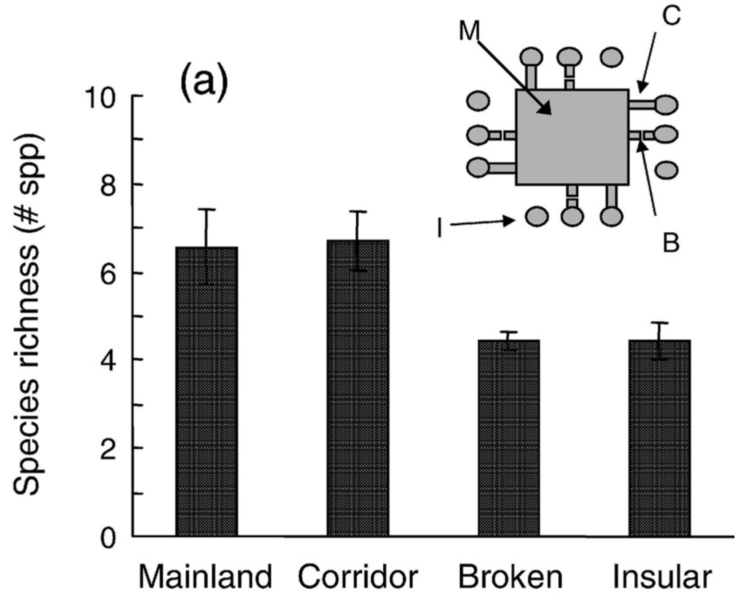
Habitat Fragmentation Impacts Arthropod Species

HOW TO USE THIS RESOURCE

Show the following figure and caption to your students. The accompanying "Student Handout" provides space below the caption for "Observations, Notes, and Questions" and space next to the "Background Information" for "Big Ideas, Notes, and Questions." The "Interpreting the Figure" and "Discussion Questions" sections of the "Educator Materials" provide additional information and suggested questions that you can use to prompt student thinking, increase engagement, or guide a class discussion about the characteristics of the figure and what it shows.

Additional information related to pedagogy and implementation can be found on [this resource's webpage](), including suggested audience, estimated time, and curriculum connections.



Caption: *Species richness (mean number of different mite species) in four types of moss habitats on boulders. The layout of the moss habitats is shown on the top right (not to scale). There is a central area covered in moss (**mainland, M**) and three types of moss fragments: fragments connected to the mainland by corridors of moss (**corridor, C**), fragments with broken corridors (**broken, B**), and fragments isolated from the mainland (**insular, I**). Mites were counted in samples of equal areas from the mainland and fragments. Error bars represent ±1 standard error of the mean (SEM) over seven boulders.*

BACKGROUND INFORMATION

Human activities — such as cutting down trees and developing roads, farms, and cities — break wild habitats into smaller, separated pieces called **fragments**. Many species struggle to survive inside isolated fragments and eventually die out. One way to make a fragment less isolated is to build a **corridor**: a passageway of suitable habitat, such as a strip of forest, that connects the fragment to another habitat.

In the study from the figure above, scientists decided to investigate how species in fragments are affected by corridors. Since it's difficult to do experiments with fragments and corridors in large natural habitats, they looked at some much smaller habitats: moss patches on boulders. **Moss** is a small plant found in many forests. It grows in dense mats and patches on moist, rocky surfaces. Moss patches are habitats for rich communities of tiny organisms, including many diverse species of **mites**: small arthropods related to spiders.

The scientists wanted to study how the number of mite species would change if their habitat was broken into fragments with or without corridors. They found seven flat moss-covered boulders with mites, then scraped off some of the moss to create fragments and corridors. The final habitat layout, which was replicated for all seven boulders, is shown in the top-right corner of the figure (not to scale). The gray parts represent moss, in which the mites usually live. The white gaps represent bare rock, on which the mites lack enough food and shelter to survive.

As shown in the figure, the layout had a central **mainland**: a large (50 × 50 cm) area covered in moss. The mainland was surrounded by 12 small, circular moss fragments (10 cm^2 each). The scientists randomly chose four fragments for each of the following treatments:

- **corridor (C):** These fragments were connected to the mainland by a corridor (a 7 × 2 cm strip of moss).
- **broken (B):** These fragments were connected to the mainland by a "broken" corridor (a 7 × 2 cm strip of moss with 2–3 cm of bare rock in the middle).
- **insular (I):** These fragments were not connected to the mainland at all.

Six months after creating the fragments and corridors, the scientists took samples of equal area from the mainland (M) and the three types of fragments (C, B, and I) on each rock. They counted the number of mite species in each sample as a measure of **species richness**: the number of different species in an area.

