

Forestry & Climate Change Seminar

What We Do to the Forest, We Do to Ourselves

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Diné Institute for Navajo Nation Educators (DINÉ)

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Author Note:

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Context & Rationale

Our School Community

This unit is created specifically for my unique and committed students at Flagstaff High School (FHS). Flagstaff is a mountain town in Northern Arizona at 6,900 feet elevation, surrounded by ponderosa pine forest. There is ample access to natural spaces and trail systems. The population of Flagstaff is 77,500, and has been growing at a rate of 17% a year since 2010 (Flagstaff, Arizona population, 2021). The economy in Flagstaff is largely based on tourism and education as it is a gateway to the Grand Canyon and the location of Northern Arizona University (NAU). The cost of living in Flagstaff is high and more than 50% of people rent living space. 19.7% of the population in Flagstaff lives in poverty, higher than the state average of 16.1% (Flagstaff, AZ, 2019). Some of the major employers in town are NAU, Flagstaff Medical Center, WL Gore & Associates, Flagstaff Unified School District, and Coconino County. Flagstaff is also home to many scientists and science institutions such as Lowell Observatory, the United States Geological Survey, US Forest Service Research Station, and NAU. Both the School of Forestry and the Ecological Restoration Institute (ERI) at NAU served as resources in creating this unit.

The Flagstaff Unified School District (FUSD) serves approximately 9,600 students at fifteen different schools. Every student in FUSD has a school issued iPad that was distributed in 2019 based on bond funding voted for by the community. There are two main high schools: Coconino High School (1,430 students), and Flagstaff High School (1,689 students). Feeder schools for FHS include the district middle schools, Mount Elden Middle, Sinagua Middle, and several other charter schools in the community (BASIS Flagstaff, Flagstaff Arts & Leadership Academy, and Northland Preparatory Academy).

FHS serves students from Flagstaff and the nearby communities of Dilkon, Tolani Lake, Cameron (all on the Navajo Nation), Doney Park, Bellemont, Parks, Baderville, Kachina Village/Mountaineer, Munds Park, and Lake Mary. Some students may travel by bus from as far away as 90 miles, which means they are starting out for school early in the morning and arriving home late in the afternoon. FHS is honored to serve a population of Native American students who live in the Kinłani Bordertown Dormitory one mile north of the school. Originally built in 1958 by the Bureau of Indian Affairs (BIA), the dormitory initially housed students from kindergarten-high school. By the 1980s, the last student to have lived in the dorm for K-12th grades graduated (Flagstaff Bordertown Dormitory, 2021). The dorm now only houses high school students, having undergone a major renovation in 2008. College-style dorm rooms provide living quarters and the building also has a cafeteria, gym, computer labs, and common areas. Students from the dorm walk back and forth to FHS and have dorm faculty who support them in academics, recreation, and residential life.

FHS has a graduation rate of 97% and was given a Report Card grade of B in 2019 by the Arizona Department of Education (Arizona Department of Education, 2020). According to the school registrar, our student population is 47% female and 53% male. Students' socio-economic status ranges from very low income and homeless to upper middle class. Our racial diversity is as follows: 49.97% White, 24.33% American Indian or Alaskan Native, 20.13% Hispanic, 0.83% Asian, 0.95% Black or African American, with 3.73% identifying in multiple categories. Fourteen

percent of our students qualify for special education services and have Individual Education Plans. Twenty-three percent of our student population qualifies for Free & Reduced Lunch.

FHS has adopted a framework for Indigenous student achievement based on the idea that what is good for our Indigenous students specifically is good for all students generally. In this framework, our school focuses on the following main ideas: power is shared, culture counts, relationships and connectedness are fundamental, and learning is interactive and dialogic. Our aim is to ensure that our Indigenous, Black, and Latino students don't feel like they are just renting, but really *owning* space in the educational community at FHS.

The unit described here will be taught in my Honors Biology course. The students who sign up for this class are mostly ninth and tenth graders who have already taken and passed an algebra course. Many will continue with other advanced classes in our school's AP Academy, although this is not required. This class is capped at 35 students, and sections are often at capacity. Our school is on a six-period day with 50-minute classes that last all year.

Students who take Honors Biology can apply it toward both the AP Academy and the Alpine Institute, a place-based experiential program within FHS. In order to graduate from the Alpine Institute, students must take several other classes and complete Alpine-related service hours, which are often provided in parallel to their coursework. Our Alpine Institute core values are critical thinking, inquiry, community, stewardship & advocacy, and reflection.

I normally teach my Biology class with a scope that grows in scale from small to large. We begin with the molecules of life, build to cells and genetics, and then end with evolution and ecology. In order to pilot-test this curriculum unit, I will flip-flop and move ecology up in order to teach my unit at the start of the year when it is also warm enough to spend significant time outside.

