“The grasses and blooms spread their sweet fragrance across the expanse, jaguars hid in the high grass and thousands of birds sang in the early morning hours. The flatness of the Llanos was only interrupted by the occasional Mauritia palm. Tall and slender, these palms spread out their fingered fronds like huge fans. They were now loaded with shiny reddish edible fruits that reminded Humboldt of fir cones... ‘We observed with astonishment,’ he reported, ‘how many things are connected with the existence of a single plant.’ The Mauritia fruits attracted birds, the leaves shielded the wind, and the soil that had blown in and accumulated behind the trunks retained more moisture than anywhere else in the Llanos, sheltering insects and worms. Just the sight of these palms, Humboldt thought, produced a feeling of ‘coolness’... For Humboldt the Mauritia palm was the ‘tree of life’ – the perfect symbol of nature as a living organism.”

-Andrea Wulf, The Invention of Nature
Author’s Statement

Ava Goodale graduated from Cornell University with a degree in natural resource management. After working in that field, she used those experiences to transition into progressive education and is now the chair of the Millbrook School Science Department in Millbrook, New York. In addition to teaching, she coordinates the department’s place-based and project-based curriculum, facilitates a student research program, and runs the school’s canopy walkway.

Ava has participated in several research and education programs throughout the Tropics, including learning from the Kayapo People of the Xingu River, Brazil. In partnership with the Morpho Institute, she has visited the Maijuna People of Peru yearly since 2017 and facilitates a professional development workshop for educators, titled Inquiry, Conservation, & Sustainability in the Amazon. It is her great honor to translate their lessons with the hope that many more will back their efforts and be part of a global effort to be better stewards of the places we call home. As Tyson Yunkaporta describes in Sand Talk, indigenous patterns of thinking, doing, and being are a wellspring, as we reexamine our own practices and relationships to people and place. This case study is intended to spark that examination and open a door of discovery for readers to see their own place in the context of other world views—to see what is familiar through a new lens.

This case study is part of a forthcoming series. For more information, please send inquiries to: curriculum@morphoinstitute.org

The Morpho Institute is a 501(c)3 nonprofit created to support the key role of K-12 education in realizing the global goal of environmental conservation and sustainability. To achieve this goal, The Morpho Institute provides professional development programs and curriculum resources which support local to global environmental stewardship in K-12 instruction.

In collaboration with US and international partners, The Morpho Institute provides US educators the opportunity to experience the Amazon rainforest as a compelling context for developing a global perspective on biological and cultural resources, participating in conservation, exploring sustainability, and inspiring environmental stewardship. Our field workshops and resources apply key elements of inquiry, STEM, and placed-based learning to assist educators in making these critical local to global connections in their classrooms, instruction, and curricula. Learn more at www.morphoinstitute.org

OnePlanet is a 501(c)3 nonprofit that partners with indigenous and traditional communities to build a more sustainable, empowered, and just future through community-based projects, outreach, and technical assistance. We respect indigenous and traditional communities by treating them as equal partners in our projects. We view them as collaborators instead of participants and we work with them rather than for them. We have witnessed that engaging communities and individuals in this way helps to build capacity and local ownership ultimately increasing the long-term sustainability and viability of our programs.

Our work is focused in the Peruvian Amazon with the Maijuna indigenous group. OnePlanet was founded in 2015 and builds on the extensive biocultural conservation work that our President and founder, Dr. Michael Gilmore, started with the Maijuna in 1999. Learn more at www.oneplanet-ngo.org/

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Introduction

Thank you for taking part in this case study. In the pages that follow, you will learn about the Maijuna indigenous people’s use of forest products, as an approach to community-based conservation in Peru. You will take the perspective of a student visiting the Maijuna village to learn about their conservation success story so you can be an agent of change in your home community. As the story unfolds, you’ll be asked to answer questions, reflect on conservation in your local community, and finally participate in a citizen science project. The icons used throughout are intended to draw your attention to specific features of the case study. The palm icon indicates a snapshot from the field in Peru, the checklist icon indicates an action item, and the pencil icon indicates questions for you to answer as you go. The blue background boxes change in size, representing different scales.

