



Curriculum Units by Fellows of the National Initiative

2020 Volume V: Caretakers versus Exploiters: Impacting Biodiversity in the Age of Humans

Ecological Effects of Strip Mining Coal on the Black Mesa Mine

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Introduction

Indigenous people around the world believe the Earth is our mother. We think she is breathing and alive. Nihasdzaan (Our Mother) cares and feeds us. She has organs inside her. The Sioux tribe believe the Black Hills is the heart of Mother, the tribes in South America believe the Rain Forest is her lungs, and the Dine People believe the coal in Black Mesa is her liver. There are other Indigenous nations globally that have a common belief that the Earth is our mother.

All native nations are worried about Mother Earth, and that the damages to her system caused her to retaliate. Many say she is angry, hurt, and in pain, and believe this is why there are stronger storms and other weather events that last longer: hurricanes, tsunamis, tornadoes, earthquakes, and heatwaves. Not only storms but also other damaging events like global warming and the extinction of animal species. The elders on the Dine Nation say, "The damage done, let her heal now." However, this will not happen because the human populations around the world demand Mother Earth's resources.

On the Dine Nation, the Navajo people who live on Black Mesa have had to endure the blasting earthquakes, aftermath explosion of dust, and the constant digging of the large dragline's bright lights and loud engine noise operating 24/7. These two mines, Black Mesa and Kayenta, stripped, extracted, and transported coal to nearby and distant power plants. These power plants burn the fuel to provide electricity to big cities such as Las Vegas with its glimmering lights, and to Los Angeles, Phoenix, and Tucson. The Page Navajo Generating Station (NGS), the Mohave Generating Plant in Nevada, were the two plants that received transported coal. The NGS uses an electric train, and the Mohave used a coal slurry pipeline needing precious water extracted from the D and N aquifer below the mesa. Using the aquifer, depleted running streams and small ponds provided water for the two tribes (Hopi and Navajo) livestock, cornfields, and daily living usages. The mine uses approximately 3,800 acre-feet or 1,425 gallons of water annually.¹

Today the shutdown mines leave a legacy of ecological devastation, the reclamation of land from strip mining, scarcity of water, archeological sites destroyed, and human rights abuse. About ten to twelve thousand Navajo families and about eight hundred to a thousand Hopi families removed from their homes were the human rights abuses. It was the most significant removal of Indians in the United States since the 1880s.² Also, ecological damage from the strip mining of the land slowed the water's natural flow into the aquifer, and

affected water need to saturate into soil and flow with the landscape. The original flora and fauna of the particular stripped area will take many years or decades to return to its natural state. It will take years for native trees to take deep roots, and the natural land formations no longer exist. The rolling hill on the Black Mesa is not a natural landscape scenery because the original structure had gullies, ravines, and cliffs, as well as various species of wildlife that are no longer present.

Rationale

As long as I can remember, Black Mesa has been the most noticeable land formation at the height of about eight thousand feet at its peak, then gradually sloping down. The mesa is south of my rural town of Kayenta, Arizona, on the Navajo reservation. The four thousand square mile mesa takes the shape of a bear's claw when viewed from the air. The Dine people call it Dziliziin, meaning Black Mountain. The plateau is not black, but strips of coal are visible in the arroyos and ravines before the mining of this fossil fuel. Since the 1960s and forty years later, the Peabody Coal Company established its rights to mine the land. Peabody planned intensive mining of approximately four thousand acres annually for 35 years to meet its contractual agreement with the owners of the Navajo Generation Station.³

The local communities on the Hopi and Navajo Reservation have reaped benefits of the mine's services, like jobs for both tribes, free coal to keep their homes warm during the winter months, and Peabody Corporation was supporting the town businesses and royalties the tribes. These benefits from the mining company have ceased, and the tribes, communities, and families need to adjust their budgets and tighten their belts to do without profits. Most families will move to the big cities to continue work and to support their families.

Based on my observation, Kayenta (Dine) and Tuba City (Hopi) were booming communities during the mine operation. Today, the communities rely on the tourism business, the local public and Bureau of Indian Education schools, and the clinic/hospitals. The Kayenta community has about five to six thousand residents. Outlying rural communities like Oljato, Dennehotso, Baby Rocks, Chilchinbeto, Black Mesa, Shonto, and Inscription House come into Kayenta for shopping needs, fast food restaurants, the Black Mesa Theater (movie, before COVID), banking, education and the sports program for their children.

I have many years of experience working within the Kayenta Unified School District. KUSD has four schools: the ABC preschool, the elementary school (KES), which has kindergarten through fourth grades, the middle school (KMS) grades fifth through eighth and the Monument Valley High School (MVHS) grade ninth through twelfth. Included with the ABC preschool are the Navajo Nation Head Start and the FACE programs for the younger students. There are two Head Start classes and one FACE program within our community to educate the younger students ages three through five years. According to the Kayenta School Board minutes (May 2020), 1,719 students attend KUSD. Included with the student count are the feeder schools within a fifty-mile radius of Kayenta, who have students attending KUSD. The Bureau of Indian Education Schools like Kayenta, Chilchinbeto, Dennehotso, Shonto, and Black Mesa Community are a few of the surrounding schools.

