

Winter 2-28-2020

The Mangroves of Costa Rica

Kylie Stewart
kmstewa@bgsu.edu

Follow this and additional works at: <https://scholarworks.bgsu.edu/honorsprojects>

 Part of the [Aquaculture and Fisheries Commons](#), [Biodiversity Commons](#), [Biology Commons](#), and the [Terrestrial and Aquatic Ecology Commons](#)

Repository Citation

Stewart, Kylie, "The Mangroves of Costa Rica" (2020). *Honors Projects*. 554.
<https://scholarworks.bgsu.edu/honorsprojects/554>

This work is brought to you for free and open access by the Honors College at ScholarWorks@BGSU. It has been accepted for inclusion in Honors Projects by an authorized administrator of ScholarWorks@BGSU.

SUSTAINABILITY AND GROWTH: THE MANGROVES OF COSTA RICA

KYLIE STEWART

HONORS PROJECT

Submitted to the Honors College
at Bowling Green State University in partial fulfillment of the
requirements for graduation with

UNIVERSITY HONORS SPRING 2022

Dr. Lara Martin Lengel, Advisor
Department of Media and Communication

Dr. Scott C. Martin, Advisor
Department of History

Abstract

Mangroves are a type of coastal vegetation present in the intertidal zone of tropical and subtropical climates. This paper explores the mangroves of Costa Rica, their significance, and various strategies the country utilizes in order to protect mangrove forests. Several books and articles about mangroves and conservationism are examined to explain why mangrove forests are vital to a coastline's health and growth. The scholarly topic pertains to mangroves located in the United States and Costa Rica along with methods used to maintain the wildlife that live within them. The concept of ecotourism will be explored and how mangrove forests are used to promote ecotourism, especially in Costa Rica. After analyzing these methods and strategies, Costa Rican efforts will be compared and contrasted with the United States' conservation of mangrove environments. The reasoning behind each country's outlook towards environmental protection of areas such as mangrove forests will be discussed. Finally, the research and findings will be used to delineate why studying a topic such as the mangroves of Costa Rica expand a student's worldview and ability to merge multiple ways of thinking.

Sustainability and Growth: The Mangroves of Costa Rica

Costa Rica is a Central American country teeming with life. Including both a Pacific and Caribbean coast, the country's shoreline harbors countless varieties of organisms and numerous landscapes. An ample amount of coastline along with the tropical nature of Costa Rica's climate means that the country possesses an ideal environment for mangrove forests to thrive.

Mangroves are a distinctive intertidal habitat and although they demonstrate hardiness in the face of unforgiving oceanic conditions, they are in danger of vanishing from the planet entirely.

However, deterioration of mangroves is often underreported, as their value is often unknown or miscalculated. Threatened by consequences of human activity such as pollution and deforestation, mangrove forests are in dire need of protective policies to survive and discontinue their pattern of disappearance globally.

Perhaps those who do not live near coastlines with mangrove forests are unknowledgeable of their existence due to a lack of awareness. Others do not see a reason to conserve such habitats, electing instead to bulldoze, pollute, and overharvest them. In order to advocate for the wellbeing of Costa Rican mangroves and any mangroves for that matter, one must understand what they are and why they are important to a healthy ecosystem. In addition to recognizing why these marine environments require protection and conservation efforts, the effectiveness of Costa Rica's tactics can help determine the future of mangroves in the region. Concerns behind methods utilized in the country are imperative ideas to expand on when determining the correct course of action that will allow a mangrove to continue to flourish.

What is a Mangrove?

According to *Ecology of Mangroves*, "...it is difficult to define precisely what constitutes a mangrove. The word 'mangrove' is used in at least two different ways. It can refer either to an

individual species of plant or to a stand, or forest, of plants that contains many species”

(Hutchings & Saenger, 1987, p. 1). Mangrove forests occur on coastlines, and they are only found in warm, humid regions such as the year-round tropical climate of Costa Rica. This paper will primarily discuss mangroves as a forest of various plant species. This is because the main focus will be on the conservation and protection of Costa Rican mangrove environments as a whole. Therefore, unless otherwise specified, “mangrove” is meant to describe the habitat in its entirety and all of the organisms that populate it. Hutchings and Saenger (1987) establish that mangrove forests have taken many names throughout history, such as “coastal woodland” and “tidal forest” (p. 1). Since mangrove forests are located on coastlines, they are flooded during high tides, leaving their plants at least partly submerged. This means the organisms that live within a mangrove must be able to withstand the temperature, salinity, and potential roughness of the ocean water that permeates their territory.

The Inhabitants of a Mangrove

If a mangrove plant requires biological features and processes that are designed to endure submergence in seawater, then the organisms that live within a mangrove must also be able to survive such conditions. In *The Biology of Mangroves* by Dr. Peter Hogarth, the first inhabitant of a mangrove forest discussed is algae. As mangroves are present in humid environments abundant with sunlight, algae often thrive on the soil of mangrove plants due to their use of photosynthesis to produce energy (Hogarth, 1999). Algae may even harm the growth of mangrove plants, as its dense, mossy structure can decrease the amount of sunlight that can reach other plants (Hogarth, 1999). Along with algae, barnacles, shipworms (mollusks that feed on rotten wood), and piddocks (clam-like bivalves that burrow into mud) can all live within and harm the root structures of a mangrove forest. The population of organisms such as mollusks is

often managed by predators such as crabs. When the amount of predators in a mangrove habitat decreases or goes extinct, the number of mollusks can increase at a quick rate, damaging the mangrove plants (Hogarth, 1999). Therefore, like other ecosystems, the volume of a species is just as important as the number of differing species available to balance the demand of food with the supply of land and predation.

Crabs are another important part of the mangrove ecosystem. Hogarth analyzes the relationship between various species of crabs and mangrove communities, beginning with the genus of *Sesarma* crabs within the family Grapsidae. These crustaceans often feed on the leaves that fall from mangrove trees (Hogarth, 1999). Decomposed biological materials such as leaves are called detritus and are a critical part of a mangrove ecosystem for their use as food. In Central American countries such as Costa Rica, the *Ucides* genus of Ocypodid crabs also consume fallen mangrove leaves (Hogarth, 1999). It would seem that the numerous crabs' consumption of discarded mangrove material allows the plants to grow without an overaccumulation of dead organic substances. According to Hogarth (1999), "Necromass is made up of fallen leaves...when the crabs' choice was between fresh, senescent, and decayed leaves, they undoubtedly preferred decayed (p. 86-87). This preference for older dead leaves allows for the herbivorous crabs to act as a sort of scavenger of the mangrove, removing the decayed leaves and providing room for additional plant growth.

Besides Grapsidae and Ocypodid crabs, there are species that climb mangrove trees to feed or avoid predators (Hogarth, 1999). Fiddler crabs are another mangrove inhabitant, and they burrow into the mud present in intertidal environments. Fiddler crabs feed off of organic matter and possess various adaptations to compensate for the different sizes of sediments that they consume (Hogarth, 1999). Hogarth states "Fiddler crabs are known to influence the productivity

of salt marsh vegetation” (1999, p. 106) and this impact is caused by their burrowing habits. Crabs are a vital part of the mangrove ecosystem due to their deposit-feeding, and they have evolved to thrive from the sediments released by mangrove plants.

Mollusks also live within mangroves, including organisms such as gastropod snails. Like crabs, the snails that populate mangroves feed off of deposited materials and must tolerate the salinity of brackish mangrove water (Hogarth, 1999). Bivalves are another form of mollusk and are found in the way of mussels and oysters in mangrove environments. These organisms are primarily eaten by larger crabs and birds. Nematodes and copepods live within the soil of mangrove trees (Hogarth, 1999). Meiofauna are harder to study than larger organisms due to their small size, but their existence within intertidal zones still contributes to primary production and sources of food for other organisms.

Perhaps the most widely-known and understood user of a mangrove habitat, fish utilize intertidal forests as nurseries. The plants’ thick roots and vegetation provide protection for fish larvae. In the book *Ecology of Mangroves* by Patricia Hutchings and Peter Saenger, the authors discuss the use of mangroves as “nursery grounds for larval and juvenile fish” (1987, p. 180). There are a few species of fish that spend their entire lives within a mangrove, while many others only temporarily visit mangroves for various reproduction and feeding purposes (Hutchings & Saenger, 1987). Like the mollusks present in intertidal habitats, fish have also adapted to survive varying salinity and water levels that are present in a mangrove’s waters. An example of this is the mudskipper, a fish that has eyes on the top of its head to improve prey hunting above the mud and has the ability to “gulp air” to move on land, sometimes even climbing trees (Hutchings & Saenger, 1987). The justification behind these seemingly bizarre variations is explained as “...typically an escape reaction, but is used also during feeding” (Hutchings & Saenger, 1987, p.

