

TALK IT OVER • 1–2 CLASS SESSIONS

OVERVIEW

Students read about four forest areas being considered for conservation on the island of Kapikua, and use the information to make an initial recommendation for which forest area should have the highest conservation priority. Then students analyze the phylogenetic diversity for the endemic primates on the island, and apply the additional evidence to reexamine their recommendation for conservation.

KEY CONTENT

1. Science is a social enterprise, but alone it only indicates what can happen, not what should happen. The latter involves human decisions about the use of knowledge.
2. Human activities can cause biodiversity to increase or decrease. Such human activities as acquisition of resources, urban growth, and waste disposal accelerate rates of natural change in organisms and ecosystems.
3. The millions of different species of plants, animals, and microorganisms that live on earth today are related by descent from common ancestors.
4. Evolutionary trees show evolutionary ancestry.
5. Biodiversity is measured on phylogenetic, species, and genetic levels.

KEY PROCESS SKILLS

1. Students consider and evaluate multiple perspectives.
2. Students interpret data.
3. Students take a position and support it with evidence.

MATERIALS AND ADVANCE PREPARATION*For the teacher*

Scoring Guide: COMMUNICATION SKILLS (CS)

Scoring Guide: EVIDENCE AND TRADE-OFFS (ET)

For each student

Student Sheet 15.1, “Writing Frame: A Conservation Decision” (optional)

Scoring Guide: COMMUNICATION SKILLS (CS) (optional)

Scoring Guide: EVIDENCE AND TRADE-OFFS (ET) (optional)

Masters for Scoring Guides are in Teacher Resources IV: Assessment.

TEACHING SUMMARY*Getting Started*

- Students review the benefits that people derive from ecosystems.

Doing the Activity

- Students read about the four forest areas under consideration for conservation on Kapikua.
- Students write an initial recommendation for which forest area should receive conservation priority.
- Students analyze the phylogenetic data for four forest areas on Kapikua and use this evidence to reexamine their initial ideas about which area should be conserved.

Follow-up

- (LITERACY) The class conducts a Walking Debate about which forest area should be conserved.
- (ET, CS ASSESSMENT) Students write a summary recommendation for which forest area should be conserved.

BACKGROUND INFORMATION

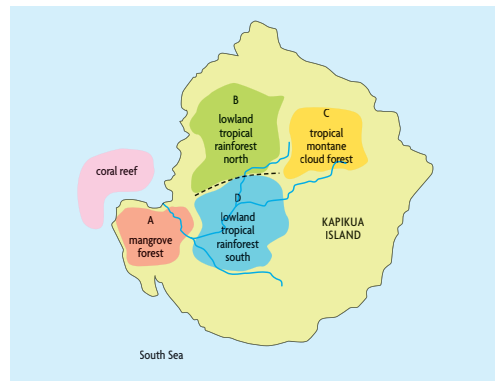
The length of the branches of a tree often reflects the amount of evolutionary change that has occurred within the lineage represented by the branch. Longer branches represent more evolutionary change. Taxa that share a more recent common ancestor on fairly short branches are most likely less diverse than taxa that share a more distant common ancestor and are on longer branches. Even more diverse is a set of taxa along branches that are dispersed across the tree because they represent more distant ancestry.

GETTING STARTED

1 Ask students to go back to a list they compiled at the beginning of Activity 1, “Biodiversity and Sustainability,” of the benefits that humans derive from ecosystems. Ask for student volunteers to share the benefits they recorded. Likely examples will include food, shelter, and building materials. Review that the benefits people obtain from ecosystems are referred to as ecosystem services. Explain that sustainable conservation decisions are complex because there are social, environmental, and economic considerations, and conflicting viewpoints on priorities. Conservationists must also take into account both the interests in ecosystem services and the biodiversity of an area.

15 Conservation of an Island Biodiversity Hotspot

1 **T**HE GOVERNMENT OF Kapikua wants to expand biodiversity conservation efforts on the island. The government has two goals: 1) to protect the overall biodiversity and sustainability of the island ecosystem, and 2) to protect the endemic primates that live in the forests on the island. The endangered primates are unique and very sensitive to habitat changes. This puts them at a higher risk of extinction. The primates have also become a well-known attraction for ecotourists from around the world. The government has enough funds to fully support conservation at only one of four forest areas being considered for conservation. You are a member of the conservation team that will advise on which area should get full conservation support.



