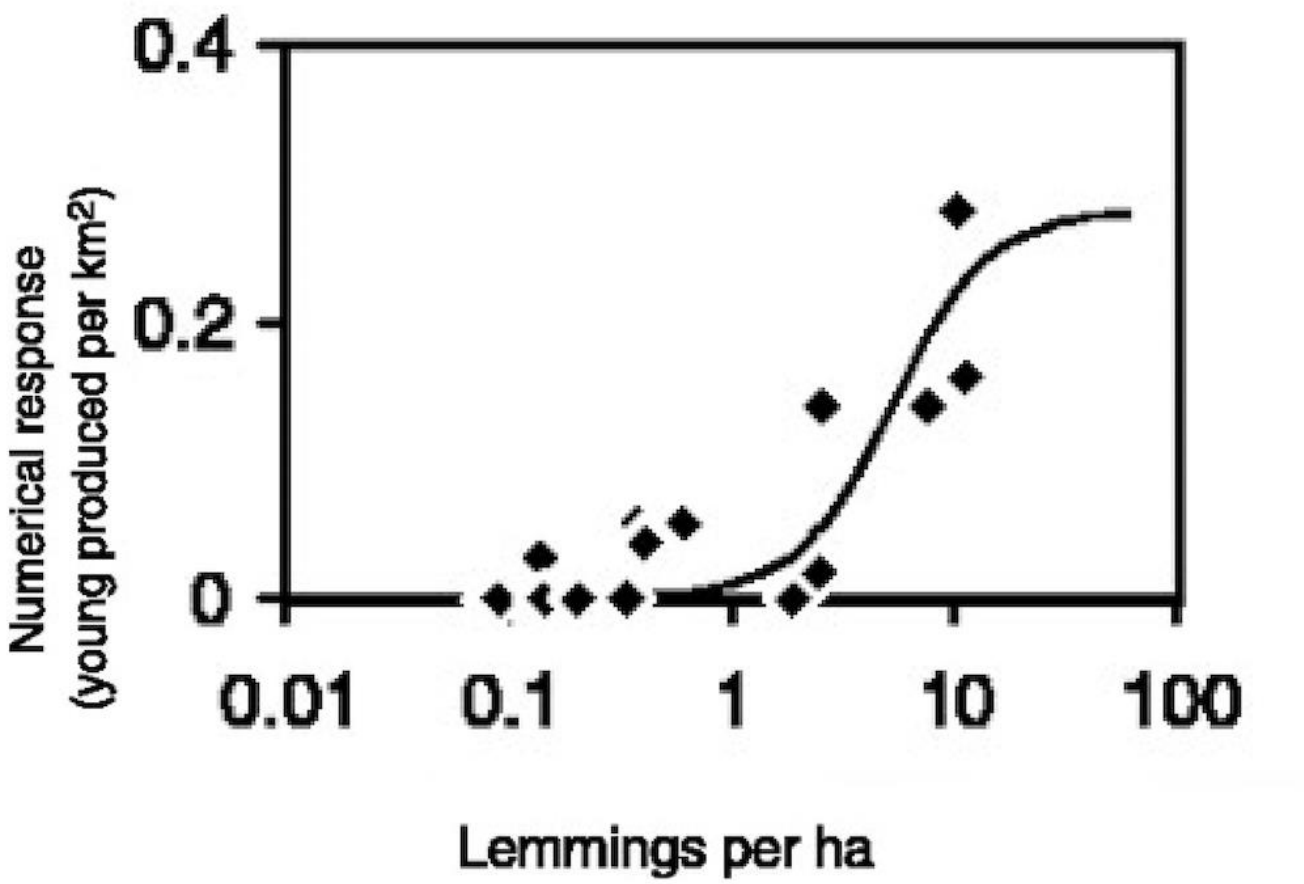
HOW TO USE THIS RESOURCE

Show the figure below to your students along with the caption and background information either by printing the student handout or by projecting the image and reading the text aloud. The "Interpreting the Graph" and "Discussion Questions" sections provide additional information and suggested questions that you can use to guide a class discussion about the characteristics of the graph and what it shows.



