Engaging Our Ways of Knowing with Forests and Global Change

If Trees Could Talk: Reading the Forest through Math and Memory

Angelique Denise Castro Pacaña

Diné Institute for Navajo Nation Educators (DINÉ)

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Author Note:
Angelique Denise C. Pacaña, a DINÈ fellow, is a sixth-eighth grade Math Interventionist at Tuba City Junior High School within the Tuba City Unified School District #15. The school is located in Tuba City, Arizona on the Western Navajo Nation. Correspondence about this curriculum unit can be addressed to Angelique Pacana, P.O. Box 829, Tuba City, Arizona 86045. Email contact: apacana@tcwarriors.net or apacana@tcusd.org.

Topic

The curriculum unit, “If Trees Could Talk: Reading the Forest through Math and Memory”, encourages students to study tree rings as a record of their life in the land and as a form of scientific evidence. With the integration of mathematical concepts (ratios, graphing, data analysis) and the Diné traditional ecological knowledge (TEK), students investigate how trees act as organic repositories of environmental change. Students are engaged in mathematical reasoning by studying dendrochronology, the study of tree rings, in Indigenous cultural contexts and apply this knowledge to understanding tree ring patterns based on the Diné philosophies of Hózhó (balance, harmony, and beauty) and Western scientific paradigms.

This curriculum unit attempts to re-engage students with their environment and enhance their comprehension of ecological interconnectedness and sustainability at a time when they are becoming more and more estranged from both nature and their cultural heritage. It seeks to use experiential learning, narrative, and cultural reflection to ask students what trees can teach us in an era of environmental degradation and global climate change. The curriculum unit invites students to consider how traditional knowledge and Western science can coexist and promote a more profound understanding of the environment.

Context

This unit is designed for a sixth-eighth grade math intervention class at Tuba City Junior High School, one of the schools of Tuba City Unified School District #15, located in Tuba City, Arizona, on the West of the Navajo Reservation. Tuba City Junior High School Math Intervention Program is a discipline focused within the district that is designed to improve student math skills, particularly those who are performing at a level below their math grade level. In middle school, Math Intervention is delivered using Specials Support Blocks.

Students identified via state AASA/ACT or i-Ready assessments are placed in dedicated intervention blocks, often during an elective period, to work in small groups on targeted math skills. This program is also focused on skill building. Teachers reteach prerequisite skills such as decimals, fractions, or proportional reasoning right before covering grade-level content—this aligns with research-backed “co-requisite support” models. Students in the class need extra help to grasp grade-level math concepts, especially in ratios, graphing, and data interpretation. Lessons that reflect their life experiences and community beliefs, as well as experiential learning and culturally appropriate content, are beneficial to many of these kids.

Students attend the class on a daily basis in a small-group setting for direct instruction. Students have a wide range of mathematics proficiency and support in language at home, including speaking Diné Bizaad (Navajo language) and English at home. Because the school exists within the Navajo Nation, the curriculum is purposely infused with Diné worldviews, language, and cultural knowledge to reinforce student identity and to contribute to students’ academic success.

Unit Placement in the Teaching Year

This curriculum unit is ideally taught in the mid to late fall, after students have had exposure to foundational math concepts and before the onset of the winter season. The unit coincides with lessons on ratios and line graphs in the Arizona Mathematics Standards for Grade 6 (e.g., 6.RP.A.3: Use ratio and rate reasoning to solve real-world problems and 6.EE.C.9: Use variables to represent relationships between quantities).

A time of change and introspection, fall is also a culturally significant season in the Diné calendar, during which lessons about the land, weather, and balance are highlighted. Students can match their learning to natural cycles they see in their own surroundings such as leaf changes, chilly temperatures, and the earth's preparation for winter by incorporating tree ring research into their coursework during this period. Incorporating Diné narratives that support the scientific investigation is appropriate during this season, which also lends itself nicely to storytelling and community discussions.

Ergo, this curriculum unit respects two ways of knowing: the holistic perspective of Indigenous ecological knowledge and the analytical accuracy of mathematics. It gives kids the confidence to discover who they are, learn more about location and climate, and take care of the land and culture. Students who are frequently underrepresented in standard STEM curricula benefit from this unit's intellectual and emotional development by grounding academic learning in cultural relevance and local ecological knowledge.

