Honey Bees– The Key to A Sustainable Future

Ashley Carter | Middle School

Unit Description

This science unit engages students in learning about native pollinators and honeybees, and how human impact on their environment is leading to their population decline. Throughout this unit, students will participate in readings/discussions about the process of pollination, the vital role bees play in pollination, and how the local agriculture industry greatly depends on bees. Students will also learn about human impact in the Peruvian Amazon, how the Maijuna use sustainable beekeeping practices, and how traditional ecological knowledge (TEK) could be implemented by farmers and gardeners in Delaware.

Content Standards

1. Design a method for monitoring and minimizing human impact on the environment. (**MS-ESS3-3**)

2. Define criteria and constraints of a design problem with sufficient precision to ensure a successful solution, while anticipating potential impacts to people and the environment. (**MS-ETS1-1**)

Objectives and Outcomes

1. Explain the importance of Traditional Ecological Knowledge (TEK), and how to apply it to modern commercial farming.

2. Explain why Indigenous people should be consulted/supported in their sustainability efforts.

3. Explain why pollinators are important to the local ecosystem, and role in agricultural farming.

Supporting Material

1. **DTI 2022 Unit**

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ACEER FOUNDATION

Delaware *Teachers* Institute

Title: Honey Bees-- The Key to A Sustainable Future

Author: Ashley Carter

"You can't save what you don't love, and you can't love what you don't know" -- Heartland Conservation Alliance[1]

Introduction/Rationale

Millsboro Middle School (MMS) is a public middle school in the Indian River School District (IRSD) in Sussex County, Delaware. It is one of three middle schools in the district, and serves approximately 750 students grades 6-8. The school district is the fifth largest in the state, serving approximately 10,700 students, and is the largest district in the state geographically, serving over 360 square miles. Due to the large service area, students live in both suburban, and rural areas.

Sussex County is rapidly growing in population as people relocate to the area to be closer to the beach; as such, the impact of development can readily be observed-- especially to those who grew up in the area. Though development is rapid, Sussex County has always focused on agriculture/farming, and sustainability; this focus can also be seen within the district. At MMS, over 600 students participate in an agricultural science elective each year, with topics ranging from plants, animals, environmental science, and food science. Additionally, over 100 students each year are heavily involved (competitively) in Future Farmers of America (FFA). The knowledge and experience students gain at MMS allows them to choose a career pathway upon entering high school; areas aligned with environmental/agricultural science include: agricultural power and engineering, agricultural structures and engineering, animal science, as well as plant and horticulture science.

This unit is designed to be taught as an extension of learning after completing the Amplify Education, Inc.© unit on "Earth's Changing Climate". In IRSD, science is taught by discipline, and students complete all Earth Science topics in the sixth grade. This Amplify unit includes topics such as: climate change, climate change solutions, energy in Earth's system, as well as how human activity impacts the climate. This unit could be extended upon, and integrated into the "Oceans, Atmosphere, and Climate" and

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[1]Heartland Conservation Alliance. 2016. https://www.heartlandconservationalliance.org/post/2016/03/10/you-cant-save-what-you-dont-love-and-you-cant-love-what-you-dont-know.

"Weather Patterns" units to create learning extension continuity, allowing students to build upon concepts throughout the entire year.

Millsboro Middle School students live in a county with deep "roots" in agriculture, so it's no surprise that Sussex County prides itself on "ag". Almost half of all land in the county is designated farmland. According to the USDA, Sussex County alone has over 780 farms totaling over 275,000 acres of farmland, is one of the top thirty counties in the nation for agriculture production, and one of the top 100 counties in the nation for vegetable production! Though the majority of crops grown in Delaware are field crops (i.e. soybeans and corn for animal consumption), an estimated 6-7% of all crops are commodity crops for human consumption, which includes: apples, blueberries, cantaloupe, cranberries, cucumbers (pickling), peaches, pumpkins, strawberries, squash, tomatoes, and watermelon. It just so happens that all of these commodity crops also rely heavily on pollination from honey bees. According to the Delaware Department of Agriculture, approximately 7,200 local (Delaware) bee colonies, and an additional 3,000 out-of-state colonies are used annually to contribute towards the production of $30 million worth of fruits and vegetables.

Many students at MMS were born and raised in Sussex County, and many have an interest in hunting, fishing, breeding/raising livestock, and farming. Though farming and hunting are important in our county, students also need to have an appreciation for long-term sustainability. Delaware land has been manipulated drastically over time for both farming and development. One of the largest reasons local bee populations have declined is due to loss of habitat for pollinators, and from pesticide use.[2] Honey bees are not the only species at risk though; currently, Delaware has 22 birds, 8 reptiles, 3 amphibians, 9 mammals, 7 fish, 7 mollusks, and 31 insects listed as "endangered" by the Delaware Division of Fish and Wildlife.[3] In 2017, a Delaware Ecological Extinction Task Force found that nearly half of Delaware's native plants are threatened, or already absent, and more than three quarters of freshwater mussels and one fifth of fish species are now missing from our state. Additionally, over thirty percent of reptiles, amphibians, and dragonfly species are missing; not to mention that Delaware's bird population has decreased by fifty percent over the past fifty years! Due to deforestation in the state, over

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[2] Christopher Wade, Faith Kuehn, and Laura Mensch, "Managed Pollinator Protection Plan Delaware Department of Agriculture," Delaware Department of Agriculture (State of Delaware, September 2016),

[3] "Delaware's Endangered Species," DNREC Alpha, August 6, 2020, https://dnrec.alpha.delaware.gov/fish-wildlife/conservation/endangered-species/.

forty percent of bird species that depended on forest cover are now rarely observed, or missing altogether from our ecosystem.[4]

By the end of this unit, students will have a greater understanding of how human impact has an effect on local species and the environment, and will be able to connect learning to what is currently happening in the Peruvian rainforest-- where deforestation, mining, and illegal poaching are all taking a toll on the environment. Additionally, students will be able to explain the importance of honey bees for both the Maijuna in the Peruvian Amazon, and the farmers in Delaware. Lastly, students will be able to explain how human impact can lead to overall climate change, and how sustainability can help mitigate, and overcome some of these obstacles.

Content Objectives

With the completion of this unit, students will be able to: explain the importance of Traditional Ecological Knowledge (TEK), and how it can be applied universally, explain why Indigenous People should be consulted, and supported, in their sustainability efforts, explain the importance of honey bees in the overall ecosystem, and how they play an integral role in agricultural farming, as well as explain how farmers and developers in Delaware could bring more sustainable practices into their industry.

Background

Amazon Rainforest

Tropical rainforests are one of Earth's most unique biomes-- covering less than 6% of Earth's surface.[5] Despite covering such a small area, these regions are some of the most biodiverse places in the world. These forests have an estimated 10 million different species of plants, animals, and insects, (more than half of all known species[6]) and there are still countless species that have not been identified yet. Some plants found in these

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[4] Stephanie Hansen, "State Senator Stephanie Hansen, 10th Senate District," Statewide Ecological Extinction Task Force & Delaware Native Species Commission, accessed October 2021, https://documents.dnrec.delaware.gov/Admin/Documents/eeft-presentation-sen-hansen.pdf.