Caption: The population density of collared lemmings (*Dicrostonyx groenlandicus*) is measured against the density of offspring produced by one of its predators, the Arctic fox (*Vulpes lagopus*). The data were collected in the High Arctic tundra in Greenland after annual snowmelt.

BACKGROUND INFORMATION

Population sizes of predators and their prey often rise and fall together, following predictable, cyclical patterns over time. These fluctuations are the direct result of the close cause-and-effect relationship between predator and prey population sizes. In other cases, population fluctuations can be caused by other factors, such as the food and habitat available. In a study investigating predator-prey population dynamics at a 75-km^2 field site in northeast Greenland between 1988 and 2002, scientists examined whether changes in population densities of Arctic fox are related to changes in population densities of its main prey, the lemming. The figure above compares the data collected on lemming and Arctic fox population sizes, showing the predator's response to changes in lemming density. The researchers counted the number of lemming winter nests at snowmelt each year and used

this number to estimate the lemming population density. Predator response was determined by counting the number of "weaned young produced" in the Arctic fox population.

INTERPRETING THE GRAPH

The figure shows a scatterplot with a fitted curve. The researchers used nonlinear regression, a statistical curve-fitting method used to estimate the relationship between two variables (here, lemming density and Arctic fox offspring density). A nonlinear regression is used because the relationship between predator and prey is not linear. In other words, Arctic fox offspring density does not increase immediately in response to the increase in the lemming population. This lag may be because the initially small fox population is limited by how many offspring it can produce independent of lemming density, resulting in an initially slow rise in offspring density. The larger prey population then allows more offspring to survive and in turn produce their own young, eventually causing offspring numbers to rise more quickly.

The number of offspring produced by the Arctic fox levels off at a lemming density of 10 per hectare, suggesting that, in the denser fox population, competition for space (because foxes are territorial) may have become the limiting factor.

Teacher Tip: Prompt your students to explain the following:

- Graph Type: Scatterplot with nonlinear regression curve
- *X*-Axis: Logarithmic scale showing the density of lemmings per hectare
- *Y*-Axis: Linear scale showing the density of Arctic fox young produced per km^2
- Data Types: Lemmings per hectare (*x*-axis) and Arctic fox young produced per km^2 are both density measurements (i.e., numbers per unit area). 1 hectare is equal to 0.01 km^2.

DISCUSSION QUESTIONS

- What relationship does the graph plot?
- Why did the scientists use a logarithmic scale on the graph's *x*-axis?
- Why was a nonlinear regression curve chosen to fit the data?
- What trends do you see in the data? Describe the shape of the plot.
- What relationship, if any, exists between Arctic fox offspring density and lemming population density?
- When does Arctic fox offspring density begin to rise? Why doesn't it begin rising earlier?
- When do offspring numbers begin to level off? Why?
- Besides prey availability, what factors might limit the density of Arctic fox offspring produced?
- In this study area, lemmings have three additional predators: stoat, snowy owl, and long-tailed skua. How would these predators affect the Arctic fox?
- What is a density-dependent factor in a population? Explain your answer using the relationship between the lemming and the Arctic fox as an example.
- Refute or support the statement: "Lemming density controls the number of Arctic fox young produced in the High Arctic tundra of Greenland." Use evidence from the graph to support your argument.
- Predict what will happen to the Arctic fox population if lemming density increases above 100 lemmings per hectare. Use evidence to support your argument.
- Why are population "densities" used to illustrate an effect instead of simply reporting total population counts?

SOURCE

Figure 1 from:
Gilg, Olivier *et al*., Cyclic dynamics in a simple vertebrate predator-prey community. *Science*. 2003, 302(5646), 866–868.
View article: http://science.sciencemag.org/content/302/5646/866.full

AUTHOR

Bob Kuhn, Centennial High School, Roswell, Georgia
Edited by: Olivier Gilg, PhD, University of Burgundy; Sandra Blumenrath, PhD, Bridget Conneely and Jessica Johnson, HHMI