Rationale

As a Math Intervention teacher for Diné students in Tuba City Unified School District #15, specifically in Tuba City Junior High School, I authored this curriculum unit “If Trees Could Talk: Reading the Forest through Math and Memory”, to put together two important and crucial objectives: improving mathematical thinking and enhancing cultural relevance in classroom instruction. This lesson was created in response to the need to respect the students’ identity, language, and traditional knowledge systems while also providing support for those who need math intervention. The curriculum unit is based on the idea that all students, particularly our Diné youth, should have their worldview, history, and land represented in the lessons they study. It is a pedagogical and individual response to the demand for academically demanding, place-based, culturally sustaining education.

Why This Topic

The Diné Institute for Navajo Nation Educators (DINÉ) program on "Engaging Our Ways of Knowing with Forests and Global Change" sparked the concept of using tree rings as an anchor for math instruction. The seminar offered a significant foundation for integrating Western science with Indigenous knowledge systems. Specifically, the scientific study of tree rings, or dendrochronology, seemed like a fitting parallel for the two stories we frequently overlook in mathematics: lived experience and numerical accuracy. In addition to providing measurable

information for graphing, ratio analysis, and pattern interpretation, tree rings also provide narratives of environmental change, survival, and resilience—concepts that are closely related to Diné teachings on relationality, change, and balance (Hózhó).

Math is often abstracted and taught in disconnected ways, especially in intervention classes where students may already feel alienated from content. In order to make math concrete, significant, and profoundly relevant, I try to base mathematical ideas in natural phenomena that students can see, feel, and even walk among in their local communities. Students discover via this unit that math is not limited to textbooks and activity sheets; it is present in the land, in natural cycles, and in the tales of their elders. Furthermore, they also learn that mathematics is an effective tool for predicting outcomes, understanding change, and conserving knowledge.

Why It's Meaningful for My Students

My 6^{th} – 8^{th} grade students are multilingual; they speak both Diné Bizaad and English. They have strong ties to land-based customs through their communities and families. They are frequently asked to leave aspects of their identities at the door, though, just like a lot of Indigenous youth in public schools. Seldom is their understanding of animal behavior, weather variations, ceremonial cycles, and planting seasons regarded as academic knowledge. By validating and elevating their modes of knowing through place-based learning and culturally sustaining pedagogy, this unit aims to disrupt that norm.

Tree rings make an ideal introductory point of this unit because they accessible and visible. Students can see them in firewood, fallen logs, or even in pictures and depictions. Through this curriculum unit, students start to understand how the stories of trees can be decoded using what they already know about difficult winters, droughts, and planting seasons. This method promotes intellectual confidence as well as cultural pride. In addition to learning math to pass an exam, students are also learning how to listen to the land and comprehend their current and past surroundings.

Additionally, this unit is in line with the Diné Content Standards, especially those that stress the value of harmony and balance, respect for the natural world, and an awareness of cycles and change. By placing Western knowledge into Indigenous frameworks of thinking, rather than by rejecting it, it is a step toward decolonizing the curriculum.

Positionality Statement

I acknowledge that, as a non-Native teacher on Diné Bikéyah (Navajo land), that I am a visitor to my students' physical and cultural environment. I bring with me a number of "funds of knowledge," including a solid foundation in math pedagogy, a history in environmental education, and a profound appreciation for community-based learning. During my college years in the Philippines, where Indigenous knowledge and community involvement also influenced educational practices, I was introduced to water and land education. My dedication to teaching that is both liberating and grounded was sown by these encounters.

I am fully aware of my understanding's limitations, though. I am constantly learning about the complex connections between land, stories, and identity in Navajo situations, even though I was not raised in Diné culture and do not speak the language well. I consider my students, their families, and the larger community to be vital co-teachers because of this. Their intergenerational knowledge, cultural customs, and life experiences are priceless assets that influence and enhance my teaching. Knowing that culturally sustaining teaching is a continuous commitment rather than a one-time lecture, I make an effort to listen, learn, and adapt.

I aim to change my role from expert to facilitator through projects like this curricular unit, allowing students to bring in their own knowledge and learn new ways to express it through arithmetic. I learn from my students that science and narrative are not mutually exclusive. Instead, they have a common thread that respects the past, pays attention to the present, and influences the future.

In summary, “If Trees Could Talk: Reading the Forest through Math and Memory” is more than just a math curriculum unit. It is a call for teachers to reconsider and reevaluate their methods, for students to reestablish a connection with their land, and for educational institutions to embrace authentic, respectful, and rooted learning.

