Research into biodiversity was just published in the journal *Science* relating to man-made islands in Thailand. Read the following article summary and answer the questions about it that follow.

Biodiversity In Forest Fragments Proves Precarious 26 September 2013
http://news.sciencemag.org/environment/2013/09/biodiversity-forest-fragments-proves-precarious

Anthony Lynam; (inset) Luke Gibson

Going, going ... Small mammal species have disappeared more quickly than expected from the forest fragments on islands created by flooding in southern Thailand. Populations of surviving species, such as this moonrat (*inset*), have plummeted.

As deforestation accelerates around the world, ecologists have increasingly pinned their hopes of preserving biodiversity on nurturing the isolated patches of forest often left behind. But new research suggests that small mammal species native to these forest fragments are at greater risk of extinction than previously thought.

The filling of the Chiew Larn Reservoir in southern Thailand in 1986 and 1987 created more than 100 islands and presented a rare opportunity to study the effects of sudden isolation on small-mammal communities. In the early 1990s, a team led by population geneticist David Woodruff of the University of California, San Diego, set traps to survey small mammals on 12 of the islands, ranging in size from 0.3 to 56.3 hectares. They found that after 5 to 7 years of isolation, the three biggest islands were still home to seven to 12 species of mice, rats, squirrels, and shrews. The range of species was similar to that found in a large, undisturbed forest on the nearby mainland. On the small islands, however, the researchers found just one to three species, indicating a rapid decline in diversity, presumably because the islands were too small to sustain animal communities.

Ecologist Luke Gibson of the National University of Singapore and colleagues revisited those islands plus four more in 2012 and 2013 to repeat the surveys, with some dramatic results. Six of 12 species present in the early 1990s, including the pencil-tailed tree mouse and the red spiny rat, have apparently disappeared. Five other species have declined dramatically. For example, the 1993 survey turned up 47 common tree shrews, but only one was found in 2013. "We documented the near-complete extinction of an entire group of animals," Gibson says.

In contrast, Malayan field rat numbers exploded, from 77 in 1992 to 289 in 2013. This rat is not normally found in the region's undisturbed forests but likely migrated to the islands from villages and agricultural areas after inundation. It now dominates the islands but is rare in the intact forests of the nearby mainland.

In the absence of other obvious causes, the researchers blame the loss of species on fragmentation and the impact of the invasive rat. This one-two punch "underscores a dire need to maintain large intact forest blocks to sustain tropical biodiversity," the authors write today in*Science*. Gibson adds that the loss of species occurred more quickly than has been reported by other groups studying other sites around the world.

"This study makes a valuable contribution in quantifying how fast the extinctions take place—very fast in this case," says Ilkka Hanski, an ecologist at the University of Helsinki. But he notes that the study does not tease out whether the fragmentation or the rat invasion had a greater impact. Robin Chazdon, an ecologist at the University of Connecticut, Storrs, notes that the mechanism by which the invasive rats contributed to the demise of native species—whether they devoured available food or introduced new diseases—is not clear. "These findings are not directly relevant to forest fragments in terrestrial landscapes," where animals from surrounding areas could recolonize the isolated patch, she says.

Gibson agrees that it is difficult to separate the impact of forest fragment size from that of the rats. "Our data don't show any direct mechanism," for how the rodents might have tipped the scales against the natives, he says. As for the implications for fragments on large land masses, he argues that these small islands provide "a sign of things to come." For example, he says a recent study of Brazil's Atlantic forests found that 80% of fragments remaining after deforestation are 50 hectares or smaller—about the size of the Thai island samples. Although most forest fragments are not ringed by water, they are nonetheless "increasingly surrounded by intensive agricultural landscapes that often harbor invasive animal species," Gibson says. Beyond preserving large intact forests, he adds, conservation efforts should aim to keep or create forested corridors to link small fragments of important habitat or to connect them to larger forests nearby.

Questions:

1. Explain how this forest ecosystem became fragmented.
2. Summarize the scientists findings about biodiversity on the
   a. Small islands
   b. Large islands
3. Make a simple graph of the overall findings by Luke Gibson between the early 1990s and 2012-13.

APES Lab: Simulation of Habitat Islands

Habitats, of various types, once covered thousands of acres of land in the United States and many other countries. These habitat areas are being reduced to small fractions of their original size as humans turn more wild lands into urban and suburban areas, farms and pastures, highways, and other areas. These habitat "patches" are like islands of safety for the animals, as well as plants, that need the area to survive; these organisms are often surrounded by a sea of unsuitable habitat. When a habitat is fragmented like this, it becomes a series of little habitat islands that are various sizes and various distances from each other. There is often a larger habitat area (like a mainland for islands in the ocean). This serves as a source of new individuals for the smaller habitat islands. For example, there are 156 protected national forests in the U.S., such as the Ocala National Forest. A national forest might serve as a source population of squirrels that migrate through farmland in order to reach the forest habitat islands.

Simulation:
A 10,000 acre part of the Ocala National Forest has been leased to the Igotubabe Lumber Company. As part of the leasing agreement, the lumber company agrees to leave a 1,000 acre island in the center of the forest uncut. In addition, they will leave several patches of forest totaling about 1,000 acres uncut.

Your Task:
Your group will be the forestry science team appointed by the government to determine what kind of forest islands are the most desirable in order to save native fauna and flora, which may migrate between habitat islands. Your choices are:

1. Islands that are near the source population and small in size
2. Islands that are near the source population and large in size
3. Islands that are far away from the source population and small in size
4. Islands that are far away from the source population and large in size

Your team will use the following materials to carry out the biogeography simulation:

100 organisms = "counters" (e.g., beans, pennies, circles of paper) and Habitat Island Patterns. The "counters" represent individuals of a migrating species that have ventured out to the islands from the source population. The chances of a counter landing on a paper island represent the same chances a migrating organism has of colonizing a real habitat island.

1. Hypothesize which island you think will have the greatest species diversity (or species richness and the greatest species abundance.
   * Rank the four types of islands (listed above 1–4) in the order you think they should be ranked, from the one you expect to have the most species surviving to the one you expect to have the least species surviving.

* Write out your hypothesis of what you think the simulation will show about the four islands' species survival (remember to use an "if-then statement").

2. The Set-Up

(A) Brown = largest circle = Source population = 25.5 cm= 10 inches diameter
Green and Yellow = two medium sized circles: Green = near, Yellow = far= 17.8 cm = 7 inches diameter
Blue and Red = two small circles: Blue = far, Red = near = 10.2 cm = 4 in. diameter.

(B) On a flat surface (floor or lab table-top), place/tape down the circles in the following manner: Brown circle in center of area; the Red 2.54 cm (1 inch) due North of Brown (source population); the Green 2.5 cm due West of Brown; Yellow 15.2 cm (6 in.) due South of Brown; Blue is placed 15.2 cm due East of Brown circle.

3. Data Collection

(A) Hold all the counters in a cup one meter above the center point of the Source Population. Drop all the counters.

(B) Record the number of counters that land on each of the islands. These are organisms that made it to the island and survived. Counters that did not land on an island are organisms that encountered unsuitable habitat. For example, a forest mouse may get eaten by a hawk while crossing farmland.

(C) Drop the counters and record the number that landed on each island four more times. (For a total of 5 drops all together). Once you have done this, find the average number of counters that landed on each island.

4. Using the Data

(A) Rank the islands again on the habitat island simulation report page, this time based on your own data. The island on which the most counters landed, on average, is the island that has the highest species survival, and the island on which the least counters landed, on average, is the island that has the lowest species survival. This will be the report you give the government to support your recommendations for the national forest.

APES: Habitat Island Simulation Report

HYPOTHESIS

1. (a) Rank the islands from the Habitat Islands Activity, with a "1" being the island you think will have the most species and a "4" being the island you think will have the fewest species.

Large Far: ___________ Small Far: ___________
Large Near: ___________ Small Near: ___________

(b) Now write out your hypothesis of what you think the simulation will show about the four islands' species survival.

DATA

2. Using the data from the Habitat Island Activity, fill in the table below and calculate the average of your five trials.

Trial #	YELLOW Large Far	GREEN Large Near	BLUE Small Far	RED Small Near
1				
2				
3				
4				
5				
Mean				

ANALYSIS

3. After you've found the average number of counters that landed on each island, rank the four islands (Small Near, Large Near, Large Far, Small Far) from the one that had the most species successfully immigrate to the island to the one that had the least species successfully immigrate.

CONCLUSIONS

4. What type of habitat islands do you think forest scientists should save to protect the greatest amount of biodiversity, and why?

5. How do your data compare to the hypothesis that you made when you answered Questions #1? How do your results compare to the results of other groups?

6. You make your recommendation to the government about which forest habitat islands should be protected. A government official asks why people are worried about the forest species going extinct if all these populations are colonizing the habitat islands. You have to explain to this official the difference between population extinction and species extinction. Then you have to explain why people are worried about species extinctions as well as population extinctions, using an example of a species from your forest habitat islands. What do you say to this official?