Many parents within the Kayenta community work at the local business, the clinic/hospital, and schools, to provide for their family needs. The poverty rate among the community is 42.55%.⁴ The poverty rate among those who worked full-time for the past 12 months was 8.20%, part-time was 41.90%, and those that did not work was 52.82%.⁵ These reports show that many families need additional support from the schools like

lunches for students during the summer months, the culture center food bank, and other necessities for their education. As a title one school, the district supports and provides other services to families like the school and community internet, laptops for each student, and free online education platforms.

From years of working in my school district, I know the school has implemented the Inclusion Model and has been using the method for many years. The inclusion model aims to commit to educating each child who enters the classroom regardless of the child's disability. The child's support service would come into the school to modify or accommodate the lessons taught for the day while addressing the child's Individual Education Plan (IEP) goals. In addition to Special Education students, the English Language Learner and 504 students are included in the classroom setting. These students need special accommodations, and teachers need to have the training to provide different methods and strategies to assist with specific students who struggle with learning the concepts.

Besides accommodations, my district has initiatives that provide educational services to students for distance learning. These platforms for online teaching will have teachers teach students. At the same time, my district decided upon the Arizona Department of Education (ADE) scenarios for the coming fall 2020, to prepare for the hybrid model or fully online learning.

The curriculum unit I am preparing will address fifth-grade students and is adaptable to fourth-grade students as well. As long as I have been teaching, I have heard from other teachers about the lack of basic science knowledge for students when they get to eighth grade. At the eighth-grade level, students take the state science and the NWEA science assessments. Many of these students do not have a strong background in science concepts because they did not receive adequate science instruction during their earlier grade level years.

Students need to know the standards and need to know the events that are happening within the Dine Nation, in the local communities, and globally. These events, like water scarcity, the closure of the mines, the arid land strip mining, ecological impact, global warming, and climate change, are essential factors our students need to know. This critical and historical information is dire for our children's knowledge. The knowledge will affect their future choices, help their people, and make a change for a better world.

Content Objective

I would like to search for more in my backyard. My backyard is the stripped coal mines on the Navajo Reservation. The Black Mesa Mine is a plateau about a forty-minute drive southwest from Kayenta. Until 1969, the coal was untouched, and the land continued to provide substance to all living creatures. The thick black veins of shiny coal were close to the surface and were visible within gullies and creek beds. I recalled seeing these very thick coal veins when my family used to drive into the pits to extract the shiny coal. The value of black coal was one of the most abundant and choice minerals sought by coal companies and individuals across the reservation. An estimated value of \$100 billion provided more energy to the big cities like Phoenix, Tucson, Las Vegas, and Los Angeles.

Forty years of striping mining, and the altered land and water usage for transporting the coal slurry from Black Mesa, made profits for the company and cities. These factors promoted progress for stakeholders who

invested in coal but not for some view the mining as irreversible damage to the land. Some sixty-five thousand acres were leased by the Hopi and Navajo tribal councils to the Peabody Coal Company of Kentucky, the largest coal producer in the United States.⁶ Thus, began the mining process.

Content Background

Strip Mining

The strip-mining process in the Western United States is quite different from the Eastern part of the nation. First, the climate in the west is arid or semiarid, with low precipitation annually. This type of environment has drought conditions with hot days and cold nights. The erosions of soil and rock are seen visibly because of sparse vegetation. Water is the key when reclaiming lands in the west. There are five main types of surface coal mining techniques: area mining, open-pit mining, contour mining, auger mining, and mountaintop removal.⁷ When the Black Mesa mines, began the implementation of strip mining, there is a process in how to excavate coal.

Surface mining follows these necessary steps to limit damages during the removal of the land.

1. First, surface vegetation (trees, bushes, and shrubs) and homes where the coal seam is found are scrapped and removed.
2. Next, the bulldozers, scrapers, and loaders remove the topsoil. The operator either stockpiles the topsoil for later use or spreads it over an area already mined.
3. Below the topsoil are layers of rocks drilled, blasted, and removed by bulldozers, shovels, bucket wheel excavators, or draglines.
4. After removing the layers of stones, the exposed coal seam is fractured by blasting.
5. The operator then loads the fractured coal onto trucks or conveyor belts to transport to silos or trains.
6. The operator dumps the rocks removed during the mining into the mined area and grades and compacts it. Special handling may be necessary if any of the stone contains toxic materials, such as acid or alkaline-producing materials.
7. Any excess rocks that remain after the mined area is completely backfilled (Eastern mines generally have substantial excess spoil) are deposited in a fill.
8. Finally, the operator redistributes the topsoil and seeds and revegetates the mined area.