Before you continue, please read the background article, The Maijuna: Fighting for Survival in the Peruvian Amazon and answer these empathy reflection questions (Ritchhart et al., 2011):

1. I am thinking of … the topic… from the viewpoint of… the viewpoint you’ve selected. I think… describe the topic from your viewpoint. Be an actor—take on the character of your viewpoint. A question I have from this viewpoint is… ask a question from this viewpoint.

2. What do you think a Maijuna person sees, observes, or notices?

3. What might a Maijuna person know, understand, hold true, or believe?

4. What might a Maijuna person care deeply about?

5. What might a Maijuna person wonder about or question?
Part 1: Slow Looking

1. Look carefully at the photo above for 30 seconds. List 10 words or phrases that describe what you notice (Tishman 2017).

2. Now, look for another 30 seconds. Add as many more descriptive words as you can. If you get stuck, think in categories to guide your eye, such as color, shape, and line. Try blurring your eyes or changing your viewing distance (Tishman 2017). Look for what is hard to notice.

You pick up a palm-sized fruit that could easily be mistaken for a dragon’s egg. It’s tawny epicarp soaks up the equatorial sun’s rays, warming your hand, as you start to chip away the overlapping rhombus-shaped scales with your fingernail. Soon the saffron-colored mesocarp bursts forward, tempting you to take a taste. The oily and acidic pulp (Padoch 1988) can’t be matched to any familiar fruits. Still holding the ellipsoidal fruit, your attention is drawn to your Maijuna teacher, Ken, who introduces the fruit’s importance. This small fruit came from racemes taller than you, baring nearly 1,000 identical fruits in total (Virapongse et al. 2017). Ken explains that these fruits are an important part of their tropical diet, as they are the richest natural source of beta carotene (Manzi & Coomes 2009). The fruit can be enjoyed raw, used as fish bait, processed into an oil, or made into a drink, called aguajina (Gilmore et al. 2013).
Part 2: Ken extends his arm upwards to reveal the single-stemmed tree this fruit belongs to—the aguaje palm (*Mauritia flexuosa*), which is only one of over 50 common names for this palm throughout the neotropics, including buriti and moriche (Smith 2016). Your gaze follows his gesture, as you take in this giant, whose height obscures the now miniature fruits dangling 30 meters overhead. Its *costapalmate* fronds split up to the sun, while the *racemes*, pendulous with fruit, droop down, offering their shade. As he organizes a pile of tan nylon straps, Ken details the many ways the Maijuna use this species beyond the fruit. The dried leaves are used as fuel for drying canoes and clearing agricultural fields. The petioles are used as fiber to make mats and bags. Downed trunks are home to beetle larva that can be eaten or used as bait (Gilmore et al. 2013). Your wildlife guide, Orlando, adds that nearly a dozen forest products can be made from every part of this towering tree—a term known as Non-timber Forest Products (NTFPs) (Sander et al. 2018)—making this species of great importance regionally (Virapongse et al. 2017) and a stand-out palms, which are considered the most useful plant family to people worldwide (Shackleton 2018). Orlando goes on a quick tangent to explain the species taxonomy, while Ken inserts names in Máiñiki (see below).

3. What do you appreciate about what the Maijuna have shared so far? How might you express that appreciation through a question of significance to the Maijuna leaders?
One of your friends asks, “Is this a rare species?” Ken quickly and emphatically says no. Rather, he explains, it is widespread and abundant near his village and throughout the entire Amazon. This strikes you as odd, since hyperdominant species are uncommon in the tropics. You now notice that this entire time Ken was setting up a harness around the smooth-trunked tree, over 50 cm in diameter. In a matter of moments, Ken is off the ground, heading toward the ripe fruits. (Photo credit: Wilfredo Martinez / OnePlanet)