In focusing on my students, I consider and acknowledge that my students have life experiences that I may or may not be able to directly relate to. For example, some students have farm animals, some live on the Navajo and Hopi Nations, some have jobs before or after school, and some are struggling with depression and anxiety and medical issues. I also have students who are accomplished athletes or have developed CTE skills like welding and graphic design. Some students are leaders within the school and some have thousands of followers on social media. There are students who have parents who are very involved with their education and others who do not have parents or have little support. Some students and/or their parents have undocumented immigration status. Just as biology celebrates the unity and diversity of life on Earth, I hope that this unit can help my students celebrate the unity and diversity they bring to the classroom.

Our Ecological Community

Flagstaff is located within a large stand of ponderosa pine forest at the edge of the Navajo Nation and at the base of Dook'o'osłíid (the San Francisco Peaks), an eroded stratovolcano and the highest point in Arizona. A great variety of life zones can be visited in a short distance from Flagstaff as you change elevation. We have alpine tundra, mixed conifer, aspen groves, pinyon juniper, grassland, desert, and even a few riparian areas. Located within the largest contiguous

ponderosa pine stand in the world, Flagstaff is a beautiful place, with pine trees almost always in view.

As a result of timber harvesting and fire suppression over the last 150 years, the ponderosa pine forest around Flagstaff has undergone a drastic departure from its historic range, with the fire regimes significantly altered (Covington & Moore, 1994). Flagstaff is also in a long-term drought, with regional precipitation measures reduced over a 26-year period (Arizona State Climate Office, 2021). These factors compound the projected effects of climate change and have already been observed in the Southwest (GlobalChange.gov, 2014).

Young People in Our Community Have Grown Up with Intense Fires

“What we are doing to the forests of the world is but a mirror reflection of what we are doing to ourselves and to one another.” -- Chris Maser (Maser, 1989)

Studying forest ecology provides a rich example for students to engage with systems thinking and relate many interacting parts to understand a bigger picture. This unit emphasizes interconnectedness in a way that includes the students themselves as one crucial piece of the puzzle. The structure allows us to spend a significant amount of time outside, at sites in the forest. Returning to the same sites and making many observations in the same area can help build a respectful and reciprocal relationship to place.

The forests of this region are significant to me in my life, and just as I share them with my own children and spend time in the forest to find peace and rejuvenation, I look forward to spending time learning in the forest ecosystem with my students.

In framing forest health as it relates to human health, the ethical question about our responsibility to restore altered forests becomes more interesting. I want students to feel empowered knowing that the conditions of the forest right now are likely to change, and that this will depend on how humans choose to manage them or not. We can use the stories the forest tells us in order to create and implement landscape restoration plans.

As I plan out this unit, I must also consider what post-COVID school may look like. In the words of Gloria Ladson-Billings in the article *“I’m here for the hard re-set: post pandemic pedagogy to preserve our culture”* (2021), I don’t want to go back to ways of pre-pandemic teaching that didn’t serve my students. After having taught online for more than a year, I know there are some things I will definitely keep and also some components of my teaching and my school that I cannot use again. With this unit, at least, I hope to provide an experiential, student-centered take on ecology, not just a presentation of discrete facts that students can learn and then discard. In a way that is related to the role that activism took on this year, one part of this unit has students research examples of forest restoration around the world that have been spurred by leadership from young and Indigenous people speaking up for their lands.

Through the Diné Institute, I have learned that we need young people, particularly those with Traditional Ecological Knowledge to get involved with natural resource management fields both to replace the people who are retiring, and to have a representative voice in how valuable lands

and resources are treated. Perhaps by engaging with forest measurements and learning about related career options in this unit, those fields may come into focus for some of my students. Studying and analyzing forest ecology, fire ecology, and forest management brings up many multi-disciplinary questions that do not have easy answers. Working through this together as a class may serve as a framework for students to consider other, large-scale challenges they are sure to face in their lives such as those related to environmental justice and climate change.

