SCIENCE·3D

LIFE IN THE TREES

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

In this **Science Mission** students will develop hypotheses and predictions and test them using data that they graph and analyze. They will investigate digestion, feeding, and movements, to determine how kinkajous and woolly opossums might move seeds around the forest and how these interactions might be influenced by how people change the environment. They will analyze results of experiments and draw conclusions from maps to assess whether these nocturnal mammals are important for rainforest ecosystems.

We are about to explore how kinkajous and other canopy mammals influence the pollination and dispersal of plants. But, to understand dispersal it is important to know about how animals digest food and where they move. We also want to know how changes to the land might affect their populations.

ACTIVITY I: KINKAJOU VS WOOLLY OPOSSUM?

Kinkajous and woolly opossums are two common canopy species that are active at night. We need to know if they are important in pollinating flowers and dispersing seeds. Learning about their body systems and how they feed will help.

To start, let's learn about their digestive systems. Kinkajous are from a group of animals that usually eat meat. They have short intestines, which means there is less area for them to absorb nutrients from their food. Woolly opossums have much longer intestines. That means there is more area for them to absorb nutrients from their food. The longer food is in the digestive system, the more time there is to absorb nutrients.

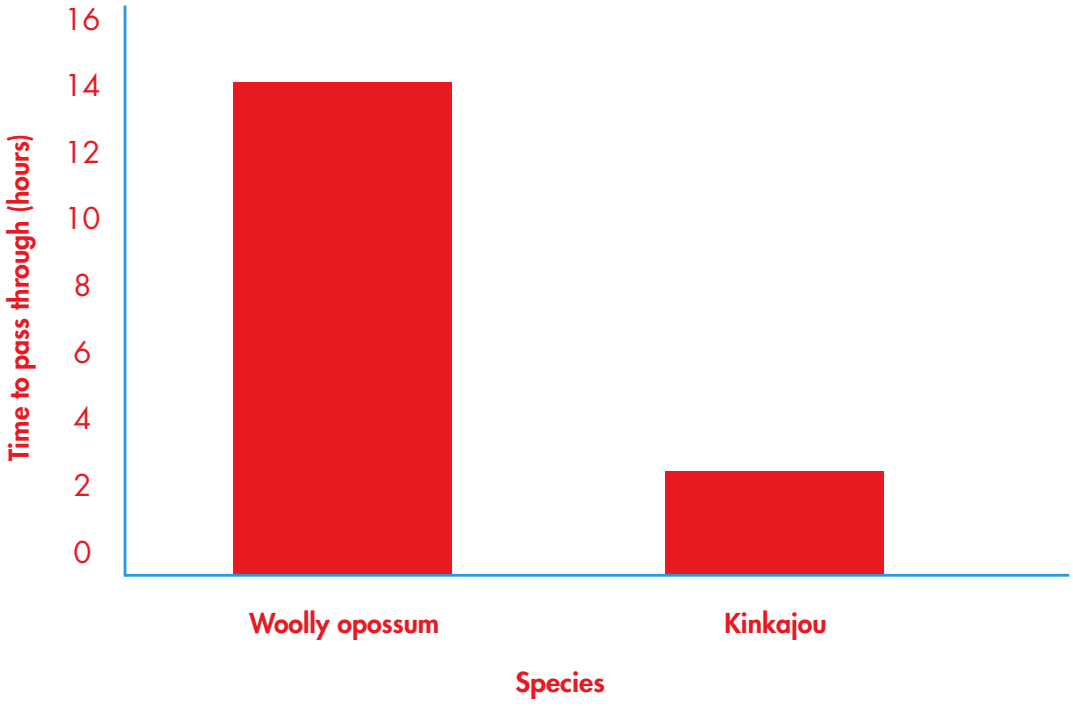
Table 1 shows data from an experiment where kinkajous and woolly opossums were fed the same type of food.

1. **Complete** Table 1 by calculating the averages.