THE ISLAND OF KAPIKUA

In this activity you will learn more about each of the four areas and select one for conservation. You will use additional evidence from an evolutionary tree for the primates to decide which area should be conserved.

Challenge

► Which of four areas should receive priority for conservation?

DOING THE ACTIVITY

2 A sample completed chart is shown on the next page.

Procedure

Part A: Four Possible Conservation Areas

1. With your group, assign to each student one of the four forest areas under consideration for conservation. Work by yourself to read below and on the next pages the summary of your assigned area.
2. In your science notebook, make a chart like the one shown below. Fill in the chart for your assigned forest area.

<i>Forest area</i>	<i>Economic outcomes if conserved</i>	<i>Social outcomes if conserved</i>	<i>Environmental outcomes if conserved</i>	<i>Benefits of conserving the area</i>	<i>Trade-offs of conserving the area</i>

- 2** 3. Present a summary of your forest area to the members of your group. As your group members present the information about their forest areas, complete the chart.

Area A: Mangrove Forest

UNIQUE CHARACTERISTICS

The mangrove forest on the island is dense with stilt mangrove trees and shrubs that grow in brackish coastal swamps. The roots of the mangrove trees filter the salts out of seawater. They also filter silt and nutrients from river water, allowing clear water to flow to the nearby coral reef. The vegetation serves an important role in the coastal area as a buffer to protect the nearby shoreline villages from hurricanes and other storms. The vegetation also prevents erosion along the riverbanks. Mangroves provide food and shelter to a variety of organisms.

CONSERVATION CONSIDERATIONS

In recent years, partly because of mangrove forest degradation, the inland areas of the island have been damaged by flooding from severe storms that have blown in. Almost all of the buildings and houses in one village were lost to the flooding. The villagers lost their crops and homes, and had to move to other areas.

Mangrove Forest	
LAND AREA TO BE CONSERVED (%)	3
NUMBER OF ENDEMIC SPECIES IN THE AREA	14
NUMBER OF ENDEMIC SPECIES THREATENED	7



Forest Conservation Areas

Forest area	Economic outcomes if conserved	Social outcomes if conserved	Environmental outcomes if conserved	Benefits of conserving the area	Trade-offs of conserving the area
Mangrove	<p>Ecotourism would provide jobs and revenue for the island.</p> <p>Fishermen who earn income from catching and selling fish and shrimp might receive less income.</p>	<p>Ecotourism would provide jobs, income, and enjoyment.</p> <p>Fishermen may have to move or find other types of work.</p> <p>Catch limits would affect a food source for people on the island.</p>	<p>Dense vegetation serves as a barrier to flooding from storms for inland villages.</p> <p>Mangrove forests prevent erosion, filter water that flows to the coral reef, and provide food and shelter to a number of organisms.</p> <p>14 endemic and 7 threatened endemic species would be protected.</p> <p>3% of land area would be conserved.</p>	<p>Ecotourism</p> <p>Area would continue to provide buffer from storms.</p> <p>Filters water and preserves coral reef</p> <p>Provides food and shelter for organisms</p>	<p>Limited boating and fishing would negatively affect the fishermen and would reduce an island food source.</p>
Lowland tropical rainforest north	<p>Lost income, jobs, and sustainable, desirable coffee crop</p>	<p>Lost income, jobs, and sustainable, desirable coffee crop</p> <p>Loss of a sustainable commodity that people worldwide enjoy</p>	<p>Area is biodiverse.</p> <p>135 endemic and 10 threatened endemic species would be protected.</p> <p>3% of land area would be conserved.</p>	<p>This would conserve only a small percentage of remaining land, but the area has a fair amount of biodiversity.</p>	<p>Coffee harvesters would not be able to harvest, causing lost profit and jobs for a relatively small number of people.</p>
Lowland tropical rainforest south	<p>Percentage of pharmaceutical profits would go back to island.</p> <p>Ecotourism to primate protection and public education center would provide jobs to island residents and income.</p>	<p>Plants used for pharmaceutical research could lead to products that could save millions of lives.</p> <p>Primate and public education center would provide enjoyment and education to ecotourists and islanders.</p>	<p>Larger area than northern rainforest and most biodiverse forest area on island</p> <p>Kapok trees provide highway system for tree-dwelling mammals.</p> <p>Primate center might reduce their risk of extinction.</p> <p>254 endemic and 75 threatened endemic species would be protected.</p> <p>7% of land area would be conserved.</p>	<p>Profit from pharmaceuticals for the company</p> <p>A percentage of the profit would go to the island.</p> <p>Pharmaceuticals would save lives.</p> <p>Protects a diverse area and tree-dwelling mammals that depend on the trees for highway</p>	<p>Primate and public education center would require the construction of roads and facilities, which could affect the environment.</p>
Tropical montane cloud forest	<p>Reduced profit for tea company because it could not expand its plantation</p> <p>No new jobs on plantation</p> <p>In times of drought other agricultural jobs and crops might be saved by irrigation from cloud forest waters.</p>	<p>Tea is a desirable commodity worldwide.</p> <p>The plantation would not provide new jobs.</p> <p>Cloud forest water provides source of power for people's homes.</p>	<p>Organisms that depend on the climate and water that is stored by the forest would be protected.</p> <p>11 endemic and 5 threatened endemic species would be protected.</p> <p>4% of land area would be conserved.</p>	<p>Organisms that depend on water and climate would be protected.</p> <p>Clean water source for drinking water for the island would be protected.</p>	<p>Loss of tea profit and jobs that would be generated from expansion of the plantation</p>