212). These features allow fish like mudskippers to live in an environment that can experience exposure to land more often than a fish that does not live in an intertidal zone.

Beyond this, larger animals that visit or inhabit mangrove environments include mammals, birds, amphibians, and reptiles. These species have also adapted to feed and live in the brackish waters of a mangrove. An example of a mammal greatly affected by mangrove forests includes the grey false water rat that “feeds on crabs and has developed a means of incapacitating them even when they are larger than itself” (Hutchings & Saenger, 1987, p. 206). The rat does this by biting off the crab’s claws, which prevents the crustacean from defending itself. This intelligent adjustment to feeding practices allows the false water rat to take advantage of the high crab populations present in mangroves. The rats even use the trees of the mangrove for shelter when they are not hunting (Hutchings & Saenger, 1987).

As for birds, there is a mangrove robin, mangrove gerygone, and several other species that occupy intertidal zones and have adapted bills in order to break the hard shells of crustaceans (Hutchings & Saenger, 1987). These curved, longer bills are unique to bird species that utilize crabs as a food source. Although they are lesser in numbers, some amphibians can also survive in intertidal zones. Amphibians such as frogs “can tolerate salinities up to 40 percent sea water...” and are thus able to handle the conditions of a mangrove (Hutchings & Saenger, 1987, p. 207). Reptiles like the acrochordid snake possess salt glands that are able to eliminate excess waste and endure the salty conditions of their environment (Hutchings & Saenger, 1987).

From algae to birds, the organisms that use a mangrove’s resources to feed and survive have adapted to the salty conditions present on coastlines. Kennedy Warne summarizes the sheer number of animals that need mangrove forests in *Let Them Eat Shrimp: The Tragic Disappearance of the Rainforests of the Sea*. She writes, “[Mangroves] provide roosting sites for

birds and attachment sites for shellfish; hunting grounds for snakes and crocodiles and nurseries for fish; a food source for monkeys, deer, and tree-climbing crabs-and even kangaroos-and a nectar source for bats and honeybees” (Warne, 2011, p. XVII). These unique creatures are not the only beings that benefit from mangrove environments. Humans are by far the most impactful users of these intertidal zones.

Humans have long known the resources present in intertidal habitats and have taken advantage of forested coastlines for the purpose of aquaculture, lumber, and protection from the rough wave action of seawater. To justify devoting resources such as time, money, and policy-making to mangrove conservation, it is important to discuss why these intertidal zones are important in multiple senses. One may be surprised as to the various uses and benefits of a mangrove forest, as they are not as well-known or discussed compared to other endangered environments, such as coral reefs or rainforests. Any country with the temperature and salinity range necessary for mangrove vegetation uses the products of its biological activity in their domestic and international markets. The mangroves of Costa Rica are vital to its economy for the reasons listed above, as both tourism and aquaculture are important parts of their culture and livelihood.

The Importance of Mangroves

Mangrove forests are built around the primary production of vegetation that grows within them, and according to *Ecology of Mangroves*, “Estuarine wetlands are among the most productive natural systems in the world (Clark 1974; Gore 1977)” (Hutchings & Saenger, 1987, p. 298). The fallen leaves and other forms of detritus contribute to the ecosystem in large proportions, feeding and providing shelter for the species within the forest. The contributions of food and energy to the ecosystem by mangrove trees and other plants that grow within mangrove

forests make the estuarine environment biologically significant. The high amount of food, nursery space, and breeding grounds provided by the land of a mangrove allows for a large number of organisms and a biodiverse selection of species including fish. The mangrove even filters the water for other habitats such as coral reefs (Samper-Villarreal et al., 2018). Mangroves are not only beneficial to the organisms that live within their trees and water. One of the most notable cases of utilization by humans of a mangrove environment is through aquaculture.

According to Hutchings and Saenger, “The main benefits from planning and sound management of estuarine communities include...the continuing profitability of shellfish cultivation and of the inshore and estuarine prawning and fishing industries” (1987, p. 299). As mangroves are isolated areas, they are often used to farm fish such as shrimp. The importance of shrimp aquaculture is especially apparent in Central American economies and is a topic presented in *Let Them Eat Shrimp* by Kennedy Warne. Issues surrounding the exploitation of both the wildlife and the people that live and work within mangrove forests are the driving force behind Warne’s narrative. Regardless of the controversy surrounding farmed shrimp, the mangroves undoubtedly fulfill an ever-growing demand for seafood in the global market. Warne explains “Aquaculture is often linked to the issue of human food security...as capture fisheries continue to decline, aquaculture has the potential to meet the shortfall” (2011, p. 34). The use of mangroves for fishing purposes cannot be fully eliminated, due to the need for industries like shrimp and other fish farming in order to feed a growing human population. Unless a new, sustainable food-growth method is adapted by the global market, mangroves will continue to be necessary vessels for aquaculture usage. As such, they are imperative grounds for use in the fishing industry.

Lumber from mangrove trees is valuable and can fulfill many different needs of the community surrounding the environment. The resources harvested through trees, similarly to the fish caught in the waters of the mangrove, can be exported to other countries. *The Biology of Mangroves* touches on the logging industry withing mangroves, stating “Mangrove wood is used in construction of buildings, as firewood and in the manufacture of charcoal...vast areas of mangrove in Southeast Asia have been cleared to support the international woodchip industry...” (Hogarth, 1999, p. 172). There are many other uses for mangrove wood, including in the construction of boats, poles, fence posts, and railway sleepers (Hogarth, 1999). The sustainability behind removing mature trees from mangroves and replacing them at a reasonable rate varies by location (Hogarth, 1999), and there are negative consequences to the mangrove when too many trees are removed from the forest.

The protection provided by mangrove trees during tropical storms is another aspect of the intertidal environment that make the forests vital to humans, especially those that call coastlines home. According to a guidance note released by the World Bank Group in 2016, “Coastal and marine habitats, particularly coral reefs and mangroves, can substantially reduce exposure and vulnerability, providing natural protection from risk” (Ahloth et al., 2016, p.11). Populations near oceans are susceptible to tropical storms that vary in severity and frequency. Hurricanes can be deadly to people and wildlife, but mangroves act as a buffer to lessen the damage from these storms. In *Let Them Eat Shrimp*, Warne interviews a boatbuilder affected by Hurricane Wilma in North Bimini, an area within the Bahamas. He tells the author:

[The] hurricane took that hotel and knocked its walls down. Boulders came up out of the sea, and the waves threw those rocks into people’s houses. That hurricane destroyed concrete and steel. Then it went around to South Bimini and ran into the mangroves, and

it didn't do one iota of damage to houses behind the mangroves. Those mangroves tamed the waves right down. (p. 67)

The mangroves prevent dangerously high and strong waves from the sea entering the coastline, thereby saving money and lives during tropical storms. The water and wind was somewhat blocked by the thick roots and vegetation growth a mangrove is known for. This is another reason why the deterioration of mangroves is detrimental to human societies. Without the protection of the dense trees mangrove forests provide, coastlines are left vulnerable during storms that create violent winds and waves.

In addition to natural resources, the livelihoods of those that live near mangroves contribute to the value the environment provides. Kennedy Warne interviews two fishermen in *Let Them Eat Shrimp* and reiterates that "They don't have regular jobs. The mangroves are 'their work, their business, their life'" (2011, p. 27). When the overall health of a mangrove is harmed for whatever reason, the people that use its waters and organisms to survive are also harmed. The importance of mangrove environments lies in organisms native to the forest, protection granted by the forest from the ocean, and resources available that create materials and creatures humans can sell to subsist. There are multiple uses of the products a mangrove forest creates. Why would these marine habitats be endangered and even rapidly approaching extinction in some areas? What do civilizations do to harm mangroves, unintentionally or deliberately in the name of profit? The answer lies in overconsumption, pollution, and human expansion that thins the land and alters the water available for a mangrove to survive.

Why Are Mangroves Endangered?

In an article entitled "A World Without Mangroves?" authors Duke et al. discuss the disappearance of mangrove forests, stating that their resources may be depleted within the next

100 years. As mangrove ecosystems are described as “essential,” this deforestation and wildlife displacement is worrying. The article also states that a loss of mangrove land would lead to a destruction of mangrove-native species, causing sustainment problems in communities that live off of mangrove wildlife and land (2007). The acknowledgment of mangrove deterioration is a common theme in literature surrounding the habitats. Makowski and Finkl write in *Threats to Mangrove Forests: Hazards, Vulnerability, and Management*, “...Mangrove forests remain at risk due to continued deforestation, land reclamation and pollution” (2018, p. 155). The next step in identifying why mangroves are disappearing is to explain what exactly is being done that harms their wildlife.