[5] Michael Gilmore, "Delaware Teachers Institute," *Delaware Teachers Institute*, (May 3, 2021).

[6] Ibid

regions cannot be found anywhere else in the world; in fact, an estimated 25% of "Western" medicine has origins that trace back to plants from the rainforests, and that is with only testing approximately 1% of the rainforest plants![7] Rainforests located near the equator have a constant climate that is both warm (70-90°F), and wet. Humidity in these forests ranges from (77-88%), and rainforests typically receive approximately 150 inches of rainfall annually, and about an eighth (⅛) of an inch of rainfall daily. One of the primary characteristics of rainforests is the quantity and variety of trees that can be seen (~70% of plants in rainforests are trees). In one study, scientists in South America found that the biodiversity of trees ranged between 100-300 different species in several 2.5 acre parcels of land. Because of all the plants in these regions, it isn't surprising that they contribute a whopping 40% of Earth's oxygen.[8]

The world's largest rainforest, the Amazon, covers approximately 2 billion square miles over nine countries-- Brazil, Bolivia, Columbia, Guyana, Ecuador, French Guyana, Peru, Suriname, Venezuela; this area is about the size of the continental United States! An internet search for photos comparing the size of the Amazon rainforest versus the United States will bring up some great infographics to share with students.

Millions of species of plants, mammals, reptiles, amphibians, and insects call the Amazon basin "home". The Amazon rainforest alone captures an estimated 90-140 billion tons of carbon (~40% of the world's carbon dioxide[9])-- which helps mitigate climate change, and produces oxygen for our ecosystem.[10] Due to the high temperatures and humidity, the Amazon makes about half of its own rainfall from the constant evaporation/condensation/precipitation cycle. The Amazon is also responsible for delivering rainfall as far south as Argentina; as such, many countries depend on the Amazon for regulating their weather/

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[7] Christa Dillabaugh, "Delaware Teachers Institute," *Delaware Teachers Institute*, (May 10, 2021).

[8] Giorgia Mocilnik, "An Exploration of Stingless Bees in the Peruvian Amazon," New Worlder, February 8, 2015, https://www.newworlder.com/an-exploration-of-stingless-bees-of-the-peruvian-amazon/.

[9] Ibid

[10] "Amazon," WWF (World Wildlife Fund), accessed November 20, 2021, https://www.worldwildlife.org/places/amazon.

climate.[11] Additionally, an estimated 20% of Earth's water travels through the Amazon and empties out into the ocean from the Amazon River.[12] As of 2011, an estimated 50% of Peru was covered by tropical forests, but that number rapidly decreases every day.[13] This is a concerning phenomenon because deforestation releases significant amounts of carbon, which can lead to global climate change.

The Amazon Rainforest is in crisis. Logging, industrial agriculture, dam construction, oil extraction, and other forms of destruction are endangering the survival of Indigenous groups and are having dramatic impacts on ecosystem services that support life throughout the world.[14] Illegal logging is perhaps the most prevalent (80% of deforestation in Peru is illegal[15]), and is happening in all sectors-- private land, national parks, and reserves/ancestral lands. These atrocities are committed without prior authorization from the Indigenous communities, and local police are often bribed to "look the other way". Without proper oversight, papers are often falsified, more wood is taken then allotted, and the surrounding rainforest is often compromised due to carelessness and greed. In the Ese'Eja tribal lands, over a dozen centuries-old trees were felled in days without knowledge, or consent. Besides timber acquisition, a major driver of deforestation is for cattle ranching, and other agricultural development. When vast sections of the rainforest are eliminated, its impact on biodiversity is swift; birds, amphibians, mammals, insects, etc. all move on, or can disappear permanently. When the wildlife the Indigenous people depend on disappears, they too begin to suffer; lack of

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[11] The World Bank, *The World Bank* (The World Bank, May 22, 2019), https://www.worldbank.org/en/news/feature/2019/05/22/why-the-amazons-biodiversity-is-critical-for-the-globe.

[12] Christa Dillabaugh, "Delaware Teachers Institute," *Delaware Teachers Institute*, (May 10, 2021).

[13] Rocío Martínez, Jon Cox, and Roger Mustalish, *Ancestral Lands of the Ese'eja: The True People* (West Chester, PA: Amazon Center for Environmental Education and Research (ACEER), 2017).

[14] Nancy Trautmann and Michael Gilmore |, "The Maijuna: Fighting for Survival in the Peruvian Amazon," Environment & Society Portal, November 11, 2020, https://www.environmentandsociety.org/arcadia/maijuna-fighting-survival-peruvian-amazon.

[15] Geoff Gallice, "Delaware Teachers Institute," *Delaware Teachers Institute*, (April 26, 2021).

resources, disappearing ancestral land, and traditional knowledge (oral histories, sacred sites, basket weaving, bow and arrow making, cloth making, etc.) begins to fade away.[16]

The Maijuna

The Maijuna are one of approximately 379 Indigenous groups in the Amazon[17], and are located in the remote wilderness of the Peruvian Amazon Rainforest. Indigenous people, like the Maijuna, have a long ancestral history of living in a particular area; in this case, the Maijuna live in northeastern Peru. The four communities, totalling less than 500 people, are only accessible by boat, or a multi-day excursion through the rainforest.[18] Over the years, their population, culture (e.g. beliefs and language), and traditional ecological knowledge have declined due to colonization-- to the point that they are currently biologically and culturally endangered.

Over the past decade, the Maijuna have made a concerted effort to take back control of their lands. Due to excessive logging, poaching, and mining, their ancestral lands were functionally destroyed and severely lacking natural resources once vital and plentiful. In order to rehabilitate their ancestral lands, the Maijuna decided they needed to create a sustainable income that aligned with their vision for their land and future generations.[19] The Maijuna pride themselves on living in a symbiotic relationship with the land, and sustain themselves by hunting (deer, monkeys, and tapirs), fishing (fish and caiman), gathering (fruits, nuts, and medicinal plants), as well as growing and harvesting their own crops (plantain and yucca).[8] In an effort to live more sustainably, the Maijuna no longer cut down trees to harvest honey and fruit; instead, they rear their own beehives,

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[16] Rocío Martínez, Jon Cox, and Roger Mustalish, *Ancestral Lands of the Ese'eja: The True People* (West Chester, PA: Amazon Center for Environmental Education and Research (ACEER), 2017).

[17] Michael Gilmore, “Delaware Teachers Institute,” *Delaware Teachers Institute*, (May 3, 2021).

[18] Nancy Trautmann and Michael Gilmore |, “The Maijuna: Fighting for Survival in the Peruvian Amazon,” Environment & Society Portal, November 11, 2020, https://www.environmentandsociety.org/arcadia/maijuna-fighting-survival-peruvian-amazon.