Table 1. Time between feeding and pooping in woolly opossums and kinkajous

Trial number	Woolly opossum (hrs)	Kinkajou (hrs)
1	13	1
2	11	2
3	15	1.5
4	12	5
5	14	2
6	13	1.5
7	13	2.5
8	15	3
9	16	6
10	12	1.5
Average	13.4	2.6

2. **Draw** a bar graph that compares the time it takes for food to pass through the digestive system of woolly opossums and kinkajous. Caption the figure and label the axes.



Amount of time between feeding and pooping in woolly opossums and kinkajous

3. Do you think that woolly opossums or kinkajous would have to eat more food to get enough nutrients? Support your reasoning with what you learned about the digestive systems of the two animals.

I think kinkajous will have to eat more. They won't get as much nutrients from the food they eat because they have shorter intestines, and the food stays in their digestive system a shorter amount of time. Note: Some students might mention that kinkajous are larger. But, this would make the difference in food needs even greater.

4. Complete the statement below by circling one of the bold words to create a hypothesis for how much time kinkajous and woolly opossums should spend feeding in a tree based on your answer to question 3.

If kinkajous need **more**/**less** food than woolly opossums, then kinkjous should spend **more**/**less** time feeding in each tree they visit.

What is most important is that their hypothesis is consistent with their answer in question 3.

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

Table 2. Duration of visits to single trees by woolly opossums and kinkajous

Visit number	Woolly opossum (min)	Kinkajou (min)
1	10	80
2	40	10
3	80	15
4	200	20
5	20	40
6	50	15
7	40	10
8	300	15
9	20	30
10	50	45
Average	81	28

6. **Describe** the differences in the average amount of time that kinkajous and woolly opossums feed.

On average, kinkajous feed for shorter periods of time than woolly opossums.

7. **Describe** the difference in range (the difference between the shortest and longest) of times that kinkajous and woolly opossums spent in a particular tree. Use evidence from Table 2 to support your answer.

Woolly opossums had a much bigger range of feeding times (between 10 and 300 minutes) than kinkajous (between 10 and 80 minutes). This is a good opportunity to reinforce the idea of collecting data across multiple trials and individuals. Ask students why they think the scientists followed many kinkajous and woolly opossums.

8. **Explain** if the data support your hypothesis.

Make sure responses are consistent with the hypothesis that were developed in question 4. Most students will probably say that their hypotheses were not supported. They likely thought that kinkajous would feed in trees for longer periods of time because they need more food than woolly opossums.

It's ok if your hypothesis was rejected. It means there is more to learn! Why do the kinkajous spend less time in the trees than woolly opossums? Maybe they eat the fruit there more quickly and have to move on to new trees. If that is the case, we can make a hypothesis about how far kinkajous will travel in a night compared to woolly opossums.

9. **Complete** the statement below to create a hypothesis for how far kinkajous and woolly opossums should travel in a night. Circle the correct phrase.

If kinkajous need more food and eat the fruit in trees faster than woolly opossums, then kinkajous should travel **farther**/**less far** than woolly opossums.

10. **Complete** Table 3 by calculating the averages.

Table 3. Total distance (in meters) traveled per night by woolly opossums and kinkajous

Trial number	Woolly opossum (m)	Kinkajou (m)
1	600	2,150
2	400	2,500
3	700	2,350
4	550	1,100
5	450	1,750
6	650	400
7	700	2,000
8	550	1,950
9	650	2,100
10	700	2,250
Average	595	1,855

11. **Explain** if the data in Table 3 support your hypothesis.

Make sure responses are consistent with the hypotheses that were developed in question 9.

Yes, these data are consistent with my hypothesis. Kinkajous traveled much farther every night.

12. Which species do you think will disperse seeds farther? **Describe** how you came up with this hypothesis. *Hint: Use the data in the previous tables and figures.*

Students could answer this multiple ways. Pay attention to their logic. For example, some may say they think kinkajous will disperse seeds farther because they move farther every night.