SCIENCE & GLOBAL ISSUES/BIOLOGY • EVOLUTION

If the area is conserved, the island government plans to offer limited permits at a reasonable cost for sustainable ecotourism to the area. For those who live on the island, ecotourism would provide jobs ranging from researchers and tour guides to restaurant waiters, cooks, hotel workers, drivers, and boat crewmen. People who make handicrafts and other goods also would earn money by selling their wares to tourists. Park fees would bring in revenue that would also contribute to the island's economy.

Currently, island residents have unlimited access to the mangrove forest for fishing and shrimping. Some fishermen have small businesses in which they sell their catch at local markets. Others fish for recreation or to feed their families. If the mangrove is conserved, a strict catch limit will be enforced in order to protect the food sources for a variety of organisms in the ecosystem. The new limits could force the local fishermen to downsize their businesses and reduce their income.

Area B: Lowland Tropical Rainforest North

UNIQUE CHARACTERISTICS

The lowland tropical rainforest is the most biodiverse area on the island, although the northern region of the rainforest is less diverse than the southern region. The earliest settlers in the northern area introduced new plants and animals to provide sources of food, medicine, building materials, and decoration. They cleared land to plant agricultural crops, and hunted lizards and birds for additional food. Since the first settlers came to the area, logging, development, and agriculture have destroyed 95% of the northern region's forest.

CONSERVATION CONSIDERATIONS

A small family-run business harvests coffee from the plants they have grown in this forest area. The exported coffee is a desirable commodity for people in other countries, and it is marketed as some of the best quality and most sustainable in the world. It benefits the family and a small number of workers hired to help with the harvest. If the forest is designated for conservation, the family will no longer have access to the forest for their coffee. This would mean lost income, with family members and the small number of people employed by the business losing their jobs. However, the species that live in the remaining 3% of undeveloped area will be protected.

Lowland Tropical Rainforest North	
LAND AREA TO BE CONSERVED (%)	3
NUMBER OF ENDEMIC SPECIES IN THE AREA	135
NUMBER OF ENDEMIC SPECIES THREATENED	10



Area C: Lowland Tropical Rainforest South

UNIQUE CHARACTERISTICS

The southern region of the lowland tropical rainforest is the most biodiverse on the island. It is larger than the northern region of the rainforest, and because the earliest settlers remained mostly in the northern region of the forest, this area was not as severely deforested as the north. Medical research scientists search for unique species in this area that may provide substances for new medicines. A number of tree-dwelling species depend on the kapok trees as a highway that allows them to move around the forest without having to travel on the ground.

