Background

Given my experiences as a young conservation advocate for nearly a decade, I saw a need to teach students the importance of interconnectedness, cultural awareness and systems-thinking skills through a spatial lens. I believe these skills are required for holistic, equitable and sustainable conservation decision-making in local and international contexts. This lesson uses geospatial tools to teach conservation ecology vocabulary and concepts from high school environmental science curriculum. Its purpose is to show students how conservationists address complex conservation and land-use challenges using the Jane Goodall Institute’s community-centered conservation approach as a case-study. My hope is that these lessons empower students to become change-agents in their communities.


Please note: An Introduction to Community Centered Conservation: Exploring the ecology and culture of the Greater Gombe Ecosystem by Madison Vorva is licensed under a [Creative Commons Attribution-NonCommercial 4.0 International License](http://creativecommons.org/licenses/by-nc/4.0/). Based on a work at [http://arcg.is/2f3j7qv](http://arcg.is/2f3j7qv).
Lesson Plan

The purpose of this mapping activity series is to learn how ecology and community knowledge can be incorporated into sustainable and equitable conservation strategies. Each map is accompanied by a set of geographic inquiries with key vocabulary, analysis activities and discussion questions for students to complete. There are activities with beginning and intermediate difficulty levels to meet the needs of teachers with varying GIS comfortability levels and classroom time:

- The mapping inquiry activities can be found in the story map: [http://arcg.is/2f3j7qv](http://arcg.is/2f3j7qv) that only requires internet access to operate. This activity is appropriate for an educator with limited to beginner GIS experience.
- Activity 2 is an additional analysis investigation through GeoPlanner that requires an Esri organizational account and an internet connection to operate. This activity is challenging and is appropriate for educators with intermediate to advanced GIS experience.
- There is an additional document containing recommended readings for teachers to assign for homework emphasizing the environmental science concepts included in the lesson plan. The reading topics include national examples of habitat corridor projects, geodesign and JGI’s community-centered conservation strategy, a study of the ecosystem services provided by tree species outside of Gombe National Park, and an article about habitat fragmentation in the Amazon.

**Target Audience:** EP Environmental Science students, 11-12th grade

**Mapping Activities and Corresponding AP Environmental Science Standards (APES):**
Maps 1 & 2: Chimpanzee range loss and Human Population Growth
- APES III B. Human Population
- APES IV G. Global Economics

Map 3: Ecosystem Services
- APES II C. Ecosystem Diversity

Map 4 & 5: Culture and Community Mapping

Map 6: Land Use Planning
- APES IV D. Other Land use

Map 7: Habitat Corridor and Biodiversity Benefits
- APES III A. Population Biology Concepts
Map 8 & 9: Soil Conservation and Water Quality
- APES I D. Soil and Soil Dynamics

Map 10 & 11: Reforestation
- APES IV B. Forestry

Learning Outcomes:
- Learn environmental science vocabulary through map exploration: ecosystem services, tragedy of the commons, habitat corridors and community mapping
- Analyze webmaps to understand basic chimpanzee biology, human community demographics, and the cultural and geographic context surrounding Gombe
- Watch media of community members, JGI’s conservation scientist and Dr. Goodall to observe how stakeholder’s interests are recognized in community-centered conservation and the impact of this strategy (through satellite imagery comparison)
- Use GeoPlanner to design land use scenarios that meet the needs of the human community, chimpanzees and gorillas given fixed criteria

Text References:
The concepts taught through the mapping activities have been cross-referenced to material from Environmental Science for AP by Friedland and Relyea and Living in the Environment by Miller.
In July 1960, 26-year-old Jane Goodall arrived at Gombe Stream Reserve in what is now Tanzania, to attempt the first study of wild chimpanzees. Her groundbreaking discovery that chimpanzees make and use tools, challenged the very definition of humans, who were thought to be the only toolmakers. Her research also revealed that chimpanzees have personalities and emotions, qualities also thought to be uniquely human.

Three decades later, Dr. Goodall and her team continued studying chimpanzee behavior at Gombe. Flying over the national park, Dr. Goodall observed a troubling fact: the forests surrounding Gombe had been chopped down, leaving bare and eroded hills. Over 65 percent of the chimpanzee habitat outside Gombe was lost.
Today, fewer than 300,000 individuals live in the wild.

Map 1: This map shows chimpanzees’ historic and current ranges in Africa.

Q1: How has the chimpanzee range changed?

To meet the needs of Africa’s growing population, more than 10 million acres of forests across the continent are cleared every year for human settlements and agriculture.

