ACTIVITY 2

Scientific Models and Scientific Questions

DATA ANALYSIS

As environmental conditions change, scientific models are used to predict what may happen to species such as polar bears.

2 : SCIENTIFIC MODELS AND SCIENTIFIC QUESTIONS

GUIDING QUESTION

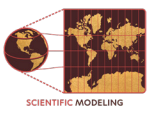
How are scientific models used to answer scientific questions?

INTRODUCTION

Imagine if New York City was moved over 800 kilometers (500 miles) south of where it is now. That is essentially what happened in terms of climate when, in 2020, the U.S. government reclassified it from a coastal temperate zone to a subtropical zone. Such changes are happening globally, and they are affecting many species.

The average annual precipitation in New York City has increased over the past 50 years, sometimes resulting in flooding.

CONCEPTUAL TOOLS



MATERIALS LIST

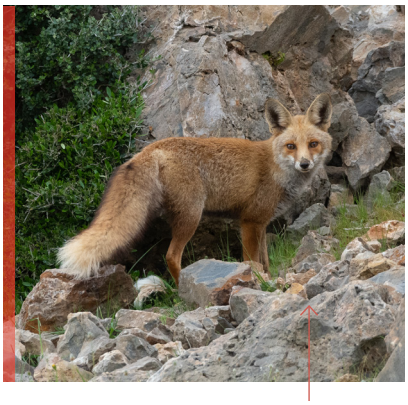
FOR EACH GROUP OF FOUR STUDENTS

- SET OF 4 SCIENTIFIC QUESTION CARDS
- SET OF 4 SCIENTIFIC MODEL CARDS

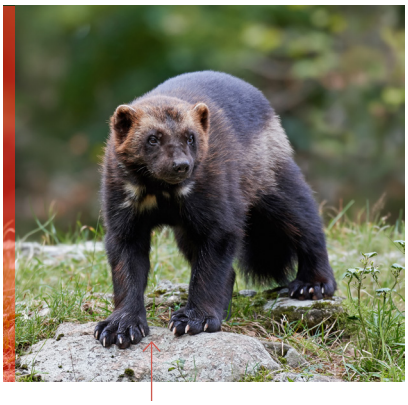
FOR EACH STUDENT

- STUDENT SHEET 2.1 "Investigating Scientific Models"

Some species are unable to adapt, resulting in population declines. For other species, environmental shifts are driving changes—in diet, location of breeding grounds, and even timing of egg laying. For example, the range of the red fox has expanded as new regions become suitable habitat. The range of other species such as the wolverine has decreased with population declines.. Many scientists are studying species distribution, the pattern of occurrence of a species within a geographic range. They are using scientific models to predict what the future might look like.



The red fox has a widespread range that includes parts of North America, Europe, Africa, Asia, and Australia (where it was introduced in the mid-1800s). With a warming climate, its range is expanding into new regions that were previously too cold.



The range of the wolverine is primarily in the subarctic areas of the northern hemisphere, and it can be found in northern regions of Canada, United States, Europe, Russia, and China. A decrease in spring snowpack is one factor contributing to its population decline.

PROCEDURE

PART A: UNDERSTANDING SCIENTIFIC MODELS

1. Each person in your group will read about one of the following four scientific models and describe it to the rest of the group. Each model is based on factual information.