While these necessary steps are relatively consistent, the environmental impacts of the five main techniques vary significantly.⁸

The final stage of strip mining is not the end. Damage to the land is irreversible because many lives were changed. The Dine people who lived there, the wildlife, the native vegetation, and the small ponds, streams, and creek beds are no longer there. The natives who live on federal reservation lands are in a unique situation because when the government says we need your natural resources, they will come in and take it. They moved the native people and their homes, their pasture ranges, and livestock to get to the coalbed. The treaties signed during the 1800s were an agreement from the government to provide the Indian people necessities to become American citizens—natural resources of uranium, coal, and oil were not stated in the treaties.

The rolling hills do not fit the natural contours of the mesa. Based on what I have seen, the stripped area is an ugly area like a bald spot. The short rain bursts caused rapid running streams, which form gullies and ravines and eventually form erosion when the vegetation is not deeply rooted. The constant wind creates twisters and sandstorms, lifting the topsoil into the air. The native vegetation on the mesa adapted to the arid climate, and these plants provide soil stability during rain and windstorms. I rarely see this previously abundant large animal wildlife (coyote, bobcats, mountain lions, badgers, deer, elks), various birds (hawks, owls, hummingbirds, and others), and smaller burrowing animals. They died or had to move to another part of the mesa. Some animals cannot adjust to the sudden change of land disturbance. These places were their habitats for breeding, and the caves and burrows were their homes. Since the mine initiated with an increase in human activities, larger game animals are rarely seen.

In addition to the strip mine issues, there is also the coal slurry pipeline problem. There have been numerous spills along the pipeline route to the Mohave Generating Station. The slurry is composed of water and coal powder. The spilled coal slurry can damage waterways and threaten wildlife. The Arizona Department of Environmental Quality and the EPA say the pipeline maintained by Black Mesa Pipeline Inc. has leaked more than half a million gallons of coal slurry in 15 separate spills.⁹ Corrosion of the pipe caused the leaks, and Peabody is not properly monitoring the pipeline. For each discharge, the company has to pay a fine and conduct the cleanup. Some spills not reported promptly caused more damage. Nearby communities and environmentalists want Peabody to pay penalties for each spill. It stated that some of the slurries' spills were never cleaned.

Done is finished, and it cannot change, but we can prevent it by learning more about what happened to the land in terms of mining, water, vegetation, wildlife, and people on the Earth.

Today, there are guidelines and regulations available to the public. We need to educate our children and ourselves and not let these large corporations come in and take what they want and leave a mess.

Water

Water is scarce in the Southwestern United States. The precipitation in the Southwest varies in elevation. Some areas receive more rain than others do. The four-corners region receives an estimated ten to twenty inches of rain per year. Water is vital to all living creatures, especially in the Southwest, where water is valuable. In the Diné Nation, about 30% of families do not have running water. The families use water for personal use, watering their livestock and cornfields. On the Diné Nation, the Navajo people quote, "Tóbee iiná," meaning water is life.

When Peabody Coal Company came onto the mesa to extract coal, it took vast amounts of water from the aquifers. The water supply for all mining operations (including coal transport) derived from five wells spread two miles apart at a depth of approximately 3,600 feet; groundwater pumped from the deep Navajo Sandstone aquifer (N-aquifer).¹⁰ The company constructed wells to transport slurry coal from the Black Mesa Pipeline to the Mohave Generating Station. The coal slurry is a mixture of water and powdered coal. Four pumping stations convey the coal slurry through an 18 inch diameter pipeline that stretches 275 miles at a velocity of five miles per hour.¹¹ The transportation of the black mud was continuous for 35 years, since 1970. From 1970 to 1978, Peabody's estimates from average and maximum annual withdrawals were exceeded in six of nine years the pipeline was in operations, which accounted for 75% of total water pumped from the N-aquifer.¹²

The water usage on Black Mesa by Peabody caused the rapid decline of the aquifer after constructing three more wells. The water table level lowered gradually to the N-aquifer that exhibited low water levels in the wells. It caused many tribal concerns, including: how much water level decline is the result of mine-related pumping, what further decreases may be expected over the life of the mine, and what will the long-term effects on the availability of water from the N-aquifer for other uses.¹³

Thank goodness! The Mohave Generating Station shut down in 2005 and ceased the use of a vast amount of water from the N-aquifer. Between 1994 and 1999, the 275 mile Black Mesa Pipeline failed twelve times; eight failures spilling coal-slurry onto the landscape or into nearby washes.¹⁴ It is estimated that approximately 2,290 tons of coal-slurry outflowed; no reclamation procedures or impact studies were performed.¹⁵ These spills impact the topsoil and cause leakage into the groundwater. The extent of damage of over two tons of coal spread onto grazing land is uncertain, and the company will not take the initiative to clean the spills. These spill incidents were not publicly disseminated for all people to be informed.