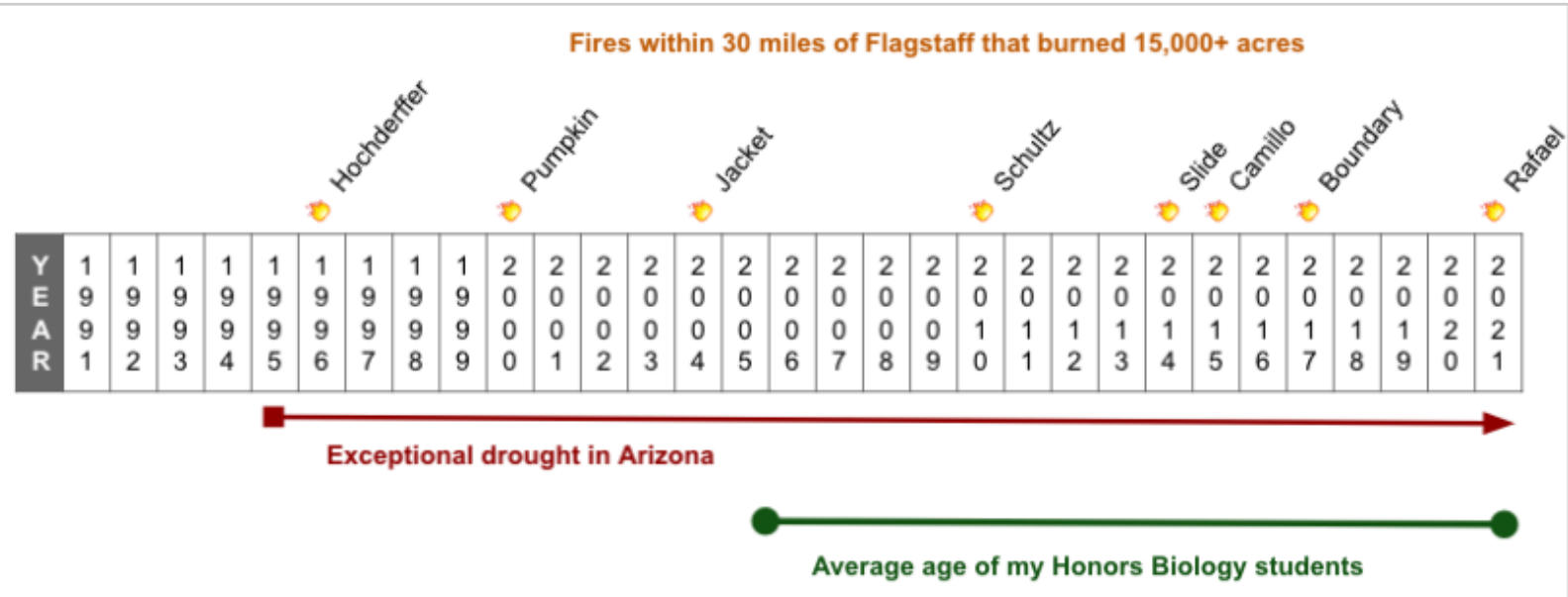


Figure 1: A timeline of recent forest history related to the lives of my students

Content Objectives

Forestry: Looking Back in Time

Our community is located in the largest contiguous stand of ponderosa pine forest in the world. Trees hold stories within their tissues that we can interpret through dendrochronology to piece together fire history and stand characteristics. In the last two hundred years, human influence has significantly modified our forest through utilization, habitation, and climate impacts. The story of this forest is a telling example of the history of land use in North America.

The 1500s to the mid-1800s marked a period of expansion accompanied by the exploitation of land in North America with the arrival of colonizers from Spain and then Europe (Cubbage, et al., 2017). The late 1800s brought about a governmental change in the approach to land resources by setting aside forest reserves and creating a forest management plan based on calculated utilization (Cubbage, et al., 2017). The exploitation of forested lands in North America occurs in parallel with the mistreatment of Indigenous peoples who were living in harmony with the environment for hundreds of years prior to European arrival (Dunbar-Ortiz, 2019). Among other atrocities, like forcibly removing Indigenous groups from their homelands and restricting their sovereign rights to manage their own resources, the US government intentionally interfered with their Traditional

Ecological Knowledge base and the sustainable relationships that Indigenous groups had developed over many, many generations.

From 1860-1950, the U.S. government adopted conservation efforts toward land management with an emphasis on the economic value of lands, particularly forests (Cubbage, et al., 2017). During this time, the government simultaneously promoted large-scale predator eradication efforts that further contributed to altered ecosystems (*The Wolf That Changed America*, 2014).

In reaction to centuries of over-utilization and mismanagement of forests and the species within, the formation of the National Environmental Protection Act in 1969 and the Endangered Species Act of 1973 helped bring the national management of forest lands toward an ecosystem management-based approach (Cubbage, et al., 2017). The legacy of these policies and the practices of fire suppression have left their mark on our ponderosa pine forest. Fire scars tell us that ponderosa pine historically experienced low severity fire every 2-20 years across this region (Dubay, 2017). As we experience higher temperatures and prolonged drought conditions in the Southwest, the potential for large-scale fires increases. Stand-replacing high intensity fires cause a decrease in the amount of carbon sequestered by the forest, further contributing to climate change (Swetnam & Falk, 2015).