Map 2: This map shows African countries’ population growth in 1960 and 2014.
Q2: What was Tanzania’s population growth rate in 1960 and 2014? How has it changed?
Q3: How do you think human population growth has impacted chimpanzee habitat?

Forest Loss and Human Population Growth

Chimpanzees’ remaining forest habitat is threatened by conversion to agriculture, logging, charcoal production, and livestock grazing.
The reason publicly-managed forests often become degraded is because they are unregulated common-property resources available to everyone. Other examples of common-property resources are fish stocks and our global climate.

In 1968, biologist Garret Hardin explained that in deciding how much of a common resource to use, everyone assumes “If I don’t use this resource, someone else will. The little bit I use or pollute is not enough to matter.” With a small number of uses, impacts are small, but the cumulative consequence results in a tragedy of the commons scenario in which the individual uses of a common resource for personal gain degrades the resource to an unsustainable level of depletion or degradation. (qtd. in Miller 226)

Think about tragedy of the commons this way: if your family shares one cellular data plan, what happens if each person acts in their self-interest? You might use a lot of data, fearing that your sibling might use it if you don’t first. It is likely that your family’s data use will exceed the allotted amount and you’ll get charged a fee.

**Community-Centered Conservation**

Concerned that habitat loss would drive chimpanzees to extinction, Jane realized: “No white people [could march in, puffing themselves up and say “You’ve made a mess; we’re going to put it right].” “Only if people living around the wilderness areas like Gombe become our partners can we hope to save the habitat and animals who live there.”

Watch the video below to learn how the Jane Goodall Institute and their local community partners use geospatial technology and community mapping for sustainable land management and development in the Greater Gombe Ecosystem: https://www.youtube.com/watch?v=Xh8Mj4vgotk

The full length Google Earth Outreach video can be found here: https://youtu.be/CNXv8EEs0P8

**Task:** You have been hired by your city council to design a conservation strategy for the community using what you will learn from the Jane Goodall Institute’s approach. The following maps will pose a series of important questions to consider and lessons to give to ideas.

**Why are forests important?**

Before proposing any changes to a community, it is important to first investigate how the landscape is working well for people, animals and the environment. **Ecosystems services** are the cultural, environmental and economic benefits and resources that an ecosystem or species produces.

Map 3: This map shows the ecosystem services provided by tree species in the Greater Gombe Ecosystem. Click on the pins to discover how different tree species benefit people, animals and the environment. Record in the table below your findings.
The different green shades represent the different habitat types in the ecosystem: evergreen woodland, deciduous dry forest, miombo woodland and grassland. Different tree species grow in different habitats that depend on geologic factors like elevation and soil type.

<table>
<thead>
<tr>
<th>Tree Species and common name/local name if given</th>
<th>Benefits for people</th>
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</table>
Q5: How does the Jane Goodall Institute work with villages to establish sustainable livelihoods?
Q6: How do chimpanzees use trees?
Q7: Name three tree or plant species found near you. What are their benefits to people, animals, and the environment?

Why does local culture matter?

Conservation scientists use satellite imagery to monitor landscape change like forest loss and forest growth. Below is an image of a village outside of Gombe.

Q8: Write a hypothesis for why you think the forest patch in the bottom left of the picture is intact, while the surrounding hills have been deforested.
Satellite imagery reveals temporal landscape change, but it cannot answer WHY this change happens. The only people who can answer this question are community members from that specific place. Villagers protected the forest patch because it contains three sacred sites (represented by the orange pins above); the rest of the forest was cleared in a classic tragedy of the commons scenario.

Conservation scientists use a tool called **community mapping** to work with local communities to identify locations of ecological and cultural significance, including sacred sites and wildlife habitat. This participatory process is an especially important method for international conservation work because it is important to recognize and respect that local people are the experts of their environment.

Q9: What places hold cultural or spiritual significance to you in your community? Why?

Map 4: This is a map of the 13 villages outside of Gombe National Park. Kagunga is the most northern village, and Kigalye is the most southern village.
Map 5: This map shows how the land is allocated to be used in the 13 villages.
Q10: How is the map of Kigalye village colored differently than this drawing of the same area by a Kigalye villager?

Map symbology (how cartographers represent objects in a map with different colors) is culturally dependent. For example, this map represents the village forest reserves in green, and agriculture in yellow, the villager represented the reserve as black, and agriculture as green.

Land use planning is a method for deciding how land should be developed and managed. Using a mapping software called geographic information systems (GIS) it is possible to overlay a map with different geological, ecological, wildlife and sociological data to model and ecosystem and human community.