CONSERVATION CONSIDERATIONS

If this area were conserved, the vast biodiversity of the area would be protected, including the plant species central to pharmaceutical research and product development. Research scientists would be assigned permits to collect specimens in a sustainable manner from the area. Recently, a team of scientists was sent to the island to research a plant found nowhere else that shows potential as a new malaria treatment. If the treatment is successful, it could save millions of lives. The research institute signed an agreement with the Kapikua government that a percentage of the profit made from products containing substances from Kapikua plants will go back into the island economy.

If this area is conserved, the government plans to build a primate center to research and protect the endemic primates that live in the island forests. This center will also be the focus of a program to educate the public. Permits will be available for ecotourists to visit the center to observe the primates and learn more about them through tours and exhibits. However, the cost of the permits will be much higher for this remote area than the cost to tour the mangrove forest. The primate center and access for ecotourists will require the construction of roads and facilities, which will be done in the most sustainable manner possible. For island residents it will provide such jobs as tour guides, drivers, lab technicians, and instructors.

Lowland Tropical Rainforest South	
LAND AREA TO BE CONSERVED (%)	7
NUMBER OF ENDEMIC SPECIES IN THE AREA	254
NUMBER OF ENDEMIC SPECIES THREATENED	75



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Area D: Tropical Montane Cloud Forest

UNIQUE CHARACTERISTICS

The tropical montane cloud forest ecosystem plays an important role in the water cycle and climate on the island. Experiments have shown that cloud forests prevent the evaporation of precipitation far better than non-cloud forests do. The precipitation in the cloud forest is mostly in the form of fog, which condenses on the trees and drips onto the ground. The water soaks into the soil, where it is stored. Any excess runoff drains into stagnant water pools in the forest. The large water supply in the soil and the pools supports a wide variety of organisms.

Tropical Montane Cloud Forest	
LAND AREA TO BE CONSERVED (%)	4
NUMBER OF ENDEMIC SPECIES IN THE AREA	11
NUMBER OF ENDEMIC SPECIES THREATENED	5



CONSERVATION CONSIDERATIONS

Such human activities as logging and clearing the land to plant crops have degraded the cloud forest on Kapikua. This is a concern because during the dry season it is important that water from the cloud forest reaches the lower elevations where it is needed for irrigation, power generation, and drinking water. Recently, there have been reports of pollution problems with the water supply in another area of the island. Because of these reports, the government is concerned that in the future there will not be an adequate supply of clean water for the island. If conserved, the cloud forest would supply one source of clean drinking water.

Two decades ago, a corporation bought a portion of the cloud forest to develop a large tea plantation. The tea is highly desirable worldwide because the unique growing conditions give it a flavor that people love. Currently, there is a plan underway to expand the plantation to meet the growing demand for the tea. If the cloud forest is conserved, the tea plantation would not be permitted to expand, the company would not increase its profits, and no additional jobs for islanders would be created.

However, if the area were conserved, the risk of further adverse effects on the water cycle, climate, and organisms that depend on these resources would be reduced. For example, the fastigo whipping frog is a rare species that inhabits only the cloud forest. It lives in bushes close to shallow pools of standing water and breeds in the standing water. If the forest area is not conserved, the frog might be further endangered.

3 Ask for student volunteers to share with the class their initial recommendations for which forest area should be conserved and their reasons. A variety of opinions are likely to be expressed. A sample response follows.

I think the mangrove forest should be conserved. The mangrove forest would help to protect the villages from the risk of further flood damage that has destroyed almost all of one village in recent years. The conservation would include permits for sustainable ecotourism that would provide recreation and education to tourists and jobs to island residents.

4 Review with students what the lengths of branches and nodes on an evolutionary tree represent. Tell students that on the tree the nodes for the primates are numbered from most distant common ancestor (node 1) to most recent common ancestor (node 6).

A final column added to the chart in Procedure Steps 6 and 7 is shown at right.