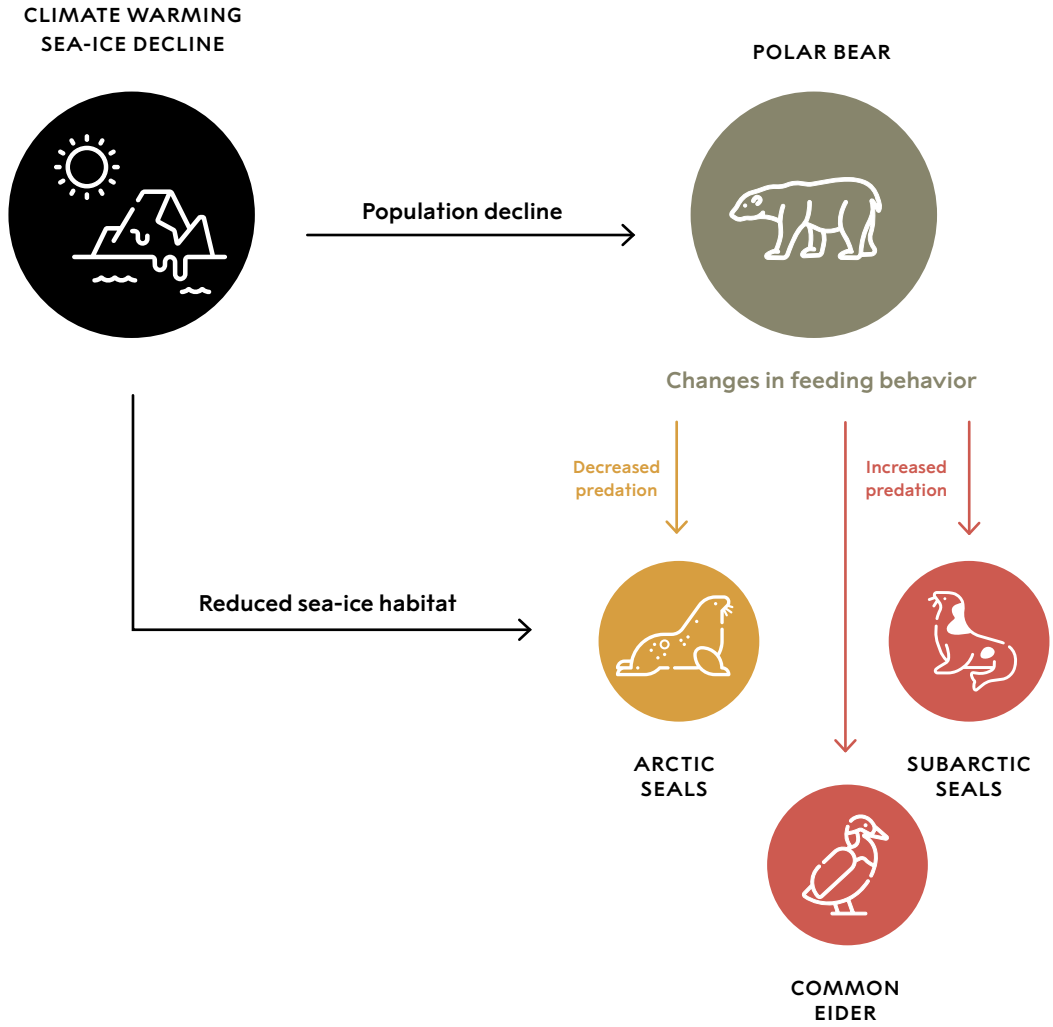
2. Read and analyze your model and record your ideas in Table 1 on Student Sheet 2.1, "Investigating Scientific Models." (Do not complete the final row of the table, "Scientific question," at this time. In Step 4, your group will think of a scientific question for each model.)

SCIENTIFIC MODEL 1

POLAR BEARS

Scientists constructed a model to predict the most likely ways that climate change will affect predation by polar bears (*Ursus maritimus*) in the Arctic, as shown in Figure 2.1. Long-term observational data and environmental data on atmospheric and oceanographic conditions were used to build the model. This model predicts both positive and negative impacts on other species. The positive predicted impact is less polar bear predation on Arctic seals. The negative predicted impact is more polar bear predation on subarctic seals and common eider ducks.

FIGURE 2.1
Model of Predicted Climate Change Effects on Polar Bear Predation
Arrows show relationships.