Other students might say they think woolly opossums will disperse seeds farther because they keep seeds in their stomachs longer than kinkajous.

13. **Describe** how would you test this hypothesis.

Accept reasonable answers.

Extend the Lesson or Differentiate Instruction: Have students think about how far kinkajous might disperse seeds. Ask them to calculate how far kinkajous move per hour if they are active for 10 hours at night (=1,855 m/10 hrs = 185.5 m/hr). Then, have them multiply how many hours on average kinkajous seeds stay in kinkajous (185.5 m/hr * 2.6 hrs = 482.3 m). Further extend the lesson by having students calculate maximum distances by using the longest passage times for food and the farthest distances traveled per night. Similar calculations could be completed for woolly opossums.

ACTIVITY 2: POLLINATE, DISPERSE, OR BOTH

To determine if kinkajous and woolly opossums pollinate flowers and disperse seeds, we need to know what they eat. We also want to know how many species of trees might rely on them. Does each animal only visit one kind of tree or do they help many different species? A specialist is a species that eats very specific types of food. A generalist eats many different types. Generalists help more species. Table 4 shows the number of species of plants that each species visited to eat fruits and drink nectar. Figure 1 shows the percentage of trees that each species visited to sip nectar from flowers and eat fruits. The information is provided for two parts of the year.

Table 4. Number of tree species visited by woolly opossums and kinkajous

Reason for visit	Woolly opossum	Kinkajou
Flowers (for nectar)	9	2
Fruits	21	28
Total	**30**	**30**

1. Use the data in Table 4 to support an argument about whether woolly opossums and kinkajous are specialists or generalists.

Both species visited 30 species of trees. This suggests that they are both generalists. Note: Some students might observe that kinkajous may be more specialists for the trees they visit for flowers because they only visited two different species. But, they visited a lot of species to eat fruits.

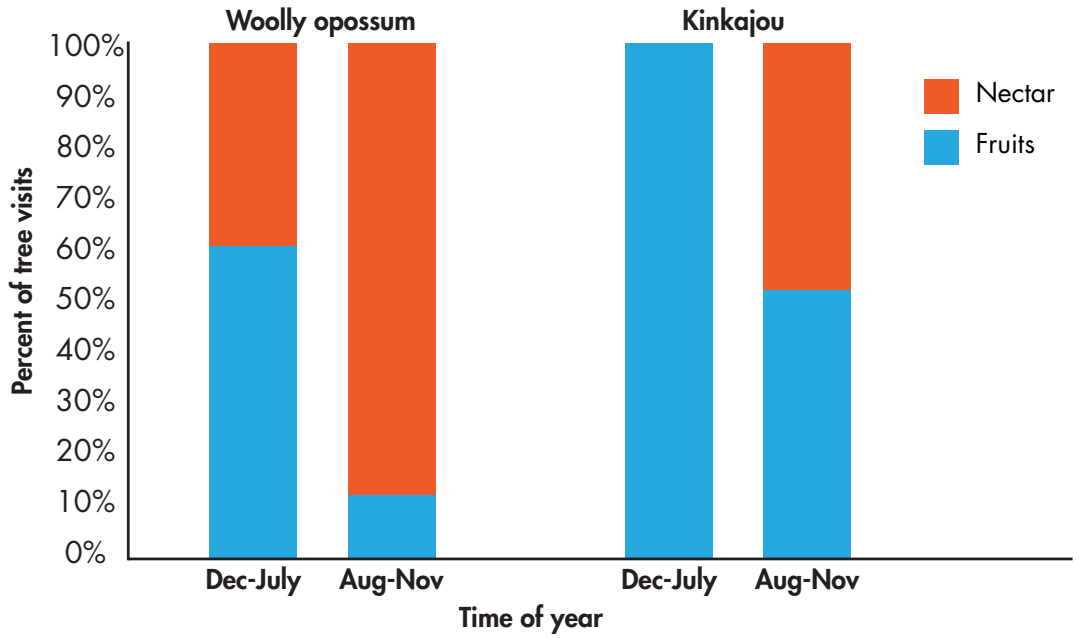


Figure 1. Percentage of trees visited to drink nectar from flowers (orange) and eat fruits (blue)

2. Based on Figure 1, do you think that flowers and fruits are both equally available all year round? Why or why not?

Accept any reasonable answer. Students should notice that fruits are probably more available in Dec-July because kinkajous don't eat anything else. The percentage of trees visited for fruits is lower for both species in Aug-Nov. This suggests there is less fruit and more flowers at that time.

