle and drag it down, and that will be our projection of population size over time.

PAUSE the video: What do you think the equation should be?

Well, we want to calculate how many rocs are in the year 1100 by computing the number of rocs in the previous year that were not shot. So I'm going to take how many rocs were in the previous time step, subtract off those that lost their lives due to a silver bullet, and I'm going to put that term in parentheses. And this represents the number of rocs that are able to breed. Each of those breeding rocs produces, on average, the clutch size that's represented in cell B1. And that is our population model - it's that simple. If I press Enter and then calculate and pull this down, I will have the projection through time.

Before I do that though, let's look at that formula up in the Formula bar and think about what's going to happen if I copy this value all the way down. When I copy this down, I want the population dynamics to always reference the number of rocs in the time step before, so that should be a relative reference.

However, when I calculate clutch size or bullets, I always want to go to cells B1 and B2. And so those need to be anchored and turned into absolute references. And, if you're working on a Windows-based machine, the fastest way to do that is to put your cursor directly on the cell of interest and press the F4 button, which will go ahead and add the dollar signs automatically. So there I've done B1. And now I want to anchor cell B2. And I press the OK button. Now my formula can be dragged down because, as I drag it down, this formula means the number of rocs in this time step is the number of rocs in the preceding time step, which is a relative reference. Minus, go to cell B2, and subtract off how many were shot by bullets. And then take that whole term and multiply it by the clutch size, which is always given in cell B1. So now I'm

ready to copy this down, and there we have our population projection of rocs, based on these values that are entered in the cells, in green.

Now one thing I want to do is, these are numbers, and so I want to change the format of these numbers by going up to the Ribbon and selecting a format and changing it to Number and then choosing the Decrease Decimal button and changing the decimal points to zero. Now all that does, is changes what you view on the spreadsheet. Those decimals are retained in the calculation so there's no rounding error involved in this.

Now the nice thing about spreadsheets is that because your formula are referencing these cells, that as you change a cell value the spreadsheet is automatically updated. And that's the beauty of spreadsheets - is that you can quickly perform what's called a Sensitivity Analysis, and see how changes in these inputs will ultimately affect your key output.

And actually while I'm hovering over this key output - I'm going to change that to a number as well - and decrease the decimals.

What most people find very useful is to actually graph these results, and so that's what we're going to do now.

To make a graph, we're going to select the cells that are in the model. And we go up to the Ribbon and choose the Insert tab, then choose a Scatter graph that is connected with lines. We're given a graph, or a chart, that Excel automatically computes for you.

Now one thing you want to do is label all of your axes and label your titles. We're going to have a little bit of cleanup work to do right here. When you click on the graph or the chart, you can see up here on the Ribbon there's some different layouts that are available to you - and if you press this button you can get a whole bunch of different layouts.

Well, we need a relatively simple layout - layout one. And so I'm going to choose that, and now there's a place for me to enter my Axis Title for the Y Axis and an Axis Title for the X Axis. Let's go ahead and enter the correct titles. Just click on the title word, and use your mouse and start typing. On the X Axis we have ‘Year’, and on the Y Axis we have ‘Number of Rocs’. Our title similarly - just click on the Title box and start typing. I want a little bit more informative title for this graph, and so this could be ‘Roc Population Size Over Time’.

Now let's do a little bit more cleaning up here. In the bottom, we have a model that projects population size from the year 1000 to the year 2000. There's no need for us to display the information from zero to 1000 or even beyond 2000. Let's click on that Axis, then right-click and choose the option called Format Axis. This dialogue box appears, and what you can see here is that there's a Minimum Axis Value and a Maximum Axis Value. And you can also change how the units in between those are displayed. By default, they're clicked as Auto, and what we want to do is change those to Fixed Values. And we want the Minimum to be 1000, and we want the Maximum to be the year 2000. And we click Close, and those changes are now reflected in our chart.

What about this Axis? Right now the numbers go from 0 to 1200, and I can see fairly clearly how the population dynamics change over time.

Watch what happens if I change the bullets from 20 to 0. You see how the Axis changed automatically? What if I make the clutch size 1.5 instead of 1.06? This changing Axis, I think is sometimes tricky and problematic because it's really difficult for you to compare different scenarios by having and comparing two different graphs where the Axes are fixed over time. That lets you really clearly see and compare two different scenarios.

I think it's important for you to fix the Axes on both of these, the X and the Y Axes, on a chart in Excel. Let's move this back to 1.06 and move our bullets back to 20. But now let's click on the Y Axis, the vertical Axis, then right-click. And again, go to Format Axis and choose Fixed for the Minimum and Fixed for the Maximum. And we want to display 0 as the minimum, meaning the roc population went extinct. And let's go ahead and graph the Maximum to be 2000.

There are other options in this dialogue box that you may want to explore.

And now I have both of my axes fixed. I have my axes labeled. If I change parameter values, the axes stay the same, and it lets me more clearly see how the dynamics of the population are changing, as I change these input parameters.

Let's save this file. And choose a spot where you're going to recognize where to find it. And we're going to call this particular model ‘Roc Population Model’. This is saved as an Excel Workbook [xlsx] , and just click Save.

Now let's return to Tony, who's going to be talking about what do you do with a model like this, now that you have it up and running.

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