The N-aquifer is a massive lake under the mesa. With time and yearly rainstorms, the aquifer will slowly increase its water level with the mine's closure. Yet, it will take years to equal the discharge from rain, stream, and creek beds. I hope when companies come onto the reservations, they will show care about the land and will not destroy the ground and taint the water. The Dine leaders need to ensure that all people who come onto the nation know how our culture respects the land, water, and air.

Reclamation

Black Mesa, as many western-mined areas, have vast lands, but water on these lands will always be an issue. Water is the main factor when environmentalists begin to reclaim mined arid regions. The choice of plants, the site of planting, time of planting, the water quality, and the erosion potential are essential elements on a successful reclamation. Expert knowledge of these essentials is the basis to reclaim the mined land back to its original state or better. The mesa's goal is to provide the residents' rangeland for their livestock (sheep, cattle, and horses) and cornfields. For most families, their herd and cornfields are their primary sources of income.

A study conducted in two land areas, one on mined land and the other on the undisturbed ground, demonstrated an important comparison. Runoff data from the watersheds evaluated the effectiveness of revegetation efforts on the distribution and yield of surface water within the mined area.¹⁶ The data collected estimates of water quality, minerals, chemicals in the sediments, soil moisture content, water movement through soil, and the distribution and availability of plant growth, to examine whether these factors impacted the land and water. These collections are primary factors in revegetating the property. It would be desirable to ensure a steady supply of water to have the last cut filled for stock water from moisture that percolates through the mined ground.¹⁷ The results are that the soil content of both the mined and natural areas are similar. The texture of both soils is loamy; however, the mine soil has a more excellent range of water availability for plant growth than the natural area.¹⁸ The mine area still has no structure, and water tends to puddle, but in due time the conditions will get better for vegetation. The stripped area needs to show growth and productivity despite the arid conditions of lack of rain, and dry winds.

The vegetation needs years and years to return to its natural state. Many of the wildlife species, such as coyote, deer, badger, bobcat, and mountain lion, will not return because of the reclaimed area changed their natural habitat. Maybe the smaller ones, like rodents, insects, and snakes, will return. Today, when I drive around the land, many of the stripped areas do not look natural. I just see hills, more hills, a few shrubs, and

no trees. The mining corporations left behind their metal structures, which are eyesores on the landscape. The mines shut down a year ago and there are no obvious signs of thorough clean up.

When the established mines are on Indian (Federal) land, the land, vegetation, wildlife, water, and people take a toll from the contamination. Therefore, when tribal herbalists search and collect the herbs used in traditional medicines, they have difficulty determining if the medicinal plant is safe for humans to use or they have problems finding the plants at all. This results in them needing to travel further to other areas, off the reservation. I experience this same problem when I attempt to collect sage, tea, and pinion branch. Peabody stated they were careful to replant species of plants that have cultural importance. But some of the medicinal plants used by medicine men for ceremonies are no longer in existence on the reclaimed land. The medicine men said the grass planted took the place of herbs.

Dine People and medicinal plants

The Dine people have been using and practicing natural medicine as long as they have been on Earth. Research says the Dine people have been in the Americas since at least the 1500s when the Spaniards made contact with the Navajos. In one of the many books and articles I read, there was evidence of an ancient hooghan (hogan) discovered in the southeastern part of Colorado, dating back to the 1300s. The Navajo people know the southwest area and use the function and purpose of different plants in the area. They use these plants for medicines and for food.

When someone is sick within a traditional family, a family member will seek a traditional herbalist. The herbalist will prescribe the herb for the specific illness, which can be for the lungs, muscle, bone, and other ailments. The patient usually drinks or applies the plant as a topical to help with the sickness. When the herbalists search for herbs, it is difficult today to find because of the damaged land, lack of water for the herbs, and some plants are not safe anymore because of human encroachment. The individual has to travel further, where no contamination has damaged the land and vegetation. For example, the ch'il ahweeh (Navajo tea) grows along certain parts of the highway. You cannot pick them because of vehicle exhaust, trash debris tossed from vehicles, and restroom pit stops along the road which are evidence of human exploiters of the environment.

There are common herbs many families know about and use readily. Herbs like Tsa'aszeh tsotsi (Banana yucca), Nidishchii (Pinion pine), and ch'il ahweeh (Navajo tea) known as Green threads are common plants grown on the Colorado Plateau and hand-picked during a particular time for food, medicine, and ceremonies. An herbalist or traditional person picks the plants reverently and respectfully. The individual begins with a prayer facing the east, then to the Earth, the surroundings, and to the particular plant. The prayer is to bless the plant and to thank the plant for providing food or medicine. A gift of corn pollen or sacred stones is placed on or under the plant for giving a part of it. Then, part of the plant is snipped above the root, about three to four stems. The individual moves to another plant and cuts again; this process is repeated until the individual feels the plant's amount is enough for food or medicine. The medicinal or food plant has completed its use; the remnant of the plant is returned to nature and not tossed into the trash. When the herb has served its purpose, it is returned to the environment and placed under a juniper tree to feed it back into the Earth. These are the actions of humans as caretakers.