Forest Health, Human Health

Kolb et al. (1991) define forest health by four criteria: trophic networks to support forest cover, resistance to change, supply and demand equilibrium of essential resources like water, and diversity of stand structures. These conditions reflect health not only as it relates to human utility, but also the ecological conditions that perpetuate the forest. Due to bark beetle infestation, risk of significant fire due to grazing and fire exclusion, as well as the climate conditions at the start of the century that were favorable for pine establishment, the ponderosa pine forests of the Southwest only meet the first of these four wide ranging criteria for forest health (Kolb, et al., 1991).

Does forest health have an impact on human health? According to Swetnam & Falk (2015), “A reorganization of all southwestern forest ecosystems is predicted in coming decades.” Ecosystems are likely to shift up the elevational gradient as temperatures rise due to climate change. A loss of mature forest systems is likely to lead to a reduction in carbon sequestration and a decline in productivity (Swetnam & Falk, 2015). The impact of drought and large-scale fires can be felt at the community level through the impacts of forest closures, concern about forest fires and evacuation orders, as well as smoke in the air from both prescribed burns and wildfire. Navajo cultural beliefs (Yazzie-Durlo & Covington 1993) highlight humans as an interconnected part of the universe living in harmony with plants and animals. This can be extended to embrace the idea that if ecosystems are healthy, the people living within them are healthy too.

Restoration

How can we begin to restore our forests to the conditions they evolved with, and what responsibility do we have to the forest? To begin, we need to have an understanding of the historical conditions of ponderosa pine forest that predate settlement and human alteration prior to

the early 1800s. Forest ecologists use data on forest structure, composition, local history, and dendrochronology to establish reference conditions to describe the forests' natural range of variability, or NRV (Dubay, 2020). Ecological restoration of forests is a versatile goal. The application of various restoration treatments at the same time--for example thinning and prescribed fire--can have compound effects on forest health and soil nutrients (Sanchez, et al., 2015). Traditional Ecological Knowledge, "a cumulative body of knowledge, practice, and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment" (Berkes, et al., 2000) can be embraced to inform restoration practices. Berkes et al. (2000) go on to justify how relying on generational understanding and interrelationships with the environment can provide examples for how human practices can support and respond to environmental feedback. In order to remediate damage to our forests, ecological restoration requires a long-term view that can be informed by a combination of Traditional Ecological Knowledge of this landscape and historical data that tells the stories of trees.

Case Studies and Activism

How is restoration being carried out in ponderosa pine forest and other places around the world? How are young, Black, and Indigenous people of color (BIPOC) leading the way in these efforts? There are many separate organizations around the world that have created programs to address the effects of climate change and human impact on our ecosystems. The United Nations has designated 2021-2030 as the "Decade on Ecosystem Restoration" based on an urgent, global need to restore ecosystems to support all life on Earth (UN Decade on Restoration, 2021). To address forest health on our local landscape, the Four Forest Restoration Initiative brings together stakeholders, land managers, and scientists for an ambitious multi-million-acre project to create sustainable ecosystems and industries (Four Forest Restoration Initiative, 2010). Additionally, here in Flagstaff, the Flagstaff Watershed Protection Plan uses funding from a municipal bond to restore and protect crucial areas at risk of fire and flood damage adjacent to the city of Flagstaff (*Project Background*, 2018). Indigenous resistance in the twenty-first century highlights activism related to water rights, land management, mining, sovereignty, and climate action (Dunbar-Ortiz, 2019). Recent examples of Indigenous environmental activism include Stand with Standing Rock-No DAPL, Save Oak Flat, Stop Line 3, and Haul No! (Stop Canyon Mine). In young people and BIPOC, we find water protectors, climate activists, and advocates for the protection and restoration of nature.

Teaching Strategies

This unit takes place in five parts. We will work outside at our field sites whenever possible to help students build a relationship with the forest that is based on respect, reverence, responsibility, and reciprocity.

Part I: An Introduction to Place

What are your forest stories? What are ecosystem services?

Students will spend time observing at Forest Site 1. After reflecting on their own relationship to nature, they will follow up by interviewing family members about their favorite places in nature and what these places provide for them. By compiling these, I hope we can build a list of benefits,

and extend it out to include other ecosystem services.

Part II: Forest Health

What is healthy about our ecosystem? How do we know if a forest is healthy?

In this part we will examine what evidence we can gather in order to measure forest health like the properties of old growth forest, dendrochronology, fire scars, evolutionary history, Traditional Ecological Knowledge, photos, and stories. We will discuss the history and impacts of fire suppression, grazing, National Forest Service practices, settlement, recreation use, and drought.

Part III: Measuring Forest Health

What data can we gather from the forest? What would it be like to work as a forester? We will set up plots to take forestry measurements at Site 1. Students will be able to collect stand measurements, including DBH, tree height, carbon content, density, and age with tree cores. We will follow up by completing the same measurements at Site 2 and compare our results. Students will be able to record their measurements using the ArcGIS application Survey123 for continuity and comparison of data.