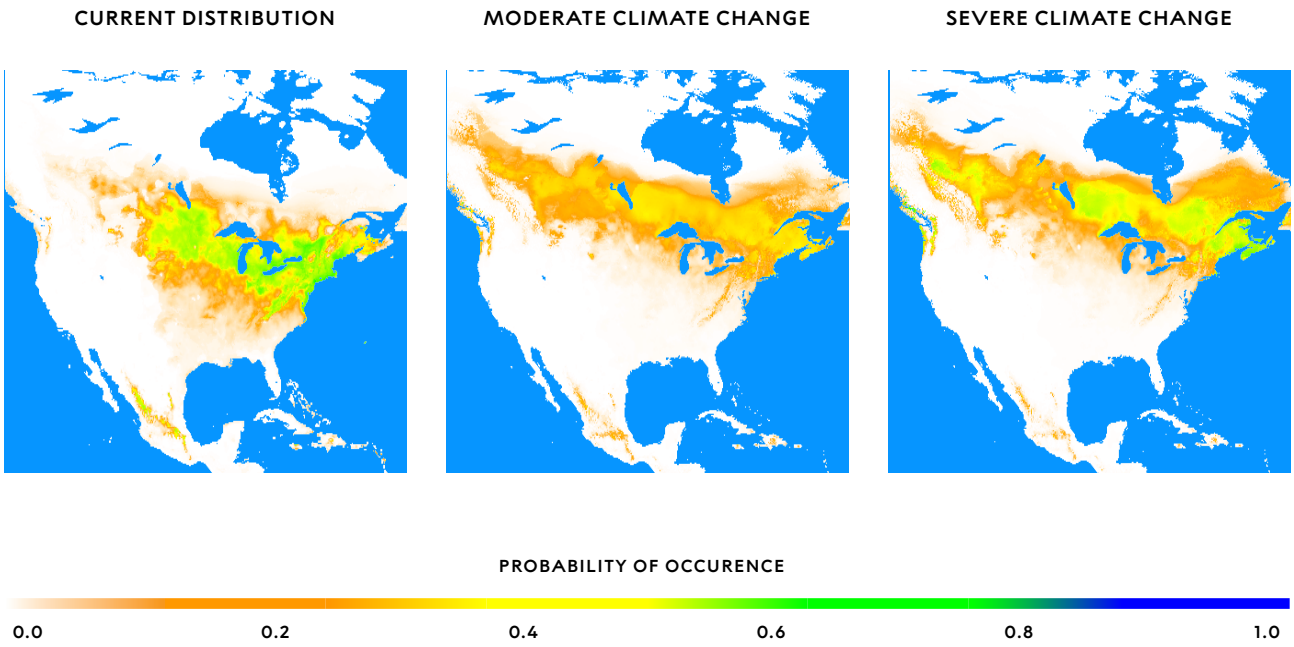


SCIENTIFIC MODEL 2

MONARCH BUTTERFLIES

Scientists are using computer software models called Species Distribution Modeling (SDM) to predict where a species might live in the future. Monarch butterflies (*Danaus plexippus*) migrate between Mexico and the United States, heading north in the summer and south in the winter. In one study, SDM was used to predict the future distribution of monarch butterflies under three different climate scenarios. The model combined data on historical butterfly distribution with food availability for butterfly larvae. These inputs were used to predict future habitat suitability in June. As shown in Figure 2.2, the geographic range is projected to move northward.

FIGURE 2.2
Predicted June Monarch Butterfly Distribution from SDM Model

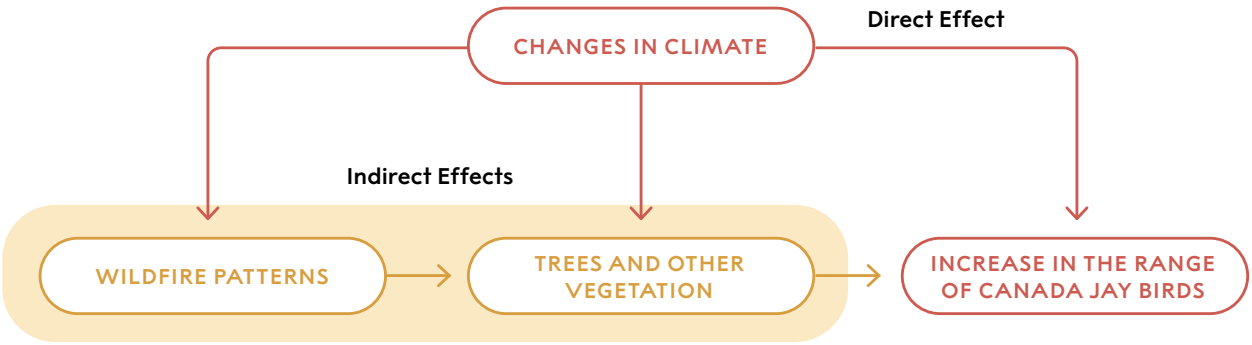


SCIENTIFIC MODEL 3

CANADA JAYS

Scientists constructed a model to predict the most likely ways that climate change will affect the distribution of Canada jay birds (*Perisoreus canadensis*) in northern Canadian forests, as shown in Figure 2.3. This model compares both direct and indirect impacts of long-term changes in temperature and precipitation. Directly, climate change affects bird populations by impacting their physical health and their ability to reproduce. Indirectly, climate change alters the environment by changing wildfire patterns and the vegetation on which the birds rely.