Reclamation teams have planted up to fifty different species of culturally and medicinally important plants. Plants including green Mormon tea, banana leaf yucca, four-wing saltbush, cliffrose, Gamble oak, fringed sage, Indian ricegrass, needle-and-thread grass, and pinion pine.¹⁹ The future of the mined areas will be an example

of a hopeful and prosperous reclaimed land.

Banana Leaf Yucca

Tsa'aszeh tsotsi (Banana yucca). Scientific name: *Yucca* spp. Plant type: cactus.²⁰ Flowers bloom in May and June, livestock and wildlife favor the fleshy and succulent fat yellow or green shaped banana. The ancient plant is found throughout the Western states. The banana yucca fruit is a traditional food. The stalks, seeds, and flowers prepared by roasting or baking are additional food luxuries. The fruits picked before they ripened, and the fleshy banana pounded into pulp to form into sweet flat cakes. Then eaten when ready or sun-dried for later. The roots are used for soap, shampoo, and as a laxative. I remember eating the flat fresh and delicious cakes. I also remember my mother digging out the roots to wash my hair, and my hair was squeaky and very clean. The leaf stems are woven into mats, ropes, and sandals. In addition, one hundred two stem leaves are used for counting win and loss points during a Navajo Shoe game.

Pinion Pine

Nidishchii (Pinion pine). Scientific name: *Pinus edulis*. Plant type: gymnosperm.²¹ The tree is a native plant found in the Southwest from 3,000 to about 8,000 feet elevation along with yucca and sagebrush plants. They grow in semiarid regions on rocky foothills, mesas, and plateaus. The leaves are needles, and the plant produces cones. The cones provide pinion nuts during the fall season in August through October. Neeshch'ii' (Pinion nuts) are preferred snacks for the natives who pick the nuts. The nuts are roasted for meals or mashed into a salve to relieve burns. The needles are boiled into a drink like tea that is used for stomach ailments and is a good source of vitamin C. The jeeh (sap) from the tree is heated and applied onto sores, cuts, bites, or boils to ooze out the infection. Chewing on the sticky juice relieves coughs, sore throat, and is used as a laxative.

Navajo Tea (Green thread)

Ch'il ahweeh (Navajo tea) is known as Green thread. Scientific name: *Thelesperma megatamicum*.²² The plant is native to the central and western parts of the United States, and is found at elevations of 4,000 to 8,000 feet. The herb is a perennial plant with stem branches up to 25 to 30 inches. The leaves are small and yellow flowers bloom at the top of the stem. The primary use of this plant is brewing for tea drinks. The tea acts as a mild diuretic to help the kidneys, alleviate stomach cramps, and purify the blood and headaches.

In arid regions with very little rain, the plant does not thrive abundantly in the wild. However, the hardy plant will grow sparsely in harsh conditions. Today, many of the Dine people begin to plant and harvest the tea plant because of human exploiters who damage the land. Some will sell them commercially, and others will donate the tea plant to people who need them for their ailments.

Cliffrose

Awééts' áál (Cliffrose). Scientific name: *Purshia mexicana*. Cliffrose is found on cliffs, mesas, and in washes, at elevations from 2,500 to 8,500 feet.²³ The shrub survives in drought conditions in the Southwest, and in the Great Basin regions. The plant grows in pinion-juniper woodland and shrubland areas. The shrub plant can grow up to eight feet tall. The flowers are white with cream to yellow color stamens and they bloom from April to June. The fruits ripen from September to October. The barks are shredded and used for padding cradleboards for the infants. The tiny leaves with dotted hairs are sticky to touch. The leaves can be pounded into a pulp and applied to sores and wounds. The leaves and twigs are made as a tea to induce vomiting for

an upset stomach.

These native plants found in the Western United States at specific elevations can survive in that zone. They are hardy plants that can survive drought conditions. However, companies come to take these resources; the demand for progress and the encroachment of humans who destroy the native vegetation and wildlife species are increasing. The elders, medicine men, herbalists, and traditional native people are worried about the struggle to find native medicinal plants. They have to travel further to collect individual medicinal plants. Even the common plants seen along the road are not suitable to pick. They need to walk to places where there is no evidence of human footprints, to choose the selected plants. Yet, when selecting these plants, they need cleaning. Washing, baking, boiling, and roasting helps clean the herbs for distributing them to the sick or for personal use.