Part IV: Managing Forest Health

How healthy is our forest? Why are we at risk for high intensity fires? How has the climate changed in our region and how might that impact forests?

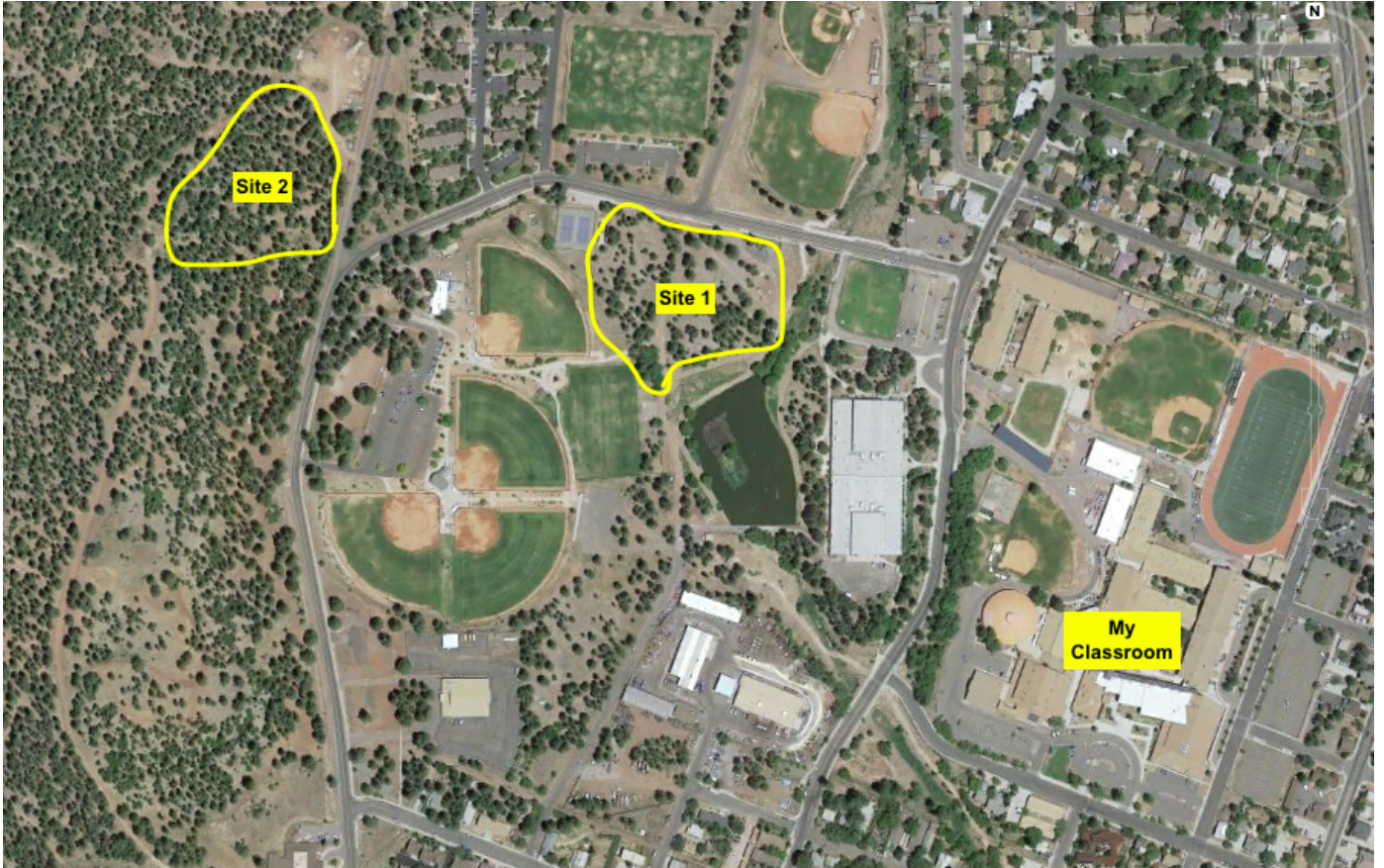
In this part of the unit, we will discuss methodologies for forest restoration such as thinning and prescribed burning. I will include regional examples of where these methods have been absent or successful.

Part V: Case Studies in Restoration

What is lost if a forest is unhealthy? What can we do about it?

Together we will research examples of how the protection of forests and forest restoration has happened in our region. As a follow-up, students will choose an example of environmental restoration or activism either from our region or beyond to research and share with the class.

Figure 2: Field research sites within walking distance



Classroom Activities

Part I: An Introduction to Place (3 days)

Activity 1: Introduction to Place

Students will visit Site 1 and carry out initial and reflective observations. What do they see, hear, smell, and feel? Does this part of the forest seem healthy to them and why or why not? How is learning outside different from working in the classroom? What norms do we need to have to approach work at this site?

