UNIT 2 : SCIENTIFIC MODELING

ACTIVITY 1

Using Models

CARD-BASED INVESTIGATION

v 1.0

SCIENTIFIC THINKING FOR ALL : A TOOLKIT

ACTIVITY 1

Using Models

ACTIVITY SUMMARY

Students examine two scientific models that inform a decision about which of two creeks to daylight (a process of bringing underground creeks back to the surface) to boost a local frog population. Students compare the models to local frog data in order to determine which model is more applicable and use the models to predict the effect of different factors on the local operation. Based on their analysis, students decide which creek to daylight.

ACTIVITY TYPE
CARD-BASED INVESTIGATION

NUMBER OF
40–50 MINUTE
CLASS PERIODS
2

KEY CONCEPTS & PROCESS SKILLS

1 Scientific models are constructed to explain phenomena and make predictions. They represent aspects of the natural world that are too small, too large, too complex, or too difficult to observe or explain directly.

NEXT GENERATION SCIENCE STANDARDS (NGSS) CONNECTION:
Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system. (*Science and Engineering Practice: Developing and Using Models*)

CONCEPTUAL TOOLS

SCIENTIFIC MODELING

VOCABULARY DEVELOPMENT

factor

something that actively contributes to the production of a result. In scientific modeling, a factor is a variable that has an effect on another variable within the model

scientific model

a representation of an idea, object, process, or system

trade-off

a desirable outcome given up to gain another desirable outcome

TEACHER BACKGROUND INFORMATION

Scientific Modeling

Scientists use models to represent and investigate the natural world. Depending on the quality and purpose of the model, models can be used to explain and/or predict natural processes. A predictive model is limited by the accuracy and precision of the data that goes into it, as well as the accuracy with which it represents the relationships of the system under investigation.

There are many types of scientific models including physical models, conceptual models, mathematical models, and computer models. A physical model is a concrete representation of an object where the scale of the model tells how big it is in relation to the real thing. For example, if a model car were at a 1:10 scale, it would be one-tenth the size of an actual car. Not all physical models are smaller than the thing they represent. A scientist might use three foam balls to make a physical model of a carbon dioxide molecule—two balls representing oxygen atoms and one ball representing a carbon atom—in order to illustrate the shape of the molecule. Not all physical models look like the thing they represent. A set of plastic disks might represent the number of organisms in a population.

Scientists also use conceptual models. Conceptual models are often used to describe relationships among different parts of a system and to define patterns governing those relationships. A food web diagram is a conceptual model that describes the way in which populations of organisms in an ecosystem are interrelated through feeding relationships, such as predator and prey. A more complicated model might try to show the flow of biomass through levels of the food web; in that case, the model might consist of a series of mathematical equations resulting in a mathematical model. When trying to model more complex mathematical relationships, scientists might enter the equations into a computer program, creating a computer model. A computer model takes advantage of the computer's ability to do rapid calculations. Computer models can quickly show how a situation might change as time goes by or as conditions change.

Feedback Loops

Feedback loops are essential processes in ecology in which the output of a system circles back to become an input, thus influencing its future behavior. Negative feedback loops are self-regulating and help to maintain equilibrium by counteracting an initial change; a classic example is the predator–prey relationship in which an increase in prey leads to an increase in predators, which then reduces the prey population. Conversely, positive feedback loops amplify or reinforce an initial change, which can drive a system away from its original state, such as in the accelerating melting of Arctic sea ice due to the albedo effect (how much sunlight a surface reflects versus absorbs). Understanding these loops is crucial for predicting how ecosystems will respond to environmental disturbances.

Feedback loops are often shown as a diagram where arrows connect the variables to show the direction of influence. The output of one variable becomes the input for the next, forming a closed circuit or loop. A sign is placed next to each arrow to indicate the type of influence. A positive sign indicates a direct relationship between the two variables. An increase in one variable causes an increase in another, and vice versa. A negative sign indicates an inverse relationship between the two variables. An increase in one variable causes a decrease in another, and vice versa.

Amphibians

Amphibians are the class of vertebrates that includes frogs, toads, salamanders, and newts. Amphibians are ectothermic (cold-blooded) and anamniotic (must lay their eggs in water). Most amphibians have three distinct life stages: an egg stage, an aquatic larval stage that breathes underwater using gills (such as tadpoles), and an adult stage that can breathe both water and air. Their skins are permeable, which makes them particularly vulnerable to waterborne toxins.

In 2023, the second Global Amphibian Assessment found that of all the vertebrate classes, amphibians are the most endangered, with 41% of 8,000 species surveyed meeting the criteria for an endangered species. Declines from 1980 to 2004 were driven primarily by disease and habitat loss. Since 2004, climate-change effects are estimated to be the most serious driver, followed by habitat loss.

