“Teaching Forest Ecosystem, Carbon Cycling and Photosynthesis through STEAM Integration and Project - Based Learning Approach”

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Introduction

This is my first unit for the TLSI fellowship, an initiative model of curriculum development for students in a diverse classroom. The topic that I have chosen is about photosynthesis and carbon cycling in forest ecosystems. Our students have a little background about the ecosystem and photosynthesis, however there are some misconceptions that need to be addressed involving climate change and mitigation to the changing climate due to wildfires around San Carlos Arizona especially.

Ecosystems that include forest is a difficult topic to teach with the students especially when they don't have a background of it in their prior grade level. Environmental education and the quality of education about ecosystem, fire and fire prevention. Environmental education is a process that increases knowledge about the environment and related issues. It helps to develop the necessary skills and expertise to address these issues, and fosters attitudes, motivations and commitments to make informed decisions and take responsible actions (UNESCO, Declaration 1978) The three objectives of the Tbilisi Declaration, one of the founding documents of the environmental education field, are

1. To foster clear awareness and concern about economic, social, political and ecological interdependence in urban and rural areas.
2. To provide every person with opportunities to acquire the knowledge, values, attitudes, commitment, and skills needed to protect and improve the environment, and
3. Create new patterns of behavior of individuals, groups and society towards the environment.

Environmental education enhances critical thinking, problem solving, and effective decision-making skills, and teaches individuals to weigh various sides of an environmental issue to make informed and responsible decisions.

To ensure ecosystem and forest fire curriculum development, I will be using an extensive multi-layered curriculum development process to guide the creation of the materials and assessment. This process includes research, surveys, writing workshops, and reviews, resource professionals.

Some activities will reflect several methods of teaching environmental literacy and values. Each activity attempts to guide the learner through the process of awareness, understanding challenge, motivation, and action using active involvement and hands-on experiences.

I will combine the PLT (Project Learning Technique) activities to academic standards for the 7th Grade Science class and assess the subject areas that will complete correlations to the Next Generation Science Standards once released. Teaching through project learning techniques will help my students learn about the concepts, understanding the breadth and the more in depth about forestry and ecosystem as a whole.

Conceptual framework through project learning techniques will cover the activity guide and other curriculum materials under the five major themes in my class:

A. Diversity
B. Interrelationships
C. Systems
D. Structure and scale
E. Patterns and change

Context

San Carlos Community is a place where about 4,000 people live in Gila County, Arizona. It is part of the San Carlos Apache Indian Reservation, a vast area of over 1.8 million acres in the southeast of Arizona. San Carlos Community is the main hub and administrative center for the reservation.

San Carlos Community is a census-designated place in Arizona that is located within the San Carlos Apache Indian Reservation. Despite the oppression and violence, they faced, the Apache people resisted and fought for their freedom and rights. They also preserved and developed their culture and identity through various forms of expression and organization.

Today, the San Carlos Apache Tribe is a sovereign and progressive nation that provides for its members and honors its heritage. The San Carlos Community is a place of pride and hope for the Apache people.

San Carlos Middle School aims to provide a quality education for its students that respects their cultural heritage and prepares them for future success. The school's mission states: "San Carlos Middle School will provide an environment that fosters academic excellence, cultural awareness, and social responsibility for all students." The school's vision statement states: "San Carlos Middle School will empower students to become lifelong learners who are respectful, responsible, and productive citizens."

I work as a teacher at San Carlos Middle School, a public school in San Carlos, Arizona. The school belongs to the San Carlos Unified School District, which educates the students of the San Carlos Apache Indian Reservation. The school serves about 378 students from grades 6 to 8 and provides a curriculum that covers language arts, math, science, social studies, physical education, and electives. The school also features a library, a cafeteria, a gymnasium, and a computer lab. The Brave is the school's mascot, and its colors are red and white.

San Carlos Middle School offers various programs and activities for its students, such as athletics, clubs, field trips, dances, and ceremonies. The school organizes field trips to places such as Point of Pines Lake, Phoenix Zoo, Arizona Science Center, and Grand Canyon University.

San Carlos Community is a place in Arizona that is located within the San Carlos Apache Indian Reservation. The community and the reservation have a history of living with fire, as fire is a natural and frequent disturbance that affects their ecosystems. Fire can have significant impacts on the carbon cycle, which is the movement of carbon among different pools and forms within ecosystems and the atmosphere. Carbon is a key element for life on Earth, as it is the main component of organic matter and a major greenhouse gas that influences climate.

The knowledge of fire and carbon cycling in the ecosystem among the San Carlos Community may vary depending on their education, experience, and interests. However, some sources of knowledge that they may have include:

- School
    - The students at San Carlos Middle School, which serves the San Carlos Apache Indian Reservation, may learn about fire and carbon cycling in their science curriculum. The school also offers various STEM activities that enhance their learning and skills, such as building a solar oven, a pollution detector, or a balloon car. These activities may teach them about renewable energy sources, air quality, environmental engineering, and physics.
- Science Fair
    - The school also participates in the San Carlos District Science Fair, which is open to all students in grades 5-8. The Science fair allows students to conduct experiments, investigations, or demonstrations on topics of their interest and present their findings to judges and peers. This encourages students to apply the scientific method, use critical thinking, and communicate effectively. Some students may choose to do projects related to fire and carbon cycling in their ecosystems.
- Traditional Ecological Knowledge
    - The San Carlos Apache tribe may have traditional ecological knowledge that has been passed down from generation to generation through oral stories, ceremonies, arts, and crafts. This knowledge may include information about the fire ecology,

such as how fire affects plants and animals, soil, water, and climate; how fire can be used as a tool for land management; and how fire can be prevented or controlled. This knowledge may also include information about carbon cycling, such as how plants use carbon cycling, such as how plants use carbon dioxide for photosynthesis; how animals use carbon for respiration, how organic matter decomposes and releases carbon, and how charcoal can store carbon.

- Research
    - The San Carlos Apache Tribe may also have access to scientific research that has been conducted on fire and carbon cycling in their ecosystems by external researchers or by their own tribal members. For example, some studies have examined how fire frequency and type regulate the response of soil carbon cycling and storage to fire across soil depths and ecosystems using a meta-analysis. Other studies have investigated how fire affects soil respiration, soil carbon content, soil microbial communities, soil enzyme activities, and soil physicochemical properties using field experiments. These studies may provide more detailed and quantitative data on fire and carbon cycling in their ecosystems.

Our school offers a curriculum that includes science, technology, engineering, and math (STEM) subjects for its students in grades 6-8. The school also provides various opportunities for its students to engage in STEM activities that enhance their learning and skills. Among the many STEM activities in which the students in San Carlos Middle School participate include:

- Science fair
    - The school participates in the San Carlos School District Science Fair, which is open to all students in grades 5-8. The Science fair allows students to conduct their own experiments, investigations, or demonstrations on topics of their interest and present their findings to judges and peers. This encourages students to apply the scientific method, use critical thinking, and communicate effectively.
- Robotics Club
    - The School has a robotics club that meets after school and teaches students how to design, build, program, and operate robots using LEGO Mindstorms kits. The robotic club also competes in local and regional robotics competitions, such as FIRST LEGO League and VEX Robotics.
- Solar Oven
    - The school conducts a STEM activity that involves building a solar oven using a pizza box and other common materials. The solar oven uses the sun’s energy to heat up food items, such as marshmallows or hot dogs. Pollution detector: The school participates in a STEM activity that involves building a pollution detector using a circuit board, an LED light, and a carbon monoxide sensor. The pollution

detector measures the amount of carbon monoxide in the air and displays it using different colors of light.

- Balloon Car
    - The school conducts a STEM activity that involves building a balloon-powered car using recycled materials, such as cardboard, plastic bottles, straws, and rubber bands. The balloon car uses the air pressure from the balloon to move forward.

These are some examples of the science activities performed by the students in San Carlos Middle School in terms of participation in STEM. These activities help the students learn about various STEM concepts and skills while having fun and being creative.

I have students with varying academic abilities and individualized learning plans. Some of my students are academically challenged, while others are highly academically accomplished. This year, I have noticed that some of my students are more socially inclined and participative than in previous years. Although I don't assume that my students will be able to grasp an understanding of the context of the lesson, I am always prepared to give instructions suited to their needs according to their learning styles.

Rationale

Fire is a natural and frequent disturbance in many forest ecosystems, especially in boreal and temperate regions. Fire can have significant impacts on the photosynthesis and carbon cycling of forest ecosystems, affecting both the sources and sinks of atmospheric carbon dioxide (CO2). Understanding how fire affects photosynthesis and carbon cycling is important for predicting the responses of forest ecosystems to climate change and fire management.

The wildfire called the "Bottom Fire" burned more than 3,000 acres on San Carlos Tribal land near Bylas in July 2021. The fire was caused by lightning and was discovered burning in a dry riverbed in Gil's River. The area's brush, tall grasses and chaparral shrub were the fire's main fuel sources. The fire crews developed a strategy to construct indirect fire lines in front of the main fire and used bulldozers to remove dense vegetation in the river corridor.

While fire is an important component of the carbon cycle, it greatly affects the carbon cycle by releasing carbon into the atmosphere through the combustion of vegetation biomass, which leads to a reduction of terrestrial biomass and impacts vegetation patterns. Fire also alters nutrient cycles, such a nitrogen or phosphorus cycle, thereby limiting vegetation productivity in regions with high losses of nutrients and increasing productivity due to fertilization in areas of deposition.