Mtiti is the Jane Goodall Institute Director in charge of facilitating land use planning in Tanzania. He explains the process, “The village management teams lay out their plans by creating a simply diorama on the ground using sticks, stones and leaves to make out different land use areas in the plan.” Then district surveyors visit the village and digitize the diorama plan using GPS coordinates. The Jane Goodall Institute plots the GPS coordinates on the map with satellite imagery. The final map is shared with and endorsed by the village and then sent to the Ministry of Natural resources to ensure that the “by-laws are legal and protected by the courts.”
Map 6: This map shows the 12 different land use types.
Scroll back to use the legend and pie chart to answer the following questions:

Q11: What is the total area of the 13 villages’ land in sq km? Don’t forget units! (1 m sq = 1 * $10^{-6}$ km sq)

Q12: What land use has the largest area and what is that area in sq m? What percentage of total village land is this land use?

Q13: Approximately how much does the village forest reserves increase chimpanzee habitat?

How did the villages choose the location for the forest reserves?

As conservation partners, every village outside of Gombe National Park decided to restore and conserve some of the forest on their land through a forest reserve. Through sustainable land-use planning, village-managed forest reserves, if restored, nearly doubled the size of available habitat for chimpanzees.
Map 7: This map shows the village-managed forest reserves.

When a landscape is developed for human purposes, the remaining habitat becomes fragmented. If habitat patches are surrounded by human land uses, they become isolated and animals may be unable to travel between them. This could cause inbreeding and increased risk of extinction.
The connecting village reserves serve as a habitat corridor for wildlife. **Habitat corridors** are used to connect habitats that have been fragmented by human development.

The village-managed forest reserves benefit chimpanzees by creating habitat corridors within the Greater Gombe-Masito-Ugalla ecosystem. But how do they help people?

Before the village forest reserves were established, as much as 90% of the vegetation had been cleared in the Greater Gombe Ecosystem watersheds. Deforestation caused soil erosion and depleted nutrient-rich topsoil which decreased agricultural yields. Soil accumulated into waterways, damaging the watershed. Numerous landslides destroyed agriculture fields and habitat. One large landslide in 2001 killed several people.

Map 8: This 3D map shows the village-managed forest reserves.
Q14: Why do you think the forest reserves were designated along a ridge with high elevation?

The village-managed forest reserves were placed along the hills’ ridges to prevent erosion. The trees’ roots hold the soil in place. Hills and mountains are prone to high erosion rates because of their steep slopes.
Map 9: This map shows the downstream water flow at different points in the village-managed forest reserves.

Q15: What is the relationship between forest regrowth upstream and water quality downstream?

Maintaining healthy forests upstream improves water quality downstream. This is important because most of the villages rely on spring water downstream for their drinking water. Clear, clean water downstream supports healthy fish populations that is a major food source for people and wildlife.

How do we monitor success?

The Jane Goodall Institute uses very high resolution satellite imagery and drone imagery to monitor the village-managed forest reserves.
It is estimated that 126 hectares of forest has regrown since 2005 in the Kigalye village forest reserve. The total forest cover in 2014 was approximately 282 hectares, or 76% of the original forest cover in 1972.

Map 10: This is a satellite image of the Kigalye forest reserve in 2005.

Map 11: This is a satellite image of the Kigalye forest reserve in 2014.
Sustainable land use planning has improved the quality of life for people and increased the amount of habitat. Forests in some of the village-managed forest reserves are returning. Kigalye village’s chairperson Kasalla reflected “We have peace of mind when we go to sleep during the rainy season. Our school that was gradually being eroded from flooding, is now stable. We are now working toward controlling illegal hunting. We are now seeing wildlife and birds coming back. We are proud because this is all from our success.” Effective conservation strategies meet the needs of people and animals.
Mapping Activity Questions for Students

Q1: How has the chimpanzee range changed?

Q2: What was Tanzania’s population growth rate in 1960 and 2014? How has it changed?

Q3: How has your community changed in your lifetime? Think about your community’s development, demographics and environmental trends.

Q4: How do you think human population growth has impacted chimpanzee habitat?
### Tree Ecosystem Services Chart

<table>
<thead>
<tr>
<th>Tree Species and common name/local name if given</th>
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Q5: How does the Jane Goodall Institute work with villages to establish sustainable livelihoods?
Q6: How do chimpanzees use trees?

Q7: Name three tree or plant species found near you. What are their benefits to people, animals, and the environment?