The content strategies and classroom activities are from the Guided Language Acquisition Design (GLAD) model. The founder, Marcia Brechtel, wrote a book, "Bringing it all Together, Language and Literacy in the Multilingual Classroom". The book has numerous strategies and classroom activities I have used with my students during my many years of teaching. When teaching the unit, I will use the Dine culture and language when using the strategies and during classroom activities.

Content Strategies

Focusing and Motivation - Cognitive Content Dictionary and Inquiry Chart. The Cognitive Content Dictionary (CCD) involves a student's metacognition. Students are thinking about their thinking. It is a word study of a specific word from the unit of part of speech, other word form, antonyms, synonyms, word origins, and syllabication. The key in using the name is, the teacher uses the word all day, as a word study to practice breaking down the word and to use body movement and gestures for the word to help students remember the name. By the end, the teacher and students have heard and said the vocabulary about 45-85 times a day.

The Inquiry Chart is similar to the KWL chart. The inquiry chart sets the purpose for student learning using their background knowledge and their answering and questioning technique. On a poster chart, two written questions, 'what do you know about strip mining and what are you questioning about strip mining?' The graph will stay up with the duration of the unit. The teacher and students will review the chart daily and will add answers to the question as the group progresses.

Input Strategies - Pictorial Input Chart (Comparative and Narrative Input Charts). The pictorial input chart is a crucial strategy because it is useful in all content areas. It makes content information comprehensible. The teacher pencil sketches the image lightly onto a poster chart. For example, within this unit, the Black Mesa strip, mined areas with the silos, conveyer belt, and dragline sketched and labeled with vocabulary words and short key phrases about the mesa are written on the chart. After the completed sketch, the teacher uses colored markers to trace the figures, vocabulary, and critical information in front of the students. This imprinting and chunking of information help students remember the concept.

Classroom Activities

Introductory Lesson or Engagement - Guided Practice: Sentence Patterning Chart (SPC), Picture File Cards, and Exploration Report - The sentence-patterning chart assists students in practicing vocabulary, sentence structure, and poetry writing. All activities are conducted with the teacher, and then students complete one as a team task. The SPC uses five of the eight parts of speech to form sentences in columns. The labeled columns begin with adjectives, then nouns, verbs, adverbs, and prepositional phrases. Students brainstorm as

many adjectives, verbs, adverbs, and prepositional phrases as possible, until the columns are full of words. Then students practice reading or singing the words on the chart.

Picture file cards are specific pictures for the unit. These pictures stimulate questions, discussions, and writing. The images need to be high interest and collections from National Geographic Magazines. There are numerous activities for the picture cards, ranging from whole class to individual student, from oral language to direct teaching, to independent use.

The Observation chart is an activity that students can use with a picture file card. Students answer orally or write three questions using a picture file card: 'what do I observe, what am I wondering, and what is my prediction.' This classroom activity encourages students to use academic discourse, use the visual prompt to inquiry thinking, and models the scientific process.

Middle Lesson or Exploratory Lesson – Reading/Writing: Expert Groups, Process Grid, Co-op Strip Paragraph. The expert group includes one student from each table/group working with the teacher in a small group setting for thirty minutes. The teacher distributes a page about the topic with a mind map. The teacher and students read the text and create a mind map category, and then complete the mind map. The teacher uses pictures to identify the main ideas that students will learn. A paragraph at a time, the expert group (students) read the text chorally. After reading each section, the teacher guides students to highlight the main ideas in the book, and for each highlight, students sketch and draw a line connecting the sketch to the stress. As the activity progresses through paragraphs, the teacher releases responsibility to students to come up with the main ideas—students record information on the mind map adding their sketch and notes.

The process grid is a grid created on chart paper that organizes information into a visual across the top and down the side. The chart assists students with the processing of their learning by adding their information to the grid. Students use prior knowledge, questioning skills, generalization, predicting, and evaluating within the content. The teacher develops the category titles depending on the type of writing preferred. The teacher can use the grid to compare and contrast, sequencing, cause and effect, and academic vocabulary. The reason for the process grid is to prepare students for writing expository paragraphs.

After the process grid, the co-op strip paragraph follows and makes a connection from the chart. The co-op strip paragraph aids students in reading and writing expository text. It models the writing process with editing and revising. The teacher generates the topic sentence based on the process grid to insert the sentence string in the pocket chart. Then each team is to write one supporting sentence using the information from the process grid then the teams place their sentence strips in the pocket chart below the topic sentence. As a whole class, students watch the teacher tear the sentence strip to arrange the pieces in a paragraph format. The students and teacher orally read through the paragraph and ask the students if there are possible revisions like changing the order of the sentences or combined sentences. Then the class and teacher orally reread the item, and this time, ask the students of possible editing, spelling, grammar, and punctuation. This classroom activity will help students see the writing process and help struggle students who need additional assistance in writing.

