Sobreviviendo un Ecosistema Cambiante

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Descripción de la Unidad

Esta unidad está diseñada para estudiantes de secundaria que estén tomando las clases de Biología o Ciencias Ambientales. Los estudiantes investigan la biodiversidad en lugares llamados lamederos de minerales, mediante el análisis de datos de cámaras trampa de la Amazonía y cámaras trampa instaladas en los terrenos de la escuela. Los estudiantes exploran las formas en que las actividades humanas, como la caza y tala, han tenido un impacto negativo en la biodiversidad y como cambiar nuestro comportamiento puede tener consecuencias positivas. Los estudiantes están expuestos a imágenes de cámaras trampa y relatos de primera mano de un cazador Maijuna sobre la biodiversidad cambiante en la Amazonía. Los estudiantes aplican su comprensión a nuestro ecosistema local cambiante. Esta unidad incorpora simulaciones, modelamiento, análisis de mapas e imágenes y argumentos escritos para un legislador local.

Estándares del Contenido

1. Evaluar como las interacciones en los ecosistemas mantienen números y tipos de organismos relativamente consistentes en condiciones estables, pero las condiciones cambiantes pueden dar como resultado un nuevo ecosistema. (**HS-LS2-6**)

2. Crear una simulación para probar una solución para mitigar impactos adversos de la actividad humana en la biodiversidad. (**HS-LS4-6**)

Objetivos y Resultados

1. Los estudiantes explicarán como los cambios en un ecosistema afectan la biodiversidad de manera positiva y negativa.

2. Los estudiantes explicarán los fenómenos naturales de los lamederos de minerales y aplicarán su importancia ecológica a los ecosistemas locales en Delaware.

Material de Apoyo

1. **DTI 2022 Unit**

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Delaware Teachers Institute

Surviving a Changing Ecosystem

Monica Cohen

Introduction

St. Georges Technical High School is one of four public vocational-technical high schools in New Castle County, Delaware. Our student population represents diverse backgrounds – urban Wilmington, suburban Newark, and rural Middletown. The unique draw for a technical high school like ours is the ability for students to study a trade and graduate with a certification or license with the opportunity to delve directly into the workforce. Our students apply to St. Georges for a variety of reasons: learn a family trade, learn in a safer school environment when compared with a feeder high school, or earn a certification to join the workforce instead of continuing to a post-secondary school. With each graduating class, approximately fifty percent of students directly enter the workforce, an apprenticeship, or post-secondary trade school. The remaining fifty percent continue on to a four-year college/university, or a branch of the military.

The technical trades school environment offers students a distinctive high school experience. Each student earns a certificate or license in their field of study upon graduation. The trades offered to our students are as diverse as the students themselves; ranging from nursing to carpentry, web design to culinary, automotive technology to early childhood education, and a dozen other options. Students study their chosen career path in addition to the state-mandated academic courses offered within St. Georges. I am one of the science instructors within the building; teaching biology to sophomores. This unit has been developed for biology, a required course for graduation by the state of Delaware. The topics covered in this course are as follows: ecology, cell biology, genetics, and evolution. This unit is intended to be incorporated into the evolution section of the course where biodiversity is studied.

As a fully-inclusive school, students of all ability levels, both regular education and special education students, are placed in the same class and therefore it is important for the instructor to differentiate each lesson. Following the blended learning educational model, this unit provides students with several choices in how they learn, express their knowledge, the pace at which they learn, and utilize technology to enhance their overall learning experience. Within the blended model, the teacher becomes a facilitator while the student becomes the gatherer, organizer, and applier of information. My role as a facilitator is to provide students with appropriate resources and experiences to extract information and scaffold the lesson. It is important that the teacher carefully identifies multiple modes of formative assessment throughout the unit to ensure all students are able to display their full understanding of the

content. This unit has the ability to be modified for a remote or hybrid setting as has been the case for the past year.