MATERIALS & ADVANCE PREPARATION

FOR THE TEACHER

- VISUAL AID 1.1
  “Interpreting Graphs”
  (OPTIONAL)
- VISUAL AID 1.2
  “Understanding Conceptual Tools”
  (OPTIONAL)

FOR EACH GROUP OF FOUR STUDENTS

- SET OF 2 FROG MODEL CARDS
- SET OF 2 FROG DATA CARDS

FOR EACH STUDENT

- STUDENT SHEET 1.1
  “Daylighting Decision”
- STUDENT SHEET 1.2
  “Writing Frame: Evidence and Trade-Offs”
  (OPTIONAL)
- STUDENT SHEET 1.3
  “Unit Concepts and Skills”
  (OPTIONAL)

TEACHING NOTES

Suggestions for **discussion questions** are highlighted in gold.

Strategies for the **equitable inclusion of diverse students** are highlighted in pink.

GETTING STARTED (10 MIN)

1 **Elicit students' prior knowledge about scientific models.**

- This activity introduces scientific modeling, and the focus of the unit will be the use of models to represent systems. Begin by eliciting prior knowledge about scientific models. Ask, What is a scientific model you are familiar with and what does it represent? While there are many possible answers, research indicates that most students tend to describe physical models such as model airplanes that represent real historical airplanes; foam-and-stick models of atoms, such as those that are sometimes built in middle school; a diorama as a model of a scene or place; a map as a model of a geographic area; and/or a globe as a model of Earth. Some students may also suggest computer models and/or mathematical models.

- Students may have personal experience with and prior knowledge of issues related to scientific models. Engaging students about their experiences can create a stronger foundation for learning. Support students, particularly those with varied life experiences, in sharing their prior knowledge of and personal experiences with this issue. Specifically validate funds of knowledge—not just textbook knowledge but also family or cultural insights, practices, and personal histories—by eliciting students' observations and experiences as assets to building understanding. Throughout this unit, encourage students to respond to any topics or questions that arise to which they feel a personal connection—during small-group or class discussions, when students respond to relevant Build Understanding items, and/or when they write reflections in their science notebooks.

- If needed, review with the class the formal definition of a *scientific model:* a representation of an idea, object, process, or system. The general purpose of such a model is to represent a real system in a simpler way so that aspects of it can be investigated. A scientific model does not have to look like the object being modeled; it should represent it in some important way.

2 **Review ecological vocabulary and amphibian life cycle as needed (optional).**

- If needed, review basic ecological concepts and vocabulary from Science Review: Populations of Organisms in Ecosystems found at the end of Activity 1 in the Student Book.

- Support students, particularly emerging multilingual learners, in sensemaking and language acquisition by reviewing the terms from the Science Review and supporting the construction of a word wall. For this activity, record the terms *organism*, *species*, *habitat*, *ecosystem*, *population*, and *range*. Students are expected to be familiar with these terms based on middle school science standards. Provide additional examples for each term as needed. For more information on a Word Wall, see Appendix 1: Literacy Strategies.

- In this activity, students make a decision affecting a fictional frog species. If needed, review information about frog life history (eggs to tadpoles to adults, which then lay eggs) and simple predator–prey relationships. You may want to explain that because most amphibians breathe through their skin, their skin is not a strong barrier against potential toxins such as pesticides and fungal infections.

3 **Present the fictional scenario from Procedure Step 1.**

- The scenario presented in Step 1 can be shared with the class in multiple ways. Read the scenario aloud to the class or have individual students read it aloud while others follow along with the text (either as a whole class or in small groups).

- Reading the scenario aloud can better support comprehension for many students, including neurodiverse students and emerging multilingual learners who often have more highly developed listening and oral skills than reading comprehension skills. Alternatively, students can read the scenario independently.

- Depending on your student population, use oral storytelling to support diverse learners in decoding scientific ideas and constructing meaning. Ask questions about the main points of the scenario to ensure comprehension. Students can refer to the text in the Student Book as needed.

- Review the map included in the scenario as needed. Point out that daylighting a creek will allow the frogs to travel between Chimbly Marsh and one of the other two marshes (Geyser or Umpawa).

- You may wish to research if there is a daylighted creek in your area or (more likely) a paved-over creek. If so, ask students if they are aware of it and point it out to connect the issue in this activity to their local context.

PROCEDURE SUPPORT (25 MIN)

4 **Hand out the Frog Model cards to each group and support students as needed.**

- In this unit, laboratories and card-based investigations use hands-on materials to support student learning. Certain student populations—including girls, gender nonconforming students, and introverted students—often take on roles in which they do not directly engage with hands-on materials, such as recorder and observer. Incorporate strategies to ensure that all students participate over time. For example, in activities like this one in which students conduct the investigation in groups of four, one strategy is to assign roles (such as group leader, recorder, observer, and timekeeper) ahead of time and then rotate them periodically. Another strategy is to create specific groupings of four that might encourage greater participation. Decide which strategy you will use to best support your student population.