INTERPRETING THE FIGURE

Studies of species loss following habitat fragmentation that test different corridor systems are challenging to do in large natural habitats. The moss "microecosystem" used in this study is small in size but rich in species, and it experiences the same ecological processes as larger ecosystems. As a result, the moss system provides an excellent experimental model for studying how species may be impacted by habitat fragmentation and whether corridors can reduce those impacts.

As shown in the figure, the number of species after six months was highest in the mainland (M) and in the fragments connected to the mainland by an uninterrupted corridor (C). In contrast, there were significantly fewer species in the fragments that were isolated from the mainland, including the fragments that were completely insular (I) and those with a broken corridor (B) that the mites could not traverse easily. Since all parts of the habitat were initially one continuous habitat, they were assumed to have started with similar numbers of species per area. As a result, the fragments with lower species richness after six months likely lost species over time.

These results are related to key principles in island biogeography. **Island biogeography** is a theory that explains how the number of species in an "island" (habitat patch or fragment) is affected by the size and isolation of that island — from actual islands surrounded by water to "islands" of natural habitat surrounded by inhospitable areas, such as human farms or cities. In this case, moss-covered areas act as "islands" of essential habitat and resources for the mites. They are surrounded by an inhospitable "sea" of bare rock where the mites cannot survive as easily.

Island biogeography focuses on how local extinction and immigration determine equilibrium species numbers on islands, including habitat fragments. In turn, the processes of immigration and extinction are affected by area and isolation. Two of the key principles are as follows:

- Fragments with *smaller areas* tend to have *higher* rates of local extinction (species loss). This is because species in smaller fragments typically have smaller populations, which are at greater risk of dying out.
- Fragments that are *less isolated* tend to have *lower* rates of local extinction. This is because they are closer to major sources of new individuals (e.g., the mainland). Individuals from the mainland can move to the fragment, thereby recolonizing lost species or replenishing existing populations. A fragment that is *less* isolated from the mainland is *more* likely to receive immigrating species, so it is less likely to lose species overall. This phenomenon is known as the **rescue effect**.

The results of the moss study reflect these principles. For one, the fragments were much *smaller* than the mainland (10 cm^2 vs. 2,500 cm^2) and would thus be expected to have *higher* rates of local extinction unless they could be "rescued" by immigrating species. Immigrating mites could travel more easily from the mainland to fragments with corridors (C). These fragments were therefore *less isolated* from the mainland and did not experience significant species loss. However, immigrating mites could not easily cross the bare rock between the mainland and the broken and insular fragments (B and I). These fragments were therefore *more isolated* from the mainland and ended up with fewer species over a given area, likely due to higher rates of local extinction.

TEACHING TIPS

Prompt students to explain the parts of the figure as applicable:

- Graph type: Bar graph
- *X*-axis: The four types of moss habitats: the mainland and the three fragment treatments (corridor, broken, and insular)
- *Y*-axis: Species richness, measured as the mean number of mite species in a given area over seven replications
- Error bars: Represent ±1 standard error of the mean (SEM), which is used to express the precision of an estimate of the mean
- Inset: A diagram showing the layout of the fragmented moss habitat (not to scale; specific dimensions are provided in the "Background Information"). The gray parts represent moss, and the white gaps represent bare rock. Labels on the diagram correspond to the labels on the *x*-axis.

Complement this Data Point with the following related resources:

- The Data Points "Habitat Size Impacts Arthropod Species" and "Habitat Isolation Impacts Arthropod Species" present two relationships in island biogeography related to the results of this Data Point. "Habitat Size" focuses on the relationship between species number and habitat area (also known as the **species-area relationship**). "Habitat Isolation" focuses on the relationship between species number and the distance from a major source of species (also known as the **distance effect**).
- The activity "Exploring Island Biogeography through Data" has students use multiple scientific figures, including the one presented in this Data Point, to explore and synthesize the key patterns in island biogeography.
- The short film *From Ants to Grizzlies: A General Rule for Saving Biodiversity* and its accompanying film activity can be used to introduce students to island biogeography concepts, with an emphasis on the species-area relationship.
- The website Conservation Corridor provides additional resources to bridge the science and practice of conservation corridors and connectivity.

DISCUSSION QUESTIONS

- Describe the design of the experiment in your own words, including the following:
  - What were the independent and dependent variables?

