RAINFOREST BIODIVERSITY

In this packet, sample student answers are provided in red and notes to teachers are in blue.

In this **Science Mission**, students will explore how natural and human changes to the environment affect biodiversity. They will also explore how populations change in response to resources and biotic and abiotic changes in the environment. Students will develop hypotheses and predications that they test using data from the field. They will use data to create and interpret graphs.

ACTIVITY I: LARGE ANIMALS OF THE FOREST FLOOR

Dr. Branko and the team have collected thousands of hours of data and observed many species from camera traps. These cameras work best for studying large animals that move a lot like birds and mammals. Table 1 shows some of the information they have collected. They have data from deep inside the forest and in a cocoa plantation. The plantation has some forest trees among the cocoa trees and doesn't have an understory. The ground in the plantation is not covered with as much leaf litter as the forest floor.

Table 1. Percent of 100 camera traps where a species was observed

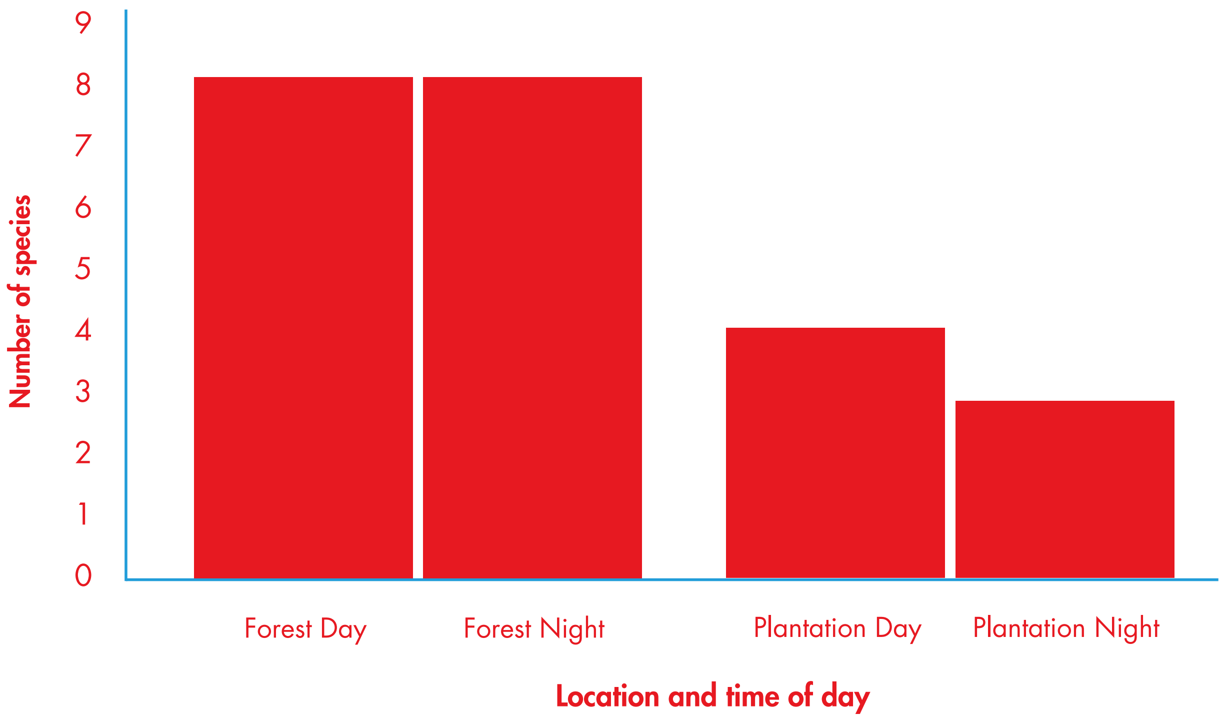
Species common name	Forest		Cocoa plantation	
	Day	Night	Day	Night
Vulture	5	0	5	0
Collared peccary	30	5	10	0
White-lipped peccary	0	0	0	0
Ocelot	0	10	0	1
Puma	0	1	0	0
Tayra	0	2	0	0
Tamandua	5	0	0	0
Tinamou	10	0	0	0
Tapir	5	0	0	0
Margay	0	3	0	0
Coati	10	1	5	0
Raccoon	2	5	0	10
Agouti	15	0	5	0
Opossum	0	5	0	5

1. Use the data in Table 1 to complete Table 2.

Table 2. Summary of results from 100 camera traps

	Forest		Cocoa plantation	
Time of day	Day	Night	Day	Night
Total number of species recorded	8	8	4	3
Most common species	Collared peccary	Ocelot	Collared peccary	Raccoon

2. **Draw** a bar graph of the number of different species recorded by camera traps in the forest and cocoa plantation in day and night. Label the axis and caption the graph.



Number of species recorded by camera traps at different locations during day and night

3. **Describe** the patterns of biodiversity between the two habitats and between night and day.

Biodiversity is higher in the forest than the plantation regardless of time of day. In both locations, biodiversity was similar between night and day, but was a little higher during the day in the plantation.

4. **State** a hypothesis for why there might be differences between the forest and the plantation.

Any plausible explanation should be accepted. Examples include: 1) the open habitat in the plantation makes species vulnerable to predators; 2) there may be less food or shelter in the plantation; 3) animals might be afraid of people that they could see in the plantation.

