DECISION ANALYSIS

Erewhon Model, Part 3

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recorded: January, 2010

Exercise: Saving the Endangered Species of Erewhon or Plants at Last

You've already explored how to solve the Species of Erewhon by graphing and finding the graphical solutions. Now, we are going to show you how to use a spreadsheet to solve this problem. And it's a tool within the spreadsheet called 'Solver'.

Now, if you think back to the first parts of the problem that Tony introduced, he said that we wanted to maximize the total number of plant species that were conserved. And we can do this by purchasing any number of valley hectares, and any number of highland hectares. And that combination we wanted to be maximized, but under the constraints that we've discussed.

We need to add a new output, and that would be the actual number of Species Conserved. And so let's go ahead and enter that in cell G6. And remember, that this is different from this in row 5, which we had used to say what combination of Highland and Valley would generate 100 species. And this line we used to move through our solution space.

In this case, we're not going to use that approach. We're actually going to calculate how many species would be conserved if we were to actually purchase Highland or Valley hectares. So for example, I entered in cell D3 that we purchased one valley hectare and ten highland hectares. Now, we need to enter an equation into cell D6 that would calculate how many species were actually conserved. What would that be?

PAUSE the video: What equation would you enter here?

It's just the number of hectares conserved in the valley, times the number of new species in the valley per hectare, plus the number of hectares conserved in the highland. And then for each of those hectares, how many species do we gain. And that is our equation there.

So for example, if we have 1 hectare in the valley and 10 in the highland, the 10 in the highland each conserve 3 species. We're up to 30 species conserved. We add 1 hectare of valley. And that gives us 5 more species, and so our result is 35 species. This is a model output, so let's shade that blue. And what Tony had mentioned is this is the value that we want to maximize. Now, before we go further, we want to do one thing that might help this problem be a little bit more understandable. And that is we want to name our cells. We've done this before, but let's just review this as well. To name a cell, we would just simply click on the cell itself, and then drop up here into the name box. Then, click on the value and just type in what you'd like to call that cell. Let's call cell D3, 'Valley'. Then press Enter. And now, when we reference this formula, it's going to say Valley as opposed to D3. And then let's name cell E3, 'Highland'. Press Enter. So you can see that the name has been correctly entered. And let's go ahead and provide some extra things as well. Cell D6 is the 'Valley Edge Effects'. Since names cannot have spaces we'll use underscores to separate our words. The 'Highland Edge Effects' is going to be in cell E6. Political Considerations - it's not really necessary that we name those. Let's go ahead and label cell D8 the 'Social Upheaval Index for Valley'. And we'll label cell E8 the 'Social Upheaval Index for Highland'. And we'll go ahead and label cell D9 'Valley Cost', and cell E9 as 'Highland Cost'. You'll see where this comes into play in just a second here.

So at this point we are going to go ahead and invoke Solver. As I said, Solver is a tool in Excel that can handle these optimization problems in a linear context. You've already installed Solver, so now just head up to the Data tab, and then choose the Solver button. When you do, a dialog box appears. This is the Solver dialog box, and all of these together constitute your objective function and the constraints.

So, let's just overview this whole dialog box to begin with. We want to set some target cell to a maximum/minimum or to a particular value. So for example, if we wanted to say, let's find, and we want to conserve 200 species, we could click on this radio button, and enter the number 200. In this case though, we want to set cell J6 to a maximum. We want to maximize the number of species conserved. And we are going to let the spreadsheet do that by changing the values listed in cell D3 and E3.

If we pressed Solve now, then it would not really find a solution because we have not added any constraints. Down here is the section where we are going to add our constraints. And we need to add quite a few constraints, because this problem has a lot of constraints.

So what were those? Let's just take those in order. The first constraint was that the number of valley hectares needed to be greater than cell D6. Press the Add button. And our cell

reference is the number of valley hectares conserved must be greater than or equal to the number of Edge Effects provided in cell D6. And we press Add.
Now let's go ahead and enter in the constraint for the highlands. The total number of highland hectares conserved must be greater than or equal to the value in cell E6. So that takes care of our edge effects.