Activity 2: Relationship to Place Interview

Students will have four days to conduct two interviews. Interview questions will focus on relationships (including where they spend the most time outside), memories, and changes they have noticed about their favorite place in nature. Students will need to interview people of different ages, and aim to interview one person at least 60 years of age or more to bring in the perspective of elders. A detail of this assignment is shown below.

Name: _____

Relationship to Place

Part I: Your Response

Where is your favorite place in the forest?

If you don't have a favorite place in the forest, where is your favorite place that is entirely outside?

When was the first and last time you went to this place? **How** many times have you been there?

Why is this your favorite place? List or describe at least three reasons.

What sort of things does this place provide for you and for others?

What is one memory you have from this place?

How has this place changed over time?

What is your age? _____

Thank you for sharing your "forest stories". On the next page, you will see the same set of questions, and your task is to interview two people about their stories. Try to interview two people of different ages, ideally one person who is over the age of 60. Please be polite when asking people their age. It is your responsibility to ask the questions and write the answers. This is an important step.

Relationship to Place

Part II: Interview #1

Who are you interviewing? _____ What is their age? _____

What is their relationship to you?

Where is your favorite place in the forest?

If you don't have a favorite place in the forest, where is your favorite place that is entirely outside?

When was the first and last time you went to this place? **How** many times have you been there?

Why is this your favorite place? List or describe at least three reasons.

What sort of things does this place provide for you and for others?

What is one memory you have from this place?

How has this place changed over time?

Activity 3: Ponderosa Pine Habitat Map

After visiting Site 1, students will create a map that highlights the range of ponderosa pine trees in North America and includes some of the main ecological features of this species such as lifespan, elevational range, scientific name, and reproductive strategy. A detailed example of this assignment is shown below.

Ponderosa Pine Background Information

Our forestry lessons are based around ponderosa pine trees, similar to the ones we visited yesterday at Site 1.

Today you will research and record some background information about these trees in preparation for future assignments.

To begin, go [to this site](#) to see the range of ponderosa pines. You will need to click the button that says, "Open in Map". On the graph below, do your best to shade in the range of these trees. Add a title and a legend.



The Ecological Restoration Institute at NAU helps to carry out some of the best research in the world on ponderosa pine trees. Go to [this website](#) to read about the ponderosa pine ecosystem.

What are some of the main ecological features of this species? Use this website (and the tabs at the bottom of the page) to help you find these details.

What is the scientific name for ponderosa pine?

How many needles do ponderosa pines have in one bundle? _____

Look at the Fire Regime tab. What is the fire interval that ponderosa pines evolved with?

Look at the Spatial Heterogeneity tab. This talks about the dispersion of ponderosa pines within their range (remember, you have this in your notes about population dynamics). In your own words, describe the historical dispersion of these trees.

Look at the Understory tab. First, what is the understory? Second, what are some important components of ponderosa pine understory?

What is the lifespan of ponderosa pines? You may have to look this up separately from the ERI website.

Based on what you know about reproductive strategies (look in your population dynamics notes for Type I, Type II, and Type III), what type do you predict ponderosa pines would be? Give two reasons why you selected this type.

This tree species is all around us in Flagstaff--what are some things that YOU know about ponderosa pines? Or what do you observe about them?