[19] Elizabeth Benson, “Stingless Bees: Sustaining Land And People In The Amazon,” Stingless Bees: Sustaining Land And People In The Amazon (ACEER Foundation, September 15, 2021), https://aceer.org/stingless-bees-sustaining-land-and-people-in-the-amazon/.

and use harnesses to scale palm trees to collect the fronds and fruit they need.[20] They also collect wood and palm fibers from the forests to build their homes, and build canoes and paddles out of logs to use for transportation.[21]

Despite their best efforts to preserve a way of life for generations to come, the Maijuna tribal lands are currently under threat by the government; plans to build a major through-way through the center of their land is in progress. This highway would not only split their tribal lands; it would create opportunities for others to exploit their limited, and most valuable natural resources, as well as negatively impact or destroy culturally significant/sacred lands. Despite Peruvian law, the Maijuna were not consulted about this project.[22]

Traditional Ecological Knowledge (TEK)

TEK is an evolving set of knowledge/practices that are acquired by Indigenous people over hundreds or thousands of years. This knowledge is often specific to a particular location, and includes a direct connection to the land (plants, animals, terrain, seasons, etc.), and includes an emphasis on human-animal, and human-land relationships. Examples of this type of knowledge include, but are not limited to: hunting, fishing, trapping, medicine, weaving, beekeeping, and farming. Often, transmission of knowledge is passed down from one generation to another through the use of stories and practice (shadowing).[23]

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[20] Nancy Trautmann and Michael Gilmore |, "The Maijuna: Fighting for Survival in the Peruvian Amazon," Environment & Society Portal, November 11, 2020, https://www.environmentandsociety.org/arcadia/maijuna-fighting-survival-peruvian-amazon.

[21] "Aiming for Sustainability; Sustainability & Conservation in the Amazon- Resource Guides," Aiming For Sustainability (The Morpho Institute, 2021), https://morphoinstitute.org/wp-content/uploads/2021/03/4-Aiming-for-Sustainability-3.10.21.pdf.

[22] Nancy Trautmann and Michael Gilmore |, "The Maijuna: Fighting for Survival in the Peruvian Amazon," Environment & Society Portal, November 11, 2020, https://www.environmentandsociety.org/arcadia/maijuna-fighting-survival-peruvian-amazon.

[23] "Traditional Ecological Knowledge for Application by Service Scientists" (U.S. Fish & Wildlife Service , February 2011), https://www.fws.gov/nativeamerican/pdf/tek-fact-sheet.pdf.

Indigenous people have cultural and practical connections with their lands and wildlife (plant and animal). More recently, the Maijuna have begun including beekeeping as part of their traditional knowledge; evidence can be seen in their songs, dances, and cooking. Though knowledge of bee species and harvesting of honey has long been a part of the Maijuna culture, knowledge of beekeeping is now being passed down from grandparents to grandchildren. This new traditional knowledge is now ensuring a sustainable livelihood for future generations to come.[24]

Recently, there has been a growing trend in the utilization of similar strategies in Western science/farming practices, as sustainability is becoming a growing concern. For example, the U.S. Fish and Wildlife Service partnered with the Chukotka, Inuit, and other Indigenous communities to gather information about the habitat, and population of the polar bear *(Ursus maritimus)* to classify the species as "threatened" under the Endangered Species Act.[25]

Importance of Bees

It is estimated that there are approximately 20,000 bee species worldwide; with the United States having approximately 4,000 bee species.[26] Bees can be found on every continent in the world, except for Antarctica.[27] In the United States, bees are the primary insect pollinator of agricultural plants[28]; however, there are approximately 200,000 different species of pollinators who are responsible for pollinating over 180,000 different plant species.[29] Though honey bees, which were imported from Europe, are responsible for pollinating most of the plants/crops in America, native bees are more efficient, as they

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[24] Ibid

[25] Ibid

[26] "What Is the Role of Native Bees in the United States?," What is the role of native bees in the United States? (U.S. Geological Survey, n.d.), https://www.usgs.gov/faqs/what-role-native-bees-united-states?qt-news_science_products=0#qt-news_science_products.

[27] "What Is the Role of Native Bees in the United States?," What is the role of native bees in the United States? (U.S. Geological Survey, n.d.), https://www.usgs.gov/faqs/what-role-native-bees-united-states?qt-news_science_products=0#qt-news_science_products.

[28] Ibid

[29] "We Need Bees" (Planet Bee Foundation, n.d.), https://www.planetbee.org/why-we-need-bees.

are specialized towards gathering pollen from a specific type of plant.[30] It is estimated that a honeybee can visit over 2,000 flowers in a single day! Because of their productivity, they are the species most commonly used in commercial farming, and are frequently utilized in over 100 crops grown in the U.S. Two specific crops (almonds and lemons) rely heavily (over 90%) on pollination from honey bees; these crops contribute over $15 billion to the U.S. economy annually.

Commercial agriculture is not the only thing bees pollinate; over 90% of wild/native plant species on Earth rely on pollination to reproduce.[31] Pollination occurs when pollen grains from the male part of the flower (anther) get transferred to the female part of the flower (stigma) within the same species. Flowers are the part of the plant that makes seeds, which contains all the genetic material to produce a new plant. This process usually occurs when an animal/insect species is interacting with the plants (usually eating/collecting pollen or nectar). In the case of bees, the pollen gets attached to the hairs on the bee, and when the bee visits another flower, pollen from the first flower can fall off and pollinate the second flower.[32]

Svastra petulca bee with pollen stuck in the body hairs
Photo credits: Anders Croft; USGS Bee Inventory and Monitoring Lab
Retrieved from https://www.flickr.com/photos/usgsbiml/29627474321/

So, why are bees so important to our ecosystem? It is estimated that approximately 20%-45% of native bee species are pollen specialists, meaning that they only visit one

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[30] Ibid

[31] Ibid

[32] "What Is Pollination," Forest Service Shield (U.S. Forest Service, n.d.), https://www.fs.fed.us/wildflowers/pollinators/What_is_Pollination/.

species of plant. If either the bee, or the plant disappears, the symbiotic relationship is destroyed due to lack of pollination/reproduction. Without these bees, a significant number of plant species could disappear-- including some of the crops Americans depend on, such as: squash/gourds, and the sunflower.[33]

Currently, both native bees and honey bees are at risk of extinction, with many species currently endangered, and a few already extinct. Common concerns/risks for the overall health of bees include parasites, pathogens, insecticides, poor nutrition, and climate change. One study completed between 2008 and 2013 showed a decline in bee population by approximately 23% across the US.[34]

Stingless Beekeeping in Maijuna Tribes

Peru has several native bee species that are stingless and still produce honey. The two common species that are kept are *Melipona eburnea*, or the "pacucho" (blonde) bee, and the *Teragonica angustula*, or the "ramichi" bee. These species are much smaller than the common bees we see in the United States, and have no stingers.[35] While both the "ramichi" and "pacucho" bees can be thought of as docile, the "pacucho" is capable of biting when threatened.[36]

These bees typically make their hives out of wax, mud, and plant fibers, and the hive is broken into two main sections-- one for pollen and honey production/storage, and the other for brooding (larvae). The honey made by these bees is light in color, has a thinner, runnier consistency, and smells florally. Though it has a sweet taste, the flavor can vary

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[33] "What Is the Role of Native Bees in the United States?," What is the role of native bees in the United States? (U.S. Geological Survey, n.d.), https://www.usgs.gov/faqs/what-role-native-bees-united-states?qt-news_science_products=0#qt-news_science_products.