The conclusions remains common across multiple sources: humans are the number one cause of mangrove destruction. According to *Let Them Eat Shrimp*, “Mangroves are sacrificed for salt pans, aquaculture ponds, housing developments, port facilities, tourist resorts, golf courses, roads, and farms” (Warne, 2011, p. XVI). These human activities limit and destroy the land that mangroves can use to grow. Additionally, threats such as rising sea levels and water pollution endanger the forests by harming the seawater their vegetation needs to survive (Warne, 2011). In terms of Costa Rican mangroves, a study conducted in 2010 found “Mangrove productivity decreased since 2001,” and “Mangrove biomass and density were relatively low” (Cortés et al., 2010). These findings are troublesome for the future of the mangroves located in Costa Rica, but the studied forests are not alone in their decreased output and destruction.

Although native mangrove organisms are often considered hardy, there is a narrow and specific range of conditions needed to allow for a sufficient amount of growth. Pollution and unsatisfactory seawater temperatures prohibit the plants within the mangrove from surviving. A study conducted on a mangrove located in Costa Rica found that an overload of nutrients from

fertilizer runoff and raw sewage may have caused lower water qualities within the mangrove (Samper-Villarreal et al., 2018). This nutrient-rich water harms the mangrove, and the agricultural industry is not the only culprit. The fishing industry contains perhaps the most harmful practices to the health of a mangrove. Mangroves serve as a nursery for shrimp and have been used in the commercial production of shrimp since the 1960s (Warne, 2011). When mangroves are used to harvest shrimp and other fish, the ponds are often abandoned afterward and are not properly replenished. Warne writes “In 2001, it was estimated that aquaculture had been responsible for 52 percent of global mangrove loss, with shrimp farming alone accounting for 38 percent of the destruction” (2011, p. 32). The nutrients used to raise shrimp are also harmful to the water quality and tree growth of the mangrove, causing an overabundance of nitrogen that leads to trees that grow too fast to support themselves. These overgrown trees block the sunlight needed to allow other plants to grow. Therefore, attempting to compensate for robbing a mangrove of vital resources by using fertilizer is an unrealistic expectation (Warne, 2011).

Along with deterioration of the water quality a mangrove requires to support healthy vegetation, aquaculture and the logging industry are also to blame for a massive amount of deforestation. Mangroves are disappearing at rapid rates due to this overharvesting of lumber and the forests are not being replenished at the rate at which they are vanishing. This combination of mistreatment and mismanagement of both the sea water that flows through the mangrove and the trees that make the coastal environment unique are catastrophic for intertidal zones. Mangroves may be considered unsightly due to their swamp-like features, or their value may be underestimated by businesses who see no reason to preserve them. Costa Rica combats this

destruction and recognizes the need to halt and reverse the aforementioned negative effects on mangroves.

The reason for Costa Rica's special attention to conservation of these atmospheres lies in the country's unique approach to consumerism and reduction of waste through environmental policy and ecotourism. What can be done to slow or stop massive losses to an important marine environment? Costa Rica recognizes the value of mangrove forests and the potential consequences of failing to protect them. Rising to meet the challenge of human consumption and its consequences on the environment, the country's dedication to conservation and tourism focused around nature allow for important landscapes such as mangroves to be properly protected and treasured for generations to come.

Mangrove Conservation Efforts in Costa Rica

According to Osa Conservation assistant Luis Solis, "There are more than 80 protected mangroves identified in Costa Rica, representing approximately 41,002 hectares" (2018). This vast amount of land gives the Central American country a great responsibility to preserve mangrove environments. Costa Rica is a country renowned for its devotion to environmentally-friendly consumer behavior and conservation activism. *Green Encounters: Shaping and Contesting Environmentalism in Rural Costa Rica* by Luis A. Vivanco explores this concept. Vivanco writes of Costa Rica "...a country dubbed "The Green Republic" (Evans 1999) for its commitment to sustainable economic development, nature conservation, and nature-oriented tourism..." (2006, p.3), clearly wanting to recognize the revolutionary "green" (or eco-friendly) politics the country embraces. The motivation behind environmentalism in Costa Rica could surpass simply wanting a cleaner, healthier atmosphere, as the green actions encouraged by the government attract citizens from around the globe to visit and explore the country.

The methods and policies Costa Rica followed to develop this reputation were widespread and affected several regions. Examples include opening additional national parks, further developing the tourism industry by marketing the rainforests present in the country, and emphasizing the pleasantness and approachability of Costa Ricans. The purpose of these efforts was to present the country as a clean and almost paradise-like vacation destination (Vivanco, 2006). These conservation efforts are also applied to Costa Rican mangroves, as environmentalists realize the importance of such marine environments along with more widely-known endangered habitats such as rain forests. Reforestation helps a mangrove recover from human destruction, and one can witness the Costa Ricans' dedication to forest recovery when visiting the country, as freshly planted trees are in abundance within the landscape. The combination of these conservation efforts produces visually stunning land. A concept known as ecotourism was recently introduced, and Costa Rica is famous for taking advantage of its beautiful scenery in order to stimulate its economy through tourist activities that are not harmful to the environment.

Ecotourism in Costa Rica

The majority of tourism in Costa Rica visits or is focused around "protected areas" such as mangroves, according to Vivanco (2006, p. 10). Visitors to Costa Rica can enjoy eco-friendly activities such as hiking or tours of native wildlife, which are "nature-based" pastimes that allow sightseers to learn about the inhabitants of the environment they visit and ways they can protect endangered species (Sanchez, 2018). As these interests are founded upon the environment or interest in nature, they are called "ecotourism" and are popular to those who visit Costa Rica. The country's focus on conservation allows for ample opportunity to showcase beautiful scenery

and native wildlife. Consequently, Costa Rica is often considered the highest-ranking location to engage in ecotourism (Sanchez, 2018).

Ecotourist activities, according to Hunt, Durham, Driscoll, and Honey (2014) are meant to have a positive impact on the community within the area such tourism is sought after. The authors write "...with the advent of ecotourism, tourism for the first time embedded ethical values and positive outcomes into its definition" (Hunt et al., 2014, p. 341). By advertising eco-friendly pastimes for visitors to Costa Rica, the country's citizens and surrounding environments are benefitted. How do mangrove forests relate to ecotourism? The answer lies in their biodiversity. Mangroves are a common site for tours and exploration because of the rare species that dwell within their forests and shallow waters. Visiting mangroves can be considered an ecotourism activity because the mangrove is not harmed by the viewing, and can benefit from the education provided to those who are exposed to intertidal zones they may not have seen beforehand.

According to Jones and Spadafora (2016), mangroves are "ecologically sensitive areas" (p. 173). Success of smaller businesses that provide nature-based tours and a rise in digital marketing allowed for Costa Rica to establish itself as an "ecotourism destination," thereby increasing interest in unique habitats such as mangrove forests. According to Amanda Jiménez, Martha Monroe, Natalia Zamora, and Javier Benayas, "...besides the approach of raising environmental knowledge, conservation education and interpretation can be also implemented with a more holistic perspective that could include targeting ecotourism experiences to build support for biodiversity conservation (Gössling 1999; Jacobson and Robles 1992; Powell and Ham 2008)" (2015). The authors' article advocates for the concept of educating tourists through

nature and conservation-associated activities, thereby helping educate individuals globally as opposed to only focusing on Costa Ricans.

Ecotourism has allowed for a reversal of deforestation patterns in Costa Rica. An example of this phenomenon is present at Manuel Antonio, a national park located in Costa Rica. In a study meant to measure the effect of ecotourism on the land surrounding a protected area such as Manuel Antonio, the researchers found that “Tourism was, on average, perceived to have positive effects on biodiversity” (Broadbent et al., 2012). Ecotourism allows for job and educational opportunities in Costa Rica that are not present in other countries that do not utilize their natural resources through tourist activities. The existence of nature-based tourism in Costa Rica benefits the entire country’s landscape, including sensitive areas such as mangrove forests.