3. **Describe** the likely differences in the role of woolly opossums and kinkajous in pollinating flowers. Use data from Table 4 and Figure 1 to support your answer.
Hint: Look at the proportion of plants visited for flowers by each species in each time period. Look at the number of different species that each animal visited for flowers and fruit.

Focus more on students' thought processes than the completeness of their responses. This question can make a good discussion topic for the class. Consider asking the following questions: What would an animal need to do to be a good pollinator? What would it need to do to be a good seed disperser?

Both species probably disperse seeds of many fruits. They visit more than 20 species of trees and eat mostly fruits from December to July. Woolly opossums are probably more important pollinators. They visit more species of trees for flowers and they visit trees for flowers more often than kinkajous. From August to November, kinkajous might be important dispersers of the two species they visit.

ACTIVITY 3: RANGE SIZES, HABITAT USE AND DISPERSAL BY KINKAJOUS

Now let's focus on kinkajous. Dr. Bernal and his team want to know about kinkajou habitats. They also want to know about areas they avoid. This will help determine whether or not kinkajous are affected by human changes to the environment. We also want to know if they might bring seeds to help restore areas in the forest that humans have cleared.

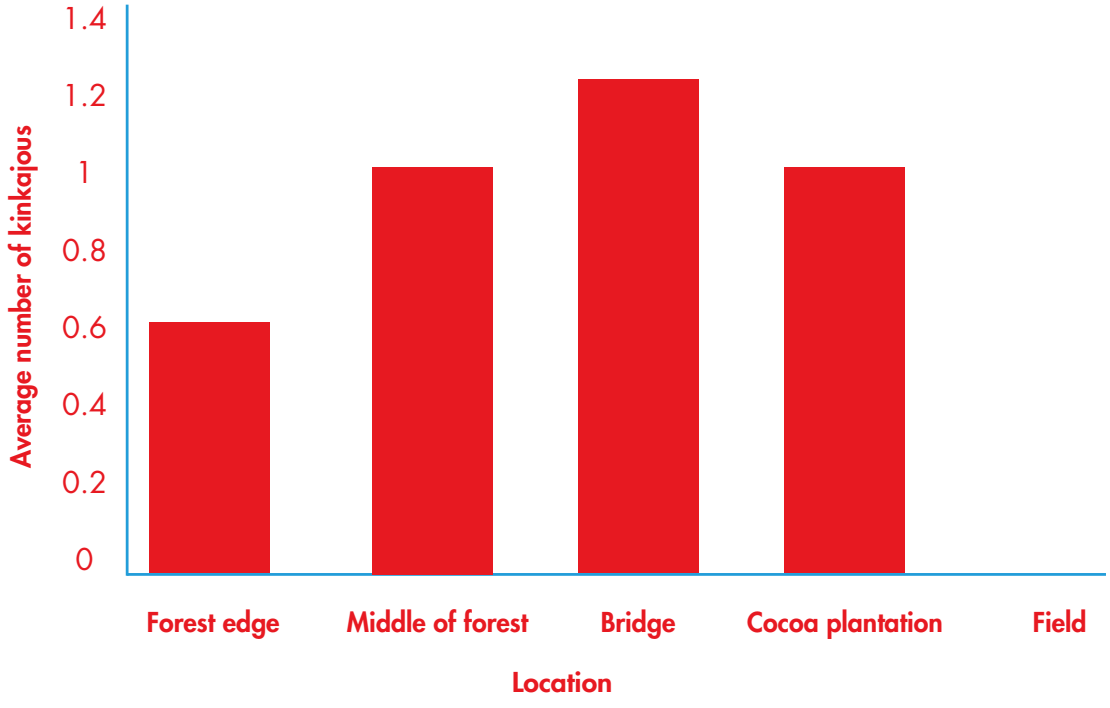
Table 5 shows the number of kinkajous caught in different habitats of the forest. These habitats include the edge of forest, the middle of forest, the bridge across the river that connects two patches of forest, a cocoa plantation, and a tree in the middle of a previously farmed field. In addition to trees that grow cocoa, the plantation also has trees that form a canopy and grow fruits that animals like to eat. There is no understory in the plantation. Before students look at the table, ask them to make predictions about which habitats they think kinkajous will be caught in the most and least. Have them explain their predictions.