The state of Delaware has adopted the Next Generation Science Standards (NGSS) and is currently implementing them into the high schools. New Castle County Vo-Tech is assessing viable curriculum for the future biology course. There has been an increase in the number of standards being taught in tenth-grade biology; therefore, the amount of depth able to reach is limited. The goal is to increase student engagement and motivation into their learning through the exploration of skills and application. Beginning with a phenomenon, students create their questions, cultivating their interest in Biology. The main skills assessed in this unit are investigating scientific concepts and demonstrating their understanding through written and oral expression.

Rationale

This unit is designed for students to investigate the impacts mineral licks have on the biodiversity of organisms within Amazonian ecosystems. These natural areas are vital to various wildlife species, yet human interactions have begun to alter species behavior at these locations. Students will explore photographic evidence downloaded from camera traps and calculate distributions of types of organisms visiting different mineral licks. Groups of students will be able to pool and then compare data to determine biodiversity in different regions of the Amazon. Students develop a curiosity about how human presence can impact these niche ecosystems and the organisms that rely on its resources. The goal of the unit is for students to apply their knowledge of camera trapping and calculating biodiversity in the Amazon to our constantly changing ecosystem in Middletown, Delaware. They compare stable conditions to the introduction of farms and roads and assess how an ecosystem can change over time.

Although ecology is the largest unit in our biology course, much of it does not incorporate real-world applications that students can relate back to our own local ecosystem. Using the camera traps set up in the Amazon creates an interesting phenomenon that students want to explore further. In the Next Generation Science Standards, phenomena are the hooks for student engagement at the beginning of a unit; eliciting student questions and curiosity that can be explored and evaluated. The result of the unit will allow students to explain their initial curiosities and answer their questions. The goals of the unit are to incorporate a literacy component, analysis of data, and computational models while continuing to practice their communication skills through class discussions and written responses.

The unit is introduced using a combination of camera trap images and data collected at mineral licks of various wildlife species that visit these sites in the Peruvian Amazon. Students ask questions about the types of organisms viewed in the images, their preferential food sources, reasons why they might be visiting mineral licks at certain times, whether species are nocturnal or diurnal, and the frequencies of these organisms' visits. Students analyze the data about types and frequency of organisms visiting mineral licks and compare this data to that of which has been collected in areas frequently visited by humans. Using their understanding of the Amazon, students investigate how the changing ecosystem surrounding our school's property is impacting

the biodiversity of the area and the local species' behaviors. Students set up camera traps on the property line of the school – part field and part forest – to discover frequent visitors. The camera traps are monitored throughout the semester to gather data as deforestation and urbanization continues. Using simulations, students can experience how changing the present conditions through human activities impacts the ecosystem. The unit is designed for groups of students to evaluate how changing an environment can have a drastic impact on local species relying on specific resources. Throughout the unit, students complete group models, analyze maps and images, explore simulations, and read various primary source texts to assess content understanding. Students have the option to display their understanding verbally or in written form.

As a result of completing the curriculum unit, students are able to explain the importance of natural resources such as mineral licks and how human interactions impact the resources and the species who rely on these resources. Students can explain biodiversity of an ecosystem and how it can change within a region over time. This unit gives students a foundation of analysis skills that are applied to multiple scenarios. By the end of the unit, students have a greater understanding of indigenous groups and their impact on local ecosystems. Students are able to communicate their position on impacts of biodiversity using evidence from the Amazon and their local ecosystem to local lawmakers in a written or video submission.

Background Knowledge

Prior Knowledge

Students have been studying ecology thus far in the biology course and therefore have a deep level of understanding of population dynamics, biological interactions, nutrient cycles and various ways humans impact the world around them. Students understand that species rely on each other, either as a food source or are participants in symbiotic relationships. Students have a general understanding that if one organisms' predator or prey population increases or decreases, there are ramifications in the other population. Human impacts are discussed as it relates to the nutrient cycles – specifically how humans are altering the carbon cycle through mining and the burning of fossil fuels. Students understand that although humans impede on an environment, there may not be any immediate detection of deeper consequences and therefore, behaviors continue. Biomes are introduced to students in middle school and not revisited in high school, so there could be some gaps in knowledge in comprehending the uniqueness of the Amazon rainforest.