[34] "We Need Bees" (Planet Bee Foundation, n.d.), https://www.planetbee.org/why-we-need-bees.

[35] "Amazon Stingless Bees Honey," Slow Food Foundation, December 10, 2018, https://www.fondazioneslowfood.com/en/ark-of-taste-slow-food/amazzonia-stingless-bees-honey/.

[36] Giorgia Mocilnik, "An Exploration of Stingless Bees in the Peruvian Amazon," New Worlder, February 8, 2015, https://www.newworlder.com/an-exploration-of-stingless-bees-of-the-peruvian-amazon/.

depending on the season it is harvested, and which plants the pollen came from.[37] The honey from the "ramichi" bee is highly appreciated for the quality of honey it produces.[38]

In the past, entire trees were felled to gain access to the hives. The hives were then destroyed when they were squeezed/smooshed to extract the valuable honey.[39] Today, in an effort to live more sustainably, the Maijuna no longer cut down entire trees everytime they need to collect honey.[40] Instead, a single tree is taken back to the village, and the entire hive is removed and placed in a hive box, or they can divide a hive they are already managing. This allows the hive to continue to grow and thrive, and also allows for easier harvesting. Instead of squeezing the hive, they now use a syringe to extract the honey without compromising the integrity of the hive.[41]

Honey being harvested sustainably from hives using a syringe.

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[37] "Amazon Stingless Bees Honey," Slow Food Foundation, December 10, 2018, https://www.fondazioneslowfood.com/en/ark-of-taste-slow-food/amazzonia-stingless-bees-honey/.

[38] Giorgia Mocilnik, "An Exploration of Stingless Bees in the Peruvian Amazon," New Worlder, February 8, 2015, https://www.newworlder.com/an-exploration-of-stingless-bees-of-the-peruvian-amazon/.

[39] Christa Dillabaugh, "Delaware Teachers Institute," *Delaware Teachers Institute*, (May 10, 2021).

[40] Nancy Trautmann and Michael Gilmore |, "The Maijuna: Fighting for Survival in the Peruvian Amazon," Environment & Society Portal, November 11, 2020, https://www.environmentandsociety.org/arcadia/maijuna-fighting-survival-peruvian-amazon.

[41] Christa Dillabaugh, "Delaware Teachers Institute," *Delaware Teachers Institute*, (May 10, 2021).

Photo credits: Brian Griffiths
Retrieved from https://morphoinstitute.org/wp-content/uploads/2021/03/4-Aiming-for-Sustainability-3.10.21.pdf

The average Maijuna family survives on less than two dollars a day; the ability for a family to have their own hive(s) not only provides nutritional value, but can also provide a means to earn additional income.[42] Each hive will produce approximately a liter of honey a year; with multiple hives, a family can begin to sell two-ounce bottles of honey for a few dollars each, and earn anywhere from $50-$500 annually. Since the cost of upkeep per hive is minimal, this allows the family to directly benefit from the majority of the proceeds.[43] Locals in the region also like to make drinks with honey, as well as consume honey for medicinal purposes; treatments include gastrointestinal concerns, respiratory diseases, pterygium, and conjunctivitis.[44] This simple change allows the Maijuna to live more sustainably since they no longer need to participate in excessive hunting or logging practices to make an income.[45] Some additional benefits to the hives include that it increases the number of local bee colonies[46], and that they can be placed amongst crops. This strategic placement allows the bees to collect pollen for their hive, while also increasing crop pollination, which leads to larger crop yields. A recent study found that 80% of tropical plant species need pollination, and that one beehive had 78 different types of pollen inside. An increase in pollination leads to increased biodiversity,

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[42] Christa Dillabaugh, "Delaware Teachers Institute," *Delaware Teachers Institute*, (May 10, 2021).

[43] Ava Goodale, "Maijuna Beekeeping: An Interrupted Case Study on Community-Based Conservation" (The Morpho Institute, 2020), https://morphoinstitute.org/wp-content/uploads/2020/10/Morpho-Institute_Sustainable-Beekeeping-Case-Study_09232021.pdf.

[44] "Amazon Stingless Bees Honey," Slow Food Foundation, December 10, 2018, https://www.fondazioneslowfood.com/en/ark-of-taste-slow-food/amazzonia-stingless-bees-honey/.

[45] "Aiming for Sustainability; Sustainability & Conservation in the Amazon- Resource Guides," Aiming For Sustainability (The Morpho Institute, 2021), https://morphoinstitute.org/wp-content/uploads/2021/03/4-Aiming-for-Sustainability-3.10.21.pdf.

[46] Elizabeth Benson, "Stingless Bees: Sustaining Land And People In The Amazon," Stingless Bees: Sustaining Land And People In The Amazon (ACEER Foundation, September 15, 2021), https://aceer.org/stingless-bees-sustaining-land-and-people-in-the-amazon/.

and a healthier ecosystem for the Maijuna to live in. One of the more prized stingless bee species is *Melipona refiventrist*; it makes a highly prized honey valued for both its taste and medicinal value. The Maijuna noticed that in areas of excessive illegal logging, a "ghost forest", or deadzone devoid of fish, game, and insects occured. They made the connection that the population of this particular species of bee became vulnerable when deforestation occurred, and could use its presence as an indicator of overall forest health.[47]

Environmental Sustainability in Delaware-- Why Bees Matter

According to the USDA, Sussex County alone has over 780 farms totaling over 275,000 acres of farmland, is one of the top thirty counties in the nation for agriculture production, and one of the top 100 counties in the nation for vegetable production! Though the majority of crops grown in Delaware are field crops, an estimated 6-7% of all crops in the state are commodity crops for human consumption, which includes: apples, blueberries, cantaloupe, cranberries, cucumbers (pickling), peaches, pumpkins, strawberries, squash, tomatoes, and watermelon.[48] All of these commodity crops also rely heavily on pollination from honey bees. According to the Delaware Department of Agriculture, approximately 7,200 local (Delaware) bee colonies, as well as an additional 3,000 out-of-state colonies are used annually to contribute towards the production of $30 million worth of fruits and vegetables.[49]

As of 2020, Delaware's largest commodity crops are soybeans and field corn, which are mainly used as feed for the local broiler chicken industry. Sussex County is the largest producer of soybeans east of the Appalachian Mountains, and approximately 150,000

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[47] Ava Goodale, "Maijuna Beekeeping: An Interrupted Case Study on Community-Based Conservation" (The Morpho Institute, 2020), https://morphoinstitute.org/wp-content/uploads/2020/10/Morpho-Institute_Sustainable-Beekeeping-Case-Study_09232021.pdf.

[48] Ed Kee, "Delaware Agriculture - National Agricultural Statistics ...," United States Department of Agriculture National Agricultural Statistics Service (Delaware Department of Agriculture, 2011), https://www.nass.usda.gov/Statistics_by_State/Delaware/Publications/DE%20Ag%20Brochure_web.pdf.