1. **Calculate** the average number of kinkajous each night in each habitat.

Table 5. Catches of kinkajous in two traps set in five habitats over 10 nights

Night number	Edge of forest	Middle of forest	Bridge	Cocoa plantation	Field
1	1	1	2	1	0
2	0	0	0	1	0
3	1	1	2	0	0
4	0	1	1	1	0
5	1	2	1	1	0
6	0	1	1	0	0
7	0	1	1	2	0
8	1	1	1	1	0
9	1	0	2	1	0
10	1	2	1	2	0
Average	0.6	1	1.2	1	0

2. **Draw** a bar graph of the number of kinkajous captured in each habitat. Label the axes and give the figure a title.



Average number of kinkajous captured in different habitats

3. **Compare and contrast** the average number of kinkajous in each habitat.

There were the same number of kinkajous caught in the middle of the forest and the cocoa plantation.

There were more kinkajous caught on the bridge. No kinkajous were caught in traps in the field.

There were fewer kinkajous in the forest edge than the middle of the forest, bridge, and plantation.

4. **Construct** a hypothesis that explains the pattern of kinkajou use of habitats.

Accept reasonable answers.

This could also serve as a good question for groups or for the whole class to discuss. Consider asking questions such as: Why do you think there were no kinkajous in the tree in the field? (Good answers include that there isn't enough food, or it is dangerous to cross the field.) Why do you think there are fewer kinkajous along the edge of the forest? (Good ideas include that there is less food, more predators, or fear of people there.) Why do you think more kinkajous are caught on the bridge? (A good answer includes it is the only way to get across the river to find more food). Why do you think there are as many kinkajous in the plantation as there are in the forest? (Good answers include that the plantation has places for kinkajous to eat and sleep in the canopy or it doesn't matter to them that there is no understory).

5. **Complete** Table 6 by calculating the average weight and range size of the kinkajous that were captured. A hectare (ha) is 100 m x 100 m.

Table 6. Weights and range sizes of caught kinkajous

Kinkajou number	Weight in trap (kg)	Weight of trap (kg)	Weight of kinkajou (kg)	Capture location	Range size (ha)
1	6.6	4.2	2.4	Forest	11.5
2	7.2	4.0	3.2	Forest	20.5
3	6.7	3.9	2.8	Forest	25.0
4	7.2	4.1	3.1	Forest	14.5
5	6.6	4.0	2.6	Bridge	25.0
6	6.9	4.2	2.7	Bridge	22.5
7	7.1	4.1	3.0	Bridge	23.0
8	6.9	4.0	2.9	Plantation	14.0
9	7	3.9	3.1	Plantation	22.0
10	6.4	4.0	2.4	Plantation	25.5
			2.82		20.35