Teaching photosynthesis to my students can be a fun and interactive experience. I want to start with the basics before delving into the intricacies of photosynthesis. Establish some foundational knowledge essential for students' learning by explaining the process of photosynthesis in simple

terms and discussing its importance in the ecosystem. I will also incorporate the use of interactive tools in my classroom by using educational resources such as videos, colorful diagrams, and virtual labs, in order to help my students visualize the process of photosynthesis and better understand its various components. I will include that conducting experiments through hands-on experiments can be a great way to reinforce the concepts learned in photosynthesis lessons like actual project making through planting under different conditions to see how they respond to changes in light, water and nutrients. Lastly, use the topic in real-life examples. Photosynthesis occurs all around us, so it's easy to find real-life examples to illustrate the concepts learned in class. We can have nature walk and point out different plants and trees that are undergoing photosynthesis.

Through continuous review, students can surely find the importance of understanding the concepts learned in class and able to complete quizzes or worksheets.

On the other hand, teaching carbon cycling and how it affects the forest systems can embed both art and the science of teaching and learning using the four cornerstones which are the key to building and sustaining any arts integration or STEAM effort (AZ ED - arts education and integration). Since I will be incorporating STEAM to my project-based learning approach, I will utilize the classroom project of focusing one specie growing around the local area of San Carlos which is the "Tus" (jar making) while understanding the growth of the "Agave plant" I would like to address it in both content and the arts area. In arts integration, the arts are an avenue through which students apply and connect previously taught content of photosynthesis and carbon cycling matter which is helpful to our study of the growth of the Agave plant.

Thus, the benefits of the project-based learning approach and the STEAM integration will develop the critical thinking skills, connective learning, student buy-in and student's empowerment. While the content and Arts standard in STEAM are naturally aligned, taught and assessed equitably through explicit instruction on at least weekly basis, while focusing on the content area in science instructions under the Population and Ecosystem Unit, specifically targeting Photosynthesis, carbon cycling and forestry.

Why integrate STEAM with Project-Based learning?

I have some compelling reasons that I have seen and had affected me in one way or another:

My students in the classroom are diverse. Some may work incredibly hard, but still struggle every day to perform on their assignments. I have also seen some students who typically get labeled as "difficult" light up the minute they walk into the room and basically just get bored during the Science class. In order to support these students, I will provide flexibility to my lesson to help them achieve their own capacity to do STEAM projects where my students can finish one project in a quarter related to carbon cycling, photosynthesis and forestry. I always believed project-based learning approach integration to STEAM is critical because this approach provides an opportunity to bring back creativity and increase student achievement at the same time. As a Science and

STEAM coordinator in San Carlos Middle School, I can say that I am brave enough to look beyond traditional approaches (yield very little result) because I want to say that students become active participants in their learning when the arts are intentionally integrated and provides an opportunity for students to own learning and have some vested interest in their own success.

Integrating carbon cycling, photosynthesis and fire lessons through project - based learning approach provides connective learning and affords equity. It yields an equitable learning environment for all learners through the teaching and learning process through their own access points. Thus, it furnishes a research-based pathway to teaching 21st century learning skills and natural avenues for differentiation activities in the class at all grade levels, while teaching carbon cycling is the movement of carbon among different pools and forms within forest ecosystems, such as plant biomass, soil organic matter, litter, charcoal, dissolved organic carbon, and CO2. I will diligently plug on with what I know works for my students and help them become more confident and excited through discovering and finding how carbon cycling is influenced by various biotic and abiotic factors, such as plant productivity, decomposition, respiration, soil moisture, temperature, and fire. I will help my students find the deeper connections and through T processes that carbon cycling determines the net carbon balance of forest ecosystems, which is the difference between carbon inputs (photosynthesis) and outputs (respiration and fire emissions).

Such passion in teaching fire and fire prevention is something that we're doing and working in the reservation area, and we want the rest of the world to do it too on how it can affect photosynthesis and the carbon cycle in forest ecosystems in several ways. According to the US Forest Service, when some or all parts of a tree decompose after death or burn during a fire, the carbon is released back into the atmosphere. Thus, the amount of carbon in forests closely mirrors the natural cycle of tree growth and death.

In addition, fires convert tremendous amounts of biomass into CO2 and charcoal (or pyrogenic carbon) that accumulate in soils and become a part of the soil organic carbon pool. This charcoal may participate in many soil biogeochemical processes that control the cycling of important elements and soil health. However, the driver of soil organic matter (SOM) decomposition Since the microbial decomposition of SOM is catalyzed by enzymes released by microbes (exoenzymes), researchers are studying how charcoal interacts with exoenzymes and which enzymes are capable of degrading charcoal.

Results from this work will fundamentally advance the current understanding of the cycling of charcoal and its impact on the global carbon cycle.

The students will use an interactive model to determine conditions that enable greater carbon cycling. The variables are displayed with graphic representations, making it accessible to students who are better visual learners. There are several variables to manipulate, and students can see the amount of carbon being cycled as represented by arrows. By further analyzing and interpreting the visual data through answering the focus and post-activity questions, students will be able to

draw conclusions about the conditions that lead to maximum carbon cycling. Background information as well as questions for pre-activity, during, and post-activity are included. The teacher can also use the supplemental links to improve their personal understanding or to enrich the lesson for students who have the ability to go further.

This unit focuses on the emphasis on describing the conservation of matter and the flow of energy into and out of various ecosystems and on defining the forest types in San Carlos Middle School, it would further lead them on the ways to protect the forest.

The curriculum is organized into three sections:

a. Ecological knowledge
b. Social knowledge
c. Sustaining resources

Sections are divided into topic areas that correspond directly to the conceptual framework, and the major purpose of having students study ecology related to forests and forest fires is to develop an awareness and understanding of relationships.

a. Access qualitative data regarding the optimal conditions for carbon in soil.
b. Conditions for the cycling of matter, specifically through the soil.
c. Research forest types, climate, and temperature for soil mapping.
d. Describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.
e. Analyze the data and visualize the carbon that is constantly moving from one part of the ecosystem to another.
f. Practice of analyzing and interpreting data

Why did I choose the Project Learning Technique for my topic?

Project Learning Technique, also known as PBL focuses learning on the real world problems, providing a clear connection between what is learned in school and how it is relevant beyond the classroom. The authentic nature of these problems and issues means they are both complex and messy, requiring students to draw on knowledge across disciplines and expertise in many areas. It promotes deeper connections to content, as it is an inquiry approach that requires time for students to make connections between the problems they are facing, to think about what they already know, and to develop lines of inquiry for new content they "need to know".

According to the Buck Institute for Education (BIE.org) they often refer to project-based learning as a "deep dive" into content. Its focus on depth over breadth helps students develop deep understanding of content both in specific disciplines, as well as it fosters the inquiry skills necessary for the success in STEM. Through the project-based approach, it fosters the development of both the analytical and creative thinking necessary for innovation. For example, a project-based

approach to learning might ask the students to consider “How do we make `tus’ (jar) out of the Agave plant? The Project-based learning approach supports the questioning skills with graphic organizers, KWL charts and 5 Whys organizers.

As a result of the questioning, students' work may focus on finding ways to make existing options in developing the ways to use the Agave plant into a creative project that includes the study of the plant locally grown in the area of San Carlos. The real-world problems and challenges used a project-based approach that required analytical thinking and creative problem solving needed for success in STEM.

Furthermore, project-based Learning fosters reflection and metacognition, as it said “we don’t learn from experience, we learn from reflecting on experience. (John Dewey). It is recursive and requires extensive reflection for successful solution development. The student would likely to develop ideas and implement them as they constantly ask the questions like:

A. What do we know? What do we need to know?
B. What do we think will happen and why?
C. What really happened? Where did our thinking go wrong?
D. What worked? What didn’t work?

The reflective nature of the project-based approach process helps students make the connections between content they are learning and how it impacts their thinking and problem solving. Such as utilizing the knowledge helps them understand not only what they are learning, but how they learn. This allows them to use the nature-journaling activity in every project they finish in this curriculum. These would enhance their deeper connections to content, connect ideas across disciplines, and build the questioning, thinking and metacognitive skills necessary for success in today’s rapidly changing world.

One of the many approaches that I am proposing to implement in my project-based learning curriculum in relation to forestry ecosystem, photosynthesis and carbon-cycling is to implement digital storytelling, nature-journaling and data collecting through notetaking.

The project-based learning curriculum that I am implementing in my class emphasizes the concept of the interdisciplinary integration in the school education that involves STEM and upgrading into STEAM that highlights the role of ART. The dimensions of STEM are expected to be effectively integrated through the cultivation of aesthetics, while the STEAM curriculum is designed to explore the impact of STEAM education on creativity. I am combining the project of Nanking ``Tus" or jar from the Agave plant while understanding the nature of the life cycle of the plant and the process of photosynthesis while protecting the forest area of San Carlos that helps the normal growth of the Agave plant and preservation of the other forest trees around the area.

The teaching process uses the strategy of creative thinking instruction that adopts a one-group pretest-posttest design based on a purposive sampling of 25 students from one class in San Carlos

Middle School. Some of the research tools included the records of learning feedback and creativity assessment. Thus, the empirical findings show that the project-based learning incorporating STEAM activity in my class has a positive significant influence on student's development of creative recognition. Despite that the STEAM course are constricted by the short-term time implementation, it has the sense of the art-oriented that would benefits the STEAM education and learning effectiveness to the San Carlos Middle School students, it is too short to affect the emotional facet of creativity and suggested to extend the teaching period and evaluated the long-term influence of Project - based learning STEAM on students' learning behavior.

