Activity 5.1: No Problem!

In this activity you are introduced to the first two steps of the modeling process. You will also begin modeling the moose problem by defining the problem and deciding which policy strategy to explore first.

PART I: PROBLEM FORMATION

The situation encountered in the Preparation Reading forms the background for the models that will be developed in this chapter. Decisions made in building those models will determine what mathematics is used to describe the model. Like most real-world problems, however, the question, *what IS the problem?* is hard to bring into focus. Some general steps that people go through when modeling situations can help guide us in forming a problem. In fact, the modeling process begins with this first step:

> **Step 1:** Identify a situation. Notice something that you wish to understand, and pose a well-defined question indicating exactly what you wish to know.

A well-defined question means that you have clearly thought out what you need to find. It also means that when you find it, you do not need to look for something else instead. It may not be obvious to you at first, but here is an approach that can help to form the question.

1. In your groups, discuss the situation described in the Preparation Reading. List anything that you wish to understand. (In brainstorming the situation, it is best to include many different ideas, thoughts, and questions, no matter how unlikely they might be or whether you think they take you in the wrong direction!)

From the group of ideas you gathered in Question 1, some are important for analyzing the situation with the moose. Other ideas are not as important. To be a good modeler, you need to figure out which questions will help the commissioner make his decision. For example, you may have identified the question, *who was given the survey?* But that has little to do with whether to spend $1.3 million to move moose into the park.

The art of posing the right question can often move you straight to the heart of the matter. Mathematical modelers take time to simply think about what they want to understand. The next question asks you to do that as well.

2. From the list you compiled in Question 1, identify all the questions that might be useful to the commissioner in advising the governor on

whether to spend the \$1.3 million. If you have more than one question, assign a number to prioritize each of them (with 1 being closest to the central problem).

Finding what is central to a model is complicated by the fact that some questions need more information, or other questions answered first. For example, to answer the question, *are the bears predators for the moose?* you need to find out how fast bears and moose can run. There are other factors that could explain the change in the moose population. It is an interesting question, and maybe even important, but it is not the central question.

3. The following questions may have been identified in your group (or class) discussion of the moose situation. In each case, determine whether the question focuses on the central problem, and provide an explanation for your answer.

    a) Why did the moose population die off? How did it restore itself naturally?

    b) Is there enough vegetation to sustain the extra moose that would be moved into the park?

    c) Could the same goal of establishing a colony be accomplished by moving less than 100 moose into the park?

    d) How many moose will eventually be in the park?

    e) How healthy are the moose that would be moved into the park?

Your work in Question 3 helped identify the central question for the models that are being developed in this chapter. In order to state it as a well-defined question, it needs to be further refined. Models often state the question in such a way that mathematics can be used to get an answer. Our work will eventually lead to the use of equations. We will want to predict an outcome from something that we know. The next two questions examine the factors that will eventually become the explanatory and response variables for our models.

MODELING NOTE

A model can be based on an understanding of the context alone, and does not always lead to the use of an equation. Often, concern about variables occurs much later in the modeling process. However, to make our central question well-defined, these factors are being considered now.

4. Here is what we know so far: There were 15–20 moose in 1988, 25–30 moose in 1993. The proposal is to bring in an extra 100 moose.

    a) In the 5-year period from 1988 to 1993, what quantity actually changed, and how is it related to our central question?

    b) How might the decision to bring extra moose into the park affect the amount of change for that quantity?

    c) If you want to build a model to predict something based upon the central question, what would you want to predict?

5. To make a prediction, you need to specify some condition. From the information provided in Question 4, what other quantity is changing?

6. Look over the work done in Questions 2–5. Write a well-defined central question using the quantities that you just identified.

A well-defined question means that there is no confusion about the task. The problem should be clearly and simply stated. The situation we are describing can be defined by the question, *how many moose will be in the park, if no additional moose (or if 100 additional moose) are moved there?*

But even that question is too broad to be well defined. Are we talking about five more years into the future? Twenty-five years? Surely the time period will affect what answer we get for the question. The conservationists who suggested moving the moose into the park in the first place used a 20-year time frame, and predicted a population of 1300 moose. Since the life span of a moose is 15–23 years, it is reasonable to see what happens to the population during one generation. In fact, we will find that decision to be a critical one in building the model. So, the problem can be refined even further by asking this question instead, *how many moose will be in the park at the end of 20 years, if no additional moose (or 100 additional moose) are moved there?*

PART II: ASSUMPTIONS FOR THE MODEL

Once the problem is well defined, the next thing is to simplify the situation and identify the key features of the problem. In the general description of the modeling process, the second step is:

> **Step 2:** Simplify the situation. List the key features (and relationships among those features) that you wish to include for consideration. These assumptions—the ones that simplify the situation, and the ones that incorporate the key features—are what your model is built upon. Also note features and relationships you choose to ignore for now.

Using simplifying assumptions is like playing make-believe with the problem. They make the situation easier to understand, even if it becomes less realistic. Putting simplifying assumptions into a model can even make finding the solution to a problem *possible*. The best part is that it is okay to do this, as long as the assumption becomes part of the model!

It can also make it easier to do the mathematics. For example, the conservationists had suggested moving 100 moose into the park over a three-year period. It is a simpler problem to consider moving them all at one time, at the beginning of the 20-year period. (You may want to return to this assumption in the future and explore the effect of changing it!)

