

Introduction to Mathematical Modeling

Professor:

Dr. Joanna Bieri

joanna_bieri@redlands.edu

OFFICE: DUKE 209

Project 2 Introduction

Most species of wild cats are endangered, including the bobcat. Scientists estimate average annual growth rates, $r = b - d$, where b is births and d is deaths, for bobcats under best, $r = 0.01676$, medium, $r = 0.00549$, and worst, $r = -0.04500$, environmental/reproductive conditions. For this project start by assuming that growth rates are constant from year to year. You can consider each growth rate as representing a different region, some regions offer better protection and more abundant food supplies. In general the medium growth rate is a good overall estimate, while the best and worst rates can be used to estimate error and define a region of certainty. We also know that there are currently about 300 bobcats, however these animals can be hard to track and count so this number could be off by ± 10 animals.

The Wildlife Management Agency (WMA), who organizes research and enforces management laws, has a goal to protect the bobcat population and better understand the effects of poaching. Currently poachers are killing the animals for their fur, and they harvest about 1-2 animals per month, this rate of poaching is included in the r values above. The big problem is that poaching is increasing because of recent budget cuts that have reduced the number of enforcement officers from 50 to 25. Each enforcement officer can cover about 5% of the total bobcat habitat during their 8 hour shift, with half of the officers patrolling days and others nights. With this change, poaching is now taking at least one additional bobcat per month. They would like you to investigate how this additional loss is affecting the population? How much additional poaching can the population sustain without going extinct? How sensitive is the population to this poaching?

Another aspect of the problem is that an outside conservation group, We Love Bobcats (WLB), has decided that they have the resources to raise bobcat cubs in captivity, although only a few young adults can be added to the population each year. If poaching were happening on an increased frequency, how many bobcats would the WLB need to add to the population to keep the animals from dying out? Is this feasible? The WLB has also offered to volunteer to report poachers to aid the WMA. Can you give a reason-

able estimate for how much the additional volunteers will need help? Keep in mind that the volunteers may not be as effective as the trained officers. You could also brainstorm other methods to help stop poaching (wildlife cameras, fund-raising to hire more officers, educational programs), but please add a discussion of the cost, assumed effectiveness, etc of these measures.

Project 2 Specific Goals

Your first goal in this project is to write a spreadsheet model that describes the current population for each of the growth rates without the addition of poaching or help from the WLB. This gives you a simple starting point (baseline) for your model it tells you what would happen if we did nothing.

Then use your model to decide what the possibilities are for the bobcat population with poaching, given the restrictions and help from the two organizations. Think about your model results and try to give the WMA and WLB a complete report of possible outcomes along with what you believe is the best solution for the bobcats.

Type up your final report discussing all of your findings so that both the WMA and WLB can understand your model and your professional suggestions. Make sure to thoroughly describe your model, mathematical analysis, error, and assumptions so that both groups can reproduce your findings and use your results. Try to come up with a good management plan or two that would be most effective (and with reasonable costs) for the groups to implement.

Some Hints

- Re-read ALL of this information and the checklist for a good model a few times while running your model and writing up your results. Make sure you are addressing all the issues.
- Brainstorm first: Make an outline of the steps of your model. Make a checklist of all the questions that you need to answer. Make a to-do list and a plan for the group so that everyone is on the same page. Communication is really important in group work!
- Look back at class notes when doing your formulation. Make sure to explicitly state all of the important assumptions in your write up. There are assumptions that we didn't explicitly state in class, can you come up with any of these? Someone not taking the class should be able to understand your model and why it makes sense. In your write-up make sure to explicitly write out your recurrence relation and draw a compartmental diagram for your model(s).
- Here are some steps that you might use in creating your model:
 - In your final write up you will want to come up with a single general recurrence relation/model that includes ALL of the parameters that you will eventually use. You can always set extra parameters to be equal to zero when considering the different cases.
 - First you should construct a spreadsheet tracking three model bobcat populations, each initially consisting of 300 individuals, over a period of 25 - 50 years under the three types of growth rates without poaching or hatching. This gives you a baseline along with some idea of the error in growth rates. Plot all three simulations on a single graph. The graph should have time on the horizontal axis, it should have a legend identifying which curve is which, and the style should have each curve identifiable. Make sure to label your graph and reference it

in the text. Explain in words what your graph is showing. Try shrinking or expanding the number of years so that your graph is easy to read and gives as much information as possible.

- After you have your baseline, then add the poaching and management strategies to your model and reconstruct your graphs. It might help to look at longer time periods. Check if your results change when you change the initial population, growth rate, poaching or helping rates.

NOTE: When copying and pasting graphs into Word make sure to use the EDIT/PASTE SPECIAL command and past your graph as an image. If you don't do this the graph will be linked to the spreadsheet and change when you run different parameters.

- I do expect some mathematical analysis of the sensitivity, robustness, fixed points and stability for your model.
 - You should submit your spreadsheet along with your paper, but you don't need to include screen-shots of you spreadsheet in your paper, you can summarize it in your write-up. Only put the most interesting and informative information in your write up. If you need to give some data to show numbers use a table that prints clearly on one page or less.
 - I would like a discussion of possible error in the model or what you would change. Creativity counts!
- Make sure that you comment your spreadsheet and that each member of the group is emailed a copy of the spreadsheet so they can use it in future assignments. Make sure that everyone understands all of the steps in your model and reads all parts of the write-up. If different group members have different ways of doing the modeling try to incorporate both models into the write up as possible options for the management groups to choose from.