FIGURE 2.3
Model of Predicted Climate Change Effects on Canada Jay Distribution in Northern Canada

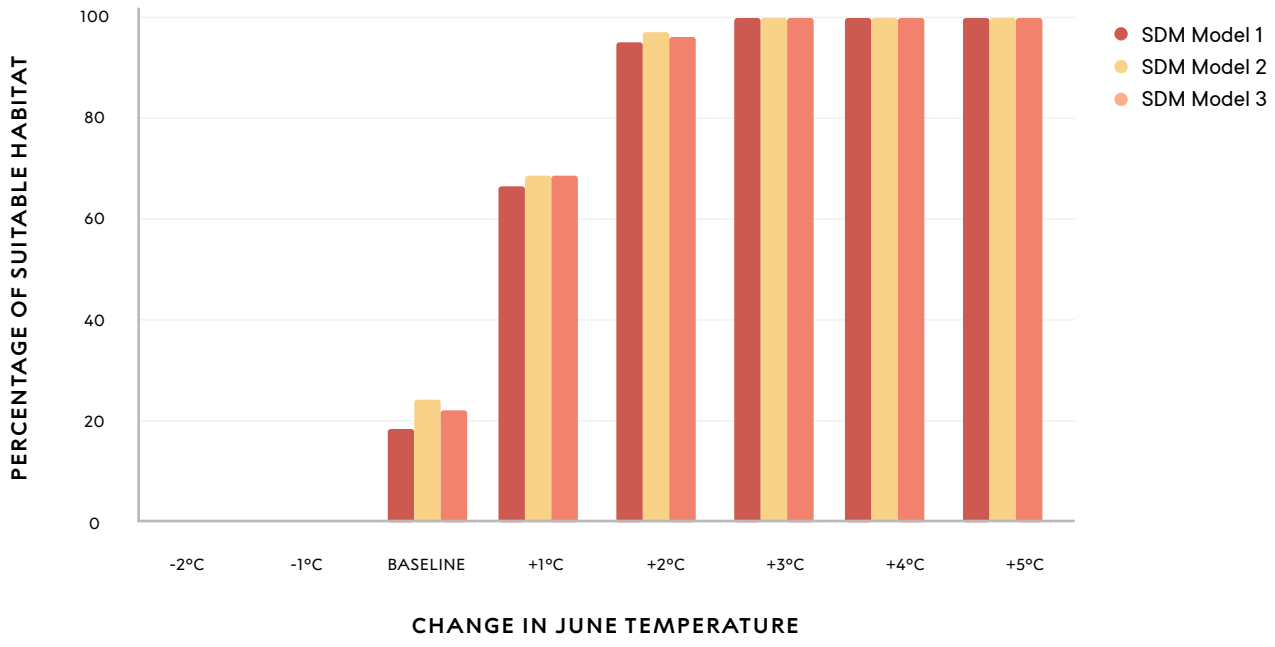


SCIENTIFIC MODEL 4

EUROPEAN COMMON FROGS

Scientists are using computer software models called Species Distribution Modeling (SDM) to predict where a species might live in the future. In one study, SDM was used to predict habitat changes for the European common frog (*Rana temporaria*) in subarctic Finland. Finland has long, cold, snowy winters (often below –30°C/–22°F) and short, mild summers. SDM combined data on current frog distribution with environmental factors such as temperature. Scientists studied 179 potential frog breeding sites. They used 3 different versions of the SDM model to predict how much of the area would provide suitable breeding sites under different climate conditions. All 3 models produced similar results, as shown in Figure 2.4. The baseline shows that about 20% of the area currently has suitable breeding sites. The SDM models all predicted that 100% of the area will likely provide suitable breeding sites if average temperatures increase by 3°C (5.4°F) or more.

FIGURE 2.4
Predicted Changes in Frog Habitat from Three SDM Models



3 Have each group member explain their model to the rest of the group. As a group, work together to understand each model by sharing additional ideas and insights. Use this information to complete the first four rows of Table 1 on Student Sheet 2.1. Remember to listen to and discuss the ideas of other group members. If you disagree with others in your group, explain why you disagree.

4 Work together to brainstorm at least one scientific question that could be investigated by using each model. Record your questions in the last row of Table 1 on Student Sheet 2.1.