[49] "Honeybees," Delaware Department of Agriculture - State of Delaware (Delaware Department of Agriculture, August 27, 2021), https://agriculture.delaware.gov/plant-industries/honeybees/.

acres of soybeans are planted/harvested annually.[50] In an attempt to optimize soybean yields, it isn't uncommon for farmers to spray pesticides (i.e. herbicides, fungicides, nematicides, and insecticides) to minimize/eliminate weeds, diseases, nematodes, and insects. Though soybeans do not depend on pollination from honey bees, the bees do frequent these crops for nectar and pollen. Direct sprays, and "drift" (overspray carried by wind) from pesticides can be detrimental to honeybee populations. A foraging bee that finds a great source of nectar/pollen from a contaminated field will not only bring that contaminant back to the hive, but it will also recruit other bees to come collect; this further increases the contaminant load on the hive, jeopardizing the entire colony's health. If the colony collapses, this could negatively impact the outcomes of surrounding pollination dependent plants/crops. Because approximately one-third of the human diet depends on crops requiring pollination[51], several strategies have been developed to help minimize the negative effects of pesticides on pollinators; these include: proper hive placement, direct communication between beekeepers and farmers, increased awareness/ education of the importance of pollinators, following proper guidelines for pesticide use, and maintaining pollinator habitats.

One of Delaware's most important tools utilized to protect pollinators is the "DriftWatch" map, which is part of the BeeCheck program. Local beekeepers can go online and register their bee colonies, and pesticide applicators can then see where active colonies are prior to spraying. This tool allows for better awareness, as well as allow pesticide applications to be made in a more educated manner. Though this tool cannot completely eliminate the possibility of drift, it can greatly mitigate the risk.[52] With the ability to have open and direct access to information, farms can ensure they are not spraying crops that are currently being pollinated; or, if drift could be an issue, they can contact the beekeepers directly to see if its possible for the hives to be relocated, or if the hives are out of foraging range. This simple, free, voluntary measure could minimize or eliminate

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[50] "2020 State Agriculture Overview," USDA/NASS 2020 State Agriculture Overview for Delaware (United States Department of Agriculture, National Agricultural Statistics Service), accessed November 20, 2021, https://www.nass.usda.gov/Quick_Stats/Ag_Overview/stateOverview.php?state=DELAWARE.

[51] "Best Management Practices (Bmps) to Protect Honey Bees and Other Pollinators in Soybean Fields," Honey Bee Health Coalition, February 15, 2020, https://honeybeehealthcoalition.org/wp-content/uploads/2020/03/HBHC_Soybean_022020.pdf.

[52] "Delaware Managed Pollinator Protection Plan," Delaware Managed Pollinator Protection Plan (Delaware Department of Agriculture - State of Delaware, August 21, 2019), https://agriculture.delaware.gov/pesticide-management/pollinator-protection-plan/.

substantial deaths from exposure to chemicals, help maintain hive nutritional stores, ensure brood production, and help maintain overall health within the colony.[53]

Another way to protect pollinators in Delaware is to create a biodiverse habitat by planting trees, shrubs, and flowers for foraging; each type of pollen/nectar offers a unique nutrient for the bees. Optimal habitat locations include field borders, buffer strips, waterways, secondary roads, flower pots, flowerbeds, and established gardens. Because approximately 70% of native bees nest in the ground, it is important that bees have access to well drained soil; however, other species prefer nesting in beetle houses, inside both living and dead trees, and under brush piles.[54] It should also be noted that nests in the ground could be susceptible to tilling when prepping land prior to seeding, as well as direct exposure to nests when soil is sprayed with pesticide. One important note is that soybean fields (one of Delaware's main crops) are often considered "no-till", which seems like it might protect ground-nesting bees; however, this then necessitates that the weeds or cover crop be sprayed with herbicide prior to seeding, which could directly impact the hives. In this case, having nearby ground with vegetation covering could offer a habitat for the bees in lieu of the crop field.[55] If funding for habitat is an issue, technical and financial assistance is available to help with installing ground cover, field borders, and hedgerows.[56] Additionally, landowners could be eligible to earn payments, or receive

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[53] "Best Management Practices (Bmps) to Protect Honey Bees and Other Pollinators in Soybean Fields," Honey Bee Health Coalition, February 15, 2020, https://honeybeehealthcoalition.org/wp-content/uploads/2020/03/HBHC_Soybean_022020.pdf.

[54] Christopher Wade, Faith Kuehn, and Laura Mensch, "Managed Pollinator Protection Plan Delaware Department of Agriculture," Delaware Department of Agriculture (State of Delaware, September 2016), https://agriculture.delaware.gov/wp-content/uploads/sites/108/2017/12/DelawarePollinatorPlan2016.pdf.

[55] "Best Management Practices (Bmps) to Protect Honey Bees and Other Pollinators in Soybean Fields," Honey Bee Health Coalition, February 15, 2020, https://honeybeehealthcoalition.org/wp-content/uploads/2020/03/HBHC_Soybean_022020.pdf.

[56] Chris Bohinski, "Helping You Help Polinators," Natural Resources Conservation Service Delaware (United States Department of Agriculture, June 2018), https://www.nrcs.usda.gov/wps/portal/nrcs/detail/de/newsroom/stories/?cid=nrcseprd1409215.

other incentives for creating and maintaining optimal pollinator habitat, which can often be built on their non-farming land.[57]

Other critical factors of maintaining habitat include using pesticides appropriately, and not spraying during the plant's blooming season. In the case of open fields, frequent mowing should be minimized, or mowing in a non-bloom season when bees are less active is optimal.[58] When farmers use all of these preventative measures, they will receive both direct and indirect benefits. In addition to reduced soil erosion, and improved soil and water quality, farmers could see a boost in soybean production. Despite the fact that pollination isn't required by honey bees, a biodiverse and healthy environment has shown that increased bee activity (pollination) can increase soybean crop yields by up to 18%.[59] This increase in soybean production not only leads to more profit gains for the farmer, but also means that less crops need to be imported into Delaware to support the feed industry for broiler chickens. According to the USDA, despite having 365,000 acres of corn and soybeans statewide, the supply is still not enough to meet the demands of the broiler chicken factories; food must be purchased from outside the state. By increasing crop yield in Delaware, it will help decrease the ecological footprint for Delaware's primary livestock crop.

Teaching Strategies

I teach under the premise that learning should be engaging, fun, and spark curiosity/ passion. I also believe that passion and excitement is contagious; if I am passionate about a topic I teach, that excitement gets passed down to my students. One of the topics I am passionate about is environmental sustainability; however, that topic in and of itself, may not be exciting enough to drive engagement in learning. The quote "You can't save what

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[57] "Best Management Practices (Bmps) to Protect Honey Bees and Other Pollinators in Soybean Fields," Honey Bee Health Coalition, February 15, 2020, https://honeybeehealthcoalition.org/wp-content/uploads/2020/03/HBHC_Soybean_022020.pdf.

[58] Christopher Wade, Faith Kuehn, and Laura Mensch, "Managed Pollinator Protection Plan Delaware Department of Agriculture," Delaware Department of Agriculture (State of Delaware, September 2016), https://agriculture.delaware.gov/wp-content/uploads/sites/108/2017/12/DelawarePollinatorPlan2016.pdf.