Instructional Guide

One of the inspirations for embedding Traditional Ecological Knowledge (TEK) into this unit comes from the experiences and teachings of Mariessa Fowler, a 2025 graduate of Northern Arizona University with a degree in Environmental Science. Mariessa describes TEK as knowledge rooted in the land, water, and biota, passed through teachings, songs, stories, and practices that include spirituality and language. Growing up on the reservation without running water, she was guided by her traditional father, who practiced the Peyote way and taught her plant harvesting, prayers, and reverence for Nahasdzáán Shima. These experiences shaped her empathy for both nature and community and inspired her pursuit of environmental science, where TEK provided a framework for understanding her lived experiences. Through coursework in food sovereignty, regenerative agriculture, and cultural perspectives, Mariessa found TEK to be both a grounding and evolving body of knowledge.

Her perspective will help students see TEK as more than static traditions, it is a living, adaptive relationship with the environment. By highlighting Mariessa’s story, the unit will encourage students to honor the wisdom carried by their own families and communities alongside classroom learning. This framing shows how TEK is deeply personal yet universally relevant, offering a model for students to engage with cultural knowledge in ways that affirm both identity and ecological responsibility.

Sherman and Brydge’s (2023) study further grounds the unit by showing how Indigenous values and philosophies are also strategies for ecosystem balance and cultural continuity. Their research emphasizes that sustainability emerges when communities live in respect, reciprocity, and relational accountability with the land. In this unit, tree ring analysis becomes a hands-on way

for students to explore these ideas. By studying how rings record times of abundance and scarcity, students connect ecological data to Diné concepts such as Hózhó, which teaches balance and harmony with nature. In Session 4, "Integrating Diné Wisdom with Math," students reflect on how both mathematics and story can reveal patterns of ecological balance, aligning with Sherman and Brydge's vision of integrating Indigenous philosophies into environmental stewardship.

Finally, Suzanne Simard's (2021) work, *Finding the Mother Tree*, adds another perspective by showing how older trees nurture younger ones through underground fungal networks. Her insights highlight reciprocity, resilience, and interdependence in forest communities—values also central to TEK. For students, this provides a powerful parallel: just as tree rings reveal the past, hidden networks reveal the present and future health of ecosystems. When paired with Diné teachings of Hózhó and reverence for Nahasdzáán Shima, Simard's findings reinforce the lesson that ecosystems are living, interconnected communities. Together, TEK and ecological science help students recognize that resilience and balance are sustained through relationships—between people, between cultures, and between all living beings.

With the help of place-based learning and Traditional Ecological Knowledge (TEK), I will introduce these ideas to my sixth-eighth graders in order for them to gain a better understanding of key mathematical concepts such as ratios, data representation, and graphing. This curriculum unit, "If Trees Could Talk: Reading the Forest through Math and Memory" was developed as a math intervention unit, where students who are often in need of a tangible, meaningful education that has a use in the real world. By connecting Indigenous knowledge and Western Science through the practice of studying tree rings or dendrochronology, this unit will allow students to see math not as simply a set of methods but as a way of knowing, of listening, of interpreting the world.

Essential Background Concepts

To understand this unit, students must be introduced to:

- Dendrochronology: the scientific method of dating tree rings to the exact year they were formed.
- Climate and environmental conditions: how trees respond to drought, rainfall, fire, and human activity.
- Ratios and proportional relationships (AZ 6.RP.A.3): how to compare quantities and interpret their meaning.
- Graphing and interpreting data (AZ 6.EE.C.9): how to represent variables and relationships using coordinate graphs.
- Sa'ah Naagháí Bik'eh Hózhóón (Diné Philosophy): understanding life cycles, balance, and harmony as frameworks for interpreting nature.

Concepts are presented in an order that helps students acquire understanding gradually and ever more deeply in terms of cultural and ecological connections.

Teaching Strategies and Sequence of Lessons

The unit consists of five lessons that are anchored in research-based teaching practices and are also correlated to Arizona Mathematics Standards and Diné Content Standards. Each lesson includes cooperative learning, visual supports, and inquiry through stories:

1. Session 1 – Discovering Tree Rings: Students examine tree cross-sections, and infer what it means when a tree has wide or narrow rings. This will allow trees to be seen as storytellers.
2. Session 2 – Graphing the Growth: Students graph tree ring measurements to interpret them as line graphs, developing mathematical literacy in reading and composing coordinate planes.
3. Session 3 – Making Ratios Tell Stories: Writing Ratios with years of different growth patterns, students write ratios comparing ring widths and investigate what the ratios tell us about the environment.
4. Session 4 – Integrating Diné Wisdom with Math: Students reflect on how tree rings embody concepts of Hózhó (balance), and how traditional stories align with scientific observations.
5. Session 5 – Telling Our Tree Stories: Students construct end of unit projects, integrating math, storytelling, and cultural introspection. Choices can be anything from visual posters, to digital presentations, to a story relayed orally. Each session provides activating prior knowledge anticipatory sets, scaffolded practice, and reflective closure activities that enable students to bring personal experiences to the mathematics.