5 Share your questions with the class. Based on the class set of questions, discuss whether one model could be used to answer different scientific questions.

PART B: MODELS AND SCIENTIFIC QUESTIONS

6 Your group will receive a set of 4 Scientific Question cards. Work together to read aloud the question on each card.

7 Your group will also receive a set of 4 Scientific Model cards. The Scientific Model cards represent the same four models that you just analyzed. Use the two sets of cards to sort and discuss which model(s) could help answer each scientific question. (Note: A question may be addressed by more than one model.)

8 Record your responses and reasoning in Table 2 on the student sheet.

9 With your group, discuss a scientific question about species distribution that you would like to have answered. Then, brainstorm a model you would like to have to help you in addressing this scientific question.

BUILD UNDERSTANDING

1. A team is developing a population model for bass fish in a local freshwater lake ecosystem. The team decides to focus only on two key factors: the population size of bass fish and water temperature.

   a. Identify at least two factors of the real-world lake system that the team is leaving out of their model.

   b. Explain how excluding these factors might lead to an inaccurate prediction about the bass population.

   c. If the team's scientific question is *How does the bass population size change in response to changes in water temperature?*, do you agree with the focus of their model? Why or why not?

2. The following diagram is another type of model that shows that a change in one part of a system causes a specific response in another part of the system.

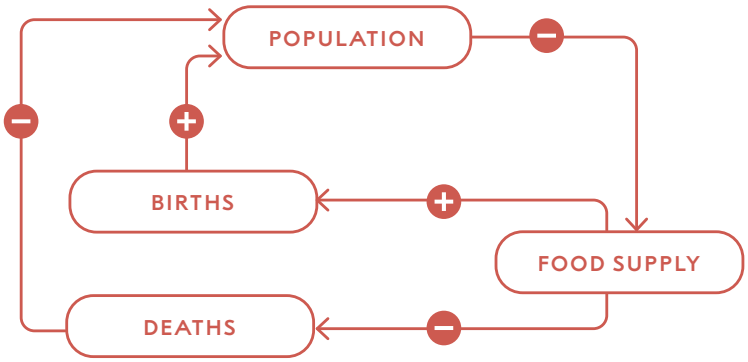


FIGURE 2.5
Population model diagram showing relationship between population, births, deaths, and food supply

Factors such as birth rate, death rate, and food supply can affect the size of a population. For example, when there is more food (+), there can be an increase in births, which increases (+) the population.

   a. According to the model, how would an increase in population affect the food supply?

   b. Revise this model to show the possible effect of at least two additional factors on a population of mice.

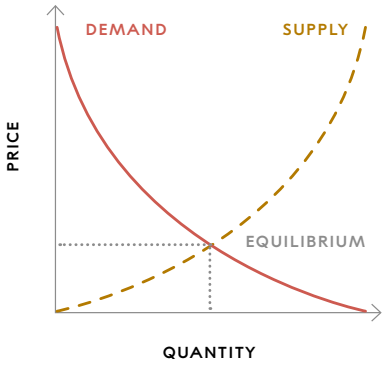
   c. List at least one scientific question that could be investigated by your revised model.

CONNECTIONS TO EVERYDAY LIFE

③ Different mapping apps provide different models of the geographic layout of Earth's surface. For example, one model, used for navigation, can tell you the best way to get from one place to another by car, foot, or public transportation as well as an estimate of how long each will take. Another model shows satellite photographs with labels to identify cities and country boundaries. Take a moment to go online to explore both of these mapping models.

- **a** What factors are included in a satellite map model but not in a navigation map model?
- **b** What factors do both models include?
- **c** Given these differences, what is one question that a satellite map model can help address but a navigation map model cannot?
- **d** What is one question that both models address equally well?

④ Other fields of study also use models. The graph to the right is one that is commonly used in economics to model the relationship between the price of goods and services based on the supply and demand for them. A clothing retailer uses it as a model to set the price for a popular vintage T-shirt.



- **a** When the supplier sets the price exactly at the equilibrium point, what is the model predicting will happen to the number of T-shirts sold?
- **b** Identify one limitation of this model.

HINT: Consider what might happen if the T-shirt became a viral trend on social media.

EXTENSION

Search for additional scientific models online. In what fields of scientific study are these models being used? What scientific questions are being investigated? Share your findings with a friend or someone in your family.

KEY SCIENTIFIC TERMS

species distribution