› Restoration Principles

› Historical Lines of Evidence

› Fire Regime

› Spatial Heterogeneity

› Understory

› Wildlife

› Ponderosa Pine LEARN Sites

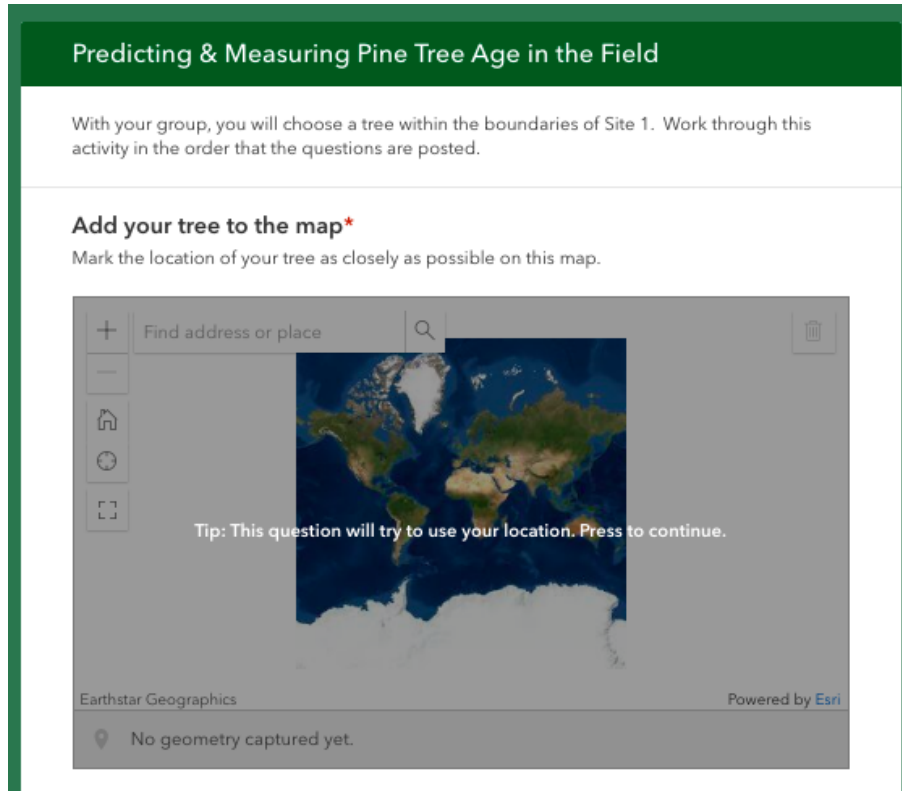
Part II: Forest Health (4 Days)

Activity 4: Timeline of Forest Management

Students will create a brief timeline based on an in-class presentation of forest management in North America from the 1500s to the 2000s, including details about utilization and management.

Activity 5: Mini Dendrochronology Lab

After starting with the question, “what stories do trees hold in their tissues?”, students will examine tree cookies and then collect tree cores at Site 1. They will be introduced to ArcGIS Survey123 when they document their tree of focus, obtain a tree core sample, and upload a photo and age to a digital class map for comparison. Here is a preview of the survey:



Photos of Your Tree*

Take one side view of your tree with the tree in the center of the frame. Then take another photo looking up to the top.

1

Select image file (number of files required: 2)



Make A Prediction*

Based on what we've talked about in class and your observations of your tree and Site 1, write a numerical prediction for the age of your tree.

Tree Age*

Follow the procedure we demonstrated to take a core sample from your tree using the increment borer. Count the rings and write in the age of your tree here:

Date & Time submission*



10/11/2021



11:37 PM

Activity 6: Drought and Fire

After discussing Figure 1 as shown above (a timeline of recent forest history related to the lives of my students), students will explore the website InciWeb Incident Information System to collect data on current fires. They will make observations about where current fires are located, which fires are the largest, and what percent of the large fires are contained. Follow-up questions will ask students to discuss their own personal experiences with wildfire and the impact of those experiences.

Activity 7: Feedback Loops

Students will work through the Project Learning Tree Southeastern Forests and Climate Change: Activity 5 (Monroe & Oxarart, 2015) to map out positive and negative feedback loops in a forest system.

Part III: Measuring Forest Health (6 Days)

Activity 8: Establish Forestry Plots

After examining our field sites on Google Earth, students will divide into research teams and discuss protocols for the plots. Five research teams will be established and each team will take on one of these sequential tasks: plot establishment (mark out a $\frac{1}{8}$ acre plot, take a photo in each direction, and measure one reference tree for age), tree labeling (move clockwise through the plot to number and label each ponderosa pine with tape, count other types of trees besides ponderosa pines in the plot, and choose one other reference tree for age), DBH crew (measure the diameter

at breast height of each labeled tree in order and record), height crew (measure the height of each labeled tree in order and record), data crunching crew (use the data from other crews to get an average DBH and use this information to calculate basal area, tree density, and an estimate of carbon content). When the plot measurements are complete, the teams that set up the plot and labeled trees will remove all materials from the site.

Activity 9: Replicate Plot Measurements at Site 2

Students will work in the same research teams establishing and collecting data for another plot, this time at Site 2.

Activity 10: Site Comparison

Students will compile and analyze the data from both sites. A set of reference conditions will be provided to compare against (Fulé et al., 1997) and students will use the data to answer the question: do these field sites represent a healthy forest? They will cite data to make their own claims with justification.

Part IV: Managing Forest Health (2 Days)

Activity 11: Management Techniques Infographic

After an in-class presentation and viewing the short film, *Fires of Change* (Southwest Fire Science Consortium, 2015), students will follow the example of the Greater Flagstaff Forest Partnership kiosk to create a simple infographic to describe forest management strategies (Greater Flagstaff Forest Partnership Kiosk, 2021).

Activity 12: Impact of Forest Management on Climate

To model projections of climate change with different forest management scenarios, students will use the En-ROADS Climate Interactive Simulator to explore how deforestation and afforestation, among other variables, impact climate change predictions (En-ROADS climate scenario, 2021).