Assessment Plan

Assessment in this unit is both formative and summative:

- Formative: Exit slips, partner reflections, group discussions, and student journaling are used to gauge ongoing understanding and to adjust instruction.
- Summative: The final project serves as a performance-based assessment where students demonstrate mastery of graphing, data analysis, and ratio writing while incorporating cultural and environmental insights.

Rubrics assess content knowledge, accuracy, creativity, and integration of Diné perspectives. Student voice and storytelling are valued as valid and meaningful demonstrations of understanding.

Culturally Responsive and Sustaining Practices

This curriculum makes extensive use of pedagogy that sustains culture. First, as a type of scientific literacy, it combines and confirms local ecological knowledge. Students are empowered to view themselves as knowledge holders and contributors when mathematical

reasoning is connected to real-world experiences. This is in line with Paris and Alim's (2017) need for "culturally sustaining pedagogies," which uphold cultural practices via academic instruction in addition to affirming them.

Second, it encourages students to participate in oral traditions and storytelling, which are essential components of Diné knowledge systems. This unit reflects the comprehensive nature of Diné learning by putting together scientific reasoning and narrative rather than separating them (McCarty & Lee, 2014). Project presentations, tale excerpts, and talking circles celebrate a variety of knowledge and expression.

Lastly, the unit adheres to the tenets of place-based learning. Students gain a knowledge of science and mathematics in a way that is both culturally and environmentally relevant by utilizing locally visible phenomena, such as tree rings, and grounding learning in the land (Gruenewald, 2003). The land turns into both text and teacher.

Teaching Plan

This unit is developed as a place-based and culturally sustainable unit and is to last for 5 sessions. Centered on tree rings as a bridge between Western Science and Traditional Ecological Knowledge (TEK), this standards-based mathematics curriculum is designed to expose teachers and students to both the academic content and cultural fluency of math through the 6th Grade Arizona Mathematics Standards and Diné Content Standards.

The utilization of forests, primarily tree rings, as chronologies in the history of environment and culture change is reviewed in this lesson plan. With math, students analyze the story trees tell about climate, resilience, and harmony. To have a more comprehensive lesson design that addresses all types of learners, the lesson plan of each session includes visual, kinesthetic, collaborative, and reflective aspects developmentally.

The lesson plan has the structured format that Tuba City Unified School District#15 uses. In addition, a learning objective, success criteria, anticipatory set, direct instruction, guided practice, active participation, independent practice, and closure frame the structured yet flexible structure of the sessions. These factors are in place to help students move from guided to independent learning with ongoing support from peers, scaffolds, and models.

Therefore, this lesson plan integrates mathematical content knowledge and Indigenous ways of knowing, positioning students to become stewards, storytellers, and cultural translators of the forest, in addition to mathematicians. It teaches that mathematics is not merely a problem to be solved but a subject of conversation, and that it carries forth throughout all corners of life with open ears, a retentive memory, and a response that is attuned to the living world that surrounds us.

During Session 1, the class will begin with an introductory lesson on dendrochronology, a scientific technique used to calculate the age of a tree as well as the conditions the tree has

experienced throughout its life, based on the study of the tree's growth rings. To begin to practice visual analysis and utilize mathematics as a tool to understand the world around us, students start by making observations and interpretations about growth patterns observed in tree cross-sections in this lesson.

Session 2 is an extension of this learning as we transfer tree ring data to line graphs and students are able to see tree growth as a way to tell a story, bringing their understanding of mathematical concepts to a whole new level in time-based relationships. This lesson is aligned to Arizona's standard for data representation and is an essential visual literacy lesson.

Session 3 is about taking the plunge into the dimensions of ratios and proportional reasoning. They "can compare whole years and look for droughts and growth spurts and breaks" using tree growth data, either actual or simulated. Students learn this quantitative way to understand tree stories and begin to articulate clearly and accurately the patterns they see by writing ratios.