Problems Facing Mangrove Protection

There is no doubt that Costa Rica makes great effort to preserve and assist its natural features including mangrove forests, as the policy-making, actions, and attitudes of its citizens reflect a population that supports environmental conservation. Nonetheless, this movement towards planetary preservation is useless if it is not effective. Unfortunately, the enforcement of mangrove protection does not mean issues are still not present in Costa Rican mangrove protection. Warne summarizes the inconsistency of appreciation and understanding of mangroves among varying populations well in *Let Them Eat Shrimp*, writing:

...the word ‘mangrove’ meant something different to each group. To the consortium and the government planners who had approved the proposal, mangroves signified an untapped resource. To environmental groups, they were a vital component of the wider marine ecosystem. To subsistence fishers, they were home and livelihood. How could

these groups communicate with each other when each was talking about a different concept? (p. 25)

To expand on this summarization, the main issue behind mangrove conservation and even environmentally-friendly policymaking and action, in general, is a difference in priorities. To those that profit from the exploitation and destruction of marine environments, there is no reason to discontinue using mangrove forests for their career fishing and logging of trees. Even when punishments are known and understood by industries such as shrimp farming, the potential of making large incomes in the global market outweighs any risk of fine or legal action by local governments. Therefore, Costa Rica must continue to enact policies that protect the wellbeing of local mangrove forests, such as laws that prohibit the extraction of trees from the forest or the overfishing of coastline waters.

The problems that face mangrove protection are not limited to human factors. The mangrove itself can be difficult to study, and this may be one of the reasons that benefits which mangrove forests provide are so underappreciated. In the book *Mangrove Ecosystems: A Global Biogeographic Perspective*, this point is discussed, as the authors write “Mangrove forests are generally problematic habitats to study” citing the dangers to humans that some of the organisms can cause, which “present significant logistical challenges” (Rivera-Monroy et al., 2018, p.56). A lack of research pertaining to mangrove organisms and their ecosystems means there is a shortage of information available to educate others, and a lack of willingness to accommodate for an important environment that few recognize the necessity of. The underwhelming amount of studies conducted pertaining to mangroves also creates challenges in taxonomy, as scientists have difficulty classifying species they know so little about. Therefore, solutions relating to mangrove destruction must address the undereducation surrounding the environment and the

economic advantages of the wildlife that live there. Those that profit from fishing, logging, or hunting within the mangrove forests will be unwilling to change or cease practices in order to protect the stability of other species.

Costa Rica contains vast amounts of mangrove forests, but these coastal habitats are not exclusive to the Central American country. There are also mangroves within the United States, although they may have a different appearance and inhabit different types of species. As mangroves are endangered globally, the ones located in North America are not excluded from exploitation and conservation issues. However, the approaches taken and problems present are unique for the United States, and the justification behind this inconsistency is important in understanding how to conserve an environment such as mangroves that is present in multiple different regions and cultures.

Mangroves in the United States

Although not as extensive as the mangrove forests of subtropical Costa Rica, there are examples of mangrove environments present in the United States. Ariel Lugo's *Old-Growth Mangrove Forests in the United States* reveals that mangrove habitats can be found in Florida, Texas, Hawaii, the U.S. Virgin Islands, and Puerto Rico (1997, p. 12). He discusses how they are usually located in protected areas, away from human activity that disturbs their growth. Lugo describes old-growth mangroves as those that are estimated to be over 200 years old, and describes the forests as easily damaged, because "succession after disturbance is usually slow" (1997, p. 17), and they are "unstable ecosystems" (1997, p.18). These mangroves take on more of a swamp-like appearance and makeup compared to Costa Rican mangroves, as the environment in the United States lacks the subtropical qualities of Costa Rica. However, the

mangroves in the United States are still home to many of the aforementioned native species and trees that require protection from human expansion and pollution.

Mangrove Conservation Efforts in the United States

Mangrove conservation within the United States occurs primarily by policymaking that aims to protect the swamps' ecosystems and prevent human expansion from disrupting the mangrove's wellbeing. Conservation within the United States includes replanting lost mangrove trees (Lugo, 1997). There are few laws that protect mangroves within the United States specifically, the 1996 Mangrove Trimming & Preservation Act being the most noticeable. This act determines that mangroves are ecologically important habitats that require protection, and through appropriate agricultural and trimming practices, they can continue to thrive in the United States. The act specifies who is permitted to trim a mangrove forest and how they can do so without harming the important mangrove plants. The act states "It is the intent of the Legislature to protect and preserve mangrove resources valuable to our environment and economy from unregulated removal, defoliation, and destruction" (1996 Mangrove Trimming & Preservation Act). Although this ruling is very useful in the fight to preserve mangrove forests, it is only a law in Florida. To determine why so few laws exist in the United States pertaining to mangrove protection, we must examine how the country's strategies differ from Costa Rica's.

An Explanation for a Difference in Preservation Tactics

Different countries approach the concepts of environmental conservation and biodiversity protection depending on their culture, legal system, and landscape. Mangrove forests are threatened globally, but this does not mean every country that contains a mangrove environment has dedicated time and money to preventing the exploitation of its resources. Costa Rica is perhaps a model for conservationism and ecotourism, but why is the population devoted to such

causes? Costa Rica possesses a climate that greatly differs from the United States, but why is there more evidence of mangrove protection in the Central American country compared to the United States? To answer these questions, one must investigate the process of environmental education, conservation policymaking, and physical environment in both countries.

Culture

Environmental education has been a focus of Costa Rican culture for quite some time. In *Education, Community Engagement and Sustainable Development: Negotiating Environmental Knowledge in Monteverde, Costa Rica*, the author Nicole Blum writes “Since the 1980s, Costa Rica has been one of the acknowledged international leaders in efforts to promote environmental learning, and national policy includes a three-fold national development strategy which simultaneously promotes education, conservation and ecotourism” (Blum, 2012, p.23). This process of education begins with children and continues long after one has finished formal education and entered the workforce in Costa Rica. The country believes that all citizens are entitled to an education, thus providing schoolchildren the resources to become environmentally-conscious residents and even policymakers in the future. Acknowledgement and protection of sensitive environments such as mangroves is encouraged within the Costa Rican government and educational system.

Blum states that “the general public in Costa Rica is keenly aware and informed about environmental issues...” (2012, p.25). This awareness means the average Costa Rican would understand both the importance of a mangrove and why they are being compromised. In the United States, however, this may not be the case. In *Living Through the End of Nature: The Future of American Environmentalism*, author Wapner comments “...American environmentalism seems to have finally found a hearing in Washington...not since the 1970s

have the political stars been aligned to enable environmentalism's message to be heard and its recommendations to be adopted" (Wapner, 2013, p.10). Without the activism necessary to educate a population on environmental issues, American citizens are less likely to know about the issues surrounding mangrove preservation. This lack of awareness is not present in the Central American country. Costa Rican citizens identify more with an environmentalism lawmaking strategy than many citizen in the United States align with, therefore they are better versed on mangrove disappearances and protection strategies.

American environmentalism is the subject of Paul Wapner's *Living Through the End of Nature: The Future of American Environmentalism*. Wapner considers the United States in a postnature age that can either revert to naturalism or move forward into a technological age that ignores environmental policy or protection (Wapner, 2013). Tourism in the United States primarily focuses on landmarks and cities, not natural habitats. This differs from Costa Rica's view of tourism. Tourism is a large part of the Costa Rican economy, and attracting tourists to their homeland is an integral part of a surveyed group's goals in the country (Broadbent et al., 2012). By conserving wildlife and positively contributing to mangrove forests, they are visually attractive to visitors who are willing to pay to tour them. This focus on preserving the subjective beauty of Costa Rica's environment leads to a sense of pride among Costa Ricans. The citizens believe protected areas are important because they contain the species of animals and fauna that attract tourists. This aspect of Costa Rican culture associated with ecotourism seems relatively young, as households involved in tourism were younger and more educated than those which were not (Broadbent et al., 2012). This result suggests that the demographic attracted to work in the tourism industry is young and highly educated, meaning that the foreseeable profit in such an industry is high.

Legal System

The United States has embraced stages of environmental protection. Other eras possess an emphasis on economic growth that oftentimes ignores the wellbeing of its habitats. An example of a period of time in the United States that experienced a growth in environmental policy occurred in the late twentieth century, as the authors of *American Environmental Policy: Beyond Gridlock* explain, “Between 1964 and 1980...the U.S. Congress enacted 22 major laws dealing with the control of pollution and the management of private lands, public lands, and wildlife...giving the government a central role in protecting and improving air and water quality” (Klyza & Sousa, 2013, p.1). The United States passed these laws in a time period where opposition to environmentalism in the country was easily overpowered by those who wished to protect the land, water, and wildlife. After this era of success, Congress had difficulty passing new environmental policies, unable to agree on how to solve environmental problems (Klyza & Sousa, 2013, p. 86). In contrast, Costa Rica has maintained an environmental-heavy focus since the nineteenth century, and has not experienced the amount of political disagreement that plagues environmental policy decision making in the United States. Consequently, mangrove protection is not a high priority in the United States because its legal system often overlooks environmental protection in favor of other issues.