Mineral Licks

Mineral licks are a phenomenon located throughout the Amazon rainforest and all other ecosystems throughout the world. These are naturally occurring areas where various species are able to obtain essential minerals lacking from a normal diet[1]. Visiting organisms might utilize the clays in the soil to relieve indigestion caused by plant-based alkaloids[2]. Organisms who consume the clay at mineral licks to soothe their digestive tract relates to humans utilizing antacids, like Tums, to relieve indigestion. In contrast, organisms like the Amazonian

bat, visit these sites to during pregnancy to gain sodium, potassium, and magnesium[3]. Mineral licks provide local organisms with necessary dietary requirements unable to be obtained through a typical diet – similar to a person taking vitamin supplements or drinking milk that has been fortified with vitamin D to gain required minerals and vitamins in their diet.

The areas categorized as mineral licks, are typically found at the base of hillsides in both floodplain and upland forests where the areas are poorly drained and muddy[4]. The area within the defined mineral lick is typically devoid of any vegetation[5]. According to one research group, the distance between mineral licks ranged from 0.7 kilometers to 7.1 kilometers depending on the forest, but often were found near the base of slopes[6]. Organisms may need to travel long distances from their territory in order to access a mineral lick which has the essential minerals and nutrients they need.

Visitors to these sites are made up of various small, medium, and larger mammal species and bird species. Camera traps have been set up to detect and record organism movement in these areas through infrared cameras. Over the course of a four-year period, and four different mineral licks, twenty-three species of mammals and fifteen species of birds have been recorded by these cameras[7]. According to the data, red brocket deer, collared peccary, paca, and south American tapir were the most common mammals recorded at multiple mineral lick sites[8]. The common piping-guan, plumbeous pigeon, and salvin's curassow were the most common bird species to visit the mineral lick sites[9]. The frequency of specific organisms and time of day visited can be dependent on the location of the mineral lick; closer to settlements or human hunting sites, decreases the biodiversity of the locations. Hunting is most intense near settlements and along roads – these mineral licks experienced the lowest biodiversity when compared with mineral licks where hunting was rare[10]. In comparing two different mineral lick sites, the site further away from local settlements captured almost four times more photographs made up of twice as many species of visiting birds and mammals than the mineral lick close to indigenous settlements[11]. The red brocket deer also timed their visits based on the lunar cycle; more likely to visit at times near a new moon to avoid being seen by predators in the moonlight[12]. Species have adapted to visiting sites further from human hunting ranges or adjusting the time of day when visiting mineral licks.

Mineral licks are vital to Indigenous groups who rely on the bird and mammalian species as their own food source. Hunting at mineral licks accounts for thirty percent of all harvested resources for some communities and can take place during the day and at night[13]. The most important species for the Maijuna, one Indigenous group with communities in the Amazon, include the paca, collared peccary, white-lipped peccary, red brocket deer, and tapir[14]. The game species desired and most regularly hunted by the Maijuna aligns with the organisms who frequent the mineral licks. Although much of the organism is consumed by the community, some meat is sold outside of the community for income[15]. Other parts of the animal are used for medicinal purposes, instruments, and crafts for tourists; for example, the red brocket deer's meat is for local consumption, while its teeth are for tourist crafts and the hide is used to make drums[16].

Traditionally, hunters would have to lie in wait either on the forest floor or higher up in the trees, even on hunting platforms, to hunt desired species[17]. Due to increased hunting pressures, some populations are becoming primarily nocturnal visitors to mineral licks than previously noted, while other species are becoming more common at certain sites because the larger game species are not visiting as frequently[18]. With the introduction of shotguns and flashlights, hunters are able to be more accurate in their shots and hunt for longer periods of time[19]. Flashlights allow hunters to kill increased numbers of nocturnal species than in previous generations[20]. With increased accuracy and longer periods of daily hunting, it is expected that vulnerable species will struggle to maintain a stable population size due to possible overhunting. Two mineral licks were compared based on frequency and number of different species visiting. It was noted that peccaries, although they are most active during the day, rarely visited the mineral lick near settlements during the afternoon hours, but were present at the mineral lick further from any settlements[21]. Altering the environment could pose evolutionary consequences on mineral requirements and population survival.