FOLLOW-UP

5 (LITERACY) Extend the discussion and prepare students for a written assessment by conducting a Walking Debate (see the Literacy section of Teacher Resources III: Literacy). This strategy works best when the question or issue has no single correct answer. Designate one corner of the room as “Lowland Tropical Rainforest North,” a second area of the room as “Lowland Tropical Rainforest South,” a third area of the room as “Tropical Montane Cloud Forest,” and a fourth area of the room as “Mangrove Forest.” Have students stand in the place that they think is the area that should have the highest conservation priority on the island. If most of the students already agree on a particular option, assign some of them to the other options to foster

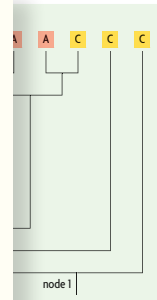
3 4. In your science notebook, write a brief summary for which forest area you would select for conservation based on the information you have so far. Explain your reasoning.

Part B: Evolutionary Tree Analysis

- 5. In your science notebook, add to the chart you created in Step 2 a column labeled “Phylogenetic diversity of primates.”
- 6. With your group, compare the evolutionary tree below for each of the four forest areas. The tree shows evolutionary data for primate taxa that are endemic to the island. In the column you created in Step 5, record the number of the node that represents the most recent common ancestor for all of the primates collectively living in each of the four areas.
- 7. In the column you created in Step 5, describe the phylogenetic diversity of the primate species living in each forest area.
- 8. Conduct a Walking Debate as a way to share your ideas with the class about which forest area should have conservation priority. Your teacher will explain how to run the debate.

Forest Conservation Areas

Forest area	Phylogenetic diversity of primates
Mangrove	Most recent common ancestor is node 3. Moderately diverse Species share a relatively distant common ancestor Branches are longer than others.
Lowland tropical rainforest north	Most recent common ancestor is node 6. Not diverse Species share a relatively recent common ancestor, and branches are short.
Lowland tropical rainforest south	Most recent common ancestor is node 1. Very diverse Species are dispersed across the tree. They share the most distant common ancestor, and branches vary in length.
Tropical montane cloud forest	Most recent common ancestor is node 5. Not diverse, but slightly more diverse than lowland tropical rainforest north Species share a relatively recent common ancestor (but slightly more distant than B), and branches are short.



the skills of debate and evidence analysis. Tell students to take with them the chart they created in Procedure Steps 2 and 3 to refer to in the discussion. Have each group of students explain to the class why they chose that option. Once each group has explained its choice, allow time for students to ask clarifying questions. Then allow students to change their minds and move to another area.

After the Walking Debate, emphasize the tensions that arise when examining where to focus sustainable conservation efforts. There can be tension between stakeholders

interested in ecosystem services versus those interested in biodiversity. For example, conservation in the cloud forest might allow for the maintenance of water storage and water sources needed for organisms to survive, but development, such as the expansion of a tea plantation, would not be permitted. However, sometimes the ecosystem services and biodiversity interests can both be met. For example, maintaining the biodiversity of an area rich in plant species that could be used for pharmaceuticals means that there is greater potential for finding the right plants for the products that could save many lives.

6 (LITERACY) (ET, CS ASSESSMENT)
Analysis Question 1 allows you to assess students' understanding of evidence and trade-offs with the EVIDENCE AND TRADE-OFFS (ET) Scoring Guide. Review the guidelines of the ET Scoring Guide, and tell the class your expectations for satisfactory work.

To help students summarize their positions you may wish to pass out Student Sheet 15.1, "Writing Frame: A Conservation Decision." This sheet provides a literacy strategy known as a writing frame, which gives students a structure for communicating their ideas. More information about the writing frame literacy strategy is in Teacher Resources III: Literacy. You may want to assess students' written summaries on the writing frame with the COMMUNICATION SKILLS (CS) Scoring Guide. If necessary, pass out copies of the CS Scoring Guide, and tell the class your expectations for satisfactory work. Review sustainability indicators. If students had the "Sustainability" unit of the *Science and Global Issues* course, they were introduced to indicators. An indicator is an observation or calculation that shows the presence or state of a condition or trend.