End of the Unit Lesson or Evaluative Lesson – Closure/Evaluation: Students create a five-minute or a power-point video about a common traditional plant that will then present on zoom. A rubric for the PowerPoint grades their presentation. The rubric is a five-point scale with content, slide creation, slide transition, picture and background, mechanics, and presentation skills. Students will search the internet, interview their parents and grandparents about the herb plant.

Another end of the unit lesson for evaluation is for students to create a Big Book about strip mining or herb plants as caretakers of the Earth. The big book needs to have six pages with a front and back cover, with the key repeating the phrase and essential concepts. Three photos, sketches, pictures on each page to support the topic. For example:

The critical thing about caretakers is they honor, respect, and revere Mother Earth. (Key pattern phrase)

- (first key concept)
- (second concept)
- (third concept)

Closing pattern phrase

When students complete the generated big book, they will use a rubric to self-assess their writing and explain why they gave themselves a particular score. Then the teacher will use the same rubric to provide the student with a score. The final score from student and teacher should be similar.

Classroom Resources

YouTube: Broken Rainbow Part one of seven, a video about the Peabody Mine Corporation beginning to extract coal on Black Mesa. The two tribes (Hopi and Dine) forced to move from the land that the company would be mining. 1985 · Documentary/Historical Documentary · 1h 10m on <https://www.youtube.com/watch?v=Vqe5wu1bSWs>

Extraction and Processing of Minerals & the Environmental Impacts of Mineral Use. <https://study.com/academy/lesson/extraction-processing-of-minerals-surface-mining-smelting.html>

Wiseman, Ellen Marie. Coal River, Kensington Publishing Co 2015.

Bang, Molly, and Chisholm, Penny. Buried Sunlight: How Fossil Fuels Have Changed the Earth. The Blue Sky Press, 2014.

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1970's coal offers America Energy. Coal Ago, 100 Anniversary. August 2012. www.coalage.com

Atwood, Genevieve. The Strip-Mining of Western Coal. Scientific American, Vol. 233, No 6. Dec. 1975.

Begay, Robert. Doo Dilzin Da: "Abuse of the Natural World" Author(s): American Indian Quarterly, winter, 2001, Vol. 25, No. 1 (winter, 2001), pp. 21- 27 Published by University of Nebraska Press Stable URL:

<http://www.jstor.com/stable/1186002>

Bruchac, Joseph, and Caduto, Michael J. *Keepers of the Earth: Native American Stories and Environmental Activities for Children*. Fulcrum, Inc. Golden Colorado. 1989.

Native American stories about Mother Earth teachers can use for environmental activities for students.

Cate, Karl; Eaton, Pam; Feaster, Seth. Peabody, in *Kayenta Exit, Is Abandoning Native Workforce Ahead of Reclamation Work*. Institute for Energy Economics and Financial Analysis. August 2019. IEEFA.org

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Additional vegetation teachers can add to the medicinal plants.

Ghioto, Gary. *The pipeline faces fines for spills*. Daily Sun News. August 7, 2002, https://azdailysun.com/pipeline-faces-fines-for-spills/article_65bf9770-e3ae-592b-b379-f3ae1f97f12e.html

Higgins, Daniel B. *The Black Mesa Case Study: A Post audit and Pathology of Coal-Energy Groundwater Exploitation in the Hopi and Dine Lands, 1968-2008*. The University of Arizona. 2010.

The case study is a piece of depth information about what happens when Peabody Coal Company established its excavation of coal from the Black Mesa mines.

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Powelson, David K. *Water harvesting on arid coal mine soil for vegetable and fruit production*. The University of Arizona, University Microfilms International, 1982.

Radford, Jeff. *Strip-mining Arid Navajo Lands in the US: Threats to Health and Heritage*. 1982 <https://www.osti.gov/etdeweb/biblio/5144348>

Schoepfle, Mark; Burton, Michael; and Begishe, Kenneth. *Navajo Attitudes towards Development and Change: A Unified Ethnographic and Survey Approach to an Understanding of Their Future*. *American Anthropologist*, Dec. 1984, Vol 86, No. 4, pp 885-904

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http://www.citizensagainstlongwallmining.org/wp-content/uploads/2017/11/Full_Strip_Mining_Handbook_08_11_09-1.pdf 15-16.

The teacher introduces the basics of strip mines in the eastern and western United States.

Wayman Leland C and Harris, Stuart K. Navajo Indian Medical Ethnobotany. The University of New Mexico Bulletin, University of New Mexico Press. 1941

World Population Review, 2020. <https://worldpopulationreview.com/>

End Notes

¹ Begay, Robert. Doo Dilzin Da: "Abuse of the Natural World" 2

² Nies, Judith. The Black Mesa Syndrome: Indian Lands, Black Gold 1998. 2

³ Higgins, Daniel B. The Black Mesa Case Study: A Postaudit and Pathology of Coal-Energy Groundwater Exploitation in the Hopi and Dine Lands, 1968-2008. 166

⁴ World Population Review, 2020.