Biodiversity

Biodiversity in an ecosystem is the number of different species inhabiting the area. Ecosystems can have a high biodiversity where there are lots of mammals, birds, plants, and insect species living in the area or a low biodiversity where there are few differing species. Some ecosystems naturally have a lower biodiversity due to fewer available resources, such as desert climates. In contrast, the Amazon rainforest and other tropical rainforests globally, are known to be the most diverse terrestrial regions on Earth due to the limited human influence and abundant natural resources. Changes in climate and human interactions have the ability to alter species biodiversity. Typically, with human intervention species biodiversity decreases within a region. Students have first-hand experience with this as forest and agricultural lands are being urbanized with housing developments, roads, and shopping plazas.

Camera traps

Camera traps are established near mineral licks and left to collect data for weeks to months. These traps detect infrared motion in order to document animal activity[22]. Researchers must determine in which direction to point the cameras in hopes of collecting multiple data points. They use evidence of animal tracks or soil disruption to best determine where cameras should be placed in order to maximize the potential for capturing any activity[23]. Camera placement must minimize any obstructions while casting a wide-enough view on the area. In order to conserve battery and storage space, the cameras were set to take five photographs at each motion detected event with one to two seconds of separation[24]. Results from the camera traps allow researchers to compare multiple sites based on organism activity without the intrusion of humans. Not all organisms visiting the mineral licks were included in the data, such as small-bodied birds and mammals, because it was less likely researchers are able to identify individuals to a species level[25]. Although many species were visible in images, only those able to be completely identified and categorized were included in data sets.

Teaching Strategies

This unit has been intentionally designed to incorporate the school's literacy focus while developing a deeper scientific understanding. The literacy initiative requires students to read, write, speak, and listen at a proficient level as recommended by the SAT and PSAT. All tenth-grade students are assessed on their literacy skills through the PSAT, with the exception of speaking and listening which are only assessed in the classroom. To comply with the school-wide implementation of improving student literacy skills and Next Generation Science Standards, the unit contains multiple scaffolded opportunities to read, write, speak, and listen.

The Next Generation Science Standards ask students to construct explanations and evaluate claims based on data and evidence. This is accomplished in a writing prompt where students make a claim about biodiversity in a changing local ecosystem and support their claim with evidence from class research. Students incorporate science concepts as reasons to connect the evidence to the claims made. Class discussions are an imperative part in reaching proficiency within the Next Generation Science Standards allowing students to build a deeper understanding of the content and core ideas. Permitting time for students to verbalize their thoughts and ideas within peer groups, with the assistance of prompts, allows groups of students to clarify their individual thinking. In small groups, students are asked to discuss the data presented about the numbers and types of organisms visiting mineral licks in the Peruvian Amazon. Groups share out ideas to the class to develop a larger discussion about the data. Groups are then challenged to make comparisons to the local ecosystem that is currently being developed to the Amazonian mineral licks that have been seeing changes with the increase in hunting and road development. After a few minutes to discuss with the small groups, the entire class is brought back together to share out take-aways.

Discussion starters are provided to groups to encourage thoughtful conversation, rather than the traditional idea where one member speaks and the other three agree. Without stem starters for conversations, groups tend to share their own ideas but do not listen and interact with the ideas with their peers. They feel compelled to share their own ideas, but do not fully understand how to develop a conversation around one person's thoughts. The talking points allow individual students to expand or clarify their thinking and challenge each other's thoughts in a positive way. Students are encouraged to listen carefully and repeat back in their own words what they heard before agreeing or disagreeing with the original statement. It is important for students to improve their reasoning skills by asking each other why they arrived at a particular conclusion.