5. **Describe** how you might test your hypothesis.

Accept any reasonable test of a hypothesis. Examples include: 1) changing the habitat in the forest; 2) adding food to the plantation; 3) having people walk through certain areas of the forest; 4) adding food or cover to the plantation and monitoring animal populations; 5) conducting further studies with other methods; 6) studying multiple plantations and forests to make sure the pattern holds.

Dr. Andrea Romero is a biologist at the University of Wisconsin, Whitewater. She and her team studied peccaries at a reserve near Tirimbina called La Selva Biological Field Station. By investigating historical records and interviewing scientists who had been studying the forests for decades, she was able to learn about how populations changed through time. White-lipped peccaries used to live in bigger groups and were more aggressive. They ate similar foods to their close relatives, collared peccaries, but were heavily hunted. Her data are summarized in Figure 1.

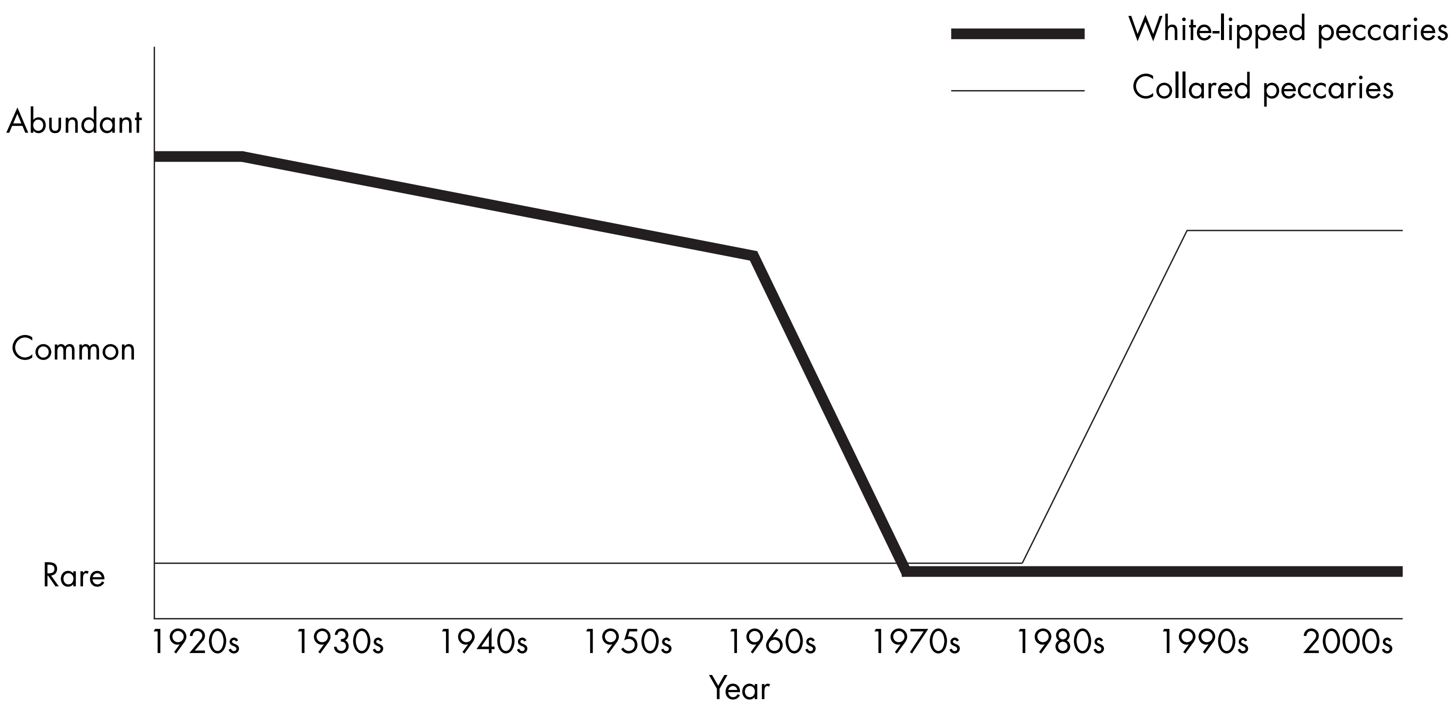


Figure 1. Abundance of two species of peccaries at La Selva Biological Field Station

6. **Construct** an explanation for why white-lipped peccary populations have nearly disappeared.

Accept any reasonable explanation. Some students might suggest they were over-hunted. Others might suggest that collared peccaries out competed them. This response does not make as much sense, because it was a long time after white-lipped peccaries disappeared that the population of collared peccaries increased. Unless something else had changed in the environment this explanation is less likely. To extend, ask students how they would test their hypotheses.

7. **Construct** an explanation for why collared peccaries have become so abundant. Use data from the figure above. Use the terms **competition** and **limited resources** in your answer.

When white-lipped peccaries were hunted out, it allowed collared peccary populations to grow. When white-lipped peccaries disappeared, there was less competition for limited resources and that allowed collared peccary populations to grow.

ACTIVITY 2: SOUNDSCAPES OF THE FOREST

For Dr. Branko's soundscape project, he has placed sound recorders in the forest canopy and near the ground at multiple locations around the Tirimbina Biological Reserve. Other researchers have used sound recorders on the edge of the forest and even in nearby pineapple plantations. Let's use these data to explore the biodiversity of some noisy species.