Methodically inching up the tree, Ken tells you about a time when the Maijuna collected fruit from the ground and only used them for subsistence. This all changed in the early 1990s when outsiders influenced the shift to large-scale commercial extraction and the production of a market good, felling hundreds to thousands of palms (Gilmore et al. 2013). “When they were cutting, they were destroying the forest.” As a dioecious species, only the female aguaje palms produce fruits, resulting in selective cutting that skewed the sex ratio and degraded the forest (Horn et al. 2012). After a peak where thousands of pounds of fruit per year were leaving the forest, the harvests declined in the early 2000s, when there was a significant drop in harvest amounts (Gilmore et al. 2013), leaving the Maijuna with a depleted resource in need of restoration.

See Ken and his neighbor to the south in action.

4. Research a species in your area that has been threatened by overharvesting. Provide a short historical overview and detail the current threats.
Part 3: Now well above your head Ken pauses the climb and shifts his gaze to the horizon, capturing a view hidden to you, still standing below. You can only imagine the terrain the treetops must create, the canopy of aguaje trees creating rolling hills continuing as far as the eye can see (click the image to the right). Now, as if talking to the forest itself, Ken broadcasts that this aguaje is only one of well over a billion in the Amazon (Smith 2016).

Typically, this palm is found in a swamp community, called aguajales or ne caudu in Máihiki, meaning aguaje in soft earth (Gilmore et al. 2013), which covers roughly 5 million ha in Peru alone (Torres et al. 2006), making it the largest swath in the tropics (Bhomia et al. 2018). There are many dozens of aguajales in the Maijuna’s ancestral forests, such as those shown below on the Maijuna’s participatory map (Gilmore & Young 2012). Over 20 of these aguajales have names to describe their size, shape, location, and significant people and events (Gilmore et al. 2013), such as toto ne cuadu for its clay deposits or jai ne cuadu for its large size.

Ken goes to restart his ascent but can’t resist the temptation to tell a story about a nearby aguajale—Gogobai ne cuadu—named after a malevolent female supernatural being who often tricks people into losing their way (Gilmore et al. 2013). The story is chilling and poignant, leaving you with an unforgettable reminder to stay vigilant in the forest—a feeling that must be shared by Maijuna children who hear this story.

Ken travels to these swamps often, where he can find many dozens of useful plants and important game species all in a unique ecosystem (Gilmore et al. 2013). You imagine the tree in front of you dominating these distinctive swamps, creating a resource island within this landscape. Those resources are also the base of the tropical food web (Torres et al. 2006), as paca, armadillos, agouti, and the legendary tapir are common visitors, consuming and dispersing aguaje seeds (Virapongse et al. 2017), Ken explains with ease, as he shifts his weight in the harness. Bats, fish, monkeys, and some reptiles are all dependent on this single species (Virapongse et al. 2017), as much as the Maijuna. Birds, such as the red-and-green macaw, red-bellied macaw, moriche oriole, sulphury flycatcher, and point-tailed palm creeper, all have a specialized relationship (Schulenberg 2010) to this floristically and compositionally distinctive habitat (Roucoux et al. 2017). From Ken’s description, you quickly count 20 species that depend upon the aguajales, half of which are game species that contribute to Maijuna subsistence and income (Gilmore et al. 2013).
To satisfy commercial demands, well over 100,000 palms are cut down each year in this region of Peru (Horn et al. 2018), resulting in a significant drop in aguaje density closest to commercial centers (Virapongse et al. 2017). This level of harvesting has had a negative effect on these habitats (Holm 2008), which have played a long and crucial role in Maijuna livelihoods (Virapongse et al. 2017) and the forest they call home. Ken laments, “people started cutting lots of aguaje and this is how things got destroyed. Degraded aguajales do not have power or strength because there is not much food for animals (Gilmore et al. 2013).”

From the above description, it is easy to see the aguaje palm as a *keystone species*. Yet, it’s direct relevance goes well beyond these ecological services, as this palm is a mainstay of Maijuna cultural stability, as are many such forest products worldwide (Shackleton 2018). Examine the table below, which summarizes elements of a *cultural keystone species*, defined as a “culturally salient species that shape in a major way the cultural identity of a people, as reflected in the fundamental roles these species have in diet, materials, medicine, and/or spiritual practices (Garibaldi & Turner 2004).”