⁵ Ibid

⁶ Nies, Judith. The Black Mesa Syndrome: Indian Lands, Black Gold 1998. 4

⁷ Udal, Morris K. Full Strip Mining Handbook 08-11-09. January 1990. 15-16

⁸ Ibid, 15-16

⁹ Ghioto, Gary. The pipeline faces fines for spills. Daily Sun News. August 7, 2002. 1

¹⁰ Higgins, Daniel B. The Black Mesa Case Study: A Post audit and Pathology of Coal-Energy Groundwater Exploitation in the Hopi and Dine Lands, 1968-2008. 159

¹¹ Ibid, 159

¹² Ibid, 165

¹³ Ibid, 169

¹⁴ Ibid, 220

¹⁵ Ibid, 220

¹⁶ Thames, J. L.; Crompton, E. J. Reclamation Studies on Black Mesa. 3

¹⁷ Ibid, 3-4

¹⁸ Ibid, 4

¹⁹ Matthews, Mark. On Black Mesa, the native makes a comeback. 1

²⁰ Elmore, Francis H. Ethnobotany of the Navajo. 33-34

²¹ Ibid, 23-24

²² Ibid, 53, 90

²³ Ibid, 54

Appendix

The Arizona science standards use a combination of research-based literature, Framework for K-12 Science Education, and Working with Big Ideas of Science Education with the crosswalk of the Next Generation Science Standards. The three dimensions of science are science and engineering practices, crosscutting concepts, and core ideas.

Life Science: Core Ideas for knowing science - L4. The unity and diversity of organisms, living and extinct, is the result of evolution. Core Ideas for using science - U3: Applications of science often have both positive and negative ethical, social, economic, or political implications.

5.L3U1.10 Construct an explanation: based on evidence that the changes in an environment can affect the development of the traits in a population of organisms. Students will investigate and evaluate environmental (strip-mined areas) changes in ways that affect a place's physical characteristics, availability of resources, and why some organisms survive and reproduce, others move to new locations, others move into the transformed environment, and some die.

5.L4U3.11 Obtain, evaluate, and communicate evidence about how natural and human-caused changes to habitats or climate can impact populations. Students will analyze and evaluate changes in an organism's habitat are sometimes beneficial to it and sometimes harmful. For a particular environment (strip land) some organisms survive well, some do not survive well, and some cannot survive at all. Students will identify and classified many plants and animals within the area. Humans in or near stripped lands obtain living and nonliving resources from the surrounding environment.

Next Generation Science Standards- 5th Grade Life

Life Science: Students develop an understanding of patterns and how genetic information passed from generation to generation. They also produce an understanding of how genetic information and environmental features influence the survival of an organism.

3-LS3-2. Use evidence to support the explanation that the environment can influence traits.

Students will compare and contrast when using evidence to support the differences between the disturbed land (strip mind land) and the undisturbed land.

3-LS4-4. Claim, the merit of a solution to a problem, caused when the environment changes and the types of plants and animals that live there may change.

Students will analyze the disturbed area and evaluate how the reclaimed land restored to its original state.

Diné Standards

4th -6th Diné Culture Standards: K'é dóó nisáhákees dóó nahat'á' náásgéé bee siih hansingo ádoolníít (I will develop an understanding of Dine way of life.)

Students will ask their clan (K'e) families about all parts of the land in terms of soil, wildlife, water, and vegetation to help them understand the meaning and importance of K'e as the umbrella of purpose to all living things.

Concept 2-Nahat'á. PO 3. Níłch'a'aan ánáá'níłgíí baa hane' yíisinísts'áą'go shił bééhózin dooleet. (I will listen to and retell stories related to elements of nature).

Students will write paragraphs about the various medicinal plants using the Diné language. They will create a PowerPoint for their writing and will include a picture sketch or photo of the specific plant.

Concept 3 - líná. PO 2. Shinaagóó kéyah dóó naaldlooshii dóó Tó ádaat'éhígíí shił bééhózin dooleet. (I will classify the Land and Water Beings in my environment.)

With help from their grandparents and parents, students will classify the native plant around their home area. They will keep a log of their classifications.

Concept 3 - líná. PO 3. Nihinaagóó nanise' daadánígíí shił bééhózin dooleet. (I will recognize the edible plants in my environment.)

With help from their grandparents and parents, students will classify the native plant around their home area. They will keep a log of their classifications for edible plants.

Concept 3 - líná. PO 4 Azee' chodao'ígíí shił bééhózin dooleet. (I will identify the usage of herbs.)

With help from their grandparents and parents, students will classify the native plant around their home area. They will keep a log of their classifications for medicinal plants.

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