Q8: Write a hypothesis for why you think the forest patch in the bottom left of the picture is intact, while the surrounding hills have been deforested.
Q9: What places hold cultural or spiritual significance to you in your community? Why?

Q10: How is the map of Kigalye village colored differently than this drawing of the same area by a Kigalye villager?

Q11: What is the total area of the 13 villages’ land?
Q12: What land use has the largest area and what is that area? What percentage of total village land is this land use?

Q13: Approximately how much does the village forest reserves increase chimpanzee habitat?

Q14: Why do you think the forest reserves were designated along a ridge with high elevation?
Q15: What is the relationship between forest regrowth upstream and water quality downstream?
Assessment

1. Explain how the individual use of common property resources often leads to a tragedy of the commons scenario.

2. What are some important ecosystem services provided by trees for people, animals and the environment?

3. What is one tool that conservation planners use to incorporate the expertise of local communities?
4. As a conservation planner, what kind of data would you collect about a species to help you better protect it? (its range, habitat, and what it eats)

5. As a conservation planner, why is it important to understand the local ecology of a place?

6. Why is it important to understand the local culture?
7. In designing your conservation strategy, who are the stakeholders you would consult and partner with? Why?

8. How would you measure the success of your conservation plan?
Mapping Activity Question Answers

Q1: How has the chimpanzees’ range changed?
*Chimpanzees’ current ranch is much smaller than their historic range.*

Q2: What was Tanzania’s population growth rate in 1960 and 2014? How has it changed?
*The growth rate in 1960 was 2.89%. The growth rate in 2014 was 3.15%. It has increased 0.26%.*

Q3: How has your community changed in your lifetime? Think about your community’s development, demographics and environmental trends.
*This could be anything related to the local community.*

Q4: How do you think human population growth has impacted chimpanzee habitat?
*An increase in human population has resulted in the degradation of chimpanzee habitat as people use forest resources unsustainably.*

Q5: How does the Jane Goodall Institute work with villages to establish sustainable livelihoods?
*Villagers are trained in agroforestry and they plant tree nurseries.*

Q6: How do chimpanzees use trees?
*Chimpanzees build nests in trees for protection from predators, parasites, biting-insects and insulation. They also eat fruit and leaves for medicinal purposes.*

Q7: Name three tree or plant species found near you. What are their benefits to people, animals, and the environment?
*These answers will depend on the specific tree or plant species found within your community.*

Q8: Write a hypothesis for why you think the forest patch in the bottom left of the picture is intact, while the surrounding hills have been deforested.
*This could anything related to forest use.*

Q9: What places hold cultural or spiritual significance to you in your community? Why?
*This could be a temple, cultural center, museum etc.*

Q10: How is the map of Kigalye village colored differently than this drawing of the same area by a Kigalye villager?
*The map represents the village forest reserves in green and agriculture in yellow. The villager represented the reserve in black and agriculture in green.*

Q11: What is the total area of the 13 villages’ land in sq km? Don’t forget units! (1 m sq = 1 * 10^-6 km sq) 353,816,900 m sq = 353.8169 km sq.

Q12: What land use has the largest area and what is that area in m sq? What percentage of total village land is this land use?
Agriculture is the largest land use. Its total area is 150,469,709.461 m sq, or about 43% of total village land use.

Q13: Approximately how much does the village forest reserves increase chimpanzee habitat? Gombe’s area is 56,408.376.60 m sq and the village forest reserve’s area is 98,140,372.06 m sq, so the reserves nearly double the available habitat for chimpanzees.

Q14: Why do you think the forest reserves were designated along a ridge with high elevation? *This could be anything.*

Q15: What is the relationship between forest regrowth upstream and water quality downstream? *Forest regrowth upstream improves water quality downstream because erosion is reduced.*