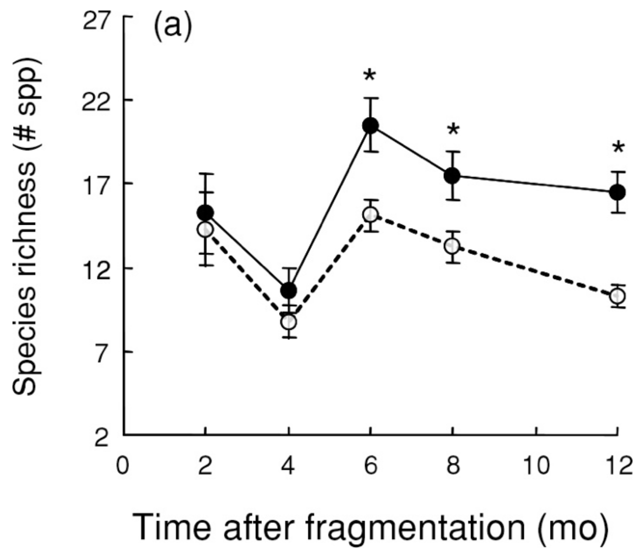
- What factors were held constant?
- Which type of moss habitat represented a "control" group (M, C, B, or I)?
- How was replication achieved in the experiment?

- Which of the three types of fragments (C, B, or I) had the highest number of species? Lowest number of species? Support your answers with evidence from the graph.
- Which of the three types of fragments (C, B, or I) is most isolated from the mainland (M)? Least isolated? Support your answers with evidence from the figure. (*Hint*: Look at the habitat layout. Can mites move between C and M, I and M, etc.?)
- What does the figure indicate about the relationship between number of species and fragment isolation?
  - Propose a biological reason for why this relationship occurs.
- Do you think each fragment had the same types of mite species? Why or why not?
- Imagine one mite species ("Mite A") that was initially present in the mainland and all of the fragments. How might the population size of Mite A in each of the fragments differ from the population size of Mite A in the mainland?
  - Species can become "locally extinct" in a certain area if their population in that area dies out. How might the probability of Mite A becoming locally extinct in any one fragment differ from the probability of Mite A becoming locally extinct in the mainland?
  - How might the probability of Mite A becoming locally extinct in a "C" fragment differ from the probability of Mite A becoming locally extinct in an "I" or "B" fragment?
- The tiny moss ecosystem is a useful model for studying habitat fragmentation. What are some advantages of studying the moss ecosystem instead of a larger ecosystem? What might be some of the disadvantages?
  - Why might it be difficult to study extinction caused by habitat fragmentation in larger ecosystems? What kinds of ethical considerations might there be?
  - Find a study that explores habitat fragmentation and corridors in a larger ecosystem, such as the Savannah River Site Corridor Project. Compare and contrast this study with the moss system study.
- The mites in the moss system are so tiny that they can be isolated by relatively small areas of bare rock. What kinds of things might isolate larger species? Give a few specific examples.
  - Do you think the examples you chose would affect all species in the same way? What types of species might be more or less isolated by the examples you chose?
  - Why might isolation be an important consideration in conservation planning?
- What other types of species and habitats might the patterns found in this study apply to?
  - How might the results of this study apply to the protection of larger species in habitat fragments, such as large mammals in national parks?
  - The short film *From Ants to Grizzlies: A General Rule for Saving Biodiversity* (12:12–16:40 in particular) describes the use of wildlife corridors to connect large natural habitats that have been fragmented by human activities. Compare and contrast the corridors in this study to the corridors shown in the film.
- The results of this study can be related to island biogeography theory. **Island biogeography** is a field of science that looks at species distribution and dynamics in isolated habitats — from actual islands surrounded by water to "islands" of natural habitat surrounded by a "sea" of inhospitable areas, such as human farms and cities.
  - What are the "islands" in the moss system? What is the "sea"?
  - The *From Ants to Grizzlies* film (6:36–7:46 in particular) describes a famous experiment in island biogeography. Compare and contrast the experiment in the film with the moss experiment. How do the experimental designs and results compare?

EXTENSION

In a related experiment, the scientists looked at how the number of mite species changed over time. They compared the mites in one large area of moss (2,500 cm^2) to those in six small fragments of moss (20 cm^2 each) on the same rock. The fragments were created by scraping moss off the rock, and the experiment was replicated over eight rocks.

The scientists surveyed the mites every two months for one year. This time period was long enough for the mites to have multiple generations and experience seasonal changes. The following figure shows the numbers of mite species over time.



Caption: *Changes in species richness (mean number of mite species) over 12 months in the large moss area (shaded circles) and the smaller moss fragments (unshaded circles). Error bars represent ±1 standard error of the mean (SEM). An asterisk (*) indicates a significant difference between the large moss area and fragments.*

How do these results compare to, support, or conflict with the results of the previous figure? Do they provide important additional information? If so, what?

SOURCE

Figures 4a and 1a from:

Gonzalez, Andrew, and Enrique J. Chaneton. "Heterotroph species extinction, abundance and biomass dynamics in an experimentally fragmented microecosystem." *Journal of Animal Ecology* 71, 4 (2002): 594–602. https://doi.org/10.1046/j.1365-2656.2002.00625.x.

CREDITS

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