Research Background

Being in a diverse community of Apache, creativity in a knowledge economic era is the key to success. Cultivating convergent and divergent thinking is the purpose of my curriculum in all levels of schools. Thus, the school should focus on creativity, problem-solving skills, humanities and capability of using some local resources. While the importance of STEAM education is highlighted, including a teaching combination of STEM, this would highlight the additional "A" (Art) in a cross-disciplinary learning toward creativity for my project-based approach (Yakman, 2008). It indicated that art benefits integrate cross-disciplinary curriculum and overcome limitations of science subjects.

Through practical projects, it would prove that creativity can be cultivated by the means of cooperating in the group, problem-solving ideas, and enhancing a sense of aesthetic. The STEAM curriculum with Project-Based Learning approach can be constructed with modern technology, Engineering, Science, Math and Arts. Students can participate in design by constructivist learning and context-specific art, and then respond to the challenges and problems they encounter. In this way, students can set up their goals, research and acquire knowledge and skills (Kokotsaki et al., 2016; Song 2020) It is more important to look into how children apply new knowledge and proceed with design thinking (Druin, 2022). STEAM education allows teachers to understand how students practice a new technology from the view of the art design, and to apply the learning process of cross disciplinary technology projects (Kure et al., 2010).

While STEM education is the foundation of STEAM education, students are expected to (1) participate in research, (2) equip logical reasoning ability, (3) have a skill of cooperation, and (4) perform an analytical skill (Maryland State Department of Education 2012). STEAM changes from a traditional teacher-centered class to a new form, which allows students to find the solution actively in real life.

Project-Based Learning Approach and STEAM

The new focus in education reform requires application, creation and ingenuity in terms of creative development. In one of the initiatives to promote creativity among students in San Carlos Middle School, STEAM involves the critical process of creativity and innovation. It allows students to connect to the established elements of STEM in art practices, design principles and assessment (James, 2016). The STEAM components include an integrated approach to learning that requires an intentional connection between standards, assessments and lesson design. The core standard of STEAM promotes inquiry, collaboration and emphasizes on Project-Based Learning Approach, which assimilates the authenticity of art curriculum (Oner et al., 2016).

Therefore, integration of STEAM -Project-Based Learning Approach into Science encouraged students to be able to see the relevance of science knowledge of phenomena in daily life, develop curiosity and problem solving and increase students' courage to ask questions and explore various sources to find information (Adriyawati et al., 2020)

In the project of making - "Tus" (drinking jar), students are required to use the Agave plant. This plant is native to Mexico and used to make a variety of products, including mezcal, and agave nectar. The sap from the agave plant is harvested and processed into syrup, which can be used to make nectar or fermented into alcohol. Little did the students know that this has been used by the Apache as a drinking jar or "Tus" about the Mescalero Apache Indians and their use of the Agave plant as "Tus" or jar. According to Edward S. Curtis, an American ethnologist and photographer, the Mescalero Apache Indians used to prepare and consume an intoxicant made from the Agave plant. The drink was made from the cooked plant, which was placed in a heated pit and left until fermentation began.

Agave Plant:

They are hardy landscaping plants in both the summer and winter months as long as they have good drainage. They only require water twice per month in the summer and only every 4-6 weeks in the fall and winter months. They love full sun and some varieties do okay with evening shade. Agave can grow very large and because they are monocarpic, they die after they bloom. However, they usually seed from this bloom and will grow many baby agave nearby that will reproduce in the yard. Because they grow large and usually have sharp edges you will want to make certain they are not growing near pathways or driveways.

During some brutal summertime, it has been reported that among the growing saguaros (cacti) in Arizona are continuously falling over, getting sunburned and agaves are melting too (Fox News).

Sunburn is a common problem in greenhouse or shade house grown plants in San Carlos, AZ. It is also problematic in plants grown in the open area of San Carlos, AZ to raise Agave plants or filtered sunlight in nurseries when these plants are transplanted into open landscapes. Those parts of the plant that have not been acclimated to direct sun will burn easily

Teaching the students to value the Agave plant and preserving the Agave plant in Mescal Mountains about 7 miles northwest of Dripping Springs and was fueled by grass and brush as well as drought conditions. While teaching the students about public safety with the highest priorities on these fire awareness activities.

Content Objectives

What is the forest ecosystem?

A forest ecosystem is a natural woodland unit consisting of all plants, animals and micro-organism in that area functioning together with all of the non-living physical factors of the environment. Forests are nature's most efficient ecosystems, with a high rate of photosynthesis affecting both plant and animal systems in a series of complex organic relationships.

There are different types of forest around the world. Some examples include:

A. Boreal Forest:
    a. Found in cool high-latitude sub polar regions, boreal forest is dominated by hardy conifers such as pines, spruces, and larches.
B. Deciduous Forest:
    a. In more temperate high-latitude climates, mixed forests of both conifers and broad-leaved deciduous trees predominate.
C. Tropical Rainforest:
    a. In the humid climates of the equatorial belt are tropical rainforests, which support incredible plant and animal biodiversity.
D. Monsoon Forest:
    a. Found in regions with a long dry season followed by an intense rainy season, monsoon forests are the deciduous forests of tropical areas.
E. Temperate Deciduous Forest:
    a. In the lower latitudes of the Southern Hemisphere, temperate deciduous forests reappear.

Each forest type is distinguished by its species composition, tree cover density, soil type and geologic history.

What is the relationship between the carbon cycle and photosynthesis to the forest ecosystem?

While the forest plays a critical role in the global carbon cycle. They are dynamic systems that constantly absorb and release carbon dioxide. Through a process called carbon sequestration,

forests remove carbon from the atmosphere for use in photosynthesis. This leads to the maintenance and growth of plants and trees. Thus, photosynthesis enables the conversion of carbon dioxide into organic molecules, while the carbon cycle ensures that carbon atoms are continuously cycled between living organisms and the environment. Forest ecosystems, with their abundant plant life contribute significantly to both processes in the carbon cycle and photosynthesis, helping carbon dioxide absorbed from the atmosphere and used to create new plant biomass, such as leaves, roots and wood.

Arizona's forests are diverse and range from riparian gallery forest in the Lower-elevation deserts to subalpine and montane forest above 9,000 feet in elevation. Forest cover approximately 27% of the state and are mostly managed by federal, tribal and state entities. Since, Arizona has identified seven major categories of forest, people and forest, climate change and culture, ecosystem health, water and air, fire and economics. It is worth noting that climate change could have a significant impact on Arizona's forest. Rising temperatures could lead to forest retreat and hotter, more volatile deserts. Human - caused climate change may accelerate changes in vegetation worldwide, potentially filling lush forests with flammable brush and worsening drought conditions.

San Carlos, Arizona is home to a diverse range of ecosystems, including **alpine meadows**, **grasslands**, and **deserts**[1]. The San Carlos Apache Tribe and the U.S. Forest Service are collaborating on landscape restoration projects in three national forests and the tribal lands that border them[1]. The San Carlos Apache Tribal project is part of a long-term strategy to address the growing wildfire crisis in the West[1]. The project aims to protect areas both on tribal lands and bordering the Apache-Sitgreaves, Tonto, and Coronado national forests[1].

Teaching Strategies

STEM has been a priority in many U.S. schools for at least a decade but, in the past few years, education experts have noticed that something was missing - that future scientists and engineers also need soft skills like creativity, collaboration, and communication to solve problems. (STEM strategies That Are teacher - Approved I Resilient Educator)

According to Sarach Elliott, EdD, language arts, social studies and visual arts are crucial and can't be taught in isolation from Science and Technology.

While STEAM isn't meant to replace the traditional teaching, it is not meant to be done all the time. San Carlos Middle School needs to teach Math facts and Science concepts, but there are ways to bring other disciplines in and incorporate STEAM - project- based approach integrating the nature-based learning project activities.

In this curriculum, I am introducing the "Agave" plant that grows locally in the San Carlos Reservation Area. My students will have opportunities to build and create "tus" drinking jars in

application of STEAM integration in my lesson and fostering the Engineering Design process and daily nature-journaling activity with my students that includes the symmetry or a civic act about plant growth caring.

STEAM- Project-based Approach:

In Science Ecosystem, Population and Ecosystems, we will focus on studying the natural habitats of the organisms and species around the San Carlos Middle School. Students investigates the biotic structure of "Agave" plant, use software to design a constructed "Agave" plant products like "Tus" (drinking jar) in application of technology; review design options and develop prototype (engineering); calculate and measure the age of "agave" plant and cost to construct in application of Math; and develop the prototype and create an advertising brochure to sell the "tus" to the local city (art).

Nature-journaling focused on the content and personal reflection:

Squeezing STEAM into your teaching can take intentional effort. It truly involves changing mindset and Science class routines. In my class, I followed a whole week's routines:

- Monday: Note Taking activities (frontloading Scientific terms and researching Scientific terms online),
- Tuesday Nature-Journaling activities (outdoor),
- Wednesday: STEAM project-based activities,
- Thursday: Data Gathering
- Friday: Assessment.

There's a lot of incredible nature for us to explore, especially around the vicinity of San Carlos Middle School. Nature-journaling is a STEAM activity that allows us to mindfully appreciate all the diverse life around us. Not only is nature journaling a great way to get outside and have fun, it also can teach us and our learners important science and engineering processes skills. The best part of engaging learners in journaling activity, is having them express their feelings and being able to write something with anything about their observation, prediction and making inferences with and a bit of curiosity!