Session 4 portrays a cultural and philosophical extension of the unit. In Diné philosophy, students explore the concept of Hózhó, or harmony and balance, and apply it to more fully understand ecological cycles. Students see the relationship between statistics and Diné teachings and overlay mathematics on an Indigenous worldview through group work, storytelling, and matching.

Session 5 rounds off with project-based learning and is followed by a time to assimilate all the learning. Students will apply arithmetic and common knowledge to produce a product that tells the story of a tree (e.g., digital story, narrated graph, visual poster). Peer assessment, creativity, spoken language, and reflection are all included in this final session and challenge students to communicate what they have learned in a way which is personal to them.

Throughout all 5 sessions, culturally responsive and sustaining pedagogy is deliberately and developmentally integrated via:

a. Local place-based learning that respects the immediate environment;
b. Culturally based investigation, framed by storytelling and oral traditions; and
c. Visual and tactile learning that can bolster learners who are not quite ready for abstract or procedural-only learning.

Tuba City Junior High School
School Year 25-26
EEI Lesson Plan

Teacher: Angelique Denise Pacaña
Grade: Sixth-Eighth Grade
Subject: Math Intervention
Week/Date: _____

Class Schedule

Time	Activity

Standard & Objective

Standards:

Math

6.RP.A.3: Use ratio and rate reasoning to solve real-world and mathematical problems, e.g., by reasoning about tables of equivalent ratios, tape diagrams, double number line diagrams, or equations.

6.EE.C.9: Use variables to represent two quantities in a real-world problem that change in relationship to one another; analyze the relationship using graphs and equations.

Dinè

I.D.3 – Analyze the use of oral tradition as a source of Diné knowledge and history.

II.D.1 – Recognize the Diné philosophy of Sa'ah Naagháí Bik'eh Hózhóón (a belief system that guides harmonious living) and how it applies to daily life and balance with nature.

III.C.1 – Demonstrate responsibility, respect, and connection to living beings and the natural world.

IV.A.2 – Apply Diné ways of knowing to understand weather, climate, and seasonal changes.

CRAIS

4. Traditional and/or cultural knowledge is included.

13. Norms, values, traditions, interests of local/regional Indigenous community are leveraged for learning opportunities.

18. Clear reference and/or integration of local/regional Indigenous context.

Objectives:

The highly effective student will be able to:

a. Use math to analyze tree ring data as evidence of environmental change.
b. Interpret graphs and calculate average growth rates to model change over time.
c. Explore how Diné teachings view trees and forests as relational beings that hold stories of balance, resilience, and climate cycles.
d. Reflect on how forests show both human impact and natural cycles, and how different ways of knowing help us understand global change.

	Essential Questions 1. What stories do tree rings tell about the past? 2. How can we use math to understand patterns in tree growth? 3. What do Diné teachings help us understand about forests, time, and balance? 4. How do forests help us notice and respond to global environmental change? **Vocabulary/Background Concepts** 1. Dendrochronology: the scientific method of dating tree rings to the exact year they were formed. 2. Climate and environmental conditions: how trees respond to drought, rainfall, fire, and human activity. 3. Ratios and proportional relationships (AZ 6.RP.A.3): how to compare quantities and interpret their meaning. 4. Graphing and interpreting data (AZ 6.EE.C.9): how to represent variables and relationships using coordinate graphs. 5. Sa'ah Naagháí Bik'eh Hózhóón (Diné Philosophy): understanding life cycles, balance, and harmony as frameworks for interpreting nature.