Grouping students is a normal challenge faced by teachers. For this unit, it is important to distribute students so that a heterogeneous mix based on talkativeness, knowledge level, and writing skill level are taken into account. Although in some scenarios, having homogeneous groups is beneficial, in this scenario, scaffolds are in place for talking points and peer feedback for writing. As part of Next Generation Science Standards, group discussion to put the content pieces together is an integral part of the curriculum and is valuable to use students whose strengths are in speaking, as a way to elicit the deeper reasoning from students who tend to be timid in a group setting. Students with accommodations who struggle with processing skills and making connections, can use the talking points to gain additional clarification from group

members.

Peer-reviewing rough drafts is an important skill where both the reviewer and original writer gain valuable feedback and knowledge. The student reviewing the draft compares the writing to the final rubric to determine where their peer was successful and where there is room for improvement. They grade the rough draft as if it was a final draft and provide written feedback to their peer. Analyzing another person's work, allows them to also self-assess their own writing – clarity and included details. The feedback is intended to help the original writer to produce a coherent and professional finished product. If students choose to create a finished product in the form of an infographic or video, they still complete the peer-review activity using either their script or rough draft of the infographic.

One of the goals of this unit is to combine the practice of a blended learning environment with the Next Generation Science Standards. Blended learning focuses on the integration of technology to create a personalized learning experience for students. The instructor provides the resources necessary for students to develop a deeper level of understanding, such as data, images, and stem-starters to facilitate small group discussions. Students have the opportunity to demonstrate their understanding by submitting work in a variety of ways such as creating a video, infographic, or written proposal. The goal is to provide students an opportunity to practice various 21st century skills: extracting information from resources, using technology as a tool for information, verbalizing ideas, applying information to a new situation, and self-assessment. The unit requires students to independently analyze data and images to make claims about biodiversity at mineral licks, orally share their conclusions with peers, and produce a written response that connects the Amazon to Middletown, Delaware. Written responses receive feedback from peers prior to revising their initial thoughts. After a final draft is developed, the instructor is able to grade the student responses on a rubric.

Student Activities

This unit can be utilized as either a long-term ecology project or a shorter experiment. The instructor has the ability to complete the first portion of the unit – data analysis and camera trap set-up – at the beginning of the ecology segment. The class continuously builds content knowledge in the classroom of ecosystems, population dynamics, and biological interactions, as they periodically check the camera trap sites. The culminating assignment, a letter to the politician, can ask students to use more than just data collected from the traps, but include all ecology topics covered during the course. The unit can be shortened with less data collection and fewer visits to the sites. One ultimate goal is to collect wildlife data over multiple seasons and years. This is best accomplished with semester courses where data is collected twice a year – once for each semester.

Unfortunately, this unit is less adaptable to a virtual learning platform due to student groups designing and setting up a camera trap experiment on the school property. If necessary, the instructor can conduct the research and create a video blog of the conducting of the experiment and provide students with the images and data to analyze.

Introductory Video

As a whole class, students will watch The Amazon introductory video and make observations about the ecosystem, the mineral licks visited, and organisms inhabiting the area. Students ask questions about what they wonder from the video. These questions might be based on mineral licks, camera traps, hunting and participatory mapping, or the ecosystem as a whole. The video sets the stage for how camera trap data was collected, and the types of images found. It also provides perspective on what mineral licks look like and how scientists identify animal behavior in these areas.

Amazonian Data Analysis

In small groups of three or four, students are provided with multiple data sets from the Amazonian mineral lick sites, chart paper, and markers. Data sets include the type and number of species visiting several mineral lick sites, the frequency of these visits, and information about the location of these areas, such as relative distance to settlements and hunting ranges. Groups are prompted to observe patterns within the data and record their findings in preparation for a class discussion. On the chart paper, students record the patterns noticed as well as any questions or wonderings they have about the data. After approximately five minutes, the class is brought back together and discussion prompts are placed on each table to help facilitate peer communication. All groups have had a chance to analyze the same data sets and therefore are able to build upon each other's notices. The teacher should compile a class consensus list of patterns identified.