Journal writing activity is a strategy that hones and improves the writing skills of my students. It is regularly recording observations, feelings and perceptions of the natural world. It offers a way to slow down and notice more of the world around us. It also gives the chance for my students to regularly practice and deepen their observation skills, creativity, and scientific thinking. Nature journals can also serve as long-term records of the environment. Scientists and naturalists use journals to observe and track changes in the natural world and how their ideas have evolved over time.

Nature-journaling

Getting Started:

- Select a format for your journal. For example, you may draw, write, or both. You can use a physical journal or make your observations on a digital platform. You could observe using video and/or voice recordings. Or consider using a mix of formats to capture your notes and observations over time.
- Select a prompt to begin your nature journal entry about the natural world. Use the simple prompt on this page or explore the resources on the next page for other ideas.
- Find a spot where you can sit quietly and observe outdoors.
- Record the date, time, location, temperature, and weather. Then, focus your attention on something natural that sparks your interest, like a rock, plant, log, the weather, an animal, etc. Focus all your attention on it. What do you notice about it? Record as many general and specific observations about it as you can (e.g., its size, color, shape, what makes you curious, etc.) .... What do you wonder about it? What does it remind you of? Record this information as well through various readings and research.

Research-Based Approach:

Research-based learning involves investigation of concepts and theories and allows students to become solution seekers through an exploratory approach. Compared to a rigid textbook-based style that encourages rote-learning, this puts the student at the center of knowledge acquisition. John Dewey's project-based approach, Jean Piaget's constructivist theory, Maria Montessori's play-way approach, Jiddu Krishnamurti's questioning mind approach are early examples of 21st century versions of Research Based Learning.

There are five stages of research-based learning which is related to STEAM and Engineering Design Processes:

a. *Identify and clarify issues, questions, challenges, and puzzles.* A key component of research-based learning is the identification and clarification of issues, problems, challenges and questions for discussion and exploration. The learner is able to seek relevancy in the work they are doing and to become deeply involved in the learning process.
b. *Find and process information.* Students are tasked with searching for, finding, closely reading, processing, and using information related to the identified issue and question from one or more sources. As they seek out resources and read information, and then organize, classify, categorize, define, and conceptualize data. In the process, they become better readers.
c. *Think critically and creatively.* Students are provided with the opportunity to use their researched information to compare and contrast, interpret, apply, infer, analyze, synthesize, and think creatively.

d. *Apply knowledge and ideas and draw conclusions*. Students use what they have learned to draw conclusions, complete an authentic task, summarize results, solve problems, make decisions, or answer key questions.
e. *Communicate results.* Students communicate results of their research activities in a number of possible ways, such as through a written research report, a persuasive essay, a book designed to teach younger students, a math problem solution, a plan of action, or a slide presentation to members of the community.

Teachers play a key role in the success of research-based instruction by engaging and involving students in information gathering and processing. While teachers might occasionally provide information through lectures, and textbooks are used as a source of information, there is an emphasis placed on students learning how to seek out and process resources themselves. A teacher provides a climate that supports student curiosity and questioning. Teachers enable students to ask questions and pose problems. Students are invited to ask and answer questions. The classroom climate is conducive to using higher-order thinking and problem-solving skills to apply knowledge to solve problems. Teachers attempt to build ways for students to take ownership of their learning, to create a value and a purpose for learning.

Application of Etymology and Semantic Field Theory

There are 45% in every household in San Carlos Community that are considered ELL. At least 7 out of 20 students in the classroom can understand Apache language and can speak 50% using their native tongue at home and in school. Etymology is one of the useful ways that helps learners to be familiar with more words with culture and history, expand vocabulary, reduce spelling errors, distinguish similar words, improve the ability of guessing words' meanings, and memorize long and complicated words efficiently. Semantic field functions is another theory that can be used in enlarging vocabulary.

As children learn their mother tongue, the first stage is one word stage, and telegraphic stage, the phrasal stage, the whole sentence, and lastly the pragmatic application. Both mother tongue and second language learning need a large vocabulary. Especially in second language learning, vocabulary is basic for the grasp of the target language. But vocabulary acquisition has not been given much importance compared with grammar learning in China. After the first few years of learning English, the greatest problem at senior stage is how to acquire English vocabulary effectively and efficiently.

Match the Etymology

Provide students with a list of root words and their meanings. For example, "therm" means "heat." Then, provide another list of words that contain those roots. Have students match the words to their correct root and discuss how the root changes the meaning of the word.

Reading Connections Approach through Storytelling

Storytelling is a powerful communication tool that can help convey complex ideas and concepts in a simple and engaging way. It is also an effective way to connect with the learners and inspire them to achieve the task of the day integrating the STEAM works.

Classroom Activities

- *Forest Stewardship*. This activity is designed for 7th Grade students to be conducted outdoors or in the classroom. This covers identification of plant species around the San Carlos Middle School through plantilla.net apps.

  Students will identify plants that are poisonous or not. They may measure the height of the plant and as well the classification of plants.

- *Tree Growth*. This activity is designed for students that teaches them about tree growth, annual rings, and plant science. The lesson takes approximately 45-60 minutes and is conducted outside the classroom but within the vicinity of San Carlos Middle School.

- *Uses of a Tree.* This activity is designed for the introduction of Photosynthesis lessons with my students. In this activity I will be teaching the students with various uses of trees such as wood, paper, sap, and food. This lesson takes about 45 minutes and is usually conducted inside and outside the classroom.

- *Measuring Tree Heights.* This is one of the simplest methods of measuring a tree's height and that is setting up a proportion. This activity is designed as an outdoor activity with the learner's using ruler or yardstick.

  Procedures:

  1. Have the student stand at the base of the tree while you walk a distance away from it.
  2. Hold a ruler at arm's length. Walk backward or forward until both the top and bottom of the ruler line up with the top and bottom of the tree.
  3. Note how tall your student appears on the ruler (example 5cm)
  4. Divide the length of the ruler by the apparent height of your student. (For example, if the ruler is 30cm, you would divide that number by the 5cm from above, to get 6).

5. Multiply this number by the actual height of your student. The result is the height of the tree (for example, if your friend is 140cm tall, you would multiply by 6cm, from above, to get 840cm or 8.4m)

- *The Nature of Fire.* In this activity, students will learn about the role of fire in forest ecosystems, will examine issues of fire in the wildland-urban interface, and will conduct a wildfire safety assessment in the community of San Carlos AZ through data collection.

    Part A - Fire effects

    Part B - prescribed fire and fire dependent species

    Part C - Wildfire safety assessment

    Part D - Communicating Fire

Students are challenged to create a group to design a home or community that would exemplify living responsibly and safely in the wildland interface. Have the groups present their designs to the class.

- *How Trees Store Carbon.* In this activity, students will learn how to create a carbon footprint. They will be instructed to print out the summary of their initial results or to write the results in their journals.

    Part A - **Your carbon footprint**. Ask your students if they heard the term carbon footprint. If they are not familiar with it, point out that it is a measure of how much carbon dioxide a person or product produces -directly and indirectly in a certain amount of time.

    Part B - **How much carbon can a tree hold?** Ask the students how they might calculate how much carbon a tree can hold. The amount of carbon an individual tree can store depends on the species of tree, how large the tree is and how old it is.

- *Words to live by.* In this activity, students will learn how people's personal experiences affect their attitude toward forest. Students will define personal attitudes and values

about forests, describe how views of forest have changed over time, and explain how attitudes toward forests affect how they are used and managed.

- *Project-based activity: "Tus" out of Agave plant (Drinking water jar out of Agave plant).* In this activity it requires teamwork among a group of students to study the life cycle of the Agave plant, then build an engaging STEAM activity for students to create a drinking jar out of Agave plant. The students will learn about the Agave plant life cycle. Through STEAM integration, students will be able to use their creativity to add design and color to the "Tus". Identify the part of the Agave tree that is being used for the "tus" and processes of making the "Tus".

Alignment to Arizona Standards (Science)

1.L2U2.7 Develop and use models about how living things use resources to grow and survive; design and evaluate habitats for organisms using earth materials.

7.L2U1.12 Construct an explanation for how some plant cells convert light energy into food energy.

7.E1U1.1 The composition of the earth and its atmosphere and the natural and human processes occurring within them shape the earth's surface and its climate

7.E1U1.5 Construct a model that shows the cycling matter and flow of energy in the atmosphere, hydrosphere, and geosphere.

LS2-1 - Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem

These alignments allow the students to explore how cause and effect take place within the context. The core idea in this unit explains phenomena using evidence obtained from observation and or scientific investigations. Evidence may lead to developing models and or theories to make sense of phenomena. On the other hand, knowledge produced by Science is used for engineering and technologies to solve problems and or create products, while applications of Science often have both positive and negative ethical, social, economic, and or political implications.

Sample Assessments and Project-Based Outputs:

1. Deforestation: Literature Integration and Data Gathering:

Deforestation of the Tropical Rain Forest

The single biggest direct cause of tropical deforestation is conversion to cropland and pasture. The conversion to agricultural land usually results from multiple factors. For example, countries build roads into remote areas to improve overland transportation of goods. The road development itself causes a limited amount of deforestation. But roads also provide entry to previously inaccessible – and often unclaimed land.

Logging, both legal and illegal, often follows road expansion. When loggers have harvested an area's valuable timber, they move on. The roads and the logged areas become a magnet for settlers – farmers and ranchers who slash and burn the remaining forest for cropland or cattle pasture, completing the deforestation chain that began with road building. In other cases, forests that have been degraded by logging become fireprone and are eventually deforested by repeated accidental fires from adjacent farms and pastures.