[59] "Best Management Practices (Bmps) to Protect Honey Bees and Other Pollinators in Soybean Fields," Honey Bee Health Coalition, February 15, 2020, https://honeybeehealthcoalition.org/wp-content/uploads/2020/03/HBHC_Soybean_022020.pdf.

you don't love, and you can't love what you don't know."[60] is what drives this unit. I can't get my students excited about sustainability if they don't know what it is, and they don't love it. As such, I am primarily focusing on honey bees, and how they are both used by the Maijuna in the Peruvian Amazon, and by farmers in Delaware. Students are naturally curious about the Amazon rainforest, and many of my students are interested in agriculture. By bringing the Amazon to Delaware, I can tap into their curiosities/interests, make it relatable to their every-day lives, and then use that to drive instruction.

21st Century Skills

These are skills that are deemed critical for both college and career readiness, and should be utilized throughout a student's K12 education. These skills include (but are not limited to): critical thinking, problem solving, collaboration, literacy (media, technology, information, etc.), communication, and social responsibility. Several of these skills are included in the variety of learning strategies/activities included throughout this unit.[61]

Anchoring Phenomenon

According to the Next Generation Science Standards (NGSS), each unit should be launched using an "anchoring phenomenon", or a hook that draws students in with natural curiosity. For this unit, students will begin by watching a video of bees in their natural habitat, collecting pollen, interacting with their colony, hive harvesting, etc.

3-2-1

After watching the anchoring phenomenon video, students will complete this activator; students will write down three things they already know about bees, two things they found interesting in the video, and one thing they want to learn about bees. According to the Teacher Toolkit[62], the strategy gives students an outlet to record their comprehension

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[60] (Heartland Conservation Alliance, 2016), https://www.heartlandconservationalliance.org/post/2016/03/10/you-cant-save-what-you-dont-love-and-you-cant-love-what-you-dont-know.

[61] Jenna Buckle, "A Comprehensive Guide to 21st Century Skills," A Comprehensive Guide to 21st Century Skills, accessed November 2021, https://www.panoramaed.com/blog/comprehensive-guide-21st-century-skills.

[62] "3-2-1" (The Teacher Toolkit, n.d.), https://www.theteachertoolkit.com/index.php/tool/3-2-1.

and/or summarize learning. Though this activity is usually reserved for an “exit ticket”, to assess learning comprehension, this can also be used at the beginning of a lesson as a “warm up” to assess current knowledge of a topic, determine if foundational knowledge needs to be met, as well as use student interest/curiosity to drive future instruction.

KWL

According to the Teacher Toolkit[63], this writing strategy is another great way to open or close out a lesson and assess student learning. Students will be using this strategy during our lesson about pesticides, drift, and their impact on bees. Students will complete the “Know” (K) section, and the “Want to Know” (W) prior to learning the material. At the end of the lesson, students will summarize their learning under the “Learned” (L) section. These can either be used to lead a group discussion as an informal formative, or submitted to the teacher for a closer assessment of student learning.

Graphic Organizer

Graphic organizers are a great way for students to visualize relationships, or compare/contrast topics/information. This is also a great tool to use for scaffolding student learning, and supports students with laying a foundation of knowledge that can be used in future activities. Students will be creating a graphic organizer to help compare/contrast TEK versus how education/knowledge is passed down in their own lives. Key considerations could include: how the knowledge is acquired, where the knowledge is acquired, topics of learning, consequences of knowledge being withheld or lost, etc. Students should be able to see similarities in how they acquire information/knowledge; however, also notice several differences.

Peer Collaboration

Collaborative learning involves students working together in groups to discuss concepts, or find solutions to a problem. This is a great way for students to take on peer mentoring, which allows students to take ownership of their learning, and gives them the autonomy to identify and overcome individual/peer misconceptions within their group. Collaborative learning can lead to higher order thinking, and deeper conversations than

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63 “KWL” (The Teacher Toolkit), accessed November 2021, https://www.theteachertoolkit.com/index.php/tool/kwl.

direct instruction on its own; other benefits include: self-management, accountability, leadership skills, and increased communication/collaboration skills.[64]

Jigsaw

This is a collaborative teaching strategy where student groups are broken up and each student is assigned to a separate group where they will work towards becoming "experts" on their unique topic. Once time is up, all the students will return to their original group, with each student being the "subject expert" on their topic. Each student will then share their knowledge with their group. This method increases student engagement and accountability, and minimizes one person from taking over the group.[65]

Movement & Learning

Research has shown that movement during lessons can not only minimize fidgeting and classroom disruptions, but it also benefits learning by increasing focus/concentration, and improves memory. By engaging multiple senses at once, learning can become more concrete as increased retention occurs. Research also shows that the use of active games (kinesthetic learning) can also increase attention and retention.[66]

Classroom Activities

Eye Spy With My Pollinator Eye

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[64] "Collaborative Learning" (Center for Teaching Innovation), accessed November 2021, https://teaching.cornell.edu/teaching-resources/active-collaborative-learning/collaborative-learning.

[65] Elliott Aronson, "Overview," The Jigsaw Classroom, accessed December 12, 2021, https://www.jigsaw.org/.

[66] Donna Wilson and Marcus Conyers, "Move Your Body, Grow Your Brain," Edutopia (George Lucas Educational Foundation, March 12, 2014), https://www.edutopia.org/blog/move-body-grow-brain-donna-wilson.

This activity could be either assigned for homework, or completed in class. Students will be given a six foot area to watch for approximately 5-10 minutes outdoors. Students will document how many pollinators they see within this location (students do not need to identify species). It is important that students have several areas to observe, with some areas having a higher percentage/likelihood of observing pollinators. Locations to consider are open sports fields (often sprayed/maintained), open grass fields, near flowering plants/bushes, hedgerows, parking lots, etc. By the end of the activity, students should have a better sense of where pollinators are more likely to be found, and if a low amount of pollinators were observed, identify possible reasons they aren't present, and come up with some ideas on how to better promote pollinators in those areas.

Busy Bee Pollinators

Students will be divided into groups/hives with the objective of acting as a bee, and collecting as much pollen as possible in a given amount of time (3-5 minutes). Students are only allowed to collect two eggs at a time before returning to the hive, and another bee (student) goes out for collection. The team that collects the most pollen wins; however, there is a caveat that the students are not aware of prior to the activity. Once time runs out, the teacher will disclose what the shapes written on the egg means, and explain the point values, and any negative impacts. Prior to the activity, a variety of plastic easter eggs will each need to have a shape drawn on the outside (students should not know what the shapes mean). Four colors should be used; one shape will represent 1 point worth of pollen, a second shape will represent 2 points worth of pollen, a third shape will represent 3 points worth of pollen, and a fourth shape will represent pesticide from drift, which takes away 2 points per egg. If a hive has four or more eggs that have been contaminated, the colony will lose half of its members. If a hive has six or more eggs that have been contaminated, the entire colony will be lost. The team whose colony survives, and has the most points will win the honeycomb prize (to be determined by the teacher). Something to consider from the teacher is how to place the "contaminated eggs"; options could include even distribution, or keeping the eggs exposed to drift to a certain location of the field/area. By the end of the activity, students should be able to explain how pesticide drift can negatively impact colony health.