	Session 1	Session 2	Session 3	Session 4	Session 5
Learning Target	I can explain how tree rings represent years of growth and identify patterns in them.	I can create a line graph to show a tree's ring growth over time.	I can use ratios to describe changes in tree ring growth over time.	I can connect tree ring data to Diné teachings about balance and environmental change.	I can create a final project that tells a tree's story using math and Diné knowledge.
Success Criteria	I can identify wide and narrow rings and explain what they might mean about the tree's environment.	I can plot points accurately and interpret trends on my graph.	I can write and simplify ratios that compare ring width in different years.	I can explain how tree rings and Diné stories both show patterns of resilience or disharmony.	My project includes a graph, ratio or data analysis, and a personal reflection or story.
Anticipatory Set	Show a cross-section image of a tree trunk. Ask: "What do you notice? What might those circles tell us?"	Ask: "How could we turn tree rings into a story that shows change over time?"	Review two graphs from previous sessions. Ask: "What comparisons could we make here?"	Listen to an excerpt or read aloud from a traditional Diné story involving trees, wind, or land.	Show example projects (digital slides, posters, or interactive maps). Ask: "How would you tell a tree's story?"
Direct Instruction "I Do"	Use a short video and discussion to introduce dendrochronology. Explain how each ring = 1 year and reflects environmental conditions.	Model graphing ring width per year from a given data table.	Teach how to write ratios (e.g., Year 5:Year 10 growth). Connect to real-world changes (e.g., drought year vs. rainy year).	Brief recap of Sa'ah Naagháí Bik'eh Hózhóón and its application to nature cycles.	Review expectations and rubric. Model combining graph + story.
Guided Practice "We Do"	Examine real or printed samples of tree ring sections in pairs. Identify and count rings. Color-code wide vs. narrow rings.	Students graph 10 years of growth data on coordinate grids.	With partners, write and simplify 3 ratios using provided growth data sets.	In small groups, match tree ring growth graphs with statements from Diné teachings or weather-related stories.	Students begin project planning using a graphic organizer.
Active Participation	Students share observations with a	In groups of 3, students interpret and	Small groups explain what their ratios say	Students discuss: "Which years in the	Peer partners give feedback on plans:

	partner and then in a whole-class discussion.	label their graphs with key events (e.g., drought year).	about climate trends over time.	tree's life show Hózhó? Which show imbalance? Why?"	"What part is clear? What could be stronger?"
Independent Practice "You Do"	Students complete a short worksheet with tree ring samples and record age, ring patterns, and interpretations.	Students receive a new tree's data and graph independently.	Each student chooses their own set of 3 years from a data table and creates two ratios. Then they write one sentence explaining their meaning.	Students write a paragraph connecting one tree ring pattern to a Diné principle or story.	Students create final projects (visual, written, oral presentation, or digital slide deck).
Closure	Reflect: "What did the tree rings tell us about this tree's life?" Introduce the idea of trees as both scientific and cultural memory keepers.	Gallery walk of graphs. Students leave sticky notes on peers' work: "I noticed..." or "I wonder..."	Journal reflection: "How do trees show us when things were out of balance? How does that connect to Hózhó?"	Talking circle: "What can trees teach us when we listen through both math and story?"	Student-led sharing of projects. Reflection prompt: "What did you learn about forests, change, and knowing?"

Worksheets

Name: _____ Date: _____

Session 1: Tree Rings Analysis

Trees are sacred beings in Navajo culture that provide valuable teachings if we observe them carefully.

Goal: Identify and interpret patterns in tree rings to understand tree age and environmental changes.

Role: You are a dendrochronologist. Dendrochronologists are the scientists that study dendrochronology, the study of tree rings.

Audience: The target audience are the 6th Grade students.

Situation: An Arizona ash tree has been cut down in Tuba City. You are to examine the trunk and decode its story. In this activity, you are a dendrochronologist who will study the tree rings. You are going to analyze the rings in tree cookies and cores where you discover the age of trees and learn about environmental conditions over many years.

Product: The product of this activity is a labeled diagram of a tree cross-section and a reflection paragraph.

Standards: Diné – I will develop an understanding of the Diné way of life.

Materials Needed

- Tree cookies
- Hand lens
- Ruler
- iPad

Do now:

1. How old are you? _____
2. Take a look at the cookie on the right and respond to the questions below:

    a. Count the number of rings. How many rings do you see? _____
    b. What do you think each ring represents? _____
    c. Highlight/circle the tree rings that correspond to your age.

Directions:

1. Look at the tree ring sample provided. Examine your tree cookie with a hand lens. Find the innermost ring, which is the pith, the spongy part of the tree. The first ring, which is the oldest ring, is the next ring that represents the tree's first year of growth.

2. Now, locate the outer ring at the inner bark edge. This shows the tree's most recent growth.

3. Count the total number of rings. This is equivalent to the tree's age in years when it was cut down. How old is the tree? _____

4. Look closely at the ring spacing and thickness. Do you notice any patterns or changes over time? _____

5. If rings are wider or narrower during certain years, what might that tell you about growing conditions like water/rainfall?
   _____
   _____

6. Reflection: In your own words, write 3-4 sentences describing what the tree's rings reveal about its life.
   _____
   _____
   _____
   _____

Douglas-fir Tree from New Mexico

Name: _____ **Date:** _____

Session 2: Graphing the Growth

Each tree ring tells us how much the tree grew in one year. In this lesson, you'll take on the role of a Forest Data Analyst, using real data to create graphs that tell stories about changing climates and growing seasons.