Although poverty is often cited as the underlying cause of tropical deforestation, analyses of multiple scientific studies indicate that the explanation is an oversimplification. Poverty does drive people to migrate to forest frontiers, where they engage in slash and burn forest clearing. But rarely does one factor alone bear the sole responsibility for tropical deforestation.

State policies to encourage economic development, such as road and railway expansion, have caused significant, unintentional deforestation in the Amazon. Agricultural subsidies and tax breaks, as well as timber concessions, have encouraged forest clearing as well. Global economic factors such as a country's foreign debt, expanding global markets for rainforest timber and pulpwood, or low domestic coasts of land, labor, and fuel can encourage deforestation over more sustainable land use.

1. What is the single biggest direct cause of tropical deforestation?

2. Describe the different factors that help account toward cropland and pastures being the direct cause of tropical deforestation.

3. Why would a country with high poverty rates see an increase in deforestation as opposed to richer countries?

Fill the chart below

Period	Estimated Remaining Forest Cover	Annual Forest loss	Percent of 1970 cover remaining	Total forest loss since 1970
Pre-1970	4,100,000			
1970	4,001,600		97.6%	98,400
1977,896	3,955,870	21,130		
1978 – 1987	3,744,570	21,130		
1988	3,723,520	21,050		
1989	3,705,750	17,770		
1990	3,692,020	13,730		
1991	3,680,990	11,030		
1992	3,667,204	13,786		
1993	3,652,308	14,896		
1994	3,637,412	14,896		
1995	3,608,353	29,059		
1996	3,590,192	18,161		
1997	3,576,965	13,227		
1998	3,559,582	17,383		
1999	3,542,323	17,259		
2000	3,524,097	18,226		
2001	3,505,932	18,165		
2002	3,484,281	21,651		
2003	3,458,885	25,396		
2004	3,431,113	27,772		
2005	3,412,099	19,014		
2006	3,397,814	14,285		
2007	3,386,163	11,651		
2008	3,373,252	12,911		
2009	3,365,788	7,464		
2010	3,358,788	7,000		
2011	3,352,370	6,418		
2012	3,347,799	4,571		
2013	3,341,908	5,891		
2014	3,336,896	5,012		

2015	3,330,689	6,207		
2016	3,322,796	7,893		
2017	3,316,172	6,624		

Create a line graph showing the annual forest loss per year for 1990 – 2014. After creating your line graph, answer the questions below using the graph you just created.

A. Graph Questions:

1. What year had the highest/lowest annual forest loss?

2. In Brazil each squatter acquires the right to use a piece of land simply by living on a plot of unclaimed public land and "using it" for at least one year and a day. After five years the squatter acquires ownership and hence the right to sell the land. Up until the mid-1990s this system was exacerbated by the governmental procedure that allowed each claimant to gain title for land up to three times the amount of forest cleared. Although it was not an official rule, it was part of the usual procedures of the governmental agency in charge of colonization of the Amazon region. Between 1995 and 1998, the government granted land in the Amazon to roughly 150,000 families.

Look at the line graph during this stretch of time. Using the information provided above, explain why there was such a sudden jump of deforestation within the Amazon. Use at least two examples in your answer to help explain your reasoning.

3.Give at least two reasons for the dramatic change of deforestation that took place from 2008 – 2012. Give details explaining why each reason chosen would contribute to the change.

B. *Types of Forest System:*

1) Which type of forest gets the most rainfall in a year? _____
   a. Coastal Forest
   b. Coniferous Forest
   c. Tropical Rain Forest
   d. Deciduous Forest

2) Which type of forest gets the least rainfall in a year? _____
   a. Coastal Forest
   b. Coniferous Forest
   c. Tropical Rain Forest
   d. Deciduous Forest

3) Which type of forest is the warmest? _____
   a. Coastal Forest
   b. Coniferous Forest
   c. Tropical Rain Forest
   d. Deciduous Forest

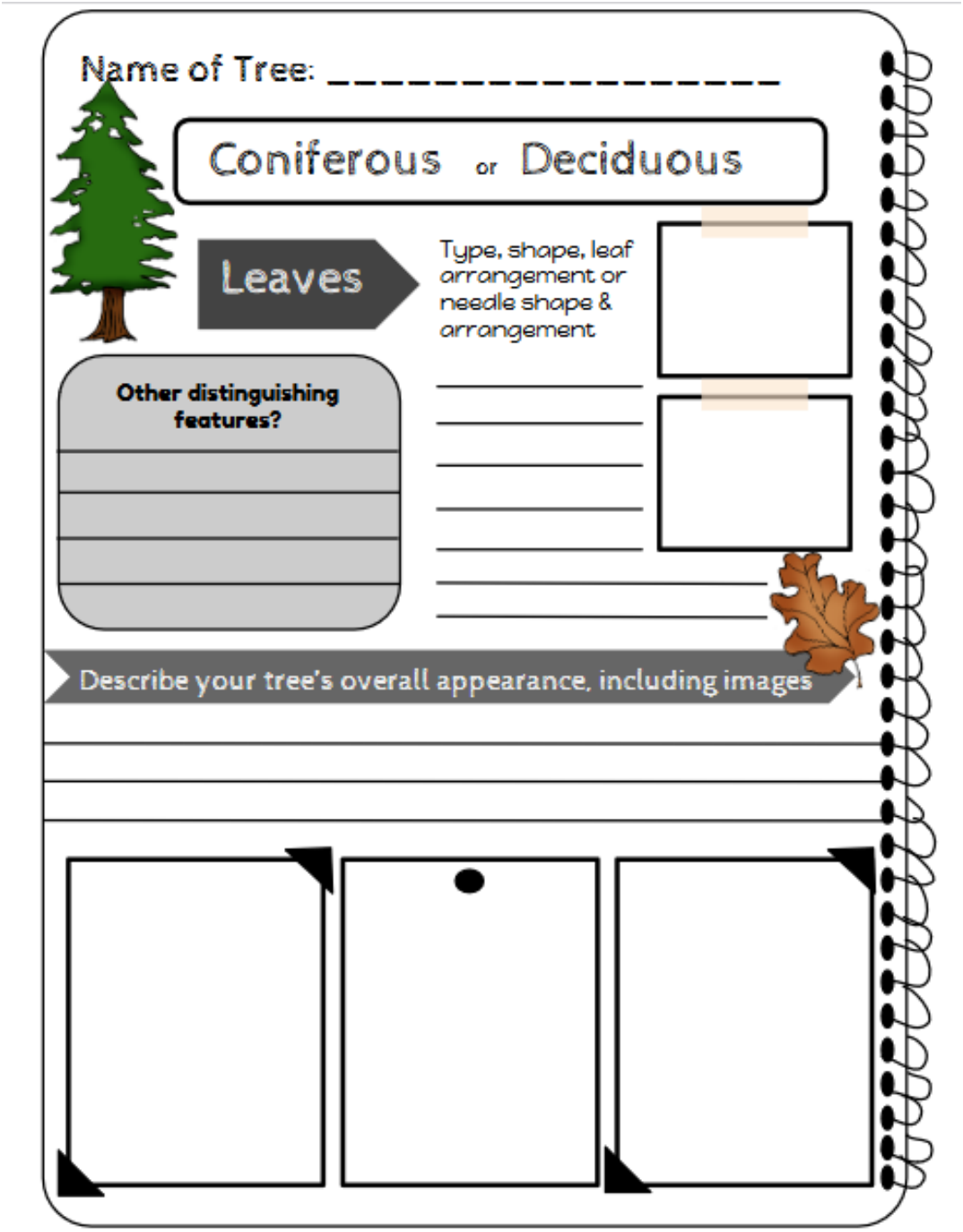
Fill in the Blank:

4) The lowest level of a rain forest is called the _____.

5) The middle layer of a rain forest is called the _____.

6) The highest layer of a rain forest is called the _____.

C. *Nature - Journaling*



Common animals who live here:

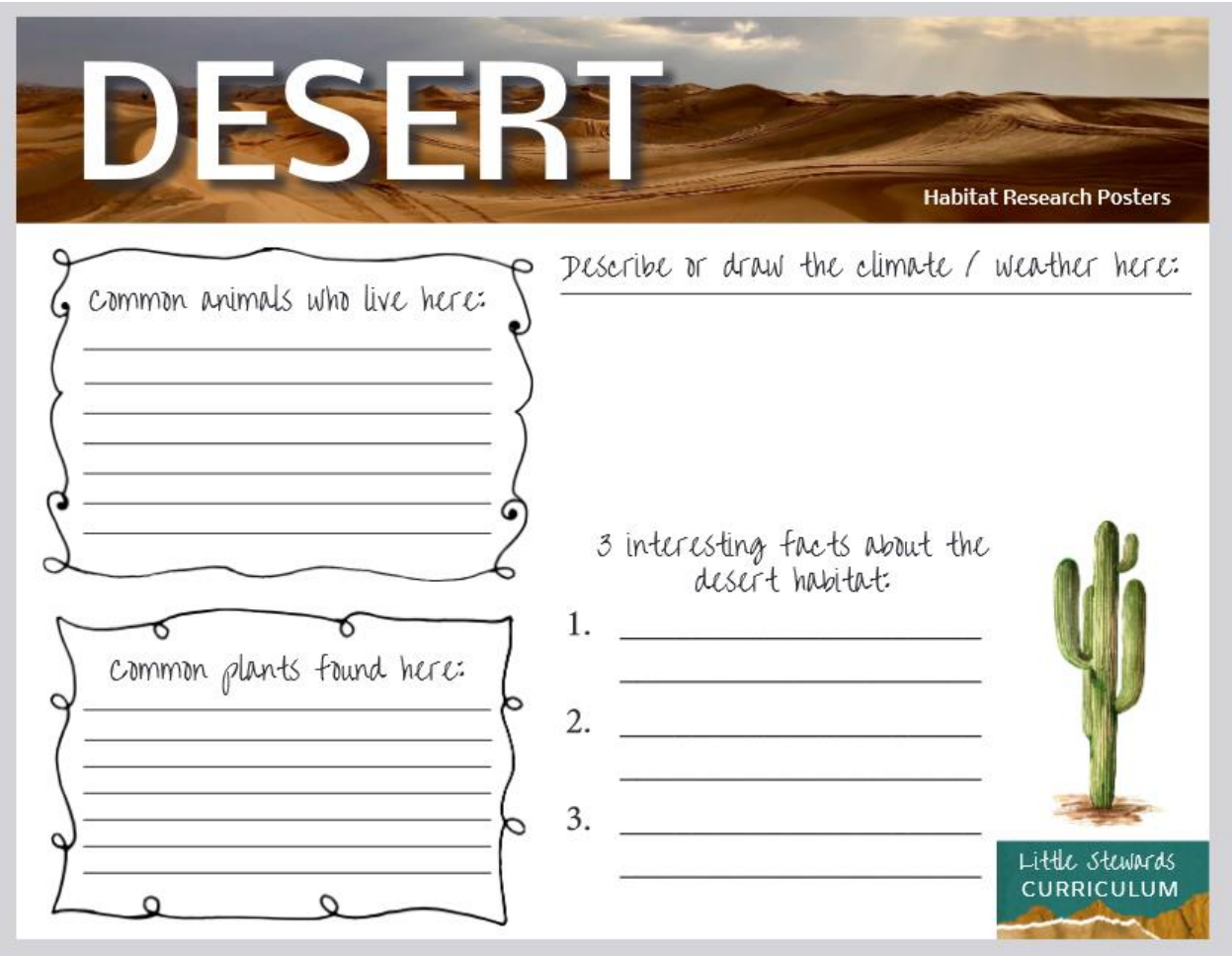
Common plants found here:

Describe or draw the climate / weather here:

3 interesting facts about the forest habitat:

1. _____
2. _____
3. _____

Little Stewards CURRICULUM



D. *Evaluate how to mitigate the effects of global warming*

More or Less?

The world and your school are becoming increasingly digital. To combat global warming, some individuals have suggested that one should use paper as much as possible, however only from renewable forests rather than only using email or the internet. They argue that by using more paper, more forests need to be planted which in turn combats global warming. This means that the more paper you use, the more forests will be planted which helps to combat global warming.

Your goal: Evaluate whether using as much as possible renewable paper combats or aids the effects of global warming.

STEP 1: Research	Discuss why plants are important for maintaining oxygen in the atmosphere. Your explanation should cover: 1. An explanation of the process of photosynthesis including the reactants and products. 2. An explanation of the processes that add carbon dioxide to the atmosphere 3. An explanation of the importance of keeping the atmosphere in balance 4. An explanation of the consequences of clearing forests This step will be completed in class and at home. Your discussion should be no longer than 500 words and may include diagrams. Your research should be handed to your teacher in hard copy on single sided, A4 paper. All research should be in your own words.
STEP 2: Discussion	In class, your teacher will facilitate a class discussion of the material you have covered in your research. Every student will be given an opportunity to contribute.
STEP 3: Evaluation	Using the information from step one and two, as well as any additional information about using renewable forests to combat global warming, write a 250-word discussion outlining your opinion as to whether you agree or disagree that by using more paper produced from renewable forests, we can combats global warming as more forests will need to be planted. This step will be completed in class, in one lesson, on refill. You may use your research and any notes you may have made from

	step two to ensure that you present a concise, scientific argument for your opinion.
STEP 4: Design	**Design a promotional item** such as a cartoon strip, info-graphic, website, brochure etc. that **explains the science** behind your choice of using more or less paper to the general public. Your promotional item should encourage the public to do the same. This step should be completed at home and should be handed in as a hard copy to your teacher on the due date.

Mark Scheme

	For basic, students must:	**For proficient, students must have met the requirements for basic and:**	**For advanced, students must have met the requirements for basic, proficient and:**
4	**Identify** the products and reactants in photosynthesis	**Describe** the process of photosynthesis.	**Explain** how and where photosynthesis is carried out.
	List three processes that add carbon dioxide to the atmosphere	**Describe** how one process adds carbon dioxide to the environment.	**Explains** how two processes add carbon dioxide to the environment including all major steps in the process.

	Lists one reason why the atmosphere should be kept in balance	**Describe** one reason why the atmosphere should be kept in balance.	**Explains** two reasons why the atmosphere should be kept in balance, clearing identifying the causes and effects.
	Lists three consequence of clearing a forest	**Describes** the effect of clearing forests in the carbon cycle.	**Explains** two consequences of clearing forests including one long term effect and one short term effect.
2	Make any valid contribution to a class discussion or forum and respond appropriately to another student's contribution		
4	**Express** their opinion for or against the recommendation		
	Describe one reason for their opinion	**Explain** two reasons for their opinion making at least one reference to scientific evidence	**Discuss** two reasons for their opinion giving scientific evidence for each reason.
4	Final product is professional in appearance	Final product shows careful consideration of layout and graphics included	A final product shows consideration for maximum impact for conveying the creator's message.

	Must meet 5 out of 8 criteria for achieved	Must meet the achieved criteria for each Merit mark and 4 out of six criteria for merit	Must meet the achieved and merit criteria for each excellence mark and 4 out of 6 criteria for excellence

Teachers Guide

Aims of this assessment

- Develop an understanding of the role of photosynthesis and how it impacts on our daily lives
- Scaffold students through the levels of Bloom's Taxonomy in order to develop deeper thinking and analytical skills
- Develop student understanding of the nature of science through giving opportunities for peer discussion and drawing evidence-based conclusions in a real world context.

This lesson is about the distribution and density of trees in urban areas. Overall, there is more tree cover in wealthier and whiter areas of cities, disproportionately impacting low-income communities and communities of color.

Step 1 - Inquire: Explore a spreadsheet and two graphs showing urban forest cover and its connection to wealth and race.

Step 2 - Investigate: Watch three videos and take notes on the benefits of trees.

Step 3 - Inspire: Complete a written reflection noticing the distribution of trees near their homes.

Lesson Plan Sample

Charting Diversity

Introduction

Created By	Maydafe Cherryl Clark
Subjects	Science

Grade Level	6th, 7th, 8th
Duration	60 minutes
Standards	**Primary Standards** AZ Science Standards: Construct a model that shows the cycling of matter and flow of energy in the atmosphere, hydrosphere, and geosphere. Learning Expectation: Student will organize different species of plants and animals according to various characteristics Supporting Standard ● L4: The unity and diversity of organisms, living and extinct, is the result of evolution. ● Students will determine how certain characteristics help species adapt to environmental conditions.
Synopsis	This lesson is about exploring the amazing diversity of life on Earth and discovering how plants and animals are adapted for survival. It provides a basis for understanding why there are so many different species and the value of biodiversity. **Step 1 - Inquire:** Students explore and gather resources for students to use for their animal and tree research inside the San Carlos Middle School, field guides, books and internet resources. **Step 2 - Investigate:** Students watch two videos and take notes on the benefits of trees. **Step 3 - Inspire:** Students complete a written reflection noticing the distribution of trees near their homes.
Essential Questions	● Why do some areas have more trees than others? ● How does the distribution and density of trees relate to environmental justice?
Learning Outcomes	Students will be able to: ● Examine the relationship between urban forest cover, wealth, and race. ● Identify the benefits of trees.

	• Complete a written reflection regarding the distribution of trees near their home.

Lesson Plan

Inquire **~25 minutes**	• Ask the students to name the different types of environments in which animals live? • Teacher shows two graphs and asks students to interpret each graph. ○ Students turn and talk to try to make sense of each graph.
Investigate **~20 minutes**	• Teacher creates groups of 2-3 students. • Using the Student Slideshow, groups write down as many benefits of trees as possible while watching two videos: Benefits of Urban Trees and What Happens If We Cut Down All of a City's Trees? • Students share their lists with the rest of the class.
Inspire **~15 minutes**	• Students complete a written reflection on the Student Document. • Guiding questions on the assignment include noticing how many trees are near their homes and if they notice any connections between wealth, race, and age.

Teaching tips

Positives	• This is an engaging lesson because it is so personal. Students will think about tree cover where they live and how that relates to demographic data. • Students will practice their data analysis skills.

Additional Prerequisites	• It is necessary to share the Student Slideshow with your students and give them editing access before beginning the lesson. All students will be writing in the same slideshow.
	• The videos list the benefits of trees pretty quickly. It might be hard for students to type fast enough to keep up. You could play the videos at 0.9 speed or replay parts of the videos as necessary.
	• The following is a list of benefits of trees. Students will create a similar list while they are watching the two videos outlining the benefits of trees.
	  ○ Reduce nearby outside temperatures
	  ○ Reduce the amount of energy used for heating and cooling buildings
	  ○ Absorb carbon dioxide, this mitigating climate change
	  ○ Filter urban pollutants and fine particulates
	  ○ Provide habitat, food, and protection to plants and animals
	  ○ Provide wood that can be used at the ends of a tree's life

	○ Improve physical and mental health of people ○ Increase property values ○ Create oxygen ○ Provide shade for people and animals ○ Control stormwater runoff, protecting water quality and reducing the need for water treatment ○ Protect against mudslides ○ Help prevent floods ○ Improve air quality ○ Increase attention spans and decrease stress levels in people ○ Improve health outcomes in hospital patients
Differentiation	● Teachers can use the glossary at the end of the slideshow at any point throughout the lesson to help students understand vocabulary. ● The resources in the Inquire section may be difficult for students to interpret. Encourage your students to turn and talk to one another for help. ● Many students will not have a good understanding of Celsius. Easy reminder: Multiply the temperature in Celsius by 1.8 to get degrees Fahrenheit. Example: 2.5°C x 1.8 = 4.5°F (The temperature difference between poorest and richest census blocks in Milwaukee, Wisconsin).