Environment

Ecotourism thrives in Costa Rica because of the country’s rich and visually appealing ecosystems that attract visitors from around the world. Central America contains a combination of landscape features found in both North and South America, acting as a biodiverse bridge that connects species which would otherwise not interact. Authors of works focusing on the biodiversity present in Central America often note this feature, as Falk Huettman writes in

Central American Biodiversity: Conservation, Ecology, and a Sustainable Future, “This unique combination of habitats and environmental setups has, over thousands and millions of years, resulted in a highly diverse land and seascape with unique weather patterns and subsequent species...” (2015, p. 15). The conditions present in Costa Rica are distinctive, and the United States simply lacks the tropical or subtropical atmosphere necessary to facilitate the conditions found in Central America.

In the United States, a colder climate presents a possibly deadly issue for mangroves: frost. As mentioned in *Old-growth Mangrove Forests in the United States*, “Frost limits mangrove establishment in many locations (McMillan 1971)” (Lugo, 1997, p.13). The mangroves present in the United States are not as developed as those found in Costa Rica due to a difference in weather patterns. The lack of subtropical conditions means that mangroves in the United States are not as biodiverse as those located in Costa Rica.

Lugo admits in his writing that “frequent disturbances prevented mangroves in the U.S. from reaching a large size” (1997, p.14). The lack of development in mangroves located in the United States leads to less unique or exotic species, as the amount of land available for the mangrove to grow correlates to the number of species that can live within its forests. A smaller number of creatures can signify a lack of demand for tourist activity, as the Costa Rican ecotours are often tied to viewing the plants and animals that inhabit the mangrove. Simply put, the mangroves of the United States are not as attractive to a tourist or worth protecting to a citizen because their smaller size means they are viewed as insignificant. Mangrove forests face challenges globally, and each country is responsible for protecting and educating their citizens on the importance of such a habitat. Taking the current attitude and methods utilized into consideration, what lies in the future for mangrove forests?

Moving Forward: The Future of Mangroves

One of the main concerns surrounding the disappearance of mangroves is the decline of biodiversity that would occur due to the loss of mangrove forests. International lawmakers have begun to recognize a need for protective measures, as Robert Pringle writes in the article “Upgrading protected areas to conserve wild biodiversity” that by 2020 10% of coastal areas “should be conserved” in the form of protected areas and conservation methods (2017, p.91). These protected mangroves will not only save wildlife, as Pringle claims that “protected areas often reduce poverty and increase the well-being of rural populations” (2017, p.91). Ten percent of all coastal areas is not enough to sustain global mangrove populations, as not all of the specified ten percent most likely contains mangrove forests. Therefore, additional action will be needed to slow the deforestation, overfishing, and pollution that plagues coastal environments.

Since true mangrove tree species are low in number, another problem mangroves will continue to face is a domino-effect that can occur if these species are disrupted and eliminated. In *Mangrove Ecosystems: A Global Biogeographic Perspective*, the authors explain “one key finding...is the disproportionately large number of species supported by a small number of mangrove tree species” (Rivera-Monroy et al., 2018, p. 76). The extinction of a single mangrove tree species could wipe out a multitude of birds, amphibians, and mammals that use the aforementioned trees to hunt, breed, and survive. Any species native to the mangrove is endangered by the extinction of a single other species within the ecosystem. As such, the protection and conservation of all a mangrove’s resources and inhabitants are vital to their future survival.

Regardless of the damage that has been done to mangrove forests, there is still hope for recovery and continuous survival. Pringle writes “Ecological degradation can be halted or

reversed, and management structures overhauled, setting ecosystems on trajectories towards recovery” (2017, p.92). Protected areas prevent problems within the food chain or ecosystem by prohibiting hunting, fishing, or extraction of forestry. By continuing to pass laws that prevent logging in mangrove forests, regulate the amount of shrimp and other fish removed from the environment, and prohibit corporations from polluting the water used by mangroves, the forests can survive and continue to serve as one of the most biodiverse ecosystems on the planet.

Mangroves, Environmentalism, and Enriching a Global Education

It is essential to connect this concept of mangrove conservation and differing protection strategies with the creation and encouragement of globally educated students. By studying environmentalism and environmental policy through the lens of mangrove forests, one gains a new perspective on the circumstances that produce natural parks, protected areas, or overharvested lands that suffer from human activity. Contrasting cultures surrounding environmental protection allows for a viewpoint unable to be found by focusing on a single country’s environmentalism. Projects such as these give a student the ability to critically analyze why two countries may approach an issue in a different way and the ideologies that drive their decision-making. Each research topic pertaining to this analysis can be applied to a global education.

By traveling to Costa Rica and seeing a mangrove forest firsthand, a student can learn through experience. There is no denying the biodiversity present in a mangrove when witnessing it firsthand, as one who travels to Costa Rica can meet the infamous capuchin monkeys, lizards, insects and plants that live within a coastal environment. A global education requires an understanding of diverse cultures, policies, and environments that make a country unique. This variety of resources may serve as a challenge to international relations, as one country’s people

can struggle to understand the perspective and culture of another population. By educating others, even through a topic as niche as mangrove conservation, an understanding and empathy for differing policies can be gained. Traveling abroad and studying another country's conservationism can lead to a student's interest in their own country's legal system and environmental policy.

Why Studying Mangroves are Important

When researching endangered habitats and ecosystems that are threatened by human activity, two of the most common results displayed by various media are coral reefs and rainforests. These are important environments to protect and the benefits of their productivity to humanity are also noteworthy and often ignored in favor of expansion or exploitation. However, mangrove forests are overlooked compared to these popular areas, and their usefulness to both wildlife and humans is often understated. This lack of information surrounding mangroves does not make them less important to protect than other endangered habitats, as the aforementioned biodiversity and human benefits contained within a mangrove are immeasurable.

By researching and publishing information related to the importance of mangrove forests, a reader can learn why these ecosystems are diminishing. Education is an important part of conservation, as is exemplified in the ecotourism present in Costa Rica. By allowing tourists to learn about a unique environment by viewing it without causing harm to its inhabitants, the creatures gain the benefit of additional advocates for their wellbeing. Tourists can go on to tell others of their newly found information, and they may be more inclined to protect an environment they find interesting and have an emotional attachment to from an experience. If one can show an audience that mangrove forests are in need of environmental policy reform in order to be saved, those readers may choose in the future to advocate for the conservation of

mangrove forests. Environmental education in Costa Rica created a culture of citizens that strive to maintain their surroundings in order to maximize its appeal, and this strategy can be applied globally to stimulate appreciation and protection of endangered habitats.

Why Studying Differing Environmental Policy is Important

A difference in approaches to environmental policy can explain a variance in environmental health and attitude towards nature between the United States and Costa Rica or other countries. The policies enacted by a country are often driven by their underlying values and culture. This is evident in the case of Costa Rica's environmentally-conscious lawmaking, the result of education surrounding conservationism that begins in a Costa Rican's childhood. In another example, the lack of prevalent lawmaking to protect mangroves in the United States is explained by their current political climate. Once the differences between two countries are understood, one can understand why they approach topic such as environmental conservation differently. The United States could adapt Costa Rica's approach to mangrove protection by educating their populace about the mangrove forests within the United States, beginning at an early age and continuing into adulthood. In analyzing the policies of multiple countries, a reader can learn new ways to combat environmental problems. Studying international environmental policy is important because it allows a student to gain new perspectives and lawmaking strategies.

Conclusion

Mangroves are biologically priceless marine environments that contribute to a massive amount of primary production, consumer good creation, and wave protection to coastlines in tropical climates. They feature thousands of unique organisms that have adapted to thrive in salty, varying water levels. Mangrove forests are endangered globally due to human expansion

and pollution which kill the vegetation that give mangroves their densely populated, biodiverse reputations. The growing market for seafood and a need for larger amounts of land cause devastation to mangrove forests. The fishing industry often harms intertidal environments by depositing nutrients into the mangrove's waters. Other human activities leave the mangroves lacking in trees, healthy water, and particular species populations.

Costa Rica combats the deterioration of mangroves by encouraging environmentally-friendly consumerism, enacting policies that prohibit exploitation of mangrove grounds, and stimulating the economy with ecotourism. Ecotourism allows for Costa Rica's tourist-heavy market to experience the unique habitat of a mangrove without harming the vegetation and animals that live within its intertidal zones. Thanks to biodiverse habitats such as mangrove forests, Costa Rica is considered a world leader in ecotourism activity. The United States also possesses mangrove forests, although their appearance and inhabitants differs from Costa Rican mangroves.