Tree Ecosystem Services Chart Handout Answers

<table>
<thead>
<tr>
<th>Tree Species and common name/local name if given</th>
<th>Benefits for people</th>
<th>Benefits for animals</th>
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<tbody>
<tr>
<td>Ficus Sur (broom cluster fig)</td>
<td>People use this species for fruit</td>
<td>Chimpanzee food source</td>
<td>Trees produce oxygen, provide flood control and habitat for species, store carbon, regulate climate and prevent erosion</td>
</tr>
<tr>
<td>Anisophyllea boehmii (mashindwe)</td>
<td>People use this species for timber, fruit and firewood</td>
<td>Chimpanzees eat mashindwe fruit</td>
<td>See above</td>
</tr>
<tr>
<td>Celtis mildbraedii (elm)</td>
<td></td>
<td>Chimpanzees eat elm bark to fight bacterial infections</td>
<td>See above</td>
</tr>
<tr>
<td>Brachystegia spp.</td>
<td>People use this species for firewood</td>
<td>Chimpanzees eat the seeds and leaves of this tree</td>
<td>See above</td>
</tr>
<tr>
<td>Cordia africana</td>
<td>People use this species for</td>
<td>Chimpanzees eat Cordia fruit, flowers</td>
<td>See above</td>
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<td>Species</td>
<td>Uses</td>
<td>Benefits</td>
<td>Notes</td>
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<tr>
<td><em>Vernonia spp.</em> (mfumya)</td>
<td>Furniture, fruit and timber, and stems to reduce the effects of tuberculosis</td>
<td>People use this species to treat malaria and for timber, fruit and firewood</td>
<td>Chimpanzees eat Mfumya leaves to treat stomach aches and parasites</td>
</tr>
<tr>
<td><em>Elaeis guineensis</em> (oil palm)</td>
<td>Harvest oil palm fruit and crush it to make palm oil</td>
<td>People harvest oil palm fruit and crush it to make palm oil</td>
<td>Chimpanzees eat oil palm fruit</td>
</tr>
<tr>
<td><em>Uapaca kirkiana</em> (sugar plum)</td>
<td>Use this species for fruit, timber, firewood</td>
<td>People use this species for fruit, timber, firewood</td>
<td>Chimpanzees eat sugar plum fruit</td>
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<tr>
<td><em>Ficus sansibarica</em> (knobbly fig)</td>
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<td>Chimpanzees eat unripe figs because they have deworming properties</td>
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Assessment Answers

1. Explain how the individual use of common property resources often leads to a tragedy of the commons scenario. *Each person uses the resource thinking that if they don’t take advantage of it, another person will. If enough people act in their self-interest, the common property resources are consumed to the point that they are degraded or exhausted.*

2. What are some important ecosystem services provided by trees for people, animals and the environment? *Trees produce oxygen and store carbon (preventing it from being released from the atmosphere and contributing to climate change). People use wood for furniture and firewood. Animals build nests in trees and eat fruit from the trees.*

3. What is one tool that conservation planners use to incorporate the expertise of local communities and how does it work? *Conservation planners use community mapping to incorporate the insights of local communities who can identify locations of cultural and ecological significance.*

4. As a conservation planner, what kind of data would you collect about a species to help you better protect it? *I would collect range, habitat and diet data. I would also find sociological data related to the human threats to this species.*

5. As a conservation planner, why is it important understand the local ecology of a place? *Knowing the local ecology of a place helps conservation planners make better decisions in terms of where to prioritize areas to conserve. For example, locations that have greater biodiversity or a water resource.*

6. Why is it important to understand the local culture? *Local culture can explain the characteristics and history of a landscape. It can explain why things are the way they are.*

7. In designing your conservation strategy, who are the stakeholders you would consult and partner with? Why? *I would partner with other conservation organizations that have different sets of expertise, city planners, ecologists, and community members whose land I was proposing to conserve.*

8. How would you measure the success of your conservation plan? *I would conduct a survey to see how community members felt about my plan. I could also conduct pre and post surveys to measure species presence/absence. Using satellite imagery, I could assess if the landscape became more degraded or restored.*
## Grading Rubric for Assessment

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<td>Answers questions clearly and thoughtfully</td>
<td>Accurately explains</td>
<td>Explains with some accuracy</td>
<td>Explains with limited accuracy</td>
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<td>Qualifies answer with examples</td>
<td>Examples are personal, detailed and creative</td>
<td>Examples are directly from the mapping activities and creative answers are lacking to localized questions</td>
<td>Examples are limited and copied directly from the mapping activities</td>
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<td>Answers demonstrate holistic systems thinking</td>
<td>Explanations show understanding of interconnectedness between people, animals and the environment</td>
<td>Explanations show limited understanding of interconnectedness between people, animals and the environment</td>
<td>Explanations show no understanding of interconnectedness between people, animals and the environment</td>
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Citations for Lesson Plan Content

Please note: The Story Map activities are for education purposes only. These resources are an introduction to the Jane Goodall Institute’s (JGI) community-centered conservation strategy and are not a product of JGI. JGI’s land-use planning and community-centered conservation approach is the work of Jane Goodall, Lilian Pintea, Emmanuel Mtiti, the JGI staff, and local communities. As technology evolves, JGI is continually refining its approach. Please visit www.janegoodall.org to learn about the latest methods being used in the field.


Photos: the Jane Goodall Institute

Text: