

## NICE TO KNOW

# **Purpose-Oriented Models**

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I want to tell some stories that illustrate the differences between some of these models, and the setting I'm going to use is South Africa. And in particular I'm going to talk about the Kruger National Park, which is one of the largest parks, if not the largest park in southern Africa.

For many years, the management strategy in the Kruger National Park was to control the buffalo population. They had determined during a very serious drought back, I think, in the 1950s or 1960s that if the buffalo population were too high and there was a serious drought that one might end up with animals dying in large numbers with all sorts of possibilities for disease and other nasty side effects. So after that, every single year they used to do a complete total census. They used to fly over an area the size of Massachusetts and count every single buffalo. And on the basis of that census, they would decide how many buffalo to kill. And they would kill buffalo by removing whole herds in such a way as to maintain the age structure and maintain the sex ratio.

Some years later they discovered that the cost of the census was too high. And they came up with the idea that they would fly the census every four or five years. But perhaps use a model to predict what was happening to the population between censuses and use that model to decide how many elephants to kill each year.

Now, buffalo are fairly sensitive to rainfall. Rainfall produces long grass, which is what buffalo like to eat. So the model would have to be stochastic. One wants to be able to put in the probability that the rainfall will be low, medium or high. And perhaps have different survival rates and calving rates depending on rainfall.

Since they are maintaining the sex structure, there's no need to model both males and females. One can just model females. But since one's looking at how changes propagate through the population from one year to the next, the age structure of the population is important. So you would probably want an age structured stochastic female population model. And this is what we developed for the Kruger Park.

Having developed it, we presented it to park management to show them what the model could do. Now, an elderly manager who was about to retire caught me at lunch time during the presentation and said, "You know, we were' running this model for four or five years. I really would like to run it for a hundred years." And I said, "Why?" And he said, "I'm not convinced we really need to manage buffalo in the way in which we are currently doing it. And I would like to see what happens if we run a model for a hundred years without management." And I said, "I'm sorry, I can't do that." And he looked very disappointed and he said, "Why?" And I said, "The model wasn't designed for that purpose. The model was designed to simulate the population for a period of four or five years."

Now, remember the very first diagram we developed when we were talking about modeling. It was the idea that you go from the real world to the model world and then from the model world you develop your model. And remember that the model world is designed in terms of the objective you have in the real world. So the model that we had been talking about for buffalo had this objective of predicting forward not more than four years. What happens if you want to predict forward a hundred years? Well, there might be all sorts of things that happen that you wouldn't normally worry about in four years. And certainly you might not be interested in some of the detail that you want to have when you are looking at a period of four years.

So let's think about what one would put into a model if one did want to run a model for a hundred years to ask the question - do you really need to manage the population, or not?'

I sat down with this manager and redesigned the model. And the model ended up looking very much like the roc model. In fact, the roc model grew out of this exercise.

You would want to keep track of just the total population. The age structure wouldn't be that important if you were looking over a period of a hundred years. But you would want to consider interesting effects like extended droughts. So, for example, speaking to the manager who had a lot of experience, he said, "You know, I believe you can on occasion get population crashes in your buffalo." A population crash might occur if the population was unusually high, if you had a high density of buffalo. And you had two or more years of severe drought. So one could build into the population model something that says, if the population is below threshold, don't worry about the effect of drought, except in the ordinary way in which drought reduces the growth rate of the population. But if you have a high population and two or more years of drought, then remove 30 or 40% of the population in a crash. It's kind of equivalent to roc flu. And from your

stochasticity of dry years, wet years and medium years, you would get a certain frequency of droughts that overlap two, three or four years.

When we put that into the model, we produced results that looked like some of the long-term record, not on paper, but as remembered by this manager who had been in the area for 30 or 40 years. And what came out of a one-hour spreadsheet modeling exercise with total population, stochasticity and the drought crashes was that you didn't really need to manage the population except when it got very, very high and there was a danger of a crash. And that could change the whole way that managers think about how to deal with that population. In other words, a one or two-hour modeling exercise can reset the parameters for management objectives. And to me, it was a tragedy that in the Kruger Park for 30 or 40 years they had followed a certain management regime without doing this kind of speculative modeling to say, gee, let's think out of the box. What might happen if we did this instead of that?

Okay. The story isn't finished. We now have two buffalo models. We have the age structured female model, which was used to predict forward one to four years. And we have the total population stochastic model with crashes that was used to look at what might happen over hundreds of years.

A few days after I'd been working in the Kruger Park I had a phone call from a manager at a small game park close to Kruger, and the conversation went something like this... he said, "I believe you have a buffalo model. I think it might be useful." So I said, "Well, actually I don't have a buffalo model. I have two different buffalo models. What is your problem?"

And his problem was something like this. His game park was a very small game park. It was being managed to attract well-heeled tourists who would spend a lot of money there. And it was surrounded by a very poor rural community, and they were hoping to get some of the benefits from running this game park. One of the benefits they got was that the predator population in the park was kept relatively low, so they used to cull some of the herbivores. And that would provide meat to the community. Another was that they got jobs. And they got some of the income from hunting, which was allowed on a limited basis in the park. And from tourists coming to high-class hotels. They wanted to keep their buffalo population at a fairly low fixed level. And they wanted to allow trophy hunting of buffalo. And their definition of a trophy was a buffalo male aged eight or more. The question was, if they were keeping their population fixed at, in this case 200 buffalo, should they be removing young females or older females in order to

keep it fixed? And these would sell as meat. And would it make a difference in the number of trophy bulls they got out of the population?

So I said to them, "Different objective, different model." And I spent a day with them developing a model for their purpose. Now, think about it. Age structure is going to be essential in this model, because we're talking about removing younger females or older females. And because a trophy bull has to be eight years or older. Keeping males and females separate in the model, keeping track of them separately, is essential. Because we are removing females to keep the population constant, but we are trying to calculate the number of trophy male bulls. But the model doesn't have to be stochastic because the density of the population in the park is so low that it doesn't particularly matter whether there's a drought or not. They're going to be able to find enough food.

So we developed this model for them, and it turned out that there was a small advantage in removing young subadult females as opposed to older females. You probably got 10% more trophy bulls. Getting that out of the model enabled them to say, "Gee, we really need to think through the economics of this. What's the economic value of removing a young female? What's the economic value of a trophy bull? What's the economic value of removing an old female?" So it was a small step from the spreadsheet population model to a resource economics model, which enabled them to make a better decision.

The point of all of these stories, is there is no such thing as a general buffalo population model. Change your purpose, you change, generally speaking, the design of your model. Each model needs to be designed specifically for that purpose. So instead of having a generalized population model, or even a generalized buffalo population model, one has a suite of purpose-oriented models. And one understands when to use which model when.

This is in direct contrast to the idea of let's produce a package, let's produce a package that is stochastic at the individual level, and then we can model anything we like. That kind of package might enable you to model anything you like. But the expense of it, not in computer time, but in terms of understanding what you're doing and explaining to people what you're doing and getting people onboard to whatever management decision comes out of the model is extremely high. I'd rather have a series of pointed, purposeful models than one all-purpose stochastic individual-based model.

Finally, here's one more example of a different problem or a different objective needing a different type of model.

More recently, bovine TB was detected in some of the buffalo herds at the south end of the Kruger National Park. How would one go about designing a model to evaluate management options for controlling this outbreak? If you think about it, none of the models we have talked about so far would really work here because this is one situation where one really does need to have a spatial model. It makes a difference whether a buffalo herd is in an infected area, is adjacent to an infected area or is far from an infected area.

So again, different objective, different problem, different model, even though we're still talking about buffaloes.

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