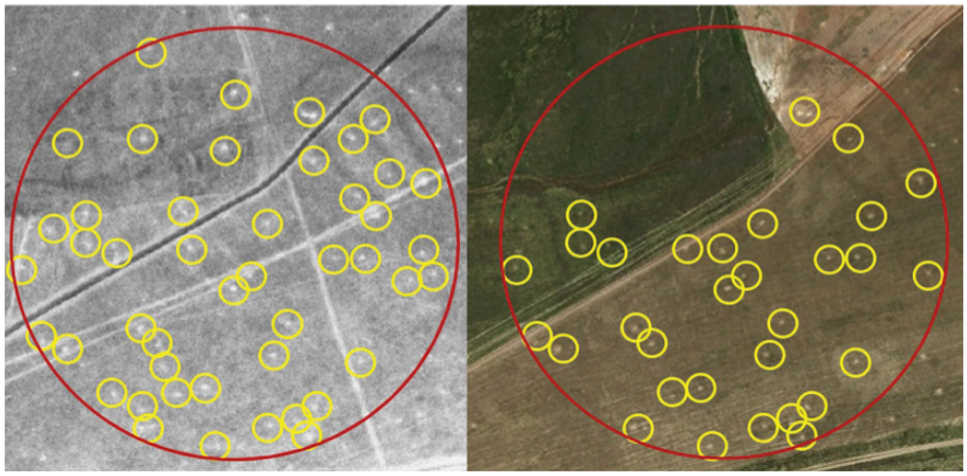
Half-Earth Phenomenal Image: Marmot Maps



Instructor Background: Marmots are a group of 14 living species. They are burrowing rodents that engineer the environments they live in and can play a keystone species role through their capacity to literally shape the landscape and influence long-term ecosystem health. These images, taken from a Cold War spy satellite and featured in an article the *Proceedings of the Royal Society Biological Sciences*, depict marmot burrows from the 1960s (left) and marmot burrows from the 2000s (right) from the same exact location. These burrows are visible because of the mounds of soil the marmots create when they tunnel below ground.

Warm Up: Compare and Share

Part 1: Compare

1. Show students the 2 images without context and ask them to jot down what they notice about each individual picture. A good target would be 5-10 observations.
2. Next ask students to explicitly compare and contrast the images and make a list of similarities and differences between the two images.
3. Ask students to write at least one question they have about the observations they made between the two images. You could remind students that their question might be a how or why question.

Part 2: Share

1. Now have students share their observations with a partner and record the similarities and differences between their lists and questions.
2. Ask the partners to formulate a new question that came from their conversation. The question could be a modification of one of their individual questions.
3. Student pairs can share out with the larger group.

Scientific Literacy: Ecological Implications of Marmots

The excerpts below were taken from an article by Munteanu et al. published in *The Proceedings of the Royal Society.* Students can read these two excerpts independently, in small groups, or as a whole class and discuss the conservation implications with the questions that follow. To up-level the lesson, the full article can be found here. For additional details on the use of satellite data to analyze the implications of farmland on marmot populations and marmot populations on the ecosystem, check out this additional study published in *Remote Sensing in Ecology and Conservation.*

Cold War spy satellite images reveal long-term declines of a philopatric keystone species in response to cropland expansion

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...Agriculture is essential for human societies, but millennia of agricultural land-use changes have transformed much of the planet's land surface and contributed to the ongoing biodiversity crisis [1–3]. The world's grasslands are particularly affected by agriculture, with as much as 80% lost on some continents [4]. This loss is worrisome because grasslands harbour astonishing biodiversity of plants, insects, birds, and large grazers—American bison and pronghorn antelope in North America; Saiga antelope, Asiatic wild ass, and Mongolian gazelle in Eurasia; and wildebeest and zebras in Africa [5–7]. Understanding the biodiversity response to agricultural expansion relies largely on satellite remote sensing [8].

> ...Burrowing rodents, such as marmots, ground squirrels, maras, and wombats, are critical for assessing long-term ecosystem functioning because they are keystone species and ecosystem engineers [25]. Burrowing rodents provide dens, nesting habitat, and shelter for many other species, such as foxes, owls, and arthropods [26,27]. Rodents are a food source for larger predators, and through digging and herbivory, they increase soil nitrogen content and forage quality for large grazers [25]. However, human activities have caused major declines in burrowing rodent populations worldwide, directly through poisoning or hunting and indirectly through agricultural expansion and intensification [23,28]. The repeated disturbance of the burrows through agricultural practices (i.e. tillage, harvest, pesticide application) might lead to population fitness declines, ultimately causing a population drop [22,23].

Conservation Discussion: Upon reading the article, have students discuss the following ecological implications of the marmot.

1. Based on what you read in the excerpts, what do you think is a logical explanation for the differences between the two satellite images? Explain your reasoning.
2. How important is this Bobak Marmot species to its habitat as an ecosystem engineer and/or keystone species?
3. What do you think the ecological impact of more or fewer burrows might be? How might it effect things like soil composition, hydrology (water movement), and other species?
4. Why is historical data useful to understanding ecology and human impact on species?

Extension:

As mentioned above, there are 14 species of Marmot. The Marmot species highlighted in the studies and phenomenal image is a grassland species called the Bobak Marmot (*Marmota bobak)* considered a keystone species of Eurasian steppes. Does this old world species share ecological similarities to the Marmots of North America? Groundhogs are the most familiar marmot to Americans. For a fun dive into the world of *Marmota monax* check out this podcast. Similarly, a Marmot species in Vancouver Island, Canada is unique to high altitude meadows.

5. Consider the nearly ubiquitous marmot of the U.S., the range-restricted species in Vancouver, and the free-range open plain species in the Eurasian steppe seen from the satellite images. Do you think the role of each of these three different Marmot species as ecosystem engineers or keystone species is the same in each case?