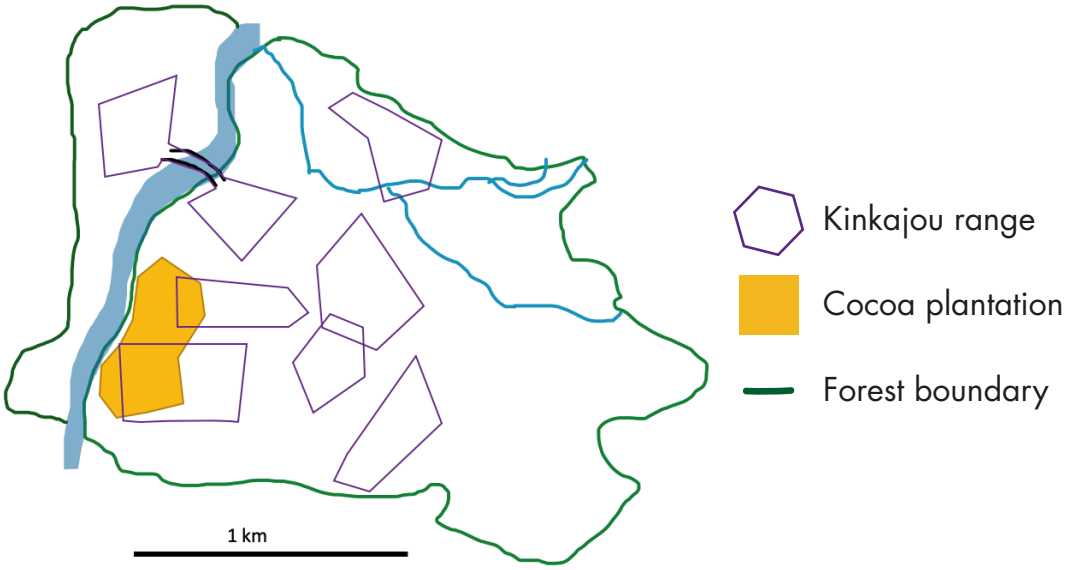


Figure 2. Forest in Tirmibina Biological Reserve
The abandoned fields occur outside of the green forest boundary line.

6. **Construct** an argument about whether kinkajous might disperse seeds into areas of abandoned fields. Use your graph from question 2 and the above map to support your answer.

I don't think that the kinkajous would take seeds into the fields. No kinkajous went out of the reserve according to the map. Also, no kinkajous were caught in the field.

7. **Describe** whether or not you think the creation of the cocoa plantation was damaging to kinkajou habitat. Use evidence to support your argument.

I do not think the cocoa plantation is damaging to the kinkajou habitat. They used this habitat as much as the forest.

Extend the Lesson/Differentiate Instruction: 1) Have students make a scatterplot of the relationship between kinkajou weight and range size shown in Table 7. Have them determine if there is enough information to know if larger kinkajous have larger ranges. (It doesn't appear, from these data, that there is a strong relationship between weight and range size). Have students calculate average ranges and weights for each habitat separately. (In this example, the forest < plantation < bridge). Have students construct possible explanations for this pattern and discuss if more research is needed to fully support them. Students might suggest that crossing the bridge makes ranges larger, and with less food in the cocoa plantation, kinkajous may have to go farther to find food. But, they should recognize that there are not that many samples in each habitat. More work is needed!

So, just how far can kinkajous move seeds within their ranges? Scientists have followed kinkajous and recorded where they ate and where they pooped.

8. **Calculate** the average dispersal distance between where kinkajous ate fruits and pooped seeds in Table 7 below.

Table 7. Total distance between where fruits were eaten and seeds were pooped out

Trial number	Dispersal distance (m)
1	0
2	300
3	175
4	0
5	300
6	175
7	350
8	150
9	325
10	250
Average	202.5

9. Based on the data in Table 7, **describe** whether you think kinkajous might disperse seeds away from their parent plant.

There is good evidence that kinkajous disperse seeds away from the parent. On average, seeds are moved 200 meters and up more than 300 meters.

If the digestive system of kinkajous breaks seeds down, then it doesn't matter how far the seeds might move. Luckily, the team tracked some seeds that kinkajous had eaten! Seeds were followed for one year and were classified as "Still Alive" or "Dead." Table 8 shows these results.

