HOW TO USE THIS RESOURCE

The images for this resource show tree growth in the Serengeti over time, which can serve as phenomena to explore the key concepts described below.

The pedagogical practice of using phenomena to provide a context for understanding science concepts and topics is an implementation practice supported by the Next Generation Science Standards (NGSS). Phenomena are observable occurrences that students can use to generate science questions for further investigation or to design solutions to problems that drive learning. In this way, phenomena connect learning with what is happening in the world while providing students with the opportunity to apply knowledge while they are building it.

The "Implementation Suggestions" and "Teaching Tips" sections provide options for incorporating the images into a curriculum or unit of study and can be modified to use as a standalone activity or to supplement an existing lesson. The "Student Handout" includes reproductions of the images and the "Background Information" section.

Additional information can be found on this resource's webpage, including suggested audience, estimated time, and curriculum connections.

KEY CONCEPTS

- The population growth of one species can directly and indirectly affect other species in an ecosystem.
- We can construct and revise models that represent interactions within an ecosystem, based on evidence about factors affecting populations in the ecosystem.

BACKGROUND INFORMATION

The **Serengeti** is a large ecosystem in Tanzania, Africa, known for its diversity of animals. It includes Serengeti National Park. Tony Sinclair, a researcher studying the park, photographed these images there over the course of 25 years. Image A was taken in 1986, Image B was taken in 1991, and Image C was taken in 2011.

Blue **wildebeest** (a kind of antelope related to cattle, goats, and sheep) are one of the species found in the Serengeti. Wildebeest are **herbivores**, meaning they eat plants. When Sinclair started researching the park in the 1960s, the population of wildebeest was relatively low because of a disease. In later years, the disease disappeared, allowing the population to grow to its present size of about 1.3 million wildebeest. Based on your observations of these images, did the tree population increase or decrease as the wildebeest population grew?

IMPLEMENTATION SUGGESTIONS

The following suggestions outline several options for incorporating the images into a unit of study as phenomena:

Engagement, establishing prior knowledge, and providing context:

- Begin the lesson by telling students that they will be examining a series of photos taken in Serengeti National Park, in Tanzania, over a 25-year period. It may be helpful to show students where Serengeti National Park and Tanzania are on a map.
- Show students Images A–C in order, with Image A (1986) first, and tell them the year in which each image was taken. Ask students to make observations using the sentence stems "I notice…", "It reminds me of…", and "I wonder…"
- Use a think-pair-share protocol to have students share their observations and questions about the images. Record class observations, noting when students make similar observations and drawing attention to the range of student-generated questions.
    - Students may observe that:
        - The park appears to contain grasslands with mountains in the distance.
        - There are different types of vegetation present, including grass, trees, and shrubs.
        - Images A (1986) and B (1991) have barren patches in the distance; Image C (2011) does not.
        - The number of trees (and the proportion of the park they cover) increases over time.
        - The area covered by dirt/barren patches and grass decreases over time.
        - The color of the trees changes and is brighter in Image C (2011) than in Images A (1986) and B (1991).
    - Students may wonder:
        - What are the different types of vegetation found in the park?
        - How much of the park is grassland (versus mountain or other biomes)?
        - What kinds of animals can you find in the park?
        - What do those animals eat?
        - What caused the change in the number of trees over time?
        - Why did the trees change color over the time period shown in the three photographs?
- It may be helpful to introduce the Serengeti by watching clips from the short film *Serengeti: Nature's Living Laboratory*, particularly the beginning to 2:22.
    - This segment introduces the Serengeti, the presence of large populations, and the question of how the Serengeti came to be the way it is (in terms of being able to support those populations). This clip will be repeated in one of the activities below, though given the density of information in the film, students may appreciate watching it twice.
- Once students have had time to consider their questions, have them list factors that could affect the number of trees over time in the Serengeti. Use the same protocol as above to have students generate ideas individually, share them with a partner or a small group, then share with the class.
    - Student suggestions may include:
        - herbivory/population size of herbivores
        - availability of water, nutrients, or soil
        - fire
        - disease or blight
        - human-caused disturbances, such as deforestation or agriculture
        - weather events, such as floods, or climate change
- Have students construct initial models about what could affect the number of trees in the Serengeti.
    - Have students select their work surface (e.g., a piece of paper, an online slide deck, a whiteboard, etc.). Tell them to divide it into three sections to represent the three images.

        - Emphasize that these are *initial* models, and students will be revising them over the course of their learning experience. It may be helpful to have students use non-permanent tools (e.g., draw in pencil or erasable marker, work with editable files) to make their preliminary models easier to revise.
    - As a class, decide how you want to represent trees in the model.
    - Introduce + and – notation for positive and negative effects.
        - Use the + symbol to represent a factor that would *increase* the number of trees over time.
        - Use the – symbol to represent a factor that would *reduce* the number of trees over time.
    - Ask students to include one factor they believe would *increase* the number of trees (+) and one factor that would *decrease* the number of trees in their models (–).
        - Students will likely choose to put herbivore populations in their models. If not, generate a model as a class that includes herbivore populations.
    - Ask students to predict how the population of herbivores would generally affect the number of trees in the Serengeti.
        - Students will likely predict that herbivores will have a negative effect on the number of trees over time, since herbivores eat plants.
- Transition to the "Exploration/Investigation" section by telling students that they'll be exploring what led to an increase in the number of trees in the Serengeti and that they will return to their models later to demonstrate their new understanding of the topic.

Exploration/Investigation:

- Have students read the "Background Information" for the images. As they are reading, they should note which of their questions have been answered and which remain.
    - The "Background Information" asks students to describe whether the tree population increased or decreased as the wildebeest population grew. Discuss this as a class.
    - Students should observe that there appear to be more trees as the wildebeest population increased. Students may find this surprising based on their previous predictions.
    - Students may also wonder what factors allowed the wildebeest population to increase and maintain its current numbers, and what allowed the number of trees to increase.
- Tell students they will be investigating what regulates the wildebeest population in the Serengeti by completing the "Population Regulation in the Serengeti" activity, which incorporates clips from *Serengeti: Nature's Living Laboratory*.
    - This activity includes a scaffolded approach to having students interpret the "Serengeti Wildebeest Population Regulation" and "Patterns of Predation" Data Point figures.
    - It also discusses wildebeests as herbivores, leading students to wonder what the relationship is between wildebeest and trees.
- Introduce the "Creating Chains and Webs to Model Ecological Relationships" activity by telling students that they'll be constructing models of food chains for Gorongosa National Park, a park in Mozambique with animals similar to those in the Serengeti.
    - Direct students' attention to what wildebeest and buffalo eat and to which animals eat them.
    - Also direct students to the effect of disturbances on the Gorongosa ecosystem, in particular how fires affect vegetation.

- After completing these activities, ask students to revise their models of tree and herbivore populations in the Serengeti to better depict the relationships between wildebeest population size and the number of trees.
  - Student models may have previously indicated that wildebeest eat trees. Students should revise this to indicate wildebeests' preference for grazing on grass.
  - Additionally, student models should now reflect that as the population of wildebeest increased, so did the number of trees.
- Transition to the next set of activities by discussing the indirect relationships in the models.
  - Food chain models focus on direct trophic ("feeding") relationships. But additional factors indirectly affect population sizes. We can represent these indirect relationships in a variety of ways, such as with dashed lines. The "Modeling Trophic Cascades" card activity includes further exploration of direct and indirect effects.
  - Have students indicate an indirect relationship between wildebeest and trees using dashed lines. Student models may reflect that the increasing population of wildebeest decreased the amount of grass, and this had some effect on the population of trees, though the exact mechanism will likely be unclear to them.
  - Have students list ways that the wildebeest population could affect the tree population. Student responses may include that wildebeest "mowing" the grass might generate space for trees to grow. Students may also answer that there is "something else" going on but aren't sure what.
- Watch *Serengeti: Nature's Living Laboratory* from 29:00 to 33:45. (This section is titled "Chapter 3: Why Is the Serengeti the Way It Is?")
  - This clip presents how Tony Sinclair set up a tree-monitoring system in Serengeti National Park and that he, like students, predicted that an increase in the wildebeest population would lead to a decrease in the tree population.
  - The clip also presents fire as a disturbance in the Serengeti that decreased as the wildebeest population increased. Ask students to articulate the effect of fire on the tree population (fire decreased the tree population by killing young trees), then ask them to hypothesize the relationship between wildebeest, grass, fire, and trees.
    - It may be helpful to have students examine the graph shown at 33:42 to help center this discussion. This graph is also featured in the "Constructing Explanations and Designing Solutions" section of the "Student Handout" of the "Investigating Science Practices in *Serengeti: Nature's Living Laboratory*" activity.
    - Student hypotheses may vary, but some may suggest that an increase in grazing by wildebeest led to a decrease in fire, and therefore an increase in trees.
- Watch the remainder of *Serengeti: Nature's Living Laboratory* from 33:42 to the end. Have students note the effects of wildebeest on fire and trees, as well as the effects of the increase in trees on other populations in the Serengeti.
- Transition to the "Assessment" section by telling students that they will be finalizing their models based on what they've learned.

Assessment:

- Ask students to revise their models to incorporate the relationships between wildebeest, trees, and fire, as well as the indirect effects on other species.

- Have students produce an explanation of this phenomenon, beginning with the observation that trees increased in the Serengeti.
  - A similar prompt is also found in the "Constructing Explanations and Designing Solutions" section of the "Student Handout" of the "Investigating Science Practices in *Serengeti: Nature's Living Laboratory*" activity.
- Student explanations should include the following components:
  - an understanding that the Serengeti can sustain a large population of wildebeest
  - recognition that the tree population increased as the wildebeest population increased
  - what caused the increase in the wildebeest population (including the effects of rinderpest vaccination in local cattle populations)
  - how the wildebeest affect other populations in the Serengeti, including the amount of grass
  - how increased herbivory leads to a decrease in grass and therefore fire, leading to an increase in trees
  - how an increase in trees affects other species

Extension:

- Tell students that they'll be extending their learning to consider how else wildebeest affect plants.
- Have students list ways wildebeest could affect plants, including both feeding and nonfeeding interactions. Student responses may include:
  - Wildebeest eat some kinds of plants directly.
  - Wildebeest eating certain kinds of plants allows other kinds of plants to grow (e.g., by creating more space or reducing fires).
  - Wildebeest trampling grass might help/hinder growth of certain plants.
  - Wildebeest dung might fertilize plants.
- Have students classify these effects as either trophic (feeding) or nontrophic (nonfeeding).
- Ask students how they could represent nontrophic interactions in their ecosystem models. Students may suggest using a different line color, line weight, labels, or some other way of representing these interactions and making their thinking visible.
- Have students complete the "Nutrient Cycling in the Serengeti" activity, which focuses on the cycling of carbon, nitrogen, and phosphorus using a typical savanna grass and wildebeest.
  - Students begin with a card activity to engage with nutrient cycling processes in the Serengeti, then complete the "Student Handout" (either the "regular" or "advanced" version).
  - Questions 12 and 13 from the regular handout can serve as an assessment of student understanding of both biotic and abiotic factors in an ecosystem, as well as the effect of a disturbance (a decrease in predators) on other populations.
- Extend student thinking beyond the Serengeti by asking them to apply the concepts learned in this activity sequence to new systems using the "Modeling Trophic Cascades" card activity or *Exploring Trophic Cascades* Click & Learn.

TEACHING TIPS

- Present students with the images first, before they read the background information.
- Encourage students to draw upon their prior experiences and knowledge to interpret the images and generate questions.
- Provide opportunities for students to explore outside sources to promote their independent explorations and discussions.

- Background information may be edited to support student proficiency, course sequence, etc.
- The images may be projected in lieu of handouts.
- Printed images can be laminated for use in multiple classes.
- Pair or group students to work through one or more of the implementation suggestions.

CREDITS

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Images courtesy of Tony Sinclair