- Students who have difficulty interpreting graphs (such as students with dyscalculia) can be provided with a copy of the graphs and optional Visual Aid 1.1, "Interpreting Graphs" in advance.

- Hand out a set of Frog Model cards to each group and Student Sheets 1.1, "Daylighting Decision," to each student. (Note: Do not provide the Frog Data cards at this time.) Each pair in a group will analyze one of the two Frog Models cards, using Student Sheet 1.1. Students who are examining Model 1 first will complete Table 1, and students who are examining Model 2 first will complete Table 2. Students complete each table by analyzing their assigned model, comparing data about the two marshes, and then making a recommendation. Sample student responses are located at the end of this activity

- If students have trouble interpreting their model, have each pair share their work with another pair who examined the same model and discuss their ideas.

- Have pairs share their findings with the other half of their group so all group members can complete Tables 1 and 2.

- Group members then discuss whether data from the two models suggested the same creek to daylight. Students should recognize that Model 1 predicts daylighting Geyser Creek will be better because Geyser Marsh has a slightly lower temperature and more insect prey. Model 2 predicts that daylighting Umpawa Creek will be better for the frogs because Umpawa Marsh has lower levels of pesticides and slightly lower rates of Bd fungal infection.

5 Hand out the Frog Data cards and have students update their recommendations.

- Hand out a set of Frog Data cards to each group. These cards provide data on the apparent effect of temperature, insects, and pesticides on the *Anura menanda* frog population.

- In Procedure Step 9, students evaluate which of the four factors (temperature, insect population, pesticides, Bd fungus) appear to have the greatest effect on the frog populations:

  Table 2 on Student Sheet 1.1 shows that the amount of Bd fungus in each marsh is very similar and so is unlikely to make a difference for this decision. In the real world, evidence is often ambiguous, and more investigations and data may be needed to better determine a relationship.

  Frog Data 1 shows a declining frog population but a steady population of insects and a steady average temperature. This indicates that some other factor, besides insects and temperature, is the reason for the decline. It does not show how insects and temperature may affect frog population size if these factors were to change.

Frog Data 2 shows an unusual pattern in the decline of the frog population—it is decreasing but irregularly. The periods of sharp frog decline correspond with periods of higher pesticide levels.

The data from the two models and the two data cards indicate that pesticides appear to have the greatest effect on the size of the frog population.

Given this data, students should conclude that Umpawa Marsh is a better habitat than Geyser Marsh because it has a lower pesticide level. It would be better to daylight Umpawa Creek so that frogs can travel between Chimbly Marsh and Umpawa Marsh.

SYNTHESIS OF IDEAS (15 MIN)

6 Introduce the idea that models can explain, predict, raise new questions, and be revised.

- Ask, Can you brainstorm the features of a model useful for making decisions, in light of the model-based decision you just made? A useful model:
  - is clear and comprehensible.
  - includes factors that relate to the question being investigated.
  - offers relevant explanations.
  - is testable.
  - produces accurate predictions.

  The models that students use in this activity address some, though not all, of these features.

- Point out that the models do not make numeric predictions. Ask, How can a model be useful for decision-making even when it does not generate precise numerical results? Models that do not generate precise numerical results provide an explanation of relationships among factors and inform the decision, such as which of several marshes would be a better environment for the frog population.

- Highlight the concept that scientific models can be used to both explain phenomena and make predictions. Some models are better for explanations, others better for predictions, and some do both. The Frog Model cards help explain factors affecting two different frog populations.

- Introduce the idea that models can raise new research questions and be revised based on new findings. Have students reconsider Model 2, which showed the relationships between frogs, pesticides, and Bd fungus. Models are constructed based on past data and present understandings. The data that informed this model would have shown that an increase in pesticides resulted in an increase in Bd fungus. Pesticides might be assumed to have a negative effect on the living fungus since it has a negative effect on frogs. This aspect of the model could be the basis of new research questions to further explore this relationship. This, in turn, could eventually result in a more complex or revised model.

7 **Introduce the conceptual tool of scientific modeling.**

- Introduce the role of scientific modeling as a tool in a student's scientific toolkit. The scientific toolkit is intended to be a set of conceptual tools that can be applied to everyday life. With each new unit, students will add conceptual tools to their toolkits. Use optional Visual Aid 1.2, "Understanding Conceptual Tools," to support the multiple contexts that are used with the word *tool*, which is defined as an implement used to carry out a particular function. The word is commonly used to refer to construction tools such as hammers, levels, and tape measures. In a science classroom, examples of scientific tools include beakers, graduated cylinders, and microscopes. In this unit, scientific tools and technology are used to gather evidence. In this course, students consider conceptual tools, such as probabilistic reasoning, as a way of exploring the application of science to everyday life.

8 **Introduce the concept of trade-offs and how it applies to the scenario of daylighting creeks.**

- Introduce the idea that decisions about solutions to scientific and engineering problems often involve trade-offs. In this activity, students use trade-offs when they respond to Build Understanding item 3. Decision-making in the context of trade-offs includes the following key ideas:
  - Decisions often involve trade-offs.
  - Identifying trade-offs involves analyzing evidence.