E. *Research-based Activity*

Students will research Agave. They will use hyperlink to connect their research to the website as their reference.

a. What is Agave?
b. 4 types of Agave
c. How to plant Agave Plant Outdoors
d. How to Care for your Agave plant
e. Tips for repotting indoor Agave plants

G. *Carbon - Cycle Assessment:*

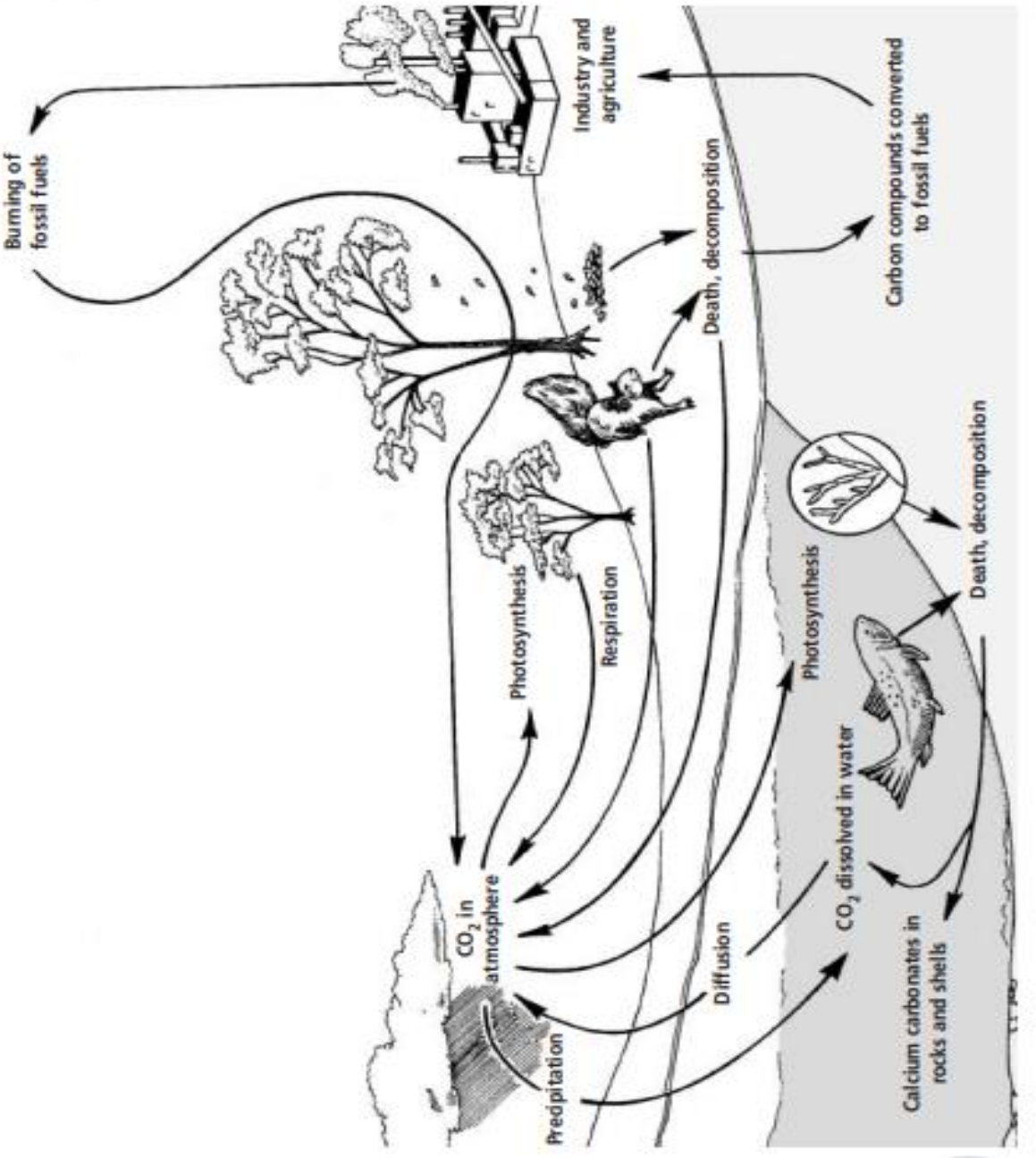
Name Date Class

Master 1

The Carbon Cycle

Reteaching Skills

Use with Chapter 2, Section 2.2



Project-based Assessment: (Tus) Drinking Jar out of Agave Stem

Lesson Plan for STEAM Project

Topic: Drinking Jar " Tus" out of Agave Plant

Objective Standard:
7.E1U1.5 I can construct a model that shows the cycling of matter and flow of energy in the atmosphere, hydrosphere, and geosphere.

Supporting standard:
7.L2U1.12 I can construct an explanation for how some plant cells convert light energy into food energy.

Essential Questions:
1. What is the process of photosynthesis? Why is it important to life on earth?

Child friendly Objective: I can construct a model that helps mitigate the increase in carbon dioxide by utilizing the Agave plant into a drinking jar "Tus" for Apache community.

Topic: STEAM Project - "Tus" out of Agave Plant

Essential Questions:
1. What causes Earth process? Where does the energy come from?
2. What are the three cycles of matter? How does cycling of matter occur in each of the three cycles?
3. What is the process of photosynthesis? Why is it important to life on earth?

Introduction: (I do Process)
Teacher: Introduce carbon and the earth system.
Frontload vocabulary terms:

Carbon	Earth System	Geosphere
Carbon cycle	Forest	Biosphere
Carbon dioxide	Greenhouse gas	Fossil fuels
Photosynthesis	DNA	
Prototype	Atmosphere	

Carbon, like water, is essential to life as we know it on Earth. It is a component of our DNA and of the foods we eat, and its presence in the atmosphere (in the form of carbon dioxide, a "greenhouse gas") helps keep our planet warm enough to be habitable. Like water, carbon continuously cycles through the major components of the Earth system—the Geosphere and the Biosphere - driven by processes that occur at incredibly different time scales, from fractions of a second (photosynthesis) to millions of years (formation of fossil fuels).

- How is the carbon cycle interconnected with other biochemical cycles, such as the nitrogen cycle?

Human activities—such as extracting fossil fuels and burning them, breaking down carboniferous rocks (such as limestone for the production of cement), and deforestation—have an enormous impact on the global carbon cycle. As a result, global atmospheric levels of carbon dioxide have been rising since the beginning of the Industrial Revolution (see "On the web"). Student understanding of climate change and the human role in the alteration of the atmosphere is greatly facilitated by knowledge of the carbon cycle.

Present the engineering design process. Begin with the problem.

We Do Process:

The teacher will use the data gathered on agave plants around San Carlos, AZ, to explain a little about photosynthesis and the life cycle of the agave plant.

Activity: Persuade the students of the urgency of mitigating the community's contribution to climate change (carbon increase) in the San Carlos Reservation and explain how to create a project out of an agave plant to be useful to minimize the increase of carbon in the atmosphere.

Brainstorming Worksheet:

With your group, brainstorm solutions utilizing the agave plant that answer the following question: *How can we use data to effectively create a project that helps mitigate the dangers of climate change and the increase of carbon in the San Carlos AZ reservation?*

Ideas for solutions	Persuasive Evidence

This activity has resulted in many excellent—and a few truly outstanding—presentations that contain research-based, creative, and realistic solutions capable of having a real impact on our town's total output of greenhouse gases. Sharing the presentations in class also results in authentic student questions and productive class discussions.

Collect the data and come up with one project to resolve the problem.

Demonstration: The teacher will show the procedures on how to take the roots of the agave plant to create a "Tus," or drinking jar. (show some pictures and video.)

Process:

a. Remove the leaves of the agave plant one by one.
b. Use the stone to clean up the inside of the agave plant. Carefully remove the hollow, soft debris of the agave until clean.
c. Use the stone again to smooth the surface of the jar. Rub it slowly until smoothness is achieved.
d. Use resin (pitch pine) to cover spaces and holes, including dents.
e. Wait for few minutes to dry up the resins.
f. Paint the model and try out putting water in the jar.

Revise the project: If the jar doesn't serve its purpose, improve it and enhance the project.

Assessment:

After completion of this activity, students should be able to:

a. Sketch a simple plan to create a "Tus" out of an agave plant.
b. List multiple ways that humans interfere with the carbon cycle.
c. Describe and construct "Tus" out of Agave plants to decrease anthropogenic inputs of greenhouse gasses.

Extensions:

Describe individual, community, and global behavior changes with the potential to decrease anthropogenic inputs of greenhouse gases.

