Elephant Model with Sensitivity Analysis

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Note: This spreadsheet exercise was developed using Microsoft Office Excel 2010.

Welcome back. By now you've been playing with your spreadsheet a bit, and that's great. That's one of the values of having a spreadsheet model, is that you can very quickly change your inputs and then study how those affect your outputs.

Tony gave us two tasks for this exercise. He asked that first we explore how changes in this initial age distribution will affect lambda. So let's look at that one first.

We populated and started our model by seeding the number of calves at 40, the number of 1, 2, 3, 4, and 5 year-olds at 20, and all the other animals and age classes at 4, four individuals per age class. And then we recorded our final lambda as the last lambda calculation in the model. So here we are at time step number 80. What we've learned is that the final lambda for this particular model, for these inputs--and yours might look a little bit different at this point--was 0.96273.

Our first goal is to ask, "How do changes in these numbers affect the lambda outputs?" Tony suggested that we change the number of animals that were age 10, and we just make this some different number. I'm going to change this to 20, and let's see what happens to our graph down here.

The initial lambda values really change quite a bit, don't they? But let's focus our attention on what happens down at this portion of the graph. I'll change it back to 4. Even though we can change the numbers of animals, in some cases, dramatically, the initial dynamics play out those initial instabilities in the age structure. But as the model is run over and over and over again, as long as these values stay the same across the model run, what happens is that the lambda values flatten out. And that the long-term value of lambda is called the 'asymptotic' lambda, and this value becomes stable over multiple model generations.

So that's an important concept when you're dealing with populations and making an assumption of whether the population is in this stable age distribution or whether it has some funny dynamics that you need to really be careful about if you're modeling a population with short-term dynamics.

So that was our first task. Feel free to put your video on pause and play around with this as much as you want to and prove to yourself that this actually is the case.

<u>PAUSE the video</u>: Experiment with your spreadsheet.

Let's reset our model as we had initially. So there are 4 animals in each age class greater than age class 5. Our second task was to calibrate our model. And we were given the challenge to calibrate our model to match the growth rate of the population as if it were not managed. Do you remember how Tony said to do that?

Well, he said that there were 7,000 animals - the population's being maintained at this number. And he mentioned that every year, 400 animals are removed from the population. So if we did not remove those animals, then we would expect that the population size would be 7,400 in the next time step.

Now we have all the information we need to calculate lambda. It's the number of animals in time step t + 1 divided by the number of animals in time step t. And we see that this is a lambda value of 1.057, so it's an increasing population. And it's increasing at a rate of 5.7143 percent per year.

Our goal is to calibrate the model such that we end up with this value, 1.057, in cell E2. And we're going to calibrate it by changing the entries here that are in green, the calving interval, which then calculates into fecundity. We won't touch the proportion of offspring that are female. We can increase the survival rate of calves, and we can increase the survival rate of the rest.

Let's start by just making these entries, the calving interval and the survival rate of the calves, be as optimal as we can, so that they increase the value of lambda in cell E2. If we want to increase lambda, then we want to set the survival rate of calves to be as high as it can be. And earlier, we said that the survival rate of calves could be as high as 0.9. So let's enter 0.9 in cell B4. And that boosts our lambda up a little bit.

What should we do with the calving interval? The calving interval can be between 3.1 and 3.3. Should we make it 3.3 or should we leave it at 3.1? We should leave it at 3.1, because we want these females to give birth as frequently as possible in order to increase the lambda. So we'll leave it at 3.1.

That gives us one more parameter to play with. And what we're aiming for here is to find a value that will increase the lambda so that it matches 1.057. Go ahead and put your video on pause and find that number now.

PAUSE the video: Work on your spreadsheet.

How'd you do? Well, if you put in 0.99, you'll find that we'll get very close to our estimate, final lambda of 1.05. And you'll see these numbers are pretty much on target. This is an amazingly high survival rate.

This is a pretty simple problem. In some cases, you'll be dealing with a model where you need to calibrate your model but the answer won't be quite so clear. And there's a tool that we can use to help calibrate our model in a spreadsheet, and that is called 'Goal Seek'. You can find this tool under the Data tab, and then go to the What-If Analysis. Click on the arrow, and then find Goal Seek. A dialogue box appears, and it has three arguments.

This is a pretty simple tool to use. First, we want to set some cell, and in our case, we want to set cell E2 to a particular value. And here we'll just type in what we want that value to be, 1.057143. The last argument is by changing cells. But we know that these are set at their optimal rates already. So the only cell that we really have left to play with is this survival rate of any animal besides calves. We press OK. And it says that Goal Seek found a solution. Its target value was 1.057143 and it found a value of 1.05735. It changed the cell B5 to 0.99.

So let's just recap what we've done so far. Our goal in this video is to model the population size in the absence of culling. We started off with a problem that there are 7,000 elephants. To maintain that number of elephants annually, 400 animals are removed. If we assume they're not removed, that gets us to 7,400 animals. We calculate lambda, and that provided us with a lambda value of 1.057, or a 5.7 percent annual increase. We have some parameters that are used to drive this model. These inputs feed into this final lambda output. We selected the most optimal value for the calving interval, as well as the survival rate of calves. That means we have just one parameter left to play with. That's the survival rate of the rest.

We used Goal Seek, or entered values in by hand, and we found that the survival rate of the rest needed to be 0.99 in order to generate a final lambda of 1.057. So now that our model is calibrated, we're in a position to start adding some management options to this particular model.

You'll want to save this spreadsheet, because we're going to be using this in our next set of tutorials in the next week. We'll see you next time.

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