  The concept of trade-offs is used throughout the units of this course, especially as part of the decision-making focus.

- A trade-off is a desirable outcome given up to gain another desirable outcome. In a decision involving trade-offs, something positive (or desirable) is given up to gain another positive (or desirable) outcome. Since many decisions involve trade-offs, students should understand that a perfect choice that maximizes all goals is often not possible. It is possible, however, to recognize and analyze the trade-offs associated with each decision.

- Provide an example of a trade-off. For example, when choosing to purchase a disposable or reusable water bottle, there are several benefits and trade-offs to consider. A consumer who chooses the disposable water bottle may want a cheap option that doesn't need to be cleaned or maintained. Disposable bottles are also easily shared with others since they are not expected to be returned. However, in choosing the disposable water bottle, the consumer is contributing to environmental problems, such as increased energy use and higher amounts of solid waste in landfills if the bottle is not recycled. A consumer choosing to purchase a reusable water bottle may do so to save money over time, to save bottles from ending up in a landfill, and—by their example—to encourage others to purchase reusable bottles. However, this option has trade-offs as well, such as the increased upfront cost of the reusable bottle and the need to clean and maintain the bottle. Neither choice is ideal, and both choices have positives and negatives. Identifying the trade-offs helps clarify the reasoning that is being applied to make a decision.

- Develop some examples of trade-offs in students' lives by brainstorming with the class a list of decisions they make every day that involve trade-offs. Choose one and talk through the associated trade-offs of deciding one way or another. This practice will familiarize students with ways to identify and consider trade-offs in this and subsequent activities.

- Optional Student Sheet 1.2, "Writing Frame: Evidence and Trade-offs" provides additional support for students responding to Build Understanding item 1. A Writing Frame can support learners, particularly emerging multilingual learners, in decoding scientific ideas, constructing meaning, sensemaking, and language acquisition. This strategy, which has been deemed effective for emerging multilingual learners, was built on and adapted from strategies for English-proficient learners. You may wish to provide students with the Writing Frame to compose their responses or simply as a reference or checklist to help them organize how they will respond. Consider posting an enlarged version of the writing frame on a classroom wall for students to refer to now and in future assessments. For more information on a Writing Frame, see Appendix 1: Literacy Strategies.

9 **Highlight opportunities for metacognition here and throughout the unit through the use of optional Student Sheet 1.3, "Unit Concepts and Skills."**

- As students build understanding about the importance of scientific modeling, they will build a conceptual tool about this idea in their minds and develop skills to utilize it at various points in the unit. You may wish to use optional Student Sheet 1.3, "Unit Concepts and Skills," to help students organize their learning. This course organizer is designed to help students reflect on their understanding of the conceptual tool, consider how they will use it to analyze problems throughout the unit, and how it may influence their decisions about unit topics.
- While a sample completed course organizer is provided for the teacher's reference in this activity, students will not be able to complete the student sheet at this time; the ideas in the sample response will be built over the course of the unit. At the end of this activity, students can add their initial ideas about scientific modeling.
- Optional Student Sheet 1.3 provides an opportunity for students to practice metacognition—thinking about one's own thought processes. Research has found that students show greater improvement in their learning when they are given opportunities to examine and evaluate their own learning.
- Highlight metacognition opportunities here and throughout the unit. Ask, In what ways could thinking about your thinking process influence your decision-making skills? Encourage students to share their ideas. Some students may note that being more aware of their own thinking may make them more likely to be more aware of mistakes or limitations in their thinking or make them more likely to change their minds. They may also enhance their skills at communicating their ideas and asking questions.
- Finish the activity by revisiting the Guiding Question, *How can models be used to inform a decision?* Use this as a chance to revisit and summarize the key concepts and process skills of the activity.

SAMPLE STUDENT RESPONSES

BUILD UNDERSTANDING

The Build Understanding and Connections to Everyday Life items are intended to guide student understanding. You may decide to assign some or all of them, depending on the needs of your students. However, some of the items are recommended in particular activities for use as assessments or to review key concepts.

1. **In this activity, you used models to investigate an ecosystem.**

   TEACHER'S NOTE: Students may select either model and either creek for daylighting. Evaluate their responses based on their explanations and reasoning for their selections and the logic of their predictions based on their selections.

   a **Which creek do you recommend for daylighting: Geyser or Umpawa?**

   I recommend that Umpawa Creek be daylighted to reconnect Chimbly Marsh with Umpawa Marsh.

   b **Explain which model—Model 1 or Model 2—was the most useful for deciding which creek to daylight and why.**

   Model 2 because the data on the Menanda frogs showed that they were most affected by pesticide vs. the other factors. Model 2 predicted how pesticides might affect a frog population.

   c **Provide at least two reasons why the model you chose supports your recommendation.**