Costa Rica and the United States do not use the same strategies to conserve mangrove forests. The reasoning behind this difference in methods pertains to each country's culture, legal system, and environment. If Costa Rica is considered a model of ecotourism and conservationism, perhaps the United States can adopt such approaches to better protect their coastal habitats. Studying environmental policy while comparing and contrasting conservation methods allows for a student to better understand why two countries may not protect an environment such as a mangrove forest in an equivalent way. Global perspective is gained through such learning, and studying mangrove habitats is important to understanding why they are endangered. In conclusion, mangrove forests require protection and conservation efforts to

cease their decline, and how each country with mangroves approaches this issue will determine the future of their mangrove forests.

Annotated Bibliography

Ahloth, S., Barbier, E., Benzaken, D., Blankespoor, B., Burke, L., Callaghan, D., ... Zang, K.

(2016, February 17). *Managing Coasts with Natural Solutions: Guidelines for Measuring and Valuing the Coastal Protection Services of Mangroves and Coral Reefs*. Retrieved November 15, 2019, from

<http://documents.worldbank.org/curated/en/995341467995379786/Managing-coasts-with-natural-solutions-guidelines-for-measuring-and-valuing-the-coastal-protection-services-of-mangroves-and-coral-reefs>.

This guidance note examines the benefits of coastal environment conservation and the value behind protecting habitats such as mangrove forests. Provided by the World Bank Group, the writing discusses various advantages of mangroves to coastlines, including the properties of a mangrove that help protect a coastline during tropical storms. The authors explain how the structure of the vegetation “reduce wave heights,” thereby preventing damage to the coastline and the infrastructure, people, or wildlife present in the area. This source will be critical in proving the validity behind mangrove conservation by detailing the money and lives saved by the presence of mangroves in coastal habitats. This source differs in its specificity of statistics, as actual money amounts are attached to the research pertaining to the effects of a mangrove on an environment. The evidence of protection a mangrove forest provides reasoning behind defending the vulnerable environment. Specializing in sustainability, the World Bank Group is a skillful source for explaining the economic benefits of a mangrove forest.

Blum, N., & Ohio Library and Information Network. (2012;2011;). *Education, Community*

Engagement and Sustainable Development: Negotiating Environmental Knowledge in

Monteverde, Costa Rica (2012th ed.). New York; Dordrecht;: Springer. doi:10.1007/978-

94-007-2527-0.

Nicole Blum is a faculty member at the UCL Institute of Education. Her book explores the consequences of current political and social attitudes on environmental awareness and knowledge in Costa Rica. How and when Costa Rica began to be recognized for its ecotourism and environmentally-conscious policies is a main topic discussed in this work. The intended audiences for this work includes those studying the impacts of educational methods on strategies used for climate change in the country. Along with other sources, this book primarily focuses on Monteverde, Costa Rica, an area of the country often emphasized as environmentally conscious. This source will be used to examine the motives behind Costa Rica’s environmental policies and protections of coastal environments. A section of the project will focus on comparing and

contrasting these methods with those used in the United States. For someone who has never visited Costa Rica or examined its educational efforts, this book bridges the gap of knowledge and will provide information necessary to contrast Costa Rican and American environmentalism.

Broadbent, E. N., Zambrano, A. M. A., Dirzo, R., Durham, W. H., Driscoll, L., Gallagher, P., . . .

Randolph, S. G. (2012). The effect of land use change and ecotourism on biodiversity: A case study of Manuel Antonio, Costa Rica, from 1985 to 2008. *Landscape Ecology*, 27(5), 731-744. doi:10.1007/s10980-012-9722-7.

This source is a research article from *Landscape Ecology*. It examines the development of ecotourism in Costa Rica, and the relationship between ecotourism and biodiversity in protected areas such as mangrove forests. The rise of nature-focused tours and activities may help spread awareness and educate travelers about the importance of protecting sensitive environments. This article examines this possibility through the interviewing of multiple Costa Rican families that work in the tourism industry. This source will be used to establish the origin and popularity of ecotourism in Costa Rica, and its intended audience includes those interested in this intimate view of the tourism industry. Since this country's tourism dominates its economy, it is important to describe how ecotourism impacts Costa Rican culture. This analysis will be used when conservation methods are compared and contrasted between Costa Rica and the United States. This source explains why ecotourism works for Costa Rica, and could possibly describe why it is not as popular in the United States. Using the conclusions drawn by the study, one can determine the demographic that engages in ecotourism and the characteristics of the landscapes that benefit from conservation-oriented tourism.

Cortés, Jorge, Fonseca, Ana C, Nivia-Ruiz, Jaime, Nielsen-Muñoz, Vanessa, Samper-Villarreal,

Jimena, Salas, Eva, Martínez, Solciré, & Zamora-Trejos, Priscilla. (2010). Monitoring coral reefs, seagrasses and mangroves in Costa Rica (CARICOMP). *Revista de Biología Tropical*, 58(Suppl. 3), 1-22. Retrieved November 15, 2019, from http://www.scielo.sa.cr/scielo.php?script=sci_arttext&pid=S0034-77442010000700003&lng=en&tlng=en.

This research paper is from CIMAR at Costa Rica University, a research center for marine studies and limnology. It examines the productivity of Costa Rican mangroves along with coral reefs and other marine environments in the country. The conclusion of the study states that "mangrove biomass and density were rather low," which is troublesome for the future of mangrove forests in that area. This research will help develop an argument to the recent deterioration of mangrove forests globally, as the study proves the frequency and diversity of mangrove species has decreased. This source differs from others used in the project because it

focuses on the specific wellbeing of Costa Rica's mangroves. The visuals and statistics provided will support the motives behind protecting coastal habitats. Using scientific evidence to support an argument is necessary when applicable, and sources such as this study tie together the endangerment of mangroves with possible methods that can be used to save and preserve them.

Duke, N. C., Meynecke, J. O., Dittman, S., Ellison, A. M., Anger, K., Berger, U., ... Nordhaus, I. (2007, July 6). A World Without Mangroves? *Science*, 317(5834), 41–42.

This source is an article from the *Science* magazine. The writing helps quantify mangrove loss and is intended for those interested in the future of mangrove environments. The survival and prosperity of mangrove forests are threatened by deforestation and water pollution. The article explains the process of a mangrove disappearing and its effects on the surrounding land and ocean. The closing paragraph features a call to action in order to “reverse the trend of mangrove loss,” which proves it useful in describing the need for mangrove preservation. This source provides details as to why mangroves are disappearing, rather than merely stating the deterioration and where it is most prevalent. It also helps to explain the complexity of mangrove forests and their place in an ecosystem, thus proving that without them the environment would suffer. The article also establishes a link between the number of plant species in a mangrove with its size, which will be an interesting topic to explore. The biodiversity of the environment is threatened as the mangrove size decreases, and this has larger implications on the surrounding ecosystem. The organisms within a mangrove are dependent on one another and their impact on oceanic and land species cannot be ignored, because the removal of a mangrove would be detrimental to those organisms. This source emphasizes the importance of mangroves while linking the need for education and conservation surrounding mangrove forests.

Hogarth, P. J. (1999). *The Biology of Mangroves*. New York, NY: Oxford University Press.

Attempting to expand on the misunderstood environment of mangrove forests, Peter J. Hogarth gives a detailed description of the species classified as mangroves. A member of The University of York's department of biology, Hogarth's research specializes on mangroves and marine biodiversity. This text is the most detailed pertaining to mangroves compared to other mentioned sources, and it was intended for those with no or little prior knowledge about mangroves and their environment. The marine species that live within such habitats are cataloged by their roles within the ecosystem concerning the production and consumption of organic materials. Coping mechanisms mangroves utilize to grow in the salty water they subsist in are extrapolated. An in-depth analysis of the biological mechanisms necessary for these forests to thrive is provided, along with connections to similar marine and coastal environments. Hogarth clearly emphasizes the impacts of pollution and natural events on intercoastal vegetation and the uses of the mangrove species to humans through food resources and tourism. A necessity for those wishing to explore what exactly constitutes a mangrove and why it is a biodiverse habitat teeming with opportunities for economic growth, *The Biology of Mangroves* does an excellent job of presenting the science behind mangrove forests worldwide.

Huettmann, F., 1967, & Ohio Library and Information Network. (2015). *Central American*

Biodiversity: Conservation, Ecology, and a Sustainable Future (1st 2015 ed.). New York:

Springer. doi:10.1007/978-1-4939-2208-6

Falk Huettmann is a professor of Wildlife Ecology at the University of Alaska Fairbanks. One of the sites his book focuses on is located in Costa Rica, and the writing is intended for those researching Central American conservation methods. The book will be used to examine the way Costa Rica as a country thinks about sustainability and eco-friendly policies, as this will eventually be compared to the United States' attitude towards environmentalism. Although Huettmann's work may primarily discuss primates in the sense of conservation, the writing is still useful to the project because many organisms interact with mangrove environments, including primates. This is another source that features a "call to action" within its descriptions of the current issues and challenges facing biodiversity and conservation, as it recognizes a need for change. The book can also be used to suggest solutions to mangrove deterioration for both the United States and Costa Rica.