<table>
<thead>
<tr>
<th>Cultural Keystone Elements (Garibaldi &amp; Turner 2004)</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Intensity, type, and multiplicity of use</strong></td>
<td></td>
</tr>
<tr>
<td>a. Is the species used intensively (routinely and/or in large quantities)?</td>
<td></td>
</tr>
<tr>
<td>b. Does the species have multiple uses?</td>
<td></td>
</tr>
<tr>
<td><strong>Naming in a language</strong></td>
<td></td>
</tr>
<tr>
<td>c. Does the language incorporate names and vocabulary relating to the species?</td>
<td></td>
</tr>
<tr>
<td><strong>Role in narratives, ceremonies, and symbolism</strong></td>
<td></td>
</tr>
<tr>
<td>d. Is it prominently featured in narratives, ceremonies and/or as a major symbol?</td>
<td></td>
</tr>
<tr>
<td><strong>Persistence and memory of use in relationship to cultural change</strong></td>
<td></td>
</tr>
<tr>
<td>e. Is the species ubiquitous in the collective cultural consciousness?</td>
<td></td>
</tr>
<tr>
<td><strong>Level of unique position in culture</strong></td>
<td></td>
</tr>
<tr>
<td>f. Would it be hard to replace this species with another available native species?</td>
<td></td>
</tr>
<tr>
<td><strong>Extent to which it provides opportunities for resource acquisition from beyond the territory</strong></td>
<td></td>
</tr>
<tr>
<td>g. Is this species used as a trade item for other groups?</td>
<td></td>
</tr>
</tbody>
</table>

5. Given what you know so far, in what ways is the aguaje palm a cultural keystone species? In the “rating” column on the table above, answer the corresponding question with yes, no, or unsure. Add notes to justify your response in the margin.

You can barely hear Ken now, as he can almost touch the lowest palm fronds. His faint words seem to blur the forest with the village, mix his people with the animals, and jump from fact to story. Your instinct is to try to categorize what you hear under familiar headings, like ecology or culture. You manage to understand his words but struggle to comprehend this holistic, synergistic view that sees these systems as indivisible manifestations of a complex whole (Maffi & Woodley 2012). The clarity of Ken’s fluidity underscores the ways in which biodiversity and cultural vitality are linked, each underpinning the other.
Now that you have come to see the aguaje palm as both a biological keystone species and a cultural keystone species (Schultz et al. 2019), you can merge your knowledge to cement this species’ importance as a *biocultural keystone species* (Shackleton et al. 2015) that maintains and restores the diversity of life from the biological to the cultural to the linguistic to the aesthetic (Maffi & Woodley 2012). These interrelated elements form an adaptive system, where resilience anywhere in the system has ramifications to resilience elsewhere, creating a feedback loop that “constitutes the very essence of the interdependence of cultural and biological diversity” (Maffi & Woodley 2012). Just as biodiversity can be mapped into hotspots, a Biocultural Diversity Index was created as a country-by-country assessment (Loh & Harmon 2005). As shown in this map, the Amazon Basin is one of three core areas identified globally for its exceptionally high biocultural diversity.

![Map of biocultural diversity Index](image)

6. **Research a species in your area that could be considered a bioculturally important species. Justify your suggestion. These books may be a helpful start:** Botany of Desire, 50 Plants that Changed the Course of History, The Triumph of Seeds, Cattail Moonshine, and the Secret Life of Plants.
Part 4: With Ken focusing on his final maneuver into the upper reaches of the palm, Orlando provides his perspective, as a long-time resident of Iquitos, the region’s largest Amazonian city and commercial center (Padoch 1988). Although aguaje plays mostly a subsistence role in Maijuna livelihoods, about 5% is sold commercially as supplemental income (Gilmore et al. 2013), making their way toward Iquitos, first by canoes or peque-peques to a small port town called Mazán. A Maijuna harvester would only make this 5-hour trip, costing about 50 soles in gas, when they have plenty to sell, perhaps 20 sacks of fruits collected over an intensive 2-day period. From Mazán sacks of fruit might travel another 4 hours to Iquitos by riverboat traders.