Goal: Create and interpret a line graph of tree ring data.

Role: You are a forest data analyst.

Audience: The target audience are the Climate Change Council of Tuba City.

Situation: You need to present a graph showing tree growth over 5 and 15 years.

Product: The product of this activity is a line graph and a short interpretation of the graph.

Standards: Math – Use variables to represent two quantities in a real-world problem that change in relationship to one another; analyze the relationship using graphs and equations.

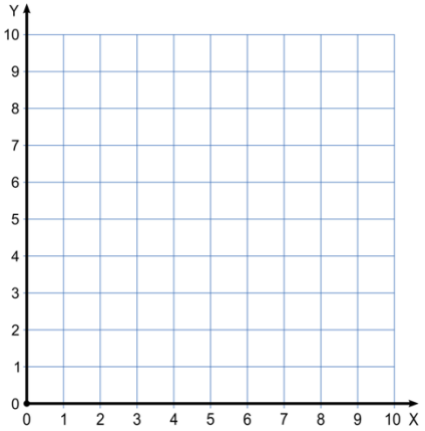
Materials Needed

- Tree cookies
- Data Sheet
- Graphing Paper
- Ruler
- Hand lens
- Ruler
- iPad

Do now:

1. Use the following data for ring width (in mm) over 5 years:

Year	Growth (Ring Width)
1	2.0
2	1.8
3	3.1
4	2.5
5	1.2



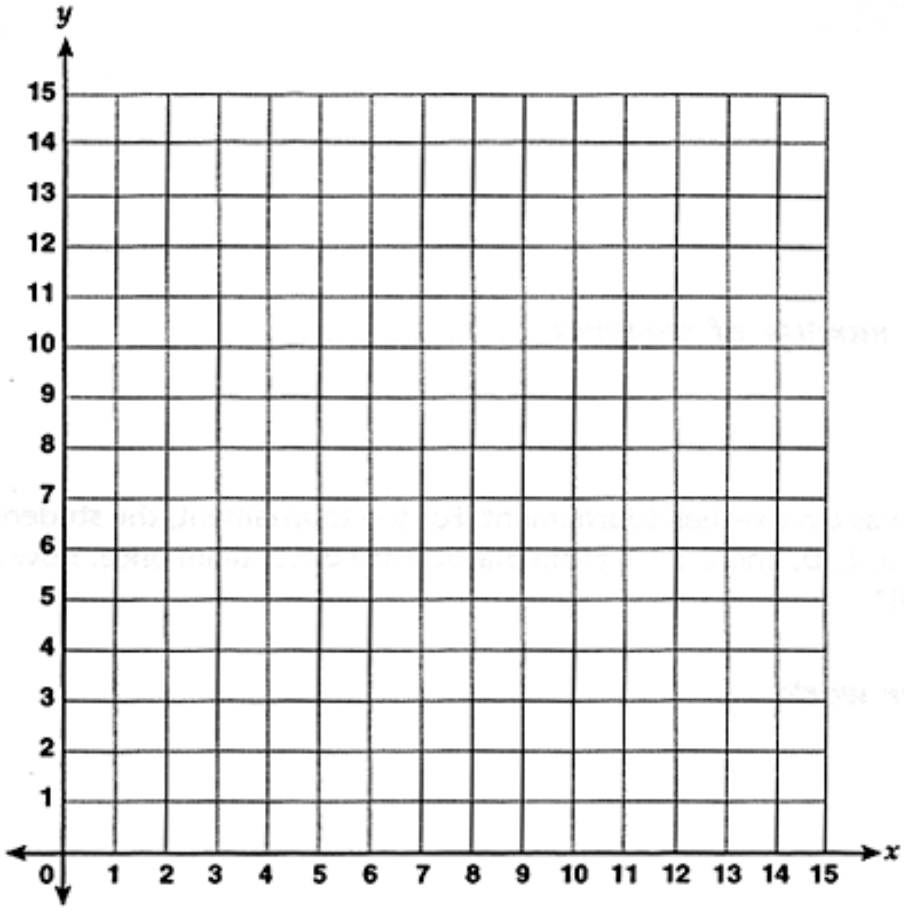
2. On the graph grid provided, plot the years on the x-axis and ring width on the y-axis.
3. Connect the points with a line.

