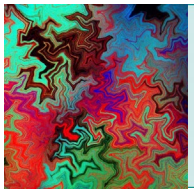

Mozambique Mounds

HOW TO USE THIS RESOURCE

The image for this resource is an aerial photo showing spatial patterning of termite mounds in Mozambique. This image can serve as a phenomenon 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 image 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 image and the "Background Information" section.

KEY CONCEPTS

A. Termites promote vegetation in savanna ecosystems through soil aeration, provision of nutrients, and retention of rainwater.

B. Competition between termite colonies leads to regular spacing of their mounds. These mounds also provide ecosystem stability by resisting change (known as ecosystem resilience), particularly during times of drought.

NGSS PERFORMANCE EXPECTATIONS

HS-LS2-2: Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.

HS-LS2-6: Evaluate claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.

BACKGROUND INFORMATION

Termites are insects that live in large groups called colonies. In certain termite species, each colony builds and lives in a structure known as a mound, which may be as large as 98 feet (30 meters) across. As termites move through their mounds, they change the texture of the soil, concentrate nutrients, and dig tunnels that improve water flow. Their actions create a rich environment for plant growth on top of the mounds.

As a result, termites play a crucial role in African savanna ecosystems. The plants that grow on termite mounds are important habitats for birds, lizards, and other small animals. The mounds also provide dense concentrations of food for larger animals, such as antelope and monkeys. The interactions between the savanna animals and the termite mounds create a positive feedback loop. The animals attracted to the plants on the mounds often bring more nutrients (in the form of dung and urine) or disperse seeds to the mounds. These events in turn reinforce the richness of the soil and vegetation on the mounds.

The image shows a bird's-eye view of the savanna in Mozambique, which has many termite mounds. The mounds are evenly spaced because neighboring termite colonies compete with each other for food and other resources.

IMPLEMENTATION SUGGESTIONS

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

Engagement, establishing prior knowledge, and providing context:

- Begin the lesson by telling students they will be examining a photo of a landscape taken from an airplane.
- Divide students into groups of two or three and provide each group with a copy of the image. Ask the groups to list their observations about the image. Encourage them to use 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 image. Record class observations, noting when students make similar observations and drawing attention to the range of student-generated questions.
    - Students may observe that the landscape consists of areas with vegetation and areas without vegetation.
    - Students may observe that the vegetated areas appear to be relatively evenly spaced, and that the landscape is surrounded by areas of denser vegetation.
    - Students may wonder what determines whether an area does or doesn't have vegetation, and what factors determine spacing between the areas with vegetation.
    - Students may also wonder what types of vegetation are present and what factors cause the vegetation to grow in clumps.
- Ask students to brainstorm what plants require in order to grow.
    - Student ideas may include sunlight, water, soil, space, nutrients, etc.
- Watch the animation *How Termites Enrich Ecosystems*, either as a class or in small groups, with the sound and subtitles off.
    - Ask students to make observations about what the termites are doing, what materials they're bringing back into the mound, and how the rain affects the plants growing on the mound.
    - Depending on students' familiarity with termites, it may be helpful to show images of termites before they watch the animation.
- Ask students to consider what the savanna ecosystem would be like without termites and to predict how removing termites would affect it. Students may express their predictions in writing, diagrams, or preliminary mathematical models.
    - It may be helpful to have students consider their predictions independently and then share representations of them in small groups.
- At this point, have students read the "Background Information" for the image, noting in particular the term "positive feedback."
    - It may be helpful to discuss students' understanding of the term "feedback." They should understand that positive feedback tends to amplify a particular effect, whereas negative feedback tends to return a system to its baseline state.

Exploration, assessment, and extension:

- Exploration/Investigation:
    - To further discuss spatial patterning driven by termites, have students explore some or all of the following BioInteractive resources:

- The *Scientists at Work* video *Analyzing Patterns in the Savanna Landscape* and accompanying worksheet explore examining and quantifying spatial patterns in termite mound formation.
  - In the worksheet, students examine a Voronoi diagram overlaid on a landscape of termite mounds, quantify the number of neighbors each mound has, and then graph the frequency distribution of these numbers. They also calculate the mean, median, and mode of the data set. Doing so helps students better articulate spacing between termite mounds and connect how resource competition leads to uniform spacing in ecosystems.
  - The worksheet also includes a question about water stress and conservation of termite ecosystems in the savanna, which leads into the Data Point activity below.
- The Data Point "Modeling Ecosystem Effects of Termite Mound Patterns" asks students to compare the modeled effects of water stress on ecosystems with and without termite mounds, in terms of vegetation biomass and resilience. The provided discussion questions help students unpack the figure and connect the data presented with approaches to conservation and preventing desertification.

- Have students read the article "Visiting the Mysterious Fairy Circles of the Namib Desert," originally published in *The Atlantic*, which discusses how researchers are investigating patterns created by termites. The article focuses on German naturalist Norbert Jürgens, but also features research by Corina Tarnita (who is featured in the *Scientists at Work* video above) and Robert Pringle (who took the photograph featured in this activity). With this article, it may be helpful to use one or more of the following strategies:
  - Reduce the amount of text, or assign different sections to different groups for close reading.
  - Identify specific words or phrases that students may struggle with. Determine whether these are scientific or technical terms, or nontechnical "academic" vocabulary that students may not be able to understand from context.
  - Provide text-dependent reading questions that students can use to guide their reading and focus on key points. Some text-dependent questions may be answered by identifying specific passages from the text. Others may require students to synthesize their understanding of the overall text.
  - Employ literacy strategies such as graphic organizers, anticipation guides, etc., depending on students' familiarity or comfort with reading long-form articles. For example, consider providing an organizer that helps students summarize and compare the different arguments for how fairy circles form, or one that helps them understand the questions that scientists are continuing to investigate.

- Assessment**:**
  - After students engage with the activities above, ask them to revise their initial predictions about the consequences of removing termites from the savanna ecosystem. Their revised predictions should include how termites facilitate vegetation biomass and how competition leads to the spatial patterning observed in the original image for this activity.
- Extension:
  - Students may be unfamiliar with how termites are able to digest wood. The *I Contain Multitudes* video *Termites Digest Wood Thanks to Microbes* and its accompanying resources explore the gut microbiome that allows termites to digest cellulose.
    - The accompanying activity includes multiple-choice and open-ended response questions, as well as a graphic organizer that asks students to classify statements as facts or inferences using evidence from the video.
    - The related *Medium* article "Symbiosis: It's Complicated" details the role of symbionts in shaping ecosystems, including how gut protists and bacteria enable termites to digest cellulose. Although the

article is relatively short, it may be helpful to divide it into sections based on its subheaders. Students can create summaries for each section using diagrams or figures.

TEACHING TIPS

- Present students with the image first, before they read the background information.
- Background information may be edited to support student proficiency, course sequence, etc.
- The image may be projected in lieu of handouts.
- Printed images can be laminated for use in multiple classes.

Resource-Pairing Suggestions

Use the image to introduce a lesson on:

- ecosystem stability and change
- population dispersion
- nutrient cycling within ecosystems

SOURCE

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