This journey is repeated in almost 300 communities, involving nearly 5,000 rural people within a week’s travel distance from Iquitos (see map), each contributing only a couple times a year as part of a diverse livelihood portfolio (Horn et al. 2018). The fruit travels from small tributaries to large ones, meeting various traders along the way, and finally to the confluence of the Amazon, Nanay, and Itaya Rivers that meet in Iquitos (Horn et al. 2018). With no roads leading directly out of the city, the fruit’s journey ends here, creating a robust regional fruit market unparalleled in size. Of 3,000 rainforest fruits, 200 contribute to this market (Kozloff 2010).

Orlando lists several that you’ve never heard of, describing their bright colors, aromas, and diverse uses—ubos (*Spondias mombin*), unguarhui (*Oenocarpus bataua*), huito (*Genipa Americana*), sacha mango (*Grias neuberthii*), marirana (*Couepia subcordata*) and mocambo (*Theobroma bicolor*). But he says, aguaje takes center stage, joking that Iquitos is the aguaje capital of the world. About 20 metric tons of aguaje are consumed in Iquitos daily, which has more than doubled since the 80s (Horn et al. 2018), resulting in as many as 200,000 trees being cut down per year (Horn 2017), mostly within a day’s travel from the city center (Padoch 1988). The Maijuna are part of a region-wide effort to keep up with market demands, which flex and flow spatio-temporally with fruiting phenology variation in each month of the year. The Napo River Watershed, which includes Maijuna lands, accounts for only 8% of the total fruit consumption in Iquitos but their harvest peak is unique in the region (see graph).

Orlando says that from his house he can buy aguaje on almost every street corner from women vendors called aguajeras. The aguajera closest to his house has run her own business there for decades, selling raw fruits by the half dozen that she will peel and salt for Orlando if he wishes. Orlando explains he can go to the market for larger amounts, buy products like chupetes (lollipops) and masa from home kitchens, or aguaje ice-cream from commercial shops. On any given day, he could find hundreds of women from street corners, kitchen markets, factories, and shops selling aguaje in any number of forms. You notice that Orlando is almost entirely describing women business owners. He explains that women often play a prominent role in markets for forest products in general, which is especially true for the aguaje markets in his city (Virapongse et al. 2017) that can be a lifeline for vulnerable groups like urban poor women (Padoch 1988). From the Maijuna to the aguajeras, this fruit represents an economic buffer (Pyhälä et al. 2006) and a safety net, resulting in financial gains that maintaining incentivize forest integrity, right along with the accompanying cultural traditions (Shackleton 2018).
Part 5: Ken reaches the top of what originally seemed like an insurmountable obstacle. He nests in the upper canopy of the aguaje, taking a moment to catch his breath. From this widest vantage point, he describes that a trek to the aguajales is almost like walking on a sponge made from deep and far-reaching palm roots that manage to function in these flooded, physiologically-demanding soils (Manzi & Coomes 2009). It is this waterlogging that encourages anaerobic and acidic conditions, slowing decomposition and allowing organic matter to accumulate over thousands of years into thick soupy layers (Roucoux et al. 2017) that cushion each footstep. You remember from your biology class that hidden within that organic matter must be carbon, sequestered from the atmosphere and stored underground. You add this unseen resource to the long list originating in this habitat—this one a globally-significant component of our shared climate system (Schultz 2019), making this habitat important also on the planetary level (Virapongse et al. 2017). As Ken prepares his descent, shifting the double loops downward, you see now how your own livelihood is connected to these carbon-rich swamps, as a climate change mitigation strategy (Roucoux et al. 2017).