   Data from Menanda shows that when pesticide levels are higher, frog populations have decreased. Umpawa Marsh has much lower levels of pesticides (0.06 µg/L vs 0.28 µg/L in Geyser Marsh). Model 2 shows a negative relationship between frogs and pesticides. Model 2 also shows that Bd fungus decreases in frogs when pesticides are present, but the amount of Bd fungus in Umpawa Marsh and Geyser Marsh is about the same (11% vs 12%).

   d **Make a prediction for what will happen to the *Anura menanda* frog population if your recommendation is followed.**

   I predict that if Umpawa Creek is daylighted, the frog population in both Chimbly and Umpawa marshes will increase. When that creek was open, frogs were seen traveling between the marshes. Because pollution is low in Umpawa, and there are plenty of insects for the frogs to eat, if more frogs can get between these two marshes, they should be able to reproduce and increase the population.

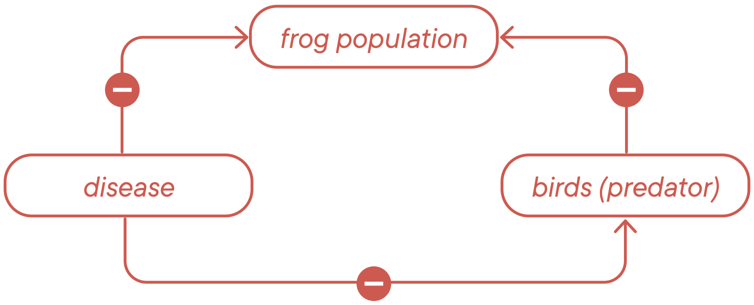
② **Simple diagrams modeled the interactions between frogs and the factors affecting its population. Identify at least two additional factors that could affect the size of a frog population.**

a **Using the following symbols, draw a model to show how these factors will likely affect a frog population.**

→ **a relationship between factors**

⊕ **a positive effect, such as an increase in population size**

⊖ **a negative effect, such as a decrease in population size**



b **What data could you collect to test the accuracy of your model?**

I could sample the frog and bird populations to assess their health and if they have a disease. I could collect data on the size of frog and bird populations over time to see if the bird population has a negative effect on the number of frogs.

③ **Time has passed. A group of residents has been working on habitat restoration of Menanda marshes. Their work has improved water quality and reduced pollution levels, including pesticides, to levels that cannot be measured. While some residents would like to daylight the other creek, it is currently buried under a pedestrian bridge. Other people do not want to daylight it because it would cost a significant amount to move the crossing.**

Would you recommend daylighting the other creek? Support your answer with evidence from Student Sheet 1.1 and identify the trade-offs of your decision. A trade-off is a desirable outcome that is given up to gain another desirable outcome.

I would not daylight the other creek. Model 2 showed pesticides decreased frog populations and increased Bd fungus. With no measurable pesticides and less Bd fungus, the frog population is likely doing better without daylighting another creek. There is already a high insect population at the site, which has a positive effect on the frogs. The trade-off is that there may be fewer frogs at Geyser Marsh than at the other marsh.

CONNECTIONS TO EVERYDAY LIFE

4. **Your smartphone uses a model to show you the estimated minutes or hours remaining on your phone's battery.**

   a. What are some of the factors this model must incorporate to calculate an accurate time estimate?

   Factors affecting a phone's battery power include whether the phone is being used (or asleep), screen brightness, which apps are being used (for example, location services use more power), and how long apps are being used for.

   b. How could you test your ideas about the factors included in this model?

   I could observe my battery percentage and what I am doing on my phone. I could look for relationships and record how quickly the battery percentage changed as I used my phone for different activities.

REFERENCES

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STUDENT SHEET 1.1 | DAYLIGHTING DECISION | NAME

Table 1: Analyzing Model 1

	MODEL 1	
Frog species and its location		
Factors included in the model		
How each factor affects the frog population		
Change in average temperature in Menanda	+1.1°C (+2°F) in Geyser Marsh	+1.7°C (+3°F) in Umpawa Marsh
Insect population of Menanda *(insects per square meter)*	233 insects/m^2 in Geyser Marsh	199 insects/m^2 in Umpawa Marsh
Prediction of which marsh—Geyser or Umpawa—will be a better habitat for *Anura menanda* and why		
Recommended creek to daylight: Geyser or Umpawa		

Table 2: Analyzing Model 2

	MODEL 2	
Frog species and its location		
Factors included in the model		
How each factor affects the frog population		
Pesticide Index in Menanda *(micrograms per liter)*	0.28 μg/L in Geyser Marsh	0.06 μg/L in Umpawa Marsh
Percentage of frogs with Bd fungus in Menanda	12% in Geyser Marsh	11% in Umpawa Marsh
Prediction of which marsh—Geyser or Umpawa—will be a better habitat for *Anura menanda* and why		
Recommended creek to daylight: Geyser or Umpawa		