Hunt, C. A., Durham, W. H., Driscoll, L., & Honey, M. (2014). Can ecotourism deliver real

economic, social, and environmental benefits? A study of the Osa Peninsula, Costa

Rica. *Journal of Sustainable Tourism*, 23(3), 339–357. doi:

10.1080/09669582.2014.965176.

This article published in the *Journal of Sustainable Tourism* explores the realistic impacts of ecotourism on Costa Rica. Multiple owners of businesses that engage in ecotourism are interviewed within the source. This is done in order to determine if there is an economic benefit for native Costa Ricans within the tourism industry, and how this benefit compares to nonnative workers who do not work in the industry. By analyzing the demographics of those that make a career from offering ecotourism in Costa Rica, one can estimate the likelihood of a similar system's profitability in the United States. Therefore, this source will be useful in the latter part of the project that will compare Costa Rican conservation efforts with those of the United States. The unique study presented in the article describes who cultivates ecotourism and may provide insight as to why they work in the industry. This information will help outline the culture within Costa Rica that allows for environmentalism to thrive.

Hutchings, P., & Saenger, P. (1987). *Ecology of Mangroves*. St. Lucia: University of Queensland

Press.

Patricia Hutchings and Peter Saenger have extensive backgrounds in coastal environmental research. Hutchings is an editor-in-chief of *Marine Pollution Bulletin* and Saenger is a professor of coastal management at Southern Cross University. *Ecology of Mangroves* offers the detail and well-organized research that Hogarth's *The Biology of Mangroves* exemplified, and

although the source is older it contains information also found in more recent works pertaining to mangroves. Intended for those researching mangroves, *Ecology of Mangroves* is full of primary research conducted by Hutchings and Saenger. There were sections devoted entirely to discussing photosynthesis, the interaction among plants, and the aftermath of natural events such as storms on mangrove forests. All of these factors and events will be important when writing about the innerworkings of Costa Rican mangroves. Food chains within the ecosystem are discussed, which are vital when researching about environmental protection, since each level of the food chain is important for the mangrove forest's population to remain stable. Hutchings and Saenger also explain zonation in a mangrove, which is a term to describe the distribution of organisms into several zones in an environment. *Ecology of Mangroves* focuses primarily on coastal environments in Australia, but the information displayed can be applied to other mangrove communities such as Costa Rica's.

Jiménez, A., Monroe, M. C., Zamora, N., & Benayas, J. (2015). Trends in environmental education for biodiversity conservation in Costa Rica. *Environment, Development and Sustainability*, 19(1), 221–238. doi: 10.1007/s10668-015-9734-y

This source outlines the importance of biodiversity and environmental conservation in Costa Rica. The authors published the article in *Environment, Development and Sustainability* and aim to explain “citizen awareness” pertaining to biodiversity in the form of education. Community projects and the engagement of schoolchildren are discussed as methods of information fulfillment. The article can be used to define the attitude surrounding conservation in Costa Rica, as it is caused by a dedication to preserving the environment from a young age. Costa Ricans are taught to respect and preserve their country's natural resources and are shown the value of their landscape throughout their lives. This source will be used in the project when comparing and contrasting mangrove conservation efforts between Costa Rica and the United States. This strategy of early-age immersion in natural conservation differs from the strategies used in the United States, making this source useful in explaining the differences between the two country's outlooks and patterns of action.

Jones, G., & Spadafora, A. (2016). Creating ecotourism in Costa Rica. *Varieties of Green Business*, 194–228. doi: 10.4337/9781788114141.00013

Geoffrey Jones and Andrew Spadafora are affiliated with the University of Chicago and Harvard Business School, respectively. This article published in *Varieties of Green Business* explains how Costa Rica established itself in the realm of ecotourism. Small business owners are emphasized in this source because their importance to the ecotourism movement in Costa Rica cannot be underestimated in order to understand its significance. As tourism in the country increased, the desire for environmentally-friendly policies and visitor activities prompted the birth of ecotourism in Costa Rica. This source claims that entrepreneurs and small business owners involved in the ecotourism movement are underappreciated and ignored in discussions, and the authors aim to give voice to the unique group of people who make their living off of marketing the beauty and biodiversity of Costa Rica to visitors from other countries. This article helps explain

the rise of ecotourism in Costa Rica, and will be used when comparing and contrasting mangrove conservation efforts with those of the United States.

Klyza, C. M. G., & Sousa, D. J. (2013). *American Environmental Policy: Beyond Gridlock*.

Christopher McGrory Klyza and David J. Sousa wrote *American Environmental Policy: Beyond Gridlock* in order to demonstrate the struggles the United States currently faces in enacting laws to protect nature and wildlife. Klyza and Sousa are both professors who teach classes focusing on environmental policy. This source will be used to outline environmental policy in the United States and how it differs from environmental policy in Costa Rica. This argument will be a key part of the section of the project that compares and contrasts mangrove preservation strategies in the United States and Costa Rica. *American Environmental Policy* differs from other sources because it specifically focuses on lawmaking in the United States, and the politics and behaviors behind environmental policy. The book explains past patterns of environmental protection in Congress and how that compares with Congress' current attitude towards environmental protection. By examining this source and using its key points in a legal policy comparison between the two countries, one can determine why the United States utilizes a different level and number of environmental laws to protect endangered habitats such as mangrove forests.

Lugo, A. E. (1997). Old-growth Mangrove Forests in the United States. *Conservation*

Biology, 11(1), 11-20. doi:10.1046/j.1523-1739.1997.96012.x.

This article was published in *Conservation Biology* and explores the classification of American mangroves. The dynamics of these coastal environments are examined, along with the species that live within mangrove forests. The main idea of the article pertains to aging mangroves, and as such this source is intended for those interested in learning about how mangrove environments are dated. "Old-growth Mangrove Forests in the United States" discusses the vulnerabilities of coastal habitats in American ecosystems. This article will be used to differentiate United States mangroves from those located in Costa Rica. Connecting the classifications of American mangroves to the policies used to protect them from deforestation and pollution, one can determine the unique aspects of mangroves located in the United States. This source will be important when comparing and contrasting mangrove preservation in Costa Rica with the United States, because it explains the dynamics and species present in American mangrove forests.

Makowski, C., Finkl, C. W., 1941, & Ohio Library and Information Network. (2018). *Threats to*

Mangrove Forests: Hazards, Vulnerability, and Management. Cham, Switzerland:

Springer. doi:10.1007/978-3-319-73016-5.

Christopher Makowski is the Editor-in-Chief of the Journal of Coastal Research, while Charles Finkl is the President and Executive Director of the Coastal Education & Research Foundation. These backgrounds in marine environments make the authors excellent choices to write about the risks that endanger mangrove forests and how a country could work to repair or prevent such damages. Makowski and Finkl's writing is intended for those researching

conservation of coastal habitats, specifically mangroves. *Mangrove Forests* provides detailed descriptions of human activities that harm mangroves around the world. Natural impacts on mangroves are also discussed, as tropical storms can often harm the vegetation and organisms that live within the environment. This source is unique in that it purely focuses on the issues mangrove forests face, while also providing solutions to numerous problems such as water contamination and pollution that is detrimental to the health of a mangrove. The book will allow the project to better identify specific issues that harm mangroves and methods that perhaps the United States or Costa Rica has utilized in order to preserve their own coastal areas. Makowski and Finkl's book will be used to prescribe conservation methods to mangroves in a problem-solution format.

Pringle, R. M. (2017). Upgrading protected areas to conserve wild

biodiversity. *Nature*, 546(7656), 91–99. doi: 10.1038/nature22902

Robert Pringle is an professor who focuses on biodiversity and conservation. This article published in *Nature* discusses land that is deemed ecologically important and protected in order to conserve endangered or threatened resources. The existence and expansion of protected areas revolves around the perceived importance of biodiversity, a term often used to describe mangrove forests due to the large variety of organisms the environment supports. This source will provide background information necessary to discuss the significance of mangrove forests due to their biodiversity. Costa Rica's environmental policies aim to maintain this balance of unique organisms in landscapes such as mangroves. This article is unlike other sources used in the project because it discusses all protected areas, not just mangroves. It provides a wide source of knowledge that can be applied to an analysis of mangrove conservation. Pringle's work will be utilized in the first portion of the project that determines the critical need for mangrove protection and the justification for devoting resources to protecting a unique environment.