SCIENCE & GLOBAL ISSUES/BIOLOGY • EVOLUTION

6 Analysis

1. Which forest did you decide should be conserved? Cite at least three pieces of evidence to explain your reasoning, and state the trade-offs of your decision.
2. Describe three indicators you would recommend using to monitor the success of the conservation over the next 10 years if your recommendation from Question 1 were implemented. These indicators can be any observations that will help determine if the recommendation is successful.
3. What social, economic, and environmental elements of sustainability were involved in your considerations about which area should be conserved?
4. What scientific evidence influenced your considerations about which area to conserve?

KEY VOCABULARY

biodiversity	lineage
ecosystem services	phylogenetic diversity
endemic	sustainability
evidence	taxa
evolution	taxon
evolutionary tree	trade-off
indicator	

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When students have completed the Analysis Questions, ask them to think about which influenced them most as they prioritized the conservation areas: biodiversity or ecosystem services. Have them discuss their ideas in pairs or groups. Bring out the idea that sustainable conservation decisions involve both the ecosystem services provided by an area and the biodiversity of the area. Sometimes there is tension between the two, and sometimes they go hand in hand. The resolution of this tension is a large part of what conservationists discuss in order to come to the most sustainable conservation decisions.

SAMPLE RESPONSES

1. (ET ASSESSMENT) (CS ASSESSMENT) A complete and correct response will include a recommendation, three pieces of evidence from the information about the forest area and from the evolutionary tree analysis, including what the tree evidence tells about the diversity of the primates. It will also explain at least one trade-off of the decision.

Sample Level-3 Response:

I recommend that Forest C, the Lowland Tropical Rain-forest South, should receive the conservation funds.

My decision is based on the following evidence:

First, the tree evidence shows that there is a great amount of biodiversity in the primates that live in the area. The primate species that live there are dispersed widely across the tree and have the most distant common ancestor. Three of the branches are the longest on the tree, which means there is probably a lot of evolutionary change in those lineages. Since evolution acts on genetic variation, this forest's populations are more likely to survive changes in the environment.

Second, if the area is conserved, a primate and public education center will protect the endemic primates, and might help to reduce their risk of extinction.

Third, if the forest is conserved, the plants that can be used for the research and development of pharmaceuticals and other products will be preserved. If successful, these products will help human health, possibly save lives, and bring profit back to the island.

Some trade-offs of my decision are that to build the primate and public education center, roads and facilities must be constructed, and lots of people will visit the area. The building and visitation could disrupt the fragile habitat.

Also, if the Montane Cloud forest is not conserved, there is a potential risk that the water quality of an island drinking water source will be affected.

2. To monitor the success of the conservation of the rain-forest, I would recommend keeping a count of the total number of all species in the area, and a count of the number of offspring of the primate species in the populations. I would also recommend tracking the phylogenetic diversity of the primates.
3. The social elements were jobs and products such as pharmaceuticals that benefit human health, and the special tea that humans enjoy as a beverage. The economic elements were income to be made from products or services and jobs. The environmental elements were the effects on species, the percentage of land to be conserved, the number of endemic species, and the number of threatened endemic species.
4. The scientific evidence included the number of endemic and threatened endemic species living in each area, the information about the water storage and drainage to lower elevations in the cloud forest, the barrier to storms and water filtration by the vegetation in the mangrove, and the phylogenetic diversity of the primates on the evolutionary tree. There was also evidence about the overall health of an ecosystem, and the effect of one ecosystem on another, as in the case of the mangrove and coral reef.

REVISIT THE CHALLENGE

Students should be able to explain that conservation decisions are complex because they involve multiple perspectives, and social, economic, and environmental considerations. These include profits and jobs, materials and goods, recreation, education, the biodiversity of an area, and the percentage of threatened species in an area. Evolutionary trees help determine the phylogenetic diversity of an area, and, therefore, its sustainability. Since evolution depends on variation, the more biodiverse a population is, the more likely it is to survive an environmental change, and is more likely sustainable as a result. Sustainable conservation decisions involve both the ecosystem services provided by an area and the biodiversity of the area. Sometimes there is tension between the two, and sometimes they are complementary.