Bats use echolocation to get around the rainforest and catch their prey. The sound recorders can tell each bat species apart by their calls. This lets scientists measure the number of species present. The recorders can also count the number of bats that pass by. Overall, 19 species were recorded on the ten nights of sampling.

1. **Complete** tables 3 and 4 by calculating the averages.

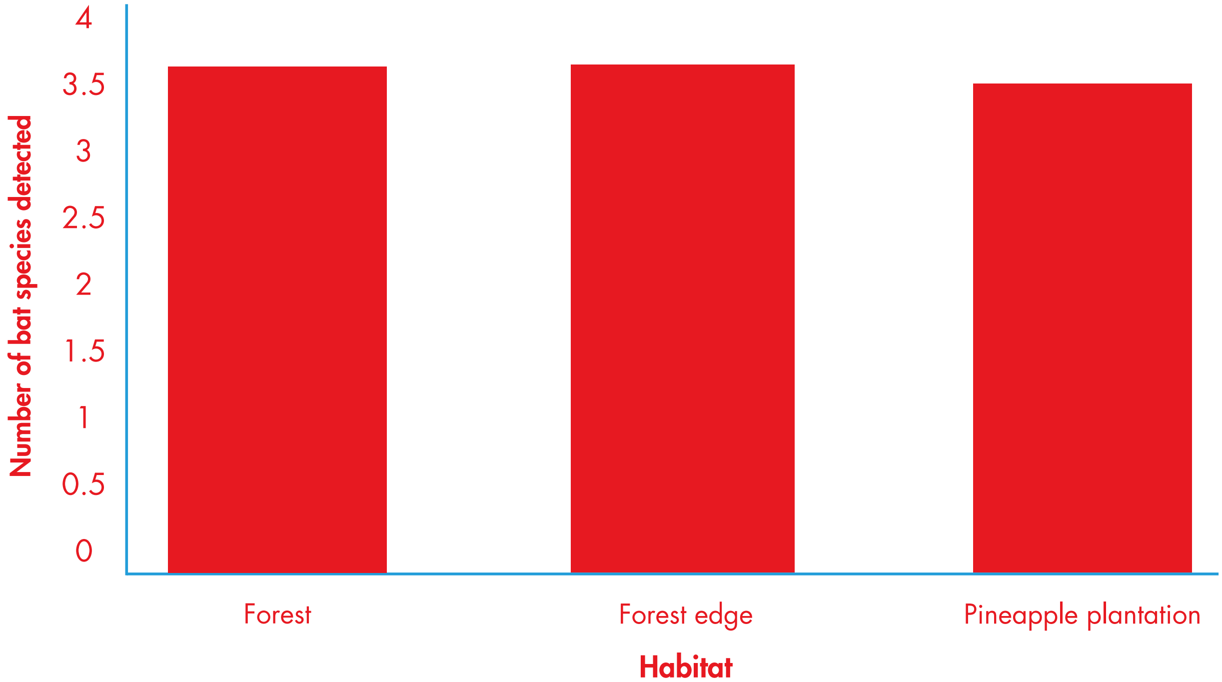
Table 3. Number of bat species recorded on sound recorders during ten nights

Night	Forest	Forest edge	Pineapple plantation
1	4	4	2
2	3	3	4
3	3	3	2
4	4	4	4
5	2	2	4
6	3	3	2
7	6	6	4
8	5	5	4
9	3	3	4
10	3	3	5
Average	3.6	3.6	3.5

Table 4. Number of passes recorded during a 30-minute period on ten nights

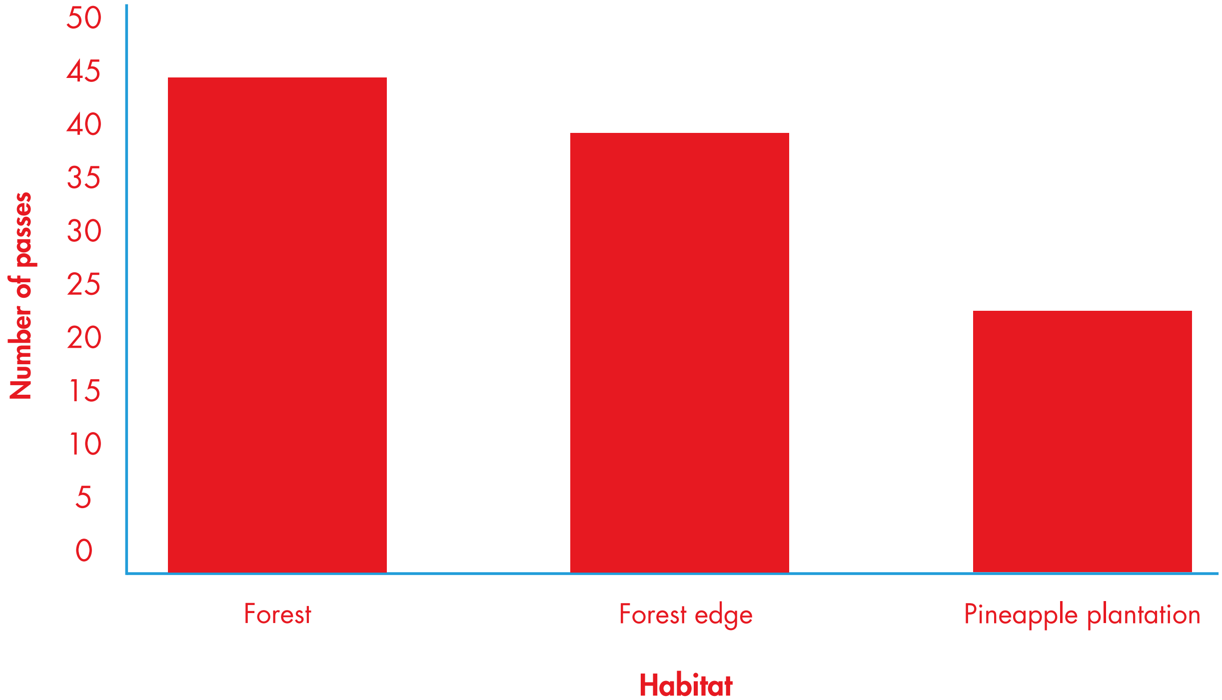
Night	Forest	Forest edge	Pineapple plantation
1	45	40	15
2	50	40	30
3	35	35	25
4	50	30	20
5	60	45	20
6	45	45	10
7	40	40	30
8	35	40	30
9	40	45	25
10	45	35	20
Average	44.5	39.5	22.5