Groups share out their observations of patterns within the data sets while making connections to the locations. Students are able to observe a difference in the types and numbers of species visiting mineral licks when comparing areas with higher human presence versus more remote sites. There is a larger variety of organisms captured on camera in the sites further from hunting ranges. Students notice there are more visits to mineral licks less frequented by humans. There are more visits to sites throughout a twenty-four-hour period further from settlements, while organisms tend to visit sites less frequently during the day when closer to settlements.

After the class creates a whole understanding of the data, an area in the classroom is designated to record questions about the data that were not able to be answered by peer groups. The teacher poses a follow-up question about how the patterns in the Amazon could connect to our local ecosystems. Groups are provided a few moments to discuss possible connections before sharing out their ideas to the whole group.

Local Camera Traps

Students continue to work in their groups as they look at ariel views of the school property using Google Earth. The ariel view is used to determine current locations of housing, forest area, streams, construction, and roads not easily visible from an eye-level perspective. Based on

ariel maps, groups decide on potential sites to set up camera traps that would be most likely to capture various local wildlife species. The class is taken on a "class trip" around the school's property to take into account potential noise pollution, air quality – specifically from construction areas – and forest density. Upon returning to the classroom, groups come to a class consensus as to where camera traps should be assembled. Depending on the number of available camera traps, your class may only be able to set up one; however, if you teach more than one section, encourage later classes to choose different potential sites to set up a camera.

Students return outside to the agreed upon sites to set up the cameras. At the location, students look for evidence of wildlife, including tracks, nests, or scat remaining from an earlier wildlife presence. Making these observations will allow students to best place cameras focused on historic sites of animal presence. Groups document evidence of wildlife using photography that can be uploaded and shared to a common document and labeled with the date and location. Students set up the traps and identify their location on a map for future retrieval. Sites with multiple pieces of evidence of wildlife are best suited to set up the camera traps because it will increase the probability of capturing organisms on camera.

After one week, the cameras are collected, and the images are gathered and analyzed. The photographs collected from all three biology classes, are aggregated, and uploaded to our learning management system for all students to have access to the images to analyze. Species are identified, counted based on number of times visiting the area, and the data is input into a spreadsheet by students. The data is kept for future use. Upcoming biology classes will continue to set up the traps and gather data; over many semesters and years, there will be enough data to determine whether or not there has been a shift in the numbers and types of organisms visiting the school grounds. Although the first semester or two that this unit is implemented, there is not enough data to make accurate conclusions about the changing landscape, students can make predictions of past and future organisms inhabiting the area.

Letter to a Politician

This activity may eventually have enough supporting evidence to actually send to local lawmakers; however, for the first few years, there is not enough data to support claims outside of being concerned citizens. Regardless of whether students are able to send the letters produced to local politicians, the responses must be filled with evidence from class to support their position and include concrete data analysis.

Students construct a letter, video, or infographic about the changing biodiversity of the local ecosystem. The audience those students should have in mind while developing their arguments is their local politicians. Student responses must cite specific evidence from their field study as well as connect their local ecosystem to the mineral licks in the Amazon. Students include content knowledge learned throughout the ecology unit – organism interactions and human impacts. Rough drafts of either the letter, video script, or other method of communication, are peer-reviewed by classmates based on the same rubric that the teacher uses for grading. The writing process is an important part of the Next Generation Science Standards and therefore feedback should be given prior to the final submission to allow students an opportunity to

revise their thinking.

Content Objectives

With the completion of this unit, students will be able to:

- Explain how changes to an ecosystem impact biodiversity.
- Explain the natural phenomena of mineral licks and apply its ecological importance to local ecosystems in Delaware.

Appendix A

HS-LS2-6: Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.