Carbon Storehouses: Covering only 6% of global land cover, the world’s wetlands, including aguajales, store the same amount of carbon as the entire atmosphere and provide other ecosystem services like food production, water purification, aquifer recharging (Kozloff 2010), erosion control, and nutrient cycling (Gumbricht et al. 2017). Peatlands, a specific type of wetland that also includes aguajales, rank second only to the world’s oceans in carbon storage capability (Hawkin 2018). And finally, the aguajales themselves store 3-5 times as much carbon as any other tropical ecosystem at a rate of about 250 tons of carbon dioxide per hectare (Kozloff 2010).

The Maijuna communities and its mosaic of aguajales belong to the northeastern arm of the Pastaza-Maranon Foreland Basin (Top map: Asner et al. 2017), adding to Peru’s most carbon-dense landscape in the north of the country (Bottom map: Arner et al. 2017, which only accounts for above-ground carbon). This area comprises only 3% of Peru’s total land cover but is nearly 50% of all above-ground carbon in the entire country (Draper et al. 2014). Similar colossal peat areas are only found in two other areas globally (Gumbricht et al. 2017), bringing the conservation opportunity in Peru’s northern region of Loreto to the international arena (Asner et al. 2014).

All told these statistics underscore the global significance of wetlands generally and aguajales specifically in spurring this internationally championed carbon-based approach to conservation (Asner et al. 2014). See Project Drawdown’s strategies on peatland protection, tropical forest restoration, and indigenous people’s forest tenure to continue learning about these issues on the global level.

7. In total, Peru’s aguajales store approximately 2.3 gigatons of carbon. However, degradation of these swamps from over extraction reduces its rate of sequestration and total biomass significantly (Bhomia et al. 2018), as well as regeneration (Holm 2008). Answer the questions below, using the provided graph, which shows biomass carbon stocks in dense palm swamps with different levels of degradation (low, medium, and high). Woody trees, aguaje palm, and other palms are represented by solid grey, dot, and stripe fills, respectively (Bhomia et al. 2018).

a. By what percent is biomass carbon stock reduced in medium and high degradation scenarios?

b. What percentage of total carbon stock do aguaje palms contribute in low, medium, and high degraded areas?
This low degradation scenario can potentially be akin to sustainable management practices, meaning that low levels of harvesting allows for the long-term persistence of the population, the whole biotic community, and ecosystem functions (Shackleton et al. 2015). In the tradeoff between harvest frequency, harvest intensity, and recovery time, aguaje populations can be dynamically stable (Holm 2008), if a minimum viable female population is maintained (20 individuals in the scenarios below). Your challenge is to identify sustainable harvest levels that will supply adequate income, while maintaining a healthy aguaje population (Holm 2008). For each of the four graphs below, which harvest percentage(s) for female aguaje palm would maximize yields, while remaining sustainable for the 100-year timeframe?

**Conclusion:** With the added distractions of bird calls and insect trills, your mind plays catch-up to absorb all this new information, while Ken quickly returns to the ground. Only 25 minutes has passed—about the same amount of time it would have taken to cut the tree for harvest (Manzi & Coomes 2009), Ken adds, dropping the harness to the tree’s base. Ken now turns to you, extending an invitation to climb! Would you pass up the chance—the chance to encounter the malevolent female supernatural being Gogobi, the chance to take refuge in the Tree of Life, the chance to eat this fruit right from the source? Never! While Ken transfers the harness to your waist, he explains that the Maijuna have been harvesting the aguaje fruits by climbing into the canopy since 2009, using this simply-designed, $75 harness that was developed by a team of brothers from nearby Parinari (Manzi & Coomes 2009) and a relationship with the non-profit, OnePlanet. He proudly states that most people in the village now have been trained to climb and have their own harnesses. They are not cutting any trees now and are even cultivating thousands of palm seedlings near their homes, all together making their operation more efficient and starting a culturally relevant natural resource management program (Gilmore et al. 2013). Ken proudly says, “Now we care for aguaje and are restoring them.” He says they changed their ways so their kids’ kids’ will have this livelihood opportunity.