2. **Draw** a graph of the average number of bat species in the three habitats. Label the axes and include a caption.



Average number of species recorded in three different habitats

3. **Draw** a graph of the average number of passes bats make in the three habitats. Label the axes and include a caption.



Number of passes recorded in three different habitats

4. **Compare** and **contrast** the number of bat species and the number of individual bats in the three habitats. Use the data in the tables and graphs.

The number of bat species (biodiversity) is very similar in the three habitats. The average is about 4 bat species per night. But, the forest has the largest number of bats passing by the sound recorders. The pineapple plantation has about half as many passes. The forest edge and forest have a similar number of passes.

5. **Explain** why you think these differences and similarities exist.

Answers will vary. Sample responses include: 1) some bats might venture into the pineapple plantation, explaining the similar number of species detected across locations; 2) there might be less food and more danger in the plantation, explaining the fewer number of passes.

6. **Propose** how you would test the answers you described in question 5.

Answers will vary. Complete answers will propose collecting data on the factors students thought contributed to the number of species and passes in each location.

7. **Describe** some additional information you would like to know about bats in these areas that are not included in the data.

Accept any reasonable answers. For example, students may say they want to know the type of species in each habitat to understand if each habitat has the same type of bats.

Extend the lesson: Have students use Tables 3 and 4 to help them discuss why it was important that the study was conducted on more than one night. They should notice that the data in each area ranged across the different nights, and only collecting data on one night would give less accurate results.

Insects are one of the most important groups of rainforest animals. They are food for many species, including birds and bats. Some species that feed on plants can hurt plant populations. Other species pollinate flowers and help plants!

Cicadas are a group of insects in the rainforest that are difficult to miss. The sound of cicadas is loud and clear upon entering a rainforest. Use the data in Table 5 to investigate when they are present.

Table 5. Detections of male cicadas singing on sound recorders

Cicada species	Time of day when calling is present	Wet season		Dry season	
		Canopy	Understory	Canopy	Understory
Species 1	8:30 a.m. - 4:30 p.m.	Rare	Rare	Common	Rare
Species 2	5:55 a.m. - 6:15 a.m. 6:05 p.m. - 6:20 p.m.	Rare	Common	Rare	Common
Species 3	11:00 a.m. - 5:00 p.m.	Common	Rare	Common	Rare
Species 4	7:30 a.m. - 4:30 p.m.	Rare	Common	Rare	Rare

8. Based on the data above, do you think that cicadas are nocturnal (active at night) or diurnal (active during the day)? **Support** your answer with evidence. (Note: assume the sun rises at 7:00 a.m. and sets at 7:00 p.m.)

I think they are diurnal; they only call during daytime.

9. Do all species of cicadas use the same parts of the rainforest at the same times? **Support** your argument with evidence from Table 5.

No, they do not. Species 1 and 3 only use the canopy, and Species 2 and 4 use the understory. Species 1 and 4 sing most of the day. Species 2 sings only around sunrise and sunset. It sings before any other species starts singing and after other species stop singing for the day. Species 3 sings in late morning and afternoon.

The soundscape detectors have been listening to other species that may be in the canopy and near the forest floor. The data on these species are listed in the following tables.

10. **Complete** the tables by calculating the averages for each species. Each cell represents data from a 60-day period.