Now we have to enter our equations for Political Constraints. The number of valley hectares conserved must be less than or equal to, 2 times the number of highland. We click Add. And also, the number of highland hectares conserved needs to be less than or equal to the value in cell D3. That takes care of our Political Constraints.

We press Add. Now we'll add the Social Upheaval Index. And we'll enter this again as an equation here. The number of highland hectares conserved must be less than or equal to, now instead of entering this as we have here in the spreadsheet, we're going to again reference the cells in our input area. We can do this with open parenthesis. Cell J3, which is our maximum social upheaval, minus the social upheaval score for the valley, times the number of hectares conserved for the valley; that whole thing divided by the social upheaval per hectare for the highland. And that one equation handles the social upheaval Index.

Note: could also simply be $D$1*$D$8+$E$1*$E$8<=$J$3

Now we need to add a Budget constraint. Our Budget constraint is down here. The number of highland hectares must be less than or equal to the total budget, minus the cost per hectare for the valley, times the number of hectares conserved in the valley. That whole term divided by the cost per hectare in the highland. That takes care of our budget constraint.

Note: could also simply be $D$1*$D$9+$E$1*$E$9<=$J$3

Now we need to deal with our Upper Limit. Our valley purchases need to be less than or equal to, and here we entered the equation 350 divided by 5. So let's stick with these inputs up here. That will allow us to change these inputs and use Solver again easily.

And our last constraint is the same for the Highland. The highland upper limit is less than or equal to, the highland hectares conserved must be less than or equal to E4 divided by E5.

Now those are all my constraints. And if I press OK, what you see is the dialog box, and your constraints are entered here. Here's where the naming helps out. When you enter an equation that uses the named cell, the actual name of the cell is recorded. And so if you would like to you can go ahead and provide names for every single one of these boxes. And so these become more or less word equations. And this is something that is always so useful, is to turn your mathematical equations into word equations.

Notice that there are many of these, and you might have to use your scroll bar to see all of your constraints. You can choose a constraint, and you can change it, or you can delete it, you can add new constraints by pressing this button.

There are some options for running Solver. And you can find those by pressing the Options button. And what you see here are some of the options for running Solver. We'll have a separate tutorial on this, but for right now, you need to choose the button Assume Linear Model. And then press OK.

And now when you press Solve, Solver is going to use the Simplex Method and will find the optimal solution for how many highland and valley hectares should be conserved. When you do this, Solver will find the solution. All constraints and optimality conditions are satisfied. And we'd like you to choose the report called Answer Report, because Tony will be walking us through this Answer Report right after this video.

When you are finished, press OK. And you can see that Solver found this solution: 60 units in the valley, 30 units in the highland. The total actual species conserved was 390.

Now let's see how this solution compares to this line as we move this line up through the solution space graphically. We'll start going by 200, 300, 350, 375 or 380. Now we've past each of these corners now, and the only corner left to get to is this one right here. Let's go ahead and put 390 in. And you'll see that that solution perfectly intersects this line. And at that location we have 60 units of valley and 30 units or hectares of highland. I'm going to drop this back to 0 just so that we can un-clutter our graph.

That is the solution that Solver had found. Notice that we didn't really need any of this graphical information at all. We could have solved this spreadsheet problem strictly by entering these values, and then really understanding the entries that need to go into the Solver dialog box.

When Solver runs and does an analysis and you ask it to provide an Answer Report, the Answer Report is provided as a new Sheet. If you click on the Answer Report, you'll see that this provides some information about the actual solving of that particular problem.
This is a Sheet that we would like you to look at, and have handy, when you go through the video you are watching with Tony next. Because he'll talk about what the 'slack', and what the 'status' actually means. These other things are fairly obvious. It tells you what cell you want to maximize. It gives you the original value and the final value. It tells you what cells you have adjusted, what the original and final value were. This is the section that we need to go ahead and focus on next.

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