Pollinator Garden Proposal

Students will work in teams of 4-6 students to design a proposal for a pollinator garden. Working within a budget of $200, students will research and design a garden that is meant to attract, and support local pollinators. Some design options students may want to consider include: native flowers, plants/bushes, pollinator habitat/homes, whether the

garden will be self-sustaining, or need tending/upkeep, whether annuals/perennials will be used, whether plants will be localized or spread out, and what practices should be used to ensure overall pollinator health. Students will need to create a presentation that will not only pitch their design, but also discuss the benefits of a pollinator garden, and any mitigation strategies they developed to ensure the health of nearby colonies. Additionally, students will also need to create a product to share/display during their presentation, such as a poster, brochure, model, etc. The top team in each class period will then pitch their idea either in person (or on video) to see if their design will be picked for a pollinator garden on school grounds.

Resources

Aronson, Elliott. n.d. “The Jigsaw Classroom.” https://www.jigsaw.org.

Educator Resource: explains the value of using this strategy, and how to implement it in the classroom.

Benson, Elizabeth. 2021. “Stingless Bees: Sustaining Land And People In The Amazon.” The ACEER Foundation. https://aceer.org/stingless-bees-sustaining-land-and-people-in-the-amazon.

Educator/Student Resource: great article about sustainable stingless beekeeping practices in Maijuna villages; includes photographs.

Bohinski, Chris. 2018. “Helping You Help Pollinators.” Natural Resources Conservation Service Delaware. https://www.nrcs.usda.gov/wps/portal/nrcs/detail/de/newsroom/stories/?cid=nrcseprd1409215.

Educator Resource: ideas on how to help pollinators on unused/open land.

Buckle, Jenna. n.d. “A Comprehensive Guide to 21st Century Skills.” Panorama Education. https://www.panoramaed.com/blog/comprehensive-guide-21st-century-skills.

Educator Resource: explains the importance of “21st century skills”, and why implementation is so valuable to students.

Center for Teaching Innovation. n.d. “Collaborative Learning.” Center for Teaching Innovation. https://teaching.cornell.edu/teaching-resources/active-collaborative-learning/collaborative-learning.

Teacher Resource: great resource on how to implement collaborative learning in the classroom, and how it benefits students.

Delaware Department of Agriculture. 2019. “Delaware Managed Pollinator Protection Plan.” https://agriculture.delaware.gov/pesticide-management/pollinator-protection-plan/.

Teacher Resource: information and resources for protecting pollinators in Delaware via the “Delaware Managed Pollinator Protection Plan”.

Delaware Department of Agriculture. 2021. “Honeybees.” Delaware Department of Agriculture. https://agriculture.delaware.gov/plant-industries/honeybees/.

Teacher Resource: information and education resources about honeybees in Delaware; includes links to the “DriftWatch” program.

Delaware Department of Natural Resources and Environmental Control. n.d. “Delaware Wildlife Action Plan - DNREC Alpha.” Delaware Department of Natural Resources and Environmental Control. Accessed October, 2021. https://dnrec.alpha.delaware.gov/fish-wildlife/conservation/wildlife-action-plan/.

Teacher Resource: link to Delaware’s “Wildlife Action Plan”, which covers steps to be made from 2015-2025.

Delaware Department of Resources and Environmental Control. n.d. “Delaware's Endangered Species - DNREC Alpha.” Delaware's Endangered Species. Accessed November 12, 2021. https://dnrec.alpha.delaware.gov/fish-wildlife/conservation/endangered-species/.

Teacher Resource: list of Delaware’s endangered species.

Dillabaugh, Christa. 2021. *The Morpho Institute: Discover New Tools and Techniques to Connect with Citizen Scientists and Bring the Amazon Home to Your Classroom*, Lecture presented at the Delaware Teachers Institute. Delaware: The Morpho Institute.

Teacher Resource: virtual presentation provided as part of the Delaware Teachers Institute.

G, Michael. 2021. “Rainforest Biome.” Blue Planet. https://www.blueplanetbiomes.org/rainforest.php.

Teacher/Student Resource: great resource about the rainforest biome; includes links to relevant resources.

Gallice, Geoff. 2021. *Understanding the Large Intact Ecosystem and Biodiversity of the Amazon Rainforest, and the Major Challenges in Conservation*, Lecture presented at the Delaware Teachers Institute. Delaware: Alliance For A Sustainable Amazon.

Teacher Resource: virtual presentation provided as part of the Delaware Teachers Institute.

Gilmore, Michael. 2021. *Maps From the Forest*, Lecture presented at the Delaware Teachers Institute. Delaware: One Planet.

Teacher Resource: virtual presentation provided as part of the Delaware Teachers Institute.

Goodale, Ava. 2020. “Maijuna Beekeeping: An Interrupted Case Study on Community-Based Conservation.” The Morpho Institute. https://morphoinstitute.org/wp-content/uploads/2020/10/Morpho-Institute_Sustainable-Beekeeping-Case-Study_09232021.pdf.

Teacher Resource: includes background information and lesson plans regarding sustainable beekeeping in Maijuna villages; also has links to valuable/relatable resources.

Hanson, Stephanie. 2017. “Statewide Ecological Extinction Task Force & Delaware Native Species Commission.” Delaware.gov. https://documents.dnrec.delaware.gov/Admin/Documents/eeft-presentation-sen-hansen.pdf.

Teacher/Student Resource: slide presentation by Senator Stephanie Hanson regarding the findings/recommendations of Delaware's Ecological Extinction Task Force and Native Species Commission; includes useful infographics, photos of invasive species, and a link to see what native species are best for your area.

Heartland Conservation Alliance. 2016. https://www.heartlandconservationalliance.org/post/2016/03/10/you-cant-save-what-you-dont-love-and-you-cant-love-what-you-dont-know.

Teacher Resource: source of quote on title page.

Honey Bee Health Coalition. 2020. "Best Management Practices (Bmps) to Protect Honey Bees and Other Pollinators in Soybean Fields." https://honeybeehealthcoalition.org/wp-content/uploads/2020/03/HBHC_Soybean_022020.pdf.

Teacher Resource: lengthy resource (27 pages) geared towards farmers about best practices to protect honey bees/pollinators in soybean fields; does include links to other relevant resources.

Kee, Ed. 2011. "United States Department of Agriculture National Agricultural Statistics Service." United States Department of Agriculture National Agricultural Statistics Service. https://www.nass.usda.gov/Statistics_by_State/Delaware/Publications/DE%20Ag%20Brochure_web.pdf.

Teacher/Student Resource: summary report of growth/sales of commodity crops in Delaware.

Martinez, Rocio, Jon Cox, and Roger Mustalish. 2017. *Ancestral Lands of the Ese'eja: The True People*. N.p.: Amazon Center for Environmental Education and Research.

Teacher/Student Resource: great "coffee style book" (lots of photos, and informative text) about the Ese'Eja in the Amazon rainforest, and how they are connected to their ancestral lands; includes information about TEK.

Mocilnik, Giorgia. 2015. "An Exploration of Stingless Bees in the Peruvian Amazon." New Worlder. https://www.newworlder.com/an-exploration-of-stingless-bees-of-the-peruvian-amazon/.

Teacher/Student Resource: informational reading about the stingless bee species found in the Peruvian Amazon, and how they create their hives; also a great resource for photos of stingless bees and their hives.