7. One way to simplify the moose situation is to assume that none of the moose die.

   a) How does making that assumption simplify the moose situation?

   b) What argument can be made that the moose do not starve to death?

   c) What argument can be made that the moose will not die of old age?

   d) Does making that assumption mean that none of the moose actually die? Explain.

One additional assumption is needed before moving to Steps 3 and 4 of the modeling process, which will be explored in the next lesson. In this situation, the key feature should explain why the moose population changed at all. In that sense, Adirondack State Park is not very different from your hometown; think about where you and your classmates have lived.

8. Give some likely reason to explain why the moose population went from:

   a) 0 (prior to 1980) to 15–20 (in 1988).

   b) 15–20 (in 1988) to 25–30 (in 1993).

Having additional facts about the situation might help determine what caused the moose population to change. This, in turn, would help identify the key feature for the model, which would become one more assumption to make for the model.

9. Here are some facts about moose, which are reproduced in Handout 5.3.

   - Moose are the largest living members of the deer (Cervid) family.
   - At birth, a moose calf weighs 24–35 pounds.
   - Moose can survive in snow up to $3\frac{1}{2}$ feet deep.
   - A Canadian bull moose may tower seven feet tall and weigh up to 1800 pounds.
   - Young bulls are more likely to travel far from their birthplace, and are sometimes driven away by stronger bulls.
   - The only predator of the moose in Adirondack State Park is the black bear.
   - Many deer carry a parasite that is benign to deer, but usually fatal to moose. The deer pass the parasite larvae to foliage that is eaten by snails. Moose may consume the snails while eating plants.

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- Well-developed moose antlers may weigh 55–75 pounds.
- The average life span of a moose in the wild is 15–23 years.
- A moose can gallop up to 35 mph for short distances.
- Moose do not tolerate prolonged temperature above 75°F.
- An adult moose consumes 35–60 pounds of plant materials daily.

Using Handout H5.3, place a checkmark next to the factors that most likely explain why the moose population changed over the five-year period from 1988 to 1993.

MODELING NOTE

It is natural to want a model to be as realistic as possible. That may make it so complicated that only an expert can do it. Here is a strong recommendation when beginning to work on a model: K.I.S.S. (Keep It Simple, Silly!). You'll *always* be able to put more details into it later!

The role of the key feature here is to suggest an explanation for why the population is growing. The facts and information that relate to the situation should support it. You want to compare what you *think* is going on with what you *already know* about the problem. Some things that you think are obvious may need to be ignored at first, especially if it is simpler to do so!

To review the key information that we have found about the moose so far, the main facts (and their source) are summarized in the **Figure 5.1** table:

Key information	Source	Details
One way that moose populations can grow	Preparation Reading (DEC policy survey)	"…favor a gradual increase in the population from migration…"
Another way for moose populations to grow	Preparation Reading (same survey)	"… an expansion of their numbers through natural reproduction"
How did the moose get there in the first place?	Preparation Reading and Question 8	0 (prior to 1980) to 15–20 (in 1988)
Was it a fluke, or is there a pattern?	Preparation Reading and Question 8	15–20 (in 1988) to 25–30 (in 1993)
Territorial behavior of moose	Handout H5.3	"Young bulls…likely to travel far …sometimes driven away…"

Figure 5.1.

10. We have already assumed that there are no deaths among the moose, and no decision has been made yet about moving more moose into the park. There are two possible key features already identified—migration and natural reproduction.

    a) If migration became the key feature, a new assumption would be that any change in the population was due to moose migrating into the park. Is there evidence to support the use of migration as the key feature? Explain.

b) If natural reproduction were the key feature, the new assumption would be that any change in the population was due to baby moose being born to moose already in the park. Is there evidence to support the use of reproduction as the key feature? Explain.

c) At this point, which one seems *simpler* to use as the key feature: migration or reproduction? Explain.

The direction for our modeling work is now set. There is evidence to support the use of migration as the key feature. In the beginning, the moose had to migrate into the park anyway. Young bulls are more likely to wander from their birthplace. If there are only males in the population, it is impossible to make babies. There is no evidence yet that any babies have been born into the park. Even if a female is found there, in such a large park, with only a handful of moose anyway, it may not be possible to get a "date" on Saturday night!

We will use the following assumptions to build a model for determining the number of moose in the park after 20 years:

- There are no deaths among the moose population.
- If the $1.3 million is spent, 100 moose will be moved into the park at the same time.
- Any other change in the moose population will be caused by moose migrating into the park.

It remains to be seen if this model will actually describe the problem best, but it is a very positive start.

Activity Summary

In this activity, you:

- were introduced to the first two steps of the modeling process.

  Step 1. Identify the situation, and describe it with a well-defined question.

  Step 2. Make assumptions, both key ones to explain what is going on, and other ones to make the situation simpler.

- defined the central question for the model being developed, regarding the moose in Adirondack State Park.
- examined information about moose behaviors and made decisions about what key feature to include first in the model, and what simplifying assumptions to make about the problem.

DISCUSSION/REFLECTION

1. What is the central question for the model being developed?
2. What simplifying assumptions have been made about the real problem?
3. What key feature will the first model use to explain *why* the population is changing?

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