10. **Calculate** the percentages of seeds that were still alive after being eaten and deposited by kinkajous in Table 8.

Table 8. Fate of seeds that were deposited by kinkajous directly under the parent tree and those that were pooped out away from the parent tree

Trial number	Seed under parent	Seed far from parent
1	Dead	Still Alive
2	Dead	Still Alive
3	Dead	Dead
4	Dead	Dead
5	Dead	Dead
6	Still Alive	Still Alive
7	Dead	Dead
8	Dead	Still Alive
9	Dead	Dead
10	Dead	Still Alive
Percentage Still Alive	10%	50%

11. Based on the data in Table 8, **construct** an argument about whether the kinkajou's digestive system breaks down seeds.

It doesn't look like the digestive system breaks down the seeds. When they move seeds away from the parent, 50% grow and survive.

12. Based on the data you have analyzed, are kinkajous important for helping plants disperse? Use evidence to support your claim (Tables 7 and 8 especially).

Yes, kinkajous are important for dispersing seeds. They usually move seeds far away from the parent plant. Eight of 10 seeds were moved more than 150 meters away. And, seeds that are moved away from the parent are more likely to survive than ones that fall under the parent.

13. The seeds in the experiment in Table 8 were from the same tree. Their genetic make-up was similar. **Describe** what this information tells you about how conditions in the environment and genetics affect growth and survival. Are growth and survival only influenced by genes?

The seeds had similar genes, but where they grew was important. Seeds right under the parent didn't survive very often. Seeds that were in a different environment away from their parent were more likely to survive.

Extend the Lesson: Ask students why they think the seeds that were far from the parent didn't all survive. It is likely that these seeds may have fallen in different areas. Some may have been shaded by other plants or eaten by animals. Others may have fallen into better environments for growth and survival.

OPTIONAL ACTIVITY 4: HEADING OUT ON THEIR OWN

Scientists like Dr. Bernal can collect hair samples when they catch kinkajous. They can also put out "hair traps." These traps have tape that grabs a few hairs when a kinkajou visits a station baited with some fruit. By looking at the genes in the hair, scientists can determine which kinkajous are related. If they have sampled a mother or father, they can tell if another individual is their offspring. This paragraph and portion of the activity can be used to reinforce standards related to genetics and inheritance.

Figure 3 is a map that shows where mother kinkajous and their grown-up offspring were found. Use the information in this map to answer the following questions.