The Morpho Institute. 2021. “Aiming for Sustainability; Sustainability & Conservation in the Amazon- Resource Guides.” https://morphoinstitute.org/wp-content/uploads/2021/03/4-Aiming-for-Sustainability-3.10.21.pdf.

Teacher Resource: lesson plan and resource guide for learning about the Maijuna, and sustainability in the Amazon rainforest; includes links to great video resources-- including the documentary “Guardians of the Forest”.

OnePlanet, dir. 2016. *Beekeeping in the Amazon*. https://youtu.be/Ca2kYBJN4tI.

Teacher/Student Resource: informative video about stingless beekeeping by the Maijuna in the Peruvian Amazon.

Planet Bee Foundation. 2020. “Endangered Species Day.” https://www.planetbee.org/planet-bee-blog/endangered-species-day.

Teacher Resource: introduction to “Endangered Species Day”, and the negative impact climate change has on bees.

Planet Bee Foundation. n.d. “We Need Bees.” https://www.planetbee.org/why-we-need-bees.

Teacher Resource: great resource for STEM lesson plans (K-12) about bees; these lessons were created specifically for hybrid learning; however they can be easily modified for in-person learning.

Slow Food Foundation. 2018. “Amazon Stingless Bees Honey.” https://www.fondazioneslowfood.com/en/ark-of-taste-slow-food/amazzonia-stingless-bees-honey/.

Teacher/Student Resource: succinct information about stingless beehives and stingless bee honey in the Amazon rainforest.

Smith, Jerry. 2017. “Ecological Extinction Task Force: It's time to save Delaware's ecosystem.” Delaware Online. https://www.delawareonline.com/story/news/2017/12/06/extinction-task-force/907075001/.

Teacher/Student Resource: article summarizing the Ecological Extinction Task Forces findings/recommendations.

The Teacher Toolkit. n.d. “3-2-1.” https://www.theteachertoolkit.com/index.php/tool/3-2-1.

Teacher Resource: discusses how to use this check-in/check-out strategy with students in the classroom; includes an informational video, and templates to download.

The Teacher Toolkit. n.d. “KWL.” The Teacher Toolkit. Accessed November, 2021. https://www.theteachertoolkit.com/index.php/tool/kwl.

Teacher Resource: discusses how to use this writing strategy with students in the classroom; includes an informational video, and templates to download.

Trautmann, Nancy, and Michael Gilmore. 2020. “The Maijuna: Fighting for Survival in the Peruvian Amazon.” Environment & Society. https://www.environmentandsociety.org/arcadia/maijuna-fighting-survival-peruvian-amazon.

Teacher/Student Resource: informative article regarding the Maijuna, and their fight to maintain their way of life in the Peruvian Amazon.

United States Department of Agriculture, National Agricultural Statistics Service. n.d. “2020 State Agriculture Overview.” USDA/NASS 2020 State Agriculture Overview for Delaware. Accessed October, 2021. https://www.nass.usda.gov/Quick_Stats/Ag_Overview/stateOverview.php?state=DELAWARE.

Teacher Resource: provides information about commodity crops, acres planted, crop value, yield, etc. of Delaware crops in 2020.

United States Geological Survey. n.d. “Do Native Bees Occur On Every Continent On the Planet?” https://www.usgs.gov/faqs/do-native-bees-occur-every-continent-planet?qt-news_science_products=0#qt-news_science_products.

Student Resource: short reading (64 words) explaining bees are on every continent except Antarctica.

United States Geological Survey. n.d. “How Many Species of Native Bees Are in the United States?” https://www.usgs.gov/faqs/how-many-species-native-bees-are-united-states?qt-news_science_products=0#qt-news_science_products.

Student Resource: short reading (246 words) about native bee species in the U.S.

U.S. Fish and Wildlife Service. 2011. “Traditional Ecological Knowledge for Application by Service Scientists.” U.S. Fish and Wildlife Service. https://www.fws.gov/nativeamerican/pdf/tek-fact-sheet.pdf.

Teacher/Student Resource: great article about TEK (what it is, why it is important, and how working with Indigenous tribes can provide great value); could be modified/parsed down to make a user friendly student resource guide.

U.S. Forest Service. n.d. “What is Pollination?” U.S. Forest Service. https://www.fs.fed.us/wildflowers/pollinators/What_is_Pollination/.

Teacher/Student Resource: explains the process of pollination.

U.S. Geological Survey. n.d. “What Is the Role of Native Bees in the United States?” https://www.usgs.gov/faqs/what-role-native-bees-united-states?qt-news_science_products=0#qt-news_science_products.

Student Resource: short reading (176 words) about the importance of native bees in the U.S.

USGS Bee Inventory and Monitoring Lab. n.d. “USGS Bee Inventory and Monitoring Lab.” https://www.flickr.com/photos/usgsbiml.

Teacher Resource: open source photographs of bees and pollinators to download and share.

Wade, Christopher, Faith Kuehn, and Laura Mensch. 2016. “Managed Pollinator Protection Plan Delaware Department of Agriculture.” Delaware Department of

Agriculture. State of Delaware. https://agriculture.delaware.gov/wp-content/uploads/sites/108/2017/12/DelawarePollinatorPlan2016.pdf.

Teacher/Student Resource: great resource about best management practices for landowners/farmers to utilize to protect bees; could be modified/parsed down to make a user friendly student resource guide.

Wilson, Donna, and Marcus Conyers. 2014. "Move Your Body, Grow Your Brain Incorporating exercise and movement throughout the school day makes students less fidgety and more focused on learning." Edutopia. https://www.edutopia.org/blog/move-body-grow-brain-donna-wilson.

Teacher Resource: discusses the physical/cognitive benefits of movement during learning.

The World Bank. 2019. "Why the Amazon's Biodiversity is Critical for the Globe: An Interview with Thomas Lovejoy." The World Bank. https://www.worldbank.org/en/news/feature/2019/05/22/why-the-amazons-biodiversity-is-critical-for-the-globe.

Teacher Resource: interview about why the Amazon's biodiversity can have global impacts (carbon/water cycles).

World Wildlife Fund. n.d. "Amazon." Accessed October, 2021. https://www.worldwildlife.org/places/amazon.

Teacher/Student Resource: full of information (facts, species, people, threats, etc.) about the Amazon rainforest; could be a fun "digital quest" to introduce students to the Amazon rainforest.

Appendix: Implementing District Standards

This unit includes the following Next Generation Science Standards (NGSS)

MS-ESS3-3:
Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment. [Clarification Statement: Examples of the design process include examining human environmental impacts, assessing the kinds of solutions that are feasible, and designing and evaluating solutions that could reduce that impact.

Examples of human impacts can include land usage (such as urban development, agriculture), and pollution (such as of the air, water, or land).]

MS-ETS1-1:
Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

Crosscutting Concepts:
Patterns can be used to identify cause and effect relationships.
Small changes in one part of a system might cause large changes in another part.
Cause and effect relationships may be used to predict phenomena in natural or designed systems.

Connections to Engineering, Technology, and Applications of Science:
All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment.

Attachments

1. Synopsis
2. Learning Focused Map