Students begin to address this standard by analyzing data from three different ecosystems – mineral licks far from settlements, mineral licks close to settlements, and a local ecosystem – and evaluate claims with evidence to support observations made based on the comparisons of biodiversity of the ecosystems.

HS-LS4-6: Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.

Students address this standard by identifying impacts of human activity on biodiversity in both the Amazon rainforest and their local ecosystem. Students propose solutions to local lawmakers about the changing biodiversity due to construction and a shifting landscape.

Teacher Resources

National Science Foundation. 2012. Checklist: Goals for Productive Discussions and Nine Talk Moves. *The Inquiry Project: Bridging Research and Practice.*

Students participate in small group and whole class discussions during this unit. The resource can be used by teachers or modified for students to provide stem starters and discussion prompts.

Research Resources

Blake, J. G., D. Mosquera, and J. Salvador. 2012. "Use of mineral licks by mammals and birds in hunted and non-hunted areas of Yasuni National Park, Ecuador." *Animal Conservation* 430-437.

This resource has been used for research purposes and content background knowledge on mineral licks and provides data sets able to be used by students.

Gilmore, Michael P., Brian M. Griffiths, and Mark Bowler. 2020. "The socio-cultural significance of mineral licks to the Maijuna of the Peruvian Amazon: implications for the sustainable management of hunting." *Journal of Ethnobiology and Ethnomedicine* 1-10

This resource has been used for research purposes and content background knowledge on mineral licks and provides data sets able to be used by students.

Griffiths, B. M., Bowler, M., Gilmore, M. P., & Luther, D. 2020. "Temporal patterns of visitation of birds and mammals at mineral licks in the Peruvian Amazon". *Ecology and Evolution*, *10*(24), 14152–14164.

This resource has been used for research purposes and content background knowledge on mineral licks and provides data sets able to be used by students.

Notes

[1] Gilmore, Michael P., Brian M. Griffiths, and Mark Bowler. 2020. "The socio-cultural significance of mineral licks to the Maijuna of the Peruvian Amazon: implications for the sustainable management of hunting." *Journal of Ethnobiology and Ethnomedicine,* 2.
[2] (Gilmore, Griffiths and Bowler 2020, 2)
[3] Griffiths, B. M., Bowler, M., Gilmore, M. P., & Luther, D. 2020. "Temporal patterns of visitation of birds and mammals at mineral licks in the Peruvian Amazon". *Ecology and Evolution*, *10*(24), 14153.
[4] (Gilmore, Griffiths and Bowler 2020, 4)
[5] (Griffiths, et al. 2020, 14154)
[6] Blake, J. G., D. Mosquera, and J. Salvador. 2012. "Use of mineral licks by mammals and birds in hunted and non-hunted areas of Yasuni National Park, Ecuador." *Animal Conservation,* 432.
[7] (Blake, Mosquera and Salvador 2012, 431)
[8] (Blake, Mosquera and Salvador 2012, 433)
[9] (Blake, Mosquera and Salvador 2012, 433)
[10] (Blake, Mosquera and Salvador 2012, 434)
[11] (Blake, Mosquera and Salvador 2012, 432)
[12] (Griffiths, et al. 2020, 14158)
[13] (Gilmore, Griffiths and Bowler 2020, 2, 4)
[14] (Gilmore, Griffiths and Bowler 2020, 4)
[15] (Gilmore, Griffiths and Bowler 2020, 4)
[16] (Gilmore, Griffiths and Bowler 2020, 4,5)
[17] (Gilmore, Griffiths and Bowler 2020, 5)
[18] (Blake, Mosquera and Salvador 2012, 435)

[19] (Gilmore, Griffiths and Bowler 2020, 8)
[20] (Gilmore, Griffiths and Bowler 2020, 8)
[21] (Blake, Mosquera and Salvador 2012, 433)
[22] (Blake, Mosquera and Salvador 2012, 432)
[23] (Blake, Mosquera and Salvador 2012, 432)
[24] (Blake, Mosquera and Salvador 2012, 432)
[25] (Griffiths, et al. 2020, 14154)