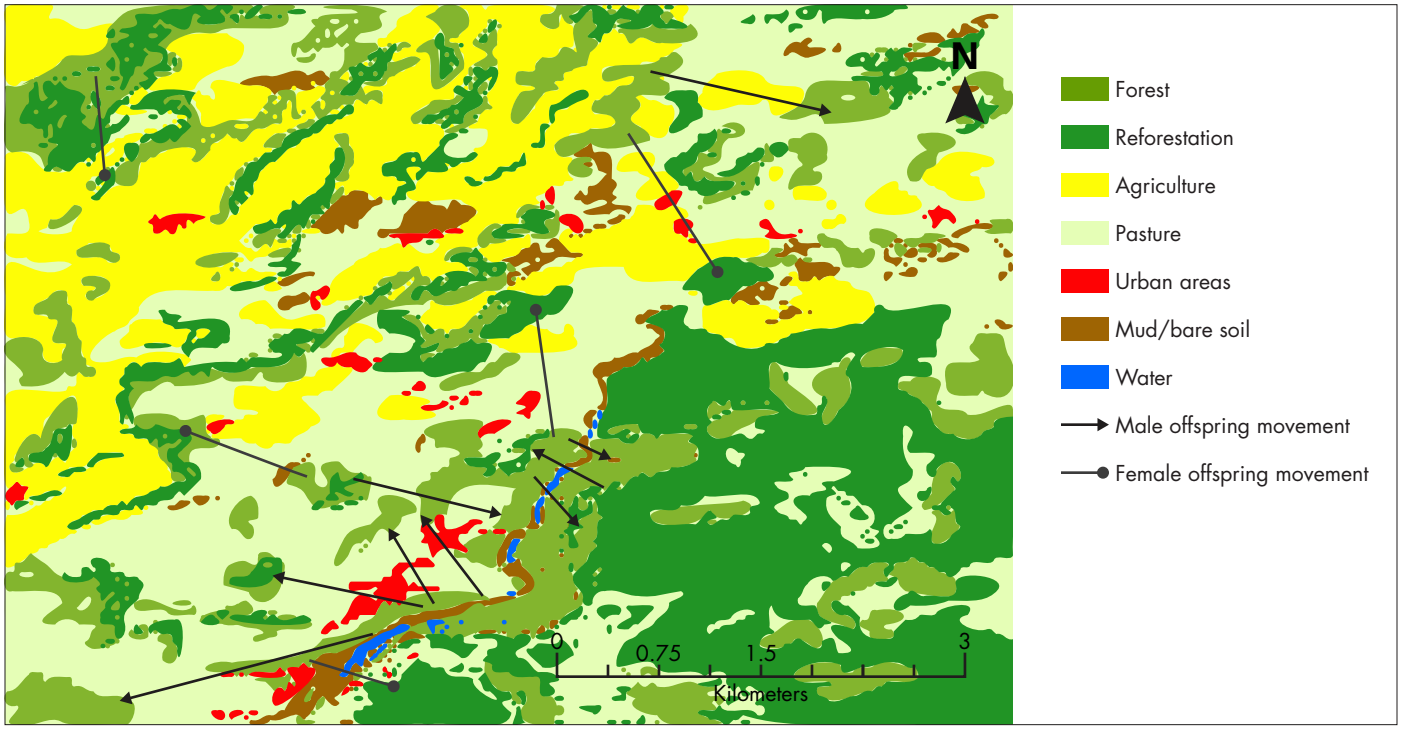


Figure 3. Locations where hair samples of mothers and their grown-up daughters were collected

1. Do daughter kinkajous stay with their mothers throughout their lives? Use evidence from the map in Figure 3 to support your answer.

No. The daughters were found several kilometers away. If they stayed with their mothers, they would have been found closer to them.

2. Based on the genetic data and the map, are kinkajous willing to cross agricultural lands and towns to find a forest patch of their own?

Yes, they will cross these habitats. There is no way they could have made it to where they were found while staying in a forest. They had to cross these habitats.

3. **Compare and contrast** the movements of kinkajous foraging in their home area to those of young moving away from their mothers.

Animals moving away from their mothers were willing to cross fields and towns. Foraging animals did not go into the field. They stayed in the forest.

OPTIONAL ACTIVITY 5: NIGHT SHIFT VS DAY SHIFT

Let's compare the nocturnal canopy critters to the mammals roaming the canopy during the day.

1. **Complete** the table by inserting your data from your earlier investigation.

Table 9. Characteristics of diurnal and nocturnal canopy mammals

	Community or group size (number of individuals that will spend time together)	Group size when foraging for food	Area of forest occupied (ha)	Daily path length	Lifespan	Normal number of young	Gut passage rate
Diurnal Species							
Spider monkey	18 to 42	4 to 5	62 to 138	1,600 to 2,100 m	22 to 24	1	4.5
Howler monkey	10 to 20 but up to 40	10 to 20	10 to 60	< 750 m	15 to 20	1	20.5
Nocturnal Species							
Kinkajou	1 to 5	1 to 2	20.35	1,855	20 to 25	1	2.6
Woolly opossum	1	1	3	595	5	1 to 7	13.4

2. **Create** a poster or presentation that compares and contrasts the different species in Table 9.

Extend the Lesson: Have students compare and contrast spider monkeys and howler monkeys. Have them investigate what they eat (fruits vs. leaves). Have them investigate how the digestive systems of these species have to differ. Then, have them look at the size of their ranges and how far they move to see if differences in their diets might explain their behavior.