Table 6. Percent of days that representative species were detected during the dry season in the canopy

	Mammals			Birds				Amphibians	
Location/ habitat	Howler monkey	Spider monkey	Tinamou	White-collared manakin	Toucan	Clay-colored thrush	Tennessee warbler	Poison dart frog	Red-eyed tree frog
Near swamp	50	25	0	0	75	0	0	0	90
Forest 1	100	30	0	0	80	0	0	0	60
Forest 2	100	25	0	0	80	5	5	0	30
Forest 3	90	35	0	0	50	0	0	0	20
Forest 4	95	20	0	0	80	0	0	0	5
Average	87	27	0	0	73	1	1	0	41

Table 7. Percent of days that representative species were detected during the wet season in the canopy

	Mammals			Birds				Amphibians	
Location/ habitat	Howler monkey	Spider monkey	Tinamou	White-collared manakin	Toucan	Clay-colored thrush	Tennessee warbler	Poison dart frog	Red-eyed tree frog
Near swamp	35	15	0	0	80	0	0	0	30
Forest 1	100	5	0	0	75	0	0	0	40
Forest 2	95	35	0	0	65	5	0	0	35
Forest 3	85	20	0	0	70	0	0	0	15
Forest 4	100	40	0	0	85	0	0	0	0
Average	83	23	0	0	75	1	0	0	24

Table 8. Percent of days that representative species were detected during the dry season near the forest floor

	Mammals			Birds				Amphibians	
Location/ habitat	Howler monkey	Spider monkey	Tinamou	White-collared manakin	Toucan	Clay-colored thrush	Tennessee warbler	Poison dart frog	Red-eyed tree frog
Near swamp	0	0	20	65	0	25	35	50	5
Forest 1	0	0	15	95	0	35	65	45	0
Forest 2	0	0	25	90	0	75	100	35	0
Forest 3	0	0	5	85	0	25	85	25	0
Forest 4	0	0	15	90	0	80	40	15	0
Average	0	0	16	85	0	48	65	34	1

Table 9. Percent of days that representative species were detected during the wet season in the forest floor

	Mammals			Birds				Amphibians	
Location/ habitat	Howler monkey	Spider monkey	Tinamou	White-collared manakin	Toucan	Clay-colored thrush	Tennessee warbler	Poison dart frog	Red-eyed tree frog
Near swamp	0	0	15	65	0	30	0	55	100
Forest 1	0	0	10	95	0	40	0	60	15
Forest 2	0	0	20	90	0	75	0	40	0
Forest 3	0	0	15	85	0	20	0	35	0
Forest 4	0	0	25	90	0	75	0	20	0
Average	0	0	17	85	0	48	0	42	23

11. Use the data in the previous tables to **complete** Table 10.

Table 10. Average percent of days with detections for nine species of rainforest animals

	Canopy		Understory	
Species	**Dry season**	**Wet season**	**Dry season**	**Wet season**
Howler monkey	87	83	0	0
Spider monkey	27	23	0	0
Tinamou	0	0	16	17
White-collared manakin	0	0	85	85
Toucan	73	75	0	0
Clay-colored thrush	1	1	48	48
Tennessee warbler	2	0	65	0
Poison dart frog	0	0	34	42
Red-eyed tree frog	41	24	1	23

12. Use the data in Table 10 to group the species into the following groups. Hint: some groups may not have any animals in them.

Canopy animals, present and use the canopy all year: Howler monkey, Spider monkey, Toucan, [Red-eyed tree frog]. Since red-eyed tree frogs come down to breed in the swamp in the rainy season, they may be classified in different areas.

Understory/forest floor animals, present all year: Tinamou, White-collared manakin, Clay-colored thrush, Poison dart frog. Some students may put red-eyed tree frogs here because they are rare but do occur in the swamp in both seasons.

Canopy animals, only present during one season: None. Some students may put red-eyed tree frogs here.

Understory/forest floor animal, only present during one season: Tennessee warbler

Animals that change their use of canopy and forest floor seasonally: Red-eyed tree frog

Extend the lesson: Have students present their classifications to the class, using data to support their answers. Alternatively, have students write descriptions of why they classified species in a particular way.

Extend the lesson further: Have students look at the data in the four tables. Have them look at how numbers vary across different sites for a particular species. Have them construct arguments to explain the level of variation. For example, students may think that the amount of food varies among sites or that some species prefer the swamp.

ACTIVITY 3: BIRD POPULATIONS THROUGH TIME

Birds are an important part of the rainforest. Some species eat insects. This can keep populations of biting insects down. It can also prevent plant-eating insect populations from growing so large that they cause plant populations to drop. Some birds, including hummingbirds, are important for pollinating plants. Other birds disperse seeds. Birds can be found at all levels of the rainforest, from the forest floor to the canopy. But some bird populations are in trouble, and a few species have even disappeared.

Scientists like Dr. Branko collect data every year to track bird populations. Table 11 shows how populations have changed for 200 species of birds that live in different parts of the rainforest near Tirimbina.

Table 11. Number of bird species increasing, decreasing, or not changing in numbers over 20 years

Direction of change	Number of species	Average change in population (% per year)
Increasing	61	6.5%
Decreasing	43	– 9.9%
Not changing	95	0%

One hypothesis for why some species are declining and others aren't is that the forest is changing. In the region around Tirimbina, temperatures and rainfall are increasing. Increasing temperatures and humidity may be causing a greater impact on species in the understory, where temperatures and humidity tend to be consistently lower. Also, the species that live in the understory are usually smaller. Their bodies have a harder time dealing with higher temperatures and humidity.

1. Use the information in Table 11 and the paragraph above to **predict** how populations of understory birds should change compared to birds at higher levels in the rainforest or along forest edges. Use the words **increase, decrease, not change**.

   If higher temperatures cause smaller understory birds to have trouble surviving, then I predict that their populations will __decrease_____. Populations of birds that live along forest edges or in the canopy should ___increase____ or __not change______.

   Note: The responses given above are the best answers, but responses may vary. Make sure student responses to question 3 use and test the provided hypothesis.