To your surprise, Orlando chimes in to add that region-wide only a fraction of harvesters use this non-destructive and safe method (Horn et al. 2018) that has so many ecological and economic benefits, while safeguarding biodiversity (Schulz et al. 2019). Orlando explains that households with strong social networks and extensive traditional ecological knowledge tend to adopt this sustainable practice more readily, especially hunters who have a clear incentive to keep the aguajales, and the game animals within, healthy (Manzi & Coomes 2009). By simply climbing this tree today, Ken has shown that the benefits of an intact forest can exceed the potential benefits of clearing it. He has shown a self-perpetuating pathway where livelihoods drive conservation through their many links and dependencies (Pyhälä et al. 2006). Now seeing Ken as a leader in a regional sustainability effort that has ramifications globally, you shimmy the loop a few inches up the tree and place your foot in the stirrup. It is your turn now to climb and be part of the solution.
What are the synergies between cultural protection, biodiversity, and carbon conservation (Schultz et al. 2019)? To answer an essential question of this nature, we’ll deploy two strategies—an indigenous thought process and a “fuzzy cognitive map.” First, try Yunkaporta’s (2020) holistic reasoning process for encoding knowledge through an indigenous thought process. Use each finger on your hand to represent one component of the aguaje system with your thumb representing “pattern mind”—a way of thinking that captures systemwide trends. Touch different combinations of fingers to consider the relationships between them. Finally, squeeze all of your fingers together to feel the synergies in their entirety.

9. Next, complete a hand drawn cognitive map or try this software that allows you to create semi-quantitative models that can identify components of the system and the relationships between them (Shackleton et al. 2015), using the example below.
   a. First, identify the important components of the aguaje system and arrange them by relatedness.
   b. Then, consider the relationships between these components by connecting them with arrows and articulating the connection with words such as increases, decreases, facilitates, harnesses, drives, provides, reconciles, triggers, etc.
   c. In a paragraph, describe your model. How many components do you have? How many are driving components (those that have only an outward arrow and influence the dynamic of the system but are not affected by other components)? How many are receiver components (only an outward arrow)? How many central components (those with the most arrows coming in and out)? Explain.
   d. Lastly, deploy your model to analyze different “what if” scenarios, feedbacks, or fluctuations to determine how the system might react under a range of circumstances. For example, what do you predict would happen if the Maijuna’s traditional ecological knowledge decreased? What do you think would happen if frugivore populations decreased? In a paragraph, articulate your own question and answer it using your model.
Bringing It Home: Your time in Peru comes to an end, and you soon find yourself back home. You now see the trees around your home in a different light. The Maijuna shared their culture, ecology, and ways of thinking. And, they shared their inspiration for you to reconnect with these things in your own home.

You find yourself entranced by a tree in a park near your house that you’ve walked past thousands of times. As you stand starring, noticing and wondering, an elderly woman stops to tell you that this is her favorite tree—a planted cork oak (Quercus suber). She tells you she is from Portugal, where this tree grows in woodlands called montados. She describes an iconic landscape and how her grandfather sustainably harvested firewood, charcoal, livestock feed, and cork, and grew crops in its shady understory. The story seems familiar, as she shares how her family’s dependence on the cork oak for subsistence and overcoming rural poverty was tied to local biodiversity (Shackleton et al. 2015). And in turn that biological system depended upon its stewards (Bugalho et al. 2011). She stands taller to say that it was in fact her family that first called for sustainable management of these systems, coining the term nachhaltig in the 17th century (Grober 2007). Seeing your interest, the woman suggests you read her favorite short story—The Man Who Planted Trees (also available as a video)—about a man whose custodianship of an oak forest patiently and persistently transformed an entire landscape, pumping life into a place and its people.