Rivera-Monroy, V. H., Lee, S. Y., Kirstensen, E., & Twilley, R. R. (2018). *Mangrove Ecosystems:*

A Global Biogeographic Perspective. Springer International Publishing.

This book was written by four professors of various marine biology specializations. Similar to *The Ecology of Mangroves*, their work describes the functions of a mangrove forest and the biological processes that make it a unique and diverse environment. *Mangrove Ecosystems* also names human uses of mangrove forests, while explaining the effects of climate change on the organisms that live within a mangrove. This source will be used for the first section of the project, which will name the purposes and importance of a mangrove forest along with the threats that endanger their existence on global coastlines. The audience of this book is anyone that would wish to inform themselves of the biological aspect of a mangrove environment. Additionally, the book features a chapter on the consequences of mangrove loss, which will be an interesting topic to include in the project's first and final sections. In order to understand why mangrove forests are important, one must consider what would happen if they no longer existed. This source allows one to research the biological significance of this coastal habitat with various visuals and statistics surrounding mangroves.

Samper-Villarreal, J., Cortés, J., & Polunin, N. V. C. (2018, June 4). Isotopic evidence of subtle nutrient enrichment in mangrove habitats of Golfo Dulce, Costa Rica. Retrieved

November 15, 2019, from <https://onlinelibrary.wiley.com/doi/abs/10.1002/hyp.13133>.

This study focuses on the effects of nutrient-rich substances being dumped by humans into a mangrove forest in Costa Rica. Samper-Villarreal, Cortés, and Polunin performed this research funded by the School of Marine Science Technology, which was published in May 2018. Since the water surrounding the gulf is not treated when entering, raw sewage is dumped into the water. The study aims to measure the result of this dumping on the health of the mangroves surrounding the water. The audience of this study includes those who are curious about the aftermath of human activity on a mangrove. This subject correlates to mangrove conservation because the analysis can be used to explain how Costa Rican and United States organization and corporations can prevent mangrove deterioration. Although the study did not find “nutrient loading” that could damage the coastal environment present in the tested water, there is a limit of the amount of additional nutrients the plants in the ecosystem can filter. Once this limit is reached, the mangroves will begin to suffer, and recognizing the actions needed to prevent this damage is vital to preventing global mangrove disappearances.

Sanchez, Ricardo Valverde. “Conservation Strategies, Protected Areas, and Ecotourism in Costa Rica.” *Journal of Park and Recreation Administration*, vol. 36, no. 3, 2018, pp. 115–128., doi:10.18666/jpra-2018-v36-i3-8355.

This source, constructed by a Costa Rican biologist, describes the rise in ecotourism in Costa Rica. Sanchez explains that the unique species present in Costa Rica’s landscapes allow for ample opportunity for its citizens to capitalize on environments such as mangroves. These areas can raise profit through touring and exploration, as many visitors to the country have never seen mangrove forests or rainforests in person. Ecotourism generates billions of dollars for the Costa Rican economy because its tropical scenery has caused worldwide attention. This source will be used to define ecotourism and its critical part in Costa Rica’s financial wellbeing. Sanchez’s work differs from other sources provided because of its specific focus on ecotourism within Costa Rica, and the research that pertains to areas within the country that are discussed in other portions of the project. There are three case studies provided in the source that relate to the rise of ecotourism in the country and its impact on protected areas such as national parks and wetlands. This article will provide background information pertaining to the importance of ecotourism in Costa Rica, and may help explain why it is more prevalent in this country than the United States.

Solis, L. (2018, May 22). Restoring Mangroves & Managing the Mangrove Fern. Retrieved

November 14, 2019, from <https://osaconservation.org/2018/05/restoring-mangroves-managing-the-mangrove-fern/>.

Osa Conservation is a nonprofit organization and focuses on environmental protection of the Osa Peninsula, located in Costa Rica. This short article identifies Térraba Sierpe National Wetland as the largest mangrove in the country and describes the problems the environment has faced due to deforestation, despite its protection from the Costa Rican government. Although brief, methods utilized to combat the destruction of the habitat are discussed in the form of restoration of the habitat. This article is useful to explain conservation methods Costa Rica uses to protect and maintain mangrove forests and the organizations behind such strategies. The problem pertaining to illegal use of the mangrove trees will be an important subject to determine the effectiveness of Costa Rican environmentalist efforts. Although Térraba Sierpe may be protected by law, this clearly does not stop all extraction practices, and therefore the actual success of the mangrove conservation efforts may be undermined. This issue can be applied to the United States' mangrove forests, as it is to be assumed that neither country can constantly monitor its mangroves and prevent all illegal activity from harming them.

Vivanco, L. A. (2007). *Green Encounters: Shaping and Contesting Environmentalism in Rural Costa Rica*. New York, NY: Berghahn Books.

A cultural anthropologist that specializes in Latin American topics such as tourism, Luis A. Vivanco culminated years of experience researching and publishing work pertaining to environmental protection in countries such as Costa Rica. With a PhD from Princeton University, Vivanco's work is well-written and gives an interesting account of "The Green Republic," a nickname given to Costa Rica for its history and devotion to conservation. The audience for this book would consist primarily of those learning about the culture and history of Costa Rica itself, but Vivanco's narration will be very useful in defining the Costa Rican attitude behind preserving mangrove forests on their coastlines. After explaining the biology and biochemistry aspects of mangroves, the second topic of the project focuses on mangrove conservation and the methods utilized by Costa Rica to ensure both economic and environmental growth. *Green Encounters* explains why the country prioritizes protection of its coastal habitats. By examining a culture that seems to respect nature in ways the United States is often accused of avoiding or ignoring entirely, one can analyze the differences between environmentalism tactics in the United States versus strategies Costa Rica utilizes. This dissection of the motives behind each country's environmentally conscious actions is necessary to develop their attitudes relating to mangrove forests.

Wapner, P. K. (2013). *Living Through the End of Nature: The Future of American Environmentalism*. Cambridge, MA: MIT Press.

Paul Wapner is a professor of Global Environmental Politics at American University. Although he has been awarded for his writing pertaining to international environmentalism, the focus of this book lies in the conflict between technological expansion and protection of nature that the United States faces. Using the term "postnature age" to describe the country's current state, Wapner discusses the emergence of environmentalism in the U.S. and the politics behind its promotion. This work will be useful when forecasting the future of American mangroves because of its chapter predicting the future of environmentalism in the United States. This book differed

from others used to build the project because of its problem and solution formatting that gives possible outcomes to the statement that “American environmentalism’s long-standing attraction to nature is coming undone.” These arguments can be applied to mangrove environments, and the country’s attitude surrounding protection of natural environments will be compared and contrasted with Costa Rica’s. Wapner’s *Living Through the End of Nature* is an insightful book useful for anyone studying American environmentalism.

Warne, K. P. (2011). *Let Them Eat Shrimp: The Tragic Disappearance of the Rainforests of the Sea*. Washington, DC: Island Press.

Kennedy Warne uses anecdotes from his personal experiences in Central and South America to paint an excellent picture of the many ways mangroves play an integral part in the lives of people who live among the coast and rely on their wildlife. Warne has work that has appeared in numerous publications such as National Geographic and co-founded a magazine of his own entitled New Zealand Geographic. The expansion and commercialization of shrimp farms are an overlapping issue for mangrove survival and growth in each country she visits. From deforestation to abandoned ponds that pollute the water sources necessary for other mangrove organisms to thrive, Warne witnesses firsthand the destruction each country she visits has caused to its coastline. The ecosystems are not the only victims of the explosion of the global shrimp market: people are left without jobs, ostracized, and even murdered for defending and living within mangrove forests. To understand why mangroves need protection, it is important to explain why they are rapidly deteriorating to begin with. *Let Them Eat Shrimp* shows a behind-the-scenes consequence of prioritizing economic profit over environmental protection. This source differed from others because of the narrative style of the writing and the emotional reaction caused by reading Warne’s interviews.

1996 Mangrove Trimming and Preservation Act, Fla. Stat. § 403.9321-403.9333

This Florida law protects mangroves located in the United States from unlawful pollution and incorrect trimming practices. By outlining who can trim a mangrove and how, this act prevents overharvesting of mangrove forests and limits who can trim mangrove trees. This is one of the few specific acts in the United States specifically created to protect mangrove forests. This source will be used to show how the United States conserves mangrove land and wildlife. It is important to cite specific laws used in a country because Costa Rica’s approach to conservation may differ. By establishing how the United States classifies, protects, and treats mangrove forests, the reader will be able to compare and contrast these strategies with those of Costa Rica. This source is unique because it offers the legal perspective of mangrove conservation, which can be more effective than activism or environmental education since it can allow for violators to be punished.