2. **Complete** Table 12 by calculating the averages.

Table 12. Average yearly changes in populations of 10 randomly selected species from three different types of birds in the rainforest of Costa Rica

Species number	Small understory bird (% change per year)	Forest edge bird (% change per year)	Canopy and multiple habitats (% change per year)
1	-10	5	6
2	-11	7	7
3	-5	0	0
4	-3	5	-1
5	-12	6	8
6	-7	0	9
7	-8	4	6
8	-9	5	6
9	-6	9	5
10	-10	3	0
Average	-8.1	4.4	4.6

3. **Draw** a bar graph to represent the means that you calculated. On your graph, mark a * to represent the minimum and maximum changes observed for each group.

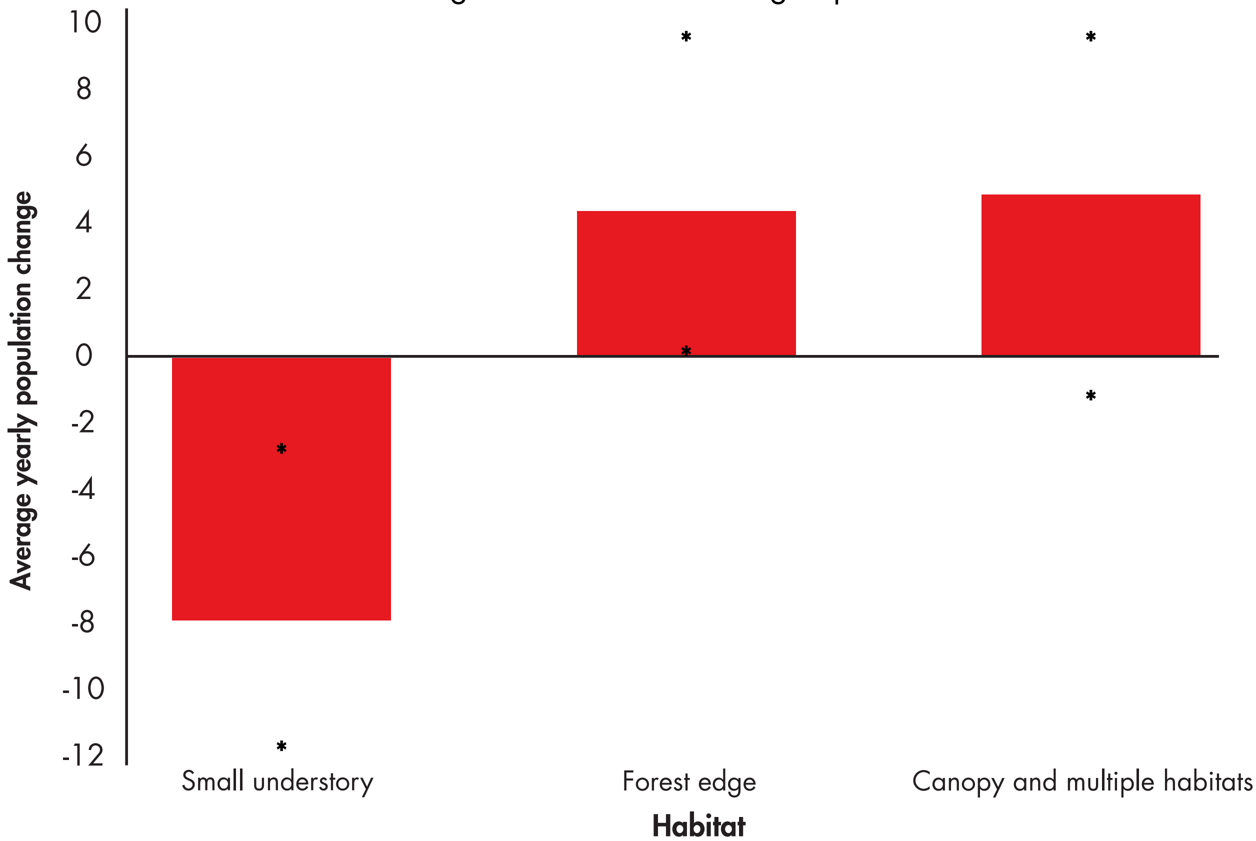


Figure 2. Population change in bird species by habitat type

4. Use the graph you made and the data in Table 12 to **describe** if your hypothesis was supported or rejected.

Assuming that they answered Question 1 consistent with the answer provided in red: My hypothesis was supported. Small understory birds declined. In fact, all populations declined. In contrast, almost all birds that used other habitats all populations that increased or stayed the same. In the other habitats, only one species declined, and that was by a very small amount.

5. Based on your findings, **predict** what will happen to birds in these three habitats if temperatures keep increasing.

Because my hypothesis was supported, I predict that more warming will result in fewer small understory birds. Some populations may disappear.

There are other hypotheses that might explain why small understory species are in trouble. Many of the bird species that live in the understory feed near vines (called lianas). Some scientists think that increasing numbers of collared peccaries might destroy lianas, resulting in fewer places for birds to feed.

First, scientists went to some places and made large fences that kept peccaries out. They found other places without fences that had the same number of lianas. In areas where peccaries could dig in the ground, the number of lianas decreased. Inside the fences, the liana numbers stayed the same.

Extend the lesson: Have students identify the control treatment and experimental treatment in the scenario described in the paragraph above. Students could also draw a picture of what they think the experiment looked like.

6. If peccaries destroying lianas causes bird populations to decline, then **describe** the relationship you expect between *the density of peccaries* and *the density of lianas* at a location.

There should be fewer lianas where there are more peccaries.

7. If peccaries destroying lianas causes bird populations to decline, then **describe** the relationship you expect between *the density of lianas* and *the density of birds* at a location.

There should be more birds where there are more lianas.

Scientists have gathered data on collared peccaries, lianas, and several bird species at five locations, including Tirimbina and La Selva. The data are shown in Table 13 and Figures 3, 4, and 5. In the figures, the dotted line shows the average relationship between the two variables on the graph. Use this information to test your ideas.

Table 13. Bird densities at five rainforest locations in Central America

Location	Peccaries density	Liana density	Checker-throated antwren density	Dot-winged antwren density
Tirimbina, Costa Rica	3	20.5	28	4
La Selva, Costa Rica	32	13.6	1.3	0.6
Barro Colorado, Panama	16	25.2	256	256
Bartola, Nicaragua	3.7	18.9	18.4	18.4
Gigante Peninsula, Panama	5.2	38.1	170	180

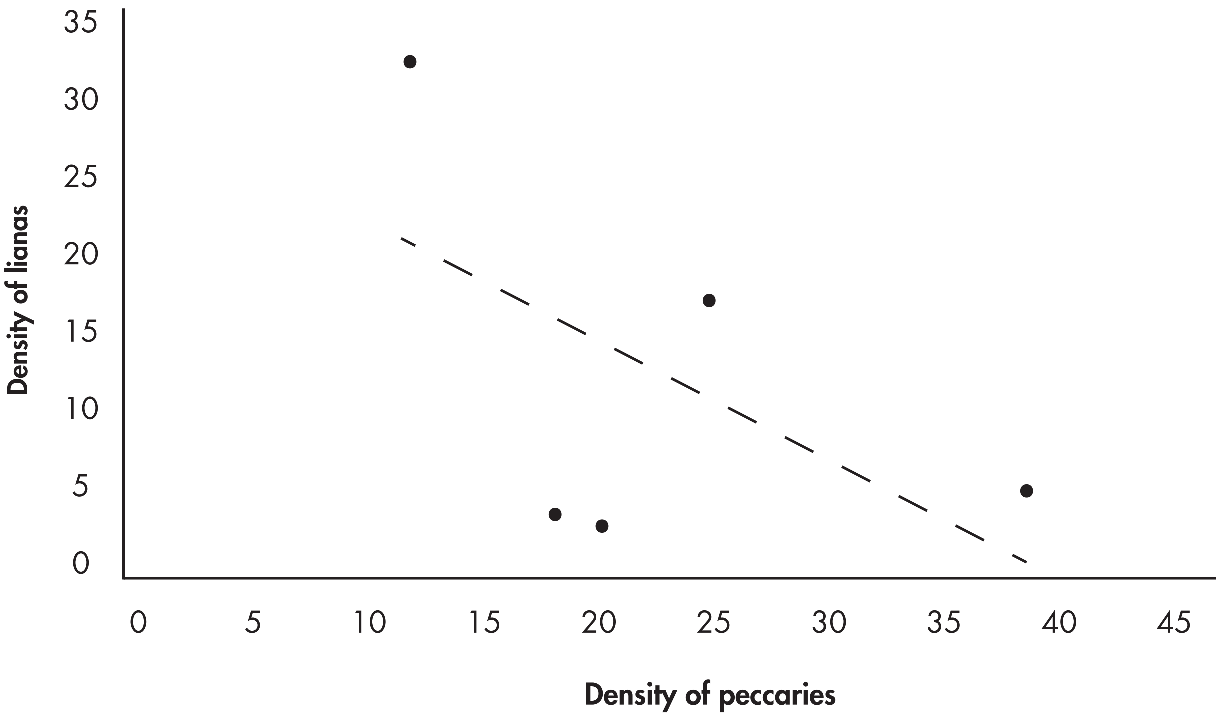


Figure 3. Relationship between the density of Peccaries and the density of Lianas

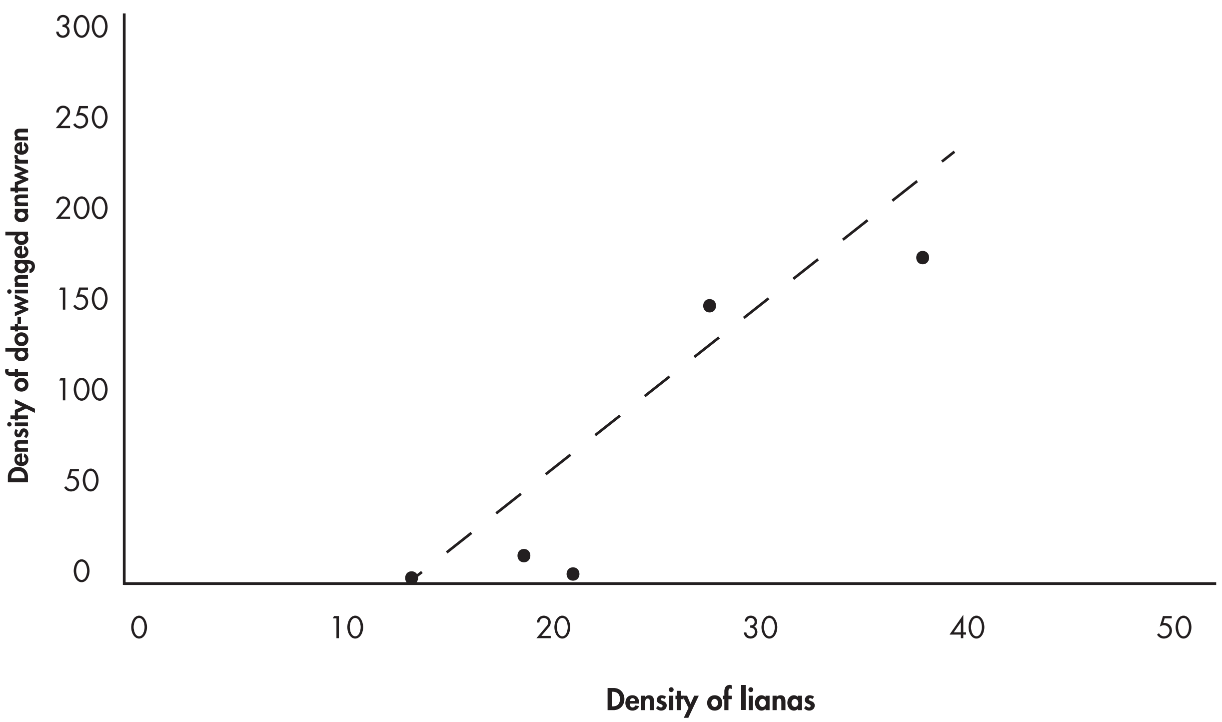


Figure 4. Relationship between the density of Lianas and the density of Dot-winged antwrens

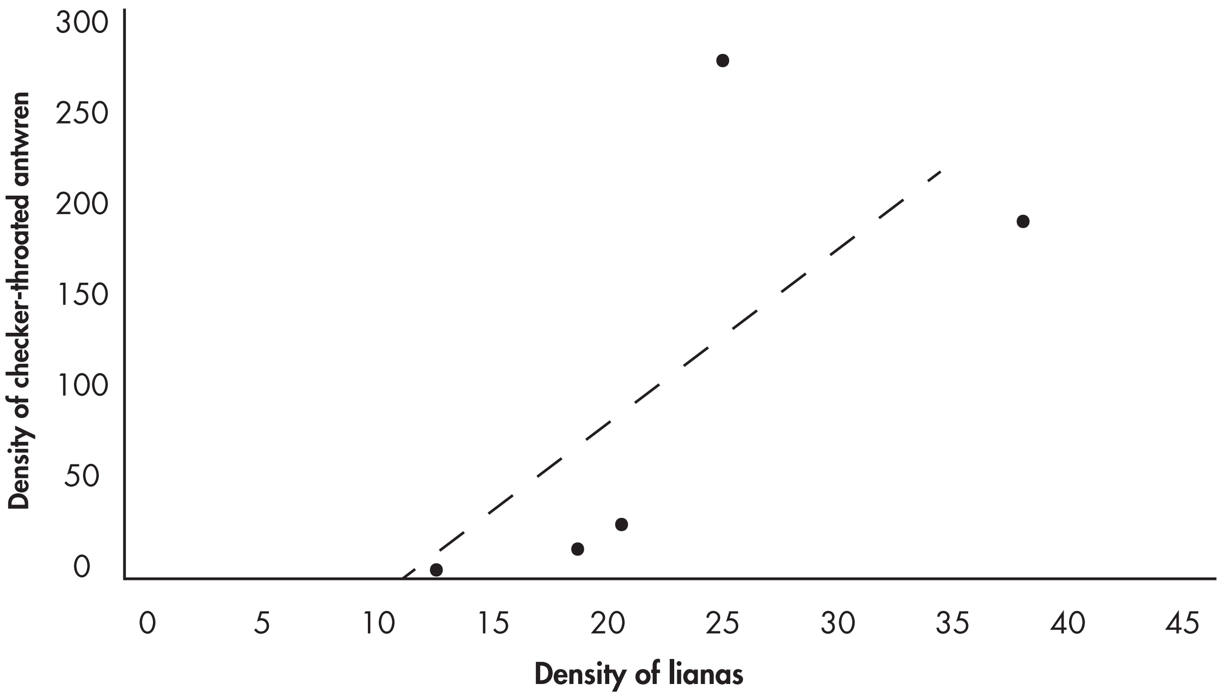


Figure 5. Relationship between the density of Lianas and the density of Checker-throated antwrens

8. Using the information in the Table 13 and Figures 3, 4, and 5, do you think that peccaries may cause declines in some bird populations? Cite data to support your answer.

Answers may vary somewhat. Most students will probably say their hypothesis is supported because there are fewer lianas where there are more peccaries and more birds where there are more lianas. However, some students may notice there is a lot of variation. This is especially true of the relationship between peccaries and lianas. The relationship is stronger between lianas and birds.

Extend the lesson: Discuss what additional studies and work would help better answer question 8 or have students think about other factors that might affect lianas and birds.

Great job team! These are just some of the hypotheses about what affects bird populations in the rainforest. Scientists are still studying rainforest biodiversity and how to protect it!