Back at school you are surprised by a field trip announcement. Today, your teacher is taking your class to Millbrook School’s canopy walkway, an aerial laboratory, nested in four northern red oak trees (Quercus rubra) 70 feet off the ground. Today, this 100-year-old forest is used for education, research, and recreation. Yet, not long ago these long-lived trees—“sole king of forests all”—supported rural livelihoods and fueled the industrial revolution, contributing its wood to ships, leather tanning, furniture, flooring, firewood, and creating landmark shade in pastures (Hartung 2006). After over 300 years of harvesting, oak forests now cover 30% of New York State, still rebounding from our intensive agricultural history (Riemann et al. 2014). In forests like Millbrook’s, oaks are a keystone species that drive forest productivity and biodiversity with nearly 100 animals eating their acorns (Fralish 2004).

Nature’s Notebook: Now that you have respected, connected, and reflected through this case study, you are ready to take directed action (Yunkaporta 2020). Although you may not be able to examine oaks in a canopy walkway, you can still contribute to important citizen science campaigns to help understand this, and many other species, better.

- Check out these background presentations on phenology, its connection to climate change, and project drawdown.
- Read the 2019 Green Wave campaign results here.
- Watch this how-to video and follow these “how to participate” directions.
10. Return to this essential question—what are the synergies between culture, biodiversity, and conservation?
   a. To answer create another fuzzy cognitive map, representing what you know so far about oak trees. Reference The Man Who Planted Trees, oak videos, and outside resources as needed.
   b. Once you have created and deployed your oak model as you did before (see question 9), compare and contrast it to your aguaje model.
   c. Finally, describe how the two systems might be interconnected at a planetary and humanitarian scale.

11. Nested Actions: The Maijuna have showed you their “agency mindset.” You also have the capacity to take responsible action in effective and informed ways. Use the organizer below to brainstorm ways you can contribute.

<table>
<thead>
<tr>
<th>Relating to the issues presented in this case study, what can I do to contribute…</th>
</tr>
</thead>
<tbody>
<tr>
<td>In my inner circle (family and friends)?</td>
</tr>
</tbody>
</table>

Once again you find yourself in a harness, eye to trunk, but this time with an oak at the base of the canopy walkway. It is your turn once again to climb and be part of the solution.

13. To conclude this case study, please finish with these final reflection prompts by finishing the sentences:
   a. I used to think…
   b. Now I think…
Acknowledgements

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References


Riemann, Rachel I.; Wilson, Barry T.; Lister, Andrew J.; Cook, Oren; Crane-Murdoch, Sierra. 2014. Modeled distributions of 12 tree species in New York. Research Map NRS-5. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. [map; ~ 1:3,900,000].


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Background and Answers

Question 1: Circle of Viewpoints activity from Harvard’s Project Zero: “this routine helps students see and explore multiple perspectives. It helps them understand that different people can have different kinds of connections to the same thing, and that these different connections influence what people see and think.”

Question 7: “Averages are 135.4 ± 4.8, 120.3 ± 5.5 and 112.3 ± 3.1 Mg C ha⁻¹ in low, medium and high degradation stands… Medium and high degradation reduce initial biomass C stocks by 11% and 17% respectively. The contribution of M. flexuosa to total C stocks decreased from 72 to 40 to 9% in low, medium, and high degradation areas, respectively.” Holm et al. 2008

Question 8: “Graph A= a 15% harvest every five years, Graph B= a 30% harvest every 10 years, Graph C= a 30% harvest every 15 years, Graph D= none. Extension note: “For all harvesting intensities (15-75%), female recovery is greatest with 15 year harvest intervals. The second method we used to find a sustainable harvest rate allowed for harvesting over an indefinite time period, assuming that population parameters do not change. We found that harvesting 22.5 percent of the females every 20 yr creates a sustainable harvest.” Holm et al. 2008

Question 9: Helpful steps in creating a fuzzy cognitive map include: (1) “defining the important components of the system, (2) defining the relationships between these components, and (3) running “what if” scenarios to determine how the system might react under a range of possible change.” Assessing this question should focus on the number of components, number of driving components (only an arrow outward and are not affected by anything else, it influences the dynamics of the system), central components (ones with the most arrows), and the number of receiver components (only an arrow inward). Holm et al. 2008