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Table 3: Analyzing Data on *Anura menanda* Frog Population	**Possible effect on *Anura menanda* frog population**
Average temperature	
Insect population	
Pesticide	
Bd fungus	
Prediction of which marsh—Geyser or Umpawa—will be a better habitat for *Anura menanda* and why	
Recommended creek to daylight: Geyser or Umpawa	

Table 1: Analyzing Model 1	MODEL 1	
Frog species and its location	*Gold frog of Yarata*	
Factors included in the model	*temperature, insects, frogs*	
How each factor affects the frog population	*temperature reduces frog population,* *insects increase frog population*	
Change in average temperature in Menanda	+1.1°C (+2°F) in Geyser Marsh	+1.7°C (+3°F) in Umpawa Marsh
Insect population of Menanda *(insects per square meter)*	233 insects/m^2 in Geyser Marsh	199 insects/m^2 in Umpawa Marsh
Prediction of which marsh—Geyser or Umpawa—will be a better habitat for *Anura menanda* and why	*Geyser Marsh will be better because it has a lower temperature and more insects. The gold frog model showed that temperature decreases population, and insects increase population.*	
Recommended creek to daylight: Geyser or Umpawa	*Geyser Creek*	

Table 2: Analyzing Model 2	MODEL 2	
Frog species and its location	*Clawed frog of Raya*	
Factors included in the model	*pesticide, fungus, frogs*	
How each factor affects the frog population	*pesticide reduces frog population,* *fungus reduces frog population*	
Pesticide Index in Menanda *(micrograms per liter)*	0.28 µg/L in Geyser Marsh	0.06 µg/L in Umpawa Marsh
Percentage of frogs with Bd fungus in Menanda	12% in Geyser Marsh	11% in Umpawa Marsh
Prediction of which marsh—Geyser or Umpawa—will be a better habitat for *Anura menanda* and why	*Umpawa Marsh will be better because it has lower concentration of pesticides and fewer frogs with fungal infections. The clawed frog model showed that pesticides and fungus both decrease population .*	
Recommended creek to daylight: Geyser or Umpawa	*Umpawa Creek*	

CONTINUED

Table 3: Analyzing Data on *Anura menanda* Frog Population	Possible effect on *Anura menanda* frog population
Average temperature	*no apparent effect based on Frog Data Card 1*
Insect population	*no apparent effect based on Frog Data Card 1*
Pesticide	*significant decline based on Frog Data Card 2*
Bd fungus	*no distinguishable effect, given 12% vs. 11% infection rates*
Prediction of which marsh—Geyser or Umpawa—will be a better habitat for *Anura menanda* and why	*Umpawa Marsh because it has a lower concentration of pesticides. Frog Data Card 2 shows a strong negative relationship between the* Anura menanda *population and pesticides.*
Recommended creek to daylight: Geyser or Umpawa	*Umpawa Creek*

STUDENT SHEET 1.2 | WRITING FRAME: EVIDENCE & TRADE-OFFS | NAME

There is a lot of discussion about the issue of

My decision is that

My decision is based on the following evidence:

First,

Second,

Third,

The trade-off(s)

People who disagree with my decision might say that

NAME *SAMPLE STUDENT RESPONSE*

There is a lot of discussion about the issue of

daylighting creeks to support frog populations.

My decision is that

the second creek should also be daylighted.

My decision is based on the following evidence:

First,

based on Model 2, pesticides have a negative impact on frogs.

Second,

the data on Menanda frogs appeared to show a negative relationship between frogs and pesticides. There was a higher level of pesticides (0.28 µg/L) at Geyser Marsh than at the other area.

Third,

the marsh now has no measurable pesticides.

The trade-off(s)

A pedestrian bridge will be taken down, and it will cost a lot.

People who disagree with my decision might say that

the safety of people is more important than the frog population.

STUDENT SHEET 1.3 | **UNIT CONCEPTS AND SKILLS** | **NAME**

UNDERSTAND		ANALYZE
CONCEPT	DESCRIPTION	UNIT EXAMPLE(S)

WHAT DECISION(S) WERE MADE OR ACTION(S) TAKEN?

STUDENT SHEET 1.3	UNIT CONCEPTS AND SKILLS	NAME	SAMPLE STUDENT RESPONSE

UNDERSTAND		ANALYZE
CONCEPT	**DESCRIPTION**	**UNIT EXAMPLE(S)**
Scientific Model	*Simplified representation of an idea, object, process, or system* *Answers scientific questions: many models can answer one question, one model can answer many questions* *Contains components, assumptions, limitations* *Can be made more accurate through revision*	Anura menanda *frog models, polar bear model, monarch butterfly model, Canada jay model, European common frog model, food web models, butterfly computer models, lobster research models, tuna game models, estimation models, population models*
Systems	*Collection of parts that interact with each other to work together as a whole* *Investigated through observations*	*Making models of local system; butterfly ecosystem, lobster ecosystem; tuna migration; Menanada ecosystems*
Orders of Understanding	*Factors included in a model based on which factors have a greater impact on the system than others*	*Rating factors in:* *computer butterfly models, Dr. Wahle's model on lobster distribution, tuna game model, constructing local species,* Anura menanda *frog sites*
Fermi Estimate	*A method of calculating an approximate value of a difficult-to-know quantity* *Uses relative scale (for example, powers of 10)*	*Estimates of the number of:* *people in line, snacks for a school dance, shoes thrown away in the world every year, trees lost to Bighorn Fire, house sparrows, local species now and 50 years in future,* Anura menanda *frogs at each site*

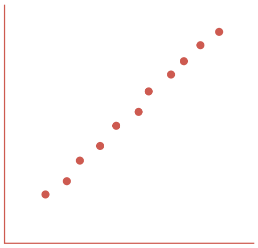
WHAT DECISION(S) WERE MADE OR ACTION(S) TAKEN?

Daylighting of creek in Mendana, Butterfly Bluff Park actions, tuna fishing locations, Bighorn tree replanting, Anura menanda *frog conservation site*

VISUAL AID 1.1 | INTERPRETING GRAPHS

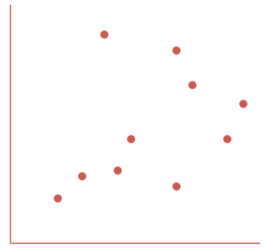
Determine the path that describes the data.

IS THERE A RELATIONSHIP?



THERE IS A PATTERN.

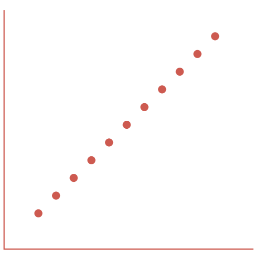
RELATIONSHIP



THERE IS NO PATTERN.

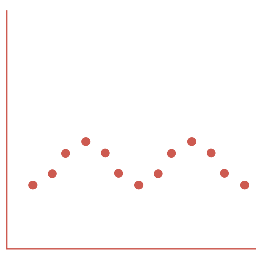
NO RELATIONSHIP

WHAT IS THE GENERAL TREND OF DATA?