The project can be extended into related subject areas. For mathematics, the student groups can create a quantitative cost/benefit statement based on actual data. Students should calculate the monetary expenditures necessary to implement their plan for decreasing their town's carbon footprint and the potential savings in pounds of carbon dioxide not added to the atmosphere. For engineering, have the student groups research, design, and report on engineering solutions for schools and city buildings that result in at least a 33% decrease in the town's overall carbon footprint. In Humanities, students can relate to the past history of the Apache as part of their livelihood and culture.

Conclusion

The activities use active, collaborative, inquiry-based learning techniques to engage students in creating models of the carbon cycle, evaluating and discussing those models with classmates, and developing ideas for community-based solutions to the problem of anthropogenic climate change. The activity is an effective way to help students connect the carbon cycle with climate change, a connection that most do not automatically make without explicit instruction. It also provides students with opportunities to connect global climate change to local activities, as well as to acquire and practice skills such as critical thinking, creativity, collaboration, and communication.

Name:

Creative Project Assessment Rubric

Category	Score of 5	Score of 4	Score of 3	Score of 2
Required Elements ***Score:***	Goes over and above all the required elements stated in the directions & instructions	Includes all of the required elements as stated in the directions/instructions	Missing one or more of the required elements as stated in the directions/instructions	Several required elements are missing from the project
Creativity ***Score:***	Exceptionally clever and unique in showing deep understanding	Thoughtfully and uniquely presented; clever at times in showing understanding of the material	A few original touches enhance the project to show some understanding of the material	Shows little creativity, originality and/or effort in understanding the material
Neatness and Attractiveness ***Score:***	Exceptionally attractive and particularly neat in design and layout	Attractive and neat in design and layout	Acceptably attractive but may be messy at times and/or show lack of organization	Distractingly messy or very poorly designed. Does not show pride in work.
Grammar ***Score:***	No grammatical or mechanical mistakes in the project	A few grammatical/mechanical mistakes which are not distracting	Several grammatical/mechanical mistakes which are distracting	Many grammatical or mechanical mistakes throughout the project. Clearly not proofread.
Understanding of Content ***Score:***	Shows a sophisticated understanding of the themes in the work	Shows an understanding of the major themes of the book	Displays a somewhat limited understanding of the book. May have a few misinterpretations.	Does not show an understanding of the text. Misses plot points and has quite a few misinterpretations.
Overall Effectiveness and Completion ***Score:***	Project is engagingly organized and presents material that is captivating for the viewer.	Project is somewhat organized, complete and holds the attention of the viewer	Project is disorganized and incomplete at times and is somewhat able to hold the attention of the viewer	Project is incomplete and not easy to follow

Comments:

H. Fire triangle Worksheet

Student Page

Fire Triangle Worksheet

1. Fires need heat, fuel, and oxygen to burn. This is known as the "fire triangle." Draw a triangle below and label each of the three sides with the word and a picture for each of the three parts.

2. Initially, the heat is provided by an ignition source, which can be human or natural. Name two natural and two human-caused sources of heat for fire ignition.

Natural	Human-caused
1. _____	1. _____
2. _____	2. _____

3. Fires need fuel to burn. Name three potential fuels you might expect to find in a forest.

1. _____
2. _____
3. _____

4. Oxygen is available in the air. Weather has a great influence on when fires occur and on how they spread. Hot temperatures and dry winds can create severe fire conditions by affecting fuel, moisture, and oxygen. What can dry winds do to fuels to make them more likely to burn?

_____

_____

5. If you cut off any one of the three elements—heat, fuel, and oxygen—a fire will not burn. What are some ways that firefighters might cut off each of the three parts of the fire triangle?

_____

_____

Habitat Assessment

NUTSHELL
Students work in small groups and use wildlife habitat requirements to assess potential animal habitat
based on map interpretation, plant and forest inventory information, on-site forest composition and
structure, and wildlife habitat needs.
BIG IDEAS
There is biodiversity within a forest. Different forests have different levels of biodiversity. (Subconcept 7)
Forests impact air and water quality, prevent soil erosion, and provide habitat for wildlife. (Subconcept 25)

OBJECTIVES
Upon completion of this lesson, students will be able to:
• Identify specific components of the forest that provide wildlife habitat.
• Assess the value of an area of the forest as habitat for a wildlife species.

LESSON/ACTIVITY TIME
Total Lesson Time: 640 minutes (including 345 minutes of student work time)
Time Breakdown:
Introduction – 10 minutes
Activity 1 – 60 minutes (including 30 minutes of student work time)
Activity 2 – 180 minutes (including 150 minutes of student work time)
Activity 3 – 120 minutes
Activity 4 – 60 minutes
Activity 5 – 180 minutes (including 165 minutes of student work time)
Conclusion – 30 minutes

TEACHING SITE
Classroom and forested site (San Carlos Middle School)

VOCABULARY
Limiting factor: something that controls (limits) growth or species population size or distribution. The availability of food, water, shelter and space as well as competition for resources, predation and diseases are examples of limiting factors.
Interspersion: the spacial relationship between the different habitats a species needs.

Mast: is the reproductive bodies of plants that serve as wildlife food sources. Mast is often divided
into categories of "hard mast" and "soft mast". "Hard mast" describes hard-shelled seeds, such as
acorns and hickory nuts. "Soft mast" describes seeds that are covered with fleshy fruit, such as
apples and berries.

MATERIALS LIST

The materials listed below are based on an example habit assessment protocol. During this lesson, students develop their own habitat assessment protocols, which will include necessary materials. Actual material needs will be determined by the students and will vary by class.

For The Teacher

• Copy of Teacher Page A1, Example Habitat Assessment Protocol

For Each Student

• Wildlife habitat information resources (see resource list)
• Clipboard

For Each Group of 4

• 100’ Tape
• Diameter tape or tree scale stick
• 2 compasses (optional)

TEACHER PREPARATION

Make arrangements for a trip to the school forest (or another forested area)

SAFETY PRECAUTIONS

Visit the teaching site ahead of time to locate any hazards such as holes, hanging branches, protruding tree roots, poison ivy, etc. Encourage students to walk at all times. Consider these:

• Are you in sight or earshot of students?
• Are boundaries for students marked?
• Have you set expectations for being out of the classroom?
• Do you have a whistle, first aid kit, insect repellent, water, and sunscreen?
• Is everyone dressed appropriately?

BACKGROUND INFORMATION

All wildlife need appropriate habitat. Habitat must provide the basic needs of wildlife: food, water,

shelter, space, and air. All habitat components must exist in sufficient quantity, quality, and arrangement to
support a species. The specific habitat needs vary by species.
Forest habitat components can be identified and compared to species needs to determine if the forest
can provide habitat for that species. There are a number of scales and components to identifying
appropriate habitat. These include:
• Species distribution/range – whether the species occurs in the geographic area of the forest
• Composition – the variety of plant species in an area
• Structure – the horizontal and vertical distribution of layers in a forest, including height, diameter, and species present.
• Interspersion of habitats – wildlife species often have different requirements during different
seasons of the year. Interspersion is the relationship between the different habitats a species needs.
• Minimum area – the minimum area of contiguous habitat that is required before an area will be
occupied by a species. Many wildlife species have minimum area preferences, that is, Regardless of the quality of habitat, size may be a limiting factor.
• Availability of food – often the availability of food is a key determinant of habitat suitability.
Carnivorous species, especially, are most often limited by food availability rather than other

ALIGNMENT TO ARIZONA STANDARDS

Objective Standard:
7.E1U1.5 I can construct a model that shows the cycling of matter and flow of energy in the atmosphere, hydrosphere, and geosphere.

Supporting standard:
7.L2U1.12 I can construct an explanation for how some plant cells convert light energy into food energy.

1.L2U2.7 Develop and use models about how living things use resources to grow and survive.
Design and evaluate habitats for organisms using earth materials.

Obtain, evaluate, and communicate information about the properties of Earth materials and **investigate** how humans use natural resources in everyday life.

References

(1) How the San Carlos Apache Tribe and the Forest Service ....
https://www.azcentral.com/story/news/local/arizona/2023/09/06/forest-service-partners-with-tribes-and-local-towns-to-reduce-wildfire-risk/70767912007/.

(2) Tonto National Forest - Districts - US Forest Service.
https://www.fs.usda.gov/main/tonto/about-forest/districts.

(3) San Carlos Apaches get federal funds to reduce Arizona wildfire risk.
https://www.azcentral.com/story/news/local/arizona-wildfires/2023/01/20/san-carlos-apaches-get-federal-funds-to-reduce-arizona-wildfire-risk/69819864007/.

(4) Black River Mainstream Trail - # 61 - US Forest Service.
https://www.fs.usda.gov/recarea/asnf/recreation/recarea/?recid=45277&actid=43.

Research Based Learning: a Lifelong Learning Necessity | (solutiontree.com)

Microsoft Word - 3--Application of Etymology and Semantic Field Theory for Second Language Acquisition (davidpublisher.com)

https://link.springer.com/article/10.1007/s10798-021-09714-1

https://www.sciencedirect.com/science/article/

https://www.wsfcs.k12.nc.us/cms/lib/NC01001395/Centricity/ModuleInstance/86679/CARBON%20CYCLE%20WORKSHEET.pdf

https://www.offidocs.com/public/?v=ext&pdfurl=https://www.wsfcs.k12.nc.us/cms/lib/NC01001395/Centricity/ModuleInstance/86679/CARBON%20CYCLE%20WORKSHEET.pdf

https://www.azed.gov/standards-practices/k-12standards/standards-science

https://www.plt.org/wp-content/uploads/pdf/PLTPreK-8_Activity-81_Living-With-Fire_Student-Page_Fire-Triangle-Worksheet.pdf