Part V: Case Studies in Restoration (3 Days)

Activity 13: Four Forest Restoration Initiative

Students will answer the who, what, when, and where of the Four Forest Restoration Initiative (4FRI) through a short class presentation and recent news articles.

Activity 14: Activism and Protection of Natural Places

Students will select from a list of provided examples (or seek out their own) related to activism that has helped to bring attention to the protection of natural places and important natural resources. Students will create a slide that describes this activism and contribute it to a class gallery. In a digital gallery walk, students will read through the examples provided by their peers and reflect on three stories. A detail of the editable slide and prompt are shown below.

Your goal is to research and describe one example from nearby or around the world that shows how people are advocating to protect the earth and its resources.

Here are some ideas you may want to explore:

- [Save Oak Flat](#)
- [Stand with Standing Rock](#)
- [Water Protectors](#)
- [Stop Line 3](#)
- [Haul No- Stop Canyon Mine](#)
- [Fridays for Future](#)
- [Guajajara Guardians](#)
- [Green Belt Movement](#)
- [Bear's Ears Intertribal Coalition](#)

**Please recommend other examples or seek out your own*

Title <i>(What is being restored or advocated for?)</i>	
<p style="text-align: center;">Image</p> <p style="text-align: center;">Paste an image here that illustrates the group that is advocating OR the place/resource that is being protected.</p>	<p>Explain, in your own words, what natural resource is being protected or advocated for. Why is it worth protecting?</p>
<p>Where is this happening? Provide a location.</p>	<p>Who is doing the advocating? Are there young people involved?</p>
	<p>What is the current status of this effort? How is attention being brought to this issue?</p>

Student Assessment Plan

<i>Learning Goal</i>	<i>Assessment Type</i>	<i>Assessment Format</i>
Relationship to Place	Formative/	Student-written response to survey

Interview	Background information	questions from at least two family or community members.
Ponderosa Pine Habitat Map	Formative/Background information	Student-created map with ponderosa habitat and species details.
Mini Dendrochronology Lab	Summative/digital submission	Students will use a common ArcGIS survey to upload data about tree location and age.
Drought & Fire InciWeb Inquiry	Formative/Exploratory	Students will seek out current data and comment on findings on this individually guided inquiry.
Feedback Loops	Formative/Homework	Students will make connections between interrelationships in a forest system and demonstrate commitment to the topic by thinking about this on their own.
Establish Forestry Plots	Formative/Lab Work	Students will contribute to their research team and help facilitate the data collection to be shared by the rest of the class.
Site Comparison	Summative/Written	Students will make claims about the health of the forest at different sites and use both experimental and reference data to justify their claims.
Management Techniques Infographic	Summative/Creative	Students will create a visual infographic to describe at least three forest management techniques and how they can contribute to forest health.
Four Forest Restoration Initiative	Summative/Written	In a short-written response, students will interpret information about 4FRI to summarize the goals and stakeholders of the project.
Activism and Protection of Natural Places	Summative/digital submission/reflection	Students will individually research an example and create a Google Slide of the highlights. Students will then read their peers' work and comment on other examples and record their thoughts about natural places at the end of this unit.

Alignment With Standards

9th-12th Diné Character Building Standards

Concept 1: K'édinisdzin dooleel: I will use my critical thinking to establish relationships with the environment.

PO 2: I will coordinate a plan to show respect of the environment.

9th-12th Diné Cultural Standards

Concept 2: Natat'á

PO3: I will practice respect of nature in my daily life.

Concept 4: Siihasin

PO2: I will appreciate the significance of water.

Arizona State Science Standards

Essential HS.L2U1.19

Develop and use models that show how changes in the transfer of matter and energy within an ecosystem and interactions between species may affect organisms and their environment.

Essential HS.L2U3.18

Obtain, evaluate, and communicate about the positive and negative ethical, social, economic, and political implications of human activity on the biodiversity of an ecosystem.

Plus HS+B.L4U1.2

Engage in argument from evidence that changes in environmental conditions or human interventions may change species diversity in an ecosystem.

Resources

Kimmerer, Robin Wall. (2013). *Braiding Sweetgrass: Indigenous Wisdom, Scientific Knowledge, and the Teachings of Plants*. Milkweed editions.

Kimmerer discusses how science as a way of knowing is not expansive enough to accommodate broader questions that require other ways of knowing like Traditional Ecological Knowledge and beauty.

Smith, Linda Tuhiwai. (2012). *Decolonizing Methodologies: Research and Indigenous Peoples* (2nd ed.). Zed Books.

While this book is primarily about research methods, it is closely comparable to teaching methods and has encouraged me to critically examine how I teach and what information I present to students.

Arizona Department of Education. (2020). *Flagstaff High School*. AZ School Report Cards.

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