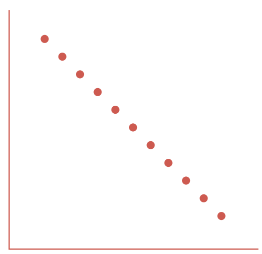
POSITIVE

as x increases, y increases



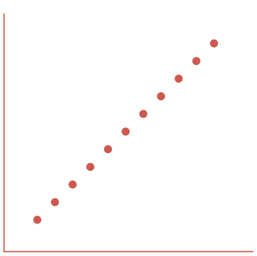
CYCLICAL

as x increases, y repetitively increases and decreases



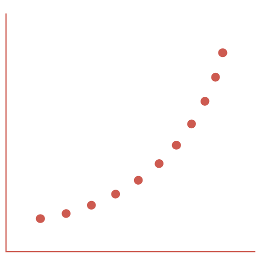
NEGATIVE

as x increases, y decreases



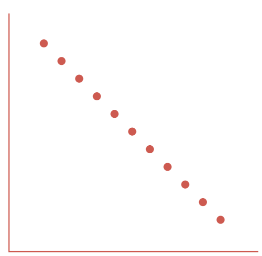
LINEAR

as x increases, y consistently increases *(sometimes called "direct")*



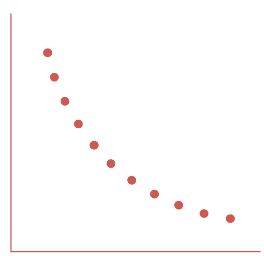
NONLINEAR

as x increases, y increases at a changing rate



LINEAR

as x increases, y consistently decreases

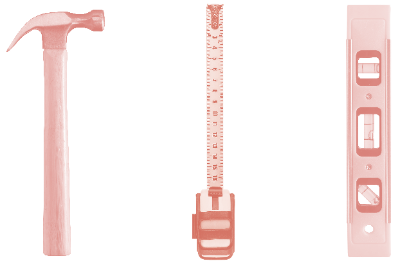


NONLINEAR

as x increases, y decreases at a changing rate *(sometimes called "inverse")*

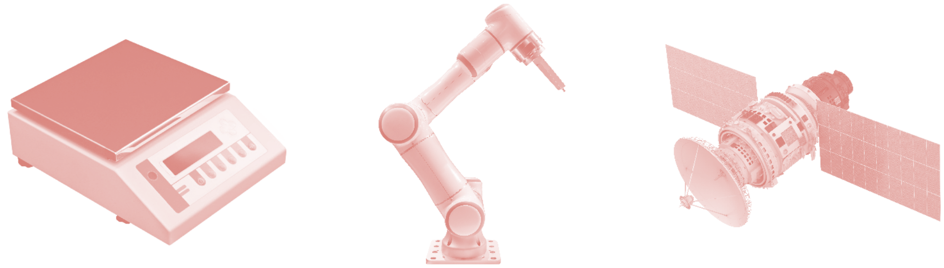
VISUAL AID 1.2 | UNDERSTANDING CONCEPTUAL TOOLS

CONSTRUCTION TOOLS



SCIENTIFIC TOOLS

SCIENTIFIC TOOLS + TECHNOLOGY

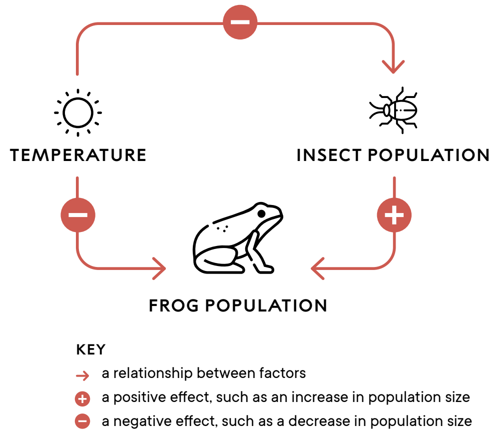


CONCEPTUAL TOOLS

FROG MODEL 1

GOLD FROG OF YARATA

Scientists have collected data on the gold frog found in the marshes of Yarata. Over the last 100 years, the average temperature in the Yarata marshes has increased. This has negatively affected the size of the gold frog population. Lots of insects, a primary food source for gold frogs, results in increases in the frog population. Scientists developed this model to show how these factors are affecting the gold frog population.

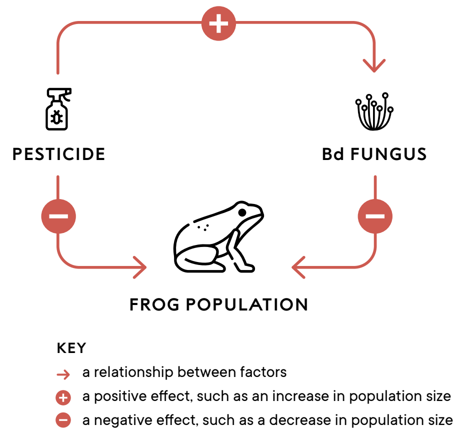


SCIENTIFIC THINKING FOR ALL: A TOOLKIT
UNIT 2: Scientific Modeling, Activity 1: Frog Model Cards

FROG MODEL 2

CLAWED FROG OF RAYA

Scientists have collected data on the clawed frog found in the marshes in Raya. Scientists found that pesticide runoff from nearby agricultural fields negatively affected the population size of clawed frogs. When Bd fungus is present in the population, it causes disease and death in the frog population. Scientists developed this model to show how these factors are affecting the clawed frog population.



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UNIT 2: Scientific Modeling, Activity 1: Frog Model Cards

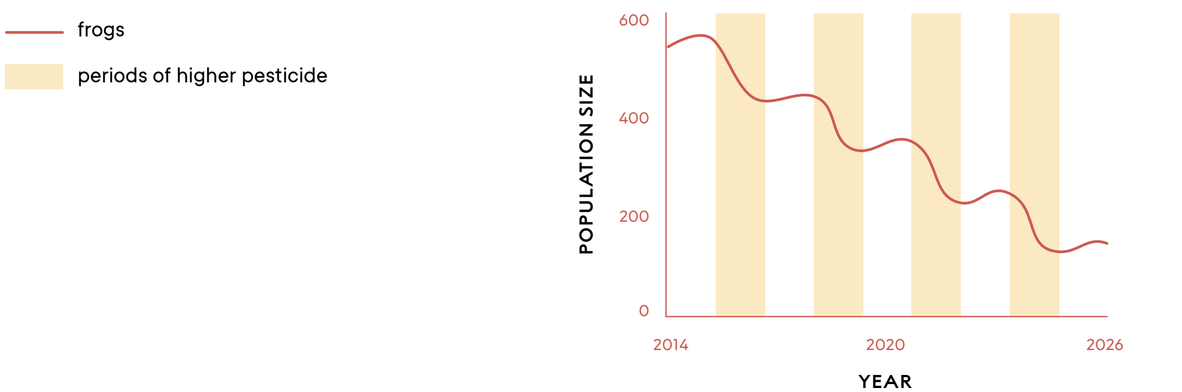
FROG DATA 1

Insects, Temperature, and *Anura Menanda* Frog Populations Over Time

SCIENTIFIC THINKING FOR ALL: A TOOLKIT
UNIT 2: Scientific Modeling, Activity 1: Frog Data Cards

FROG DATA 2

Effect of Pesticides on *Anura Menanda* Frog Populations



SCIENTIFIC THINKING FOR ALL: A TOOLKIT
UNIT 2: Scientific Modeling, Activity 1: Frog Data Cards