Directions:

1. Look at the tree ring sample provided. Examine your tree cookie with a hand lens. Using the ruler, measure the width between rings for over 10 years.
2. Complete the table below with the following data for ring width (in mm) over 10 years:

Year	Growth (Ring Width)
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	

3. On the graph grid provided, plot the years on the x-axis and ring width on the y-axis.



4. Connect the points with a line.

5. Color one year of high growth in green and one year of low growth in red.

6. Interpretation: What do you notice about the growth pattern over 10 years? Write 2-3 interpretation sentences.

_____

_____

_____

_____

Name: _____ **Date:** _____

Session 3: Making Ratios tell Stories

By comparing how a tree grew in different years, you can find out what was happening in the environment. As an Environmental Math Researcher, you'll use ratios to compare tree growth and explain what they say about the world around the tree.

Goal: Use ratios to describe and compare tree growth across years.

Role: You are an environmental Math researcher.

Audience: The target audience are your fellow scientists and your community leaders.

Situation: You are analyzing how different years affected a tree's growth.

Product: The product of this activity is a set of ratios and a written analysis.

Standards: Math – Use ratio and rate reasoning to solve real-world and mathematical problems, e.g., by reasoning about tables of equivalent ratios, tape diagrams, double number line diagrams, or equations.

Material/s Needed

- Session 2 Data Sheet

Do now:

1. Use the graph/data from Session 2 (Do now).

Year	Growth
1	2.0
2	1.8
3	3.1
4	2.5
5	1.2

2. Write 2 ratios comparing different years:
   Example: Ring width for Year 1: Ring width for Year 3 2.0 : 3.1

   Year 2 : Year 4 _____ : _____
   Year 3 : Year 5 _____ : _____
3. Simplify each ratio.
   Year 2 : Year 4 _____ : _____
   Year 3 : Year 5 _____ : _____

Directions:

1. Use the graph/data from Session 2.
2. Write 5 ratios comparing different years:

Year 1 : Year 10	_____ : _____
Year 2 : Year 9	_____ : _____
Year 3 : Year 8	_____ : _____
Year 4 : Year 7	_____ : _____
Year 5 : Year 6	_____ : _____

3. Simplify each ratio.

Year 1 : Year 10	_____ : _____
Year 2 : Year 9	_____ : _____
Year 3 : Year 8	_____ : _____
Year 4 : Year 7	_____ : _____
Year 5 : Year 6	_____ : _____

4. Choose one ratio and write 2-3 sentences explaining what it reveals about the environment during those years.

_____
_____
_____
_____

5. Journal Prompt: What does your ratio show about balance or imbalance in nature?

_____
_____
_____
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_____

Name: _____ **Date:** _____

Session 4: Integrating Diné Wisdom with Math

Diné teachings tell us that balance, or Hózhó, is essential in all things. In this session, you will explore how tree ring data connects with traditional teachings about living in harmony with nature. You will become a Student of Dual Knowledge—combining science with story.

Goal: Connect mathematical patterns to Diné teachings about balance and cycles.

Role: You are a student of Dual Knowledge (Science and Story).

Audience: The target audience are your classmates and community elders.

Situation: You are asked to explain how a tree's growth connects with Hózhó.

Product: The product of this activity is a paragraph connecting tree ring data with a Diné teaching or story.

Standards: Diné - (1) Analyze the use of oral tradition as a source of Diné knowledge and history.
(2) Recognize the Diné philosophy of Sa'ah Naagháí Bik'eh Hózhóón (a belief system that guides harmonious living) and how it applies to daily life and balance with nature.
(3) Demonstrate responsibility, respect, and connection to living beings and the natural world.
(4) Apply Diné ways of knowing to understand weather, climate, and seasonal changes.

Material/s Needed

- Growth Graph Data (from Sessions 1 – 3)
- Tree Ring Cookies

Directions:

1. Review the growth graph or tree ring images.
2. Identify one set of years showing when the tree grew fast and when the tree grew slow.
3. Choose a Diné concept (e.g., Hózhó, Sa'ah Naagháí Bik'eh Hózhóón).
4. Write a paragraph explaining how that concept is reflected in the tree's growth.
5. Bonus: Share one traditional teaching or story you know about trees, seasons, or change.

Name: _____ **Date:** _____

Session 5: Telling Our Tree Stories

Now it's time to tell the full story of your tree—through numbers, graphs, and personal reflections. As a Storyteller-Scientist, you'll combine math, culture, and observation into a final project that brings the tree's life to light.

Goal: Create a final project that tells the story of a tree using math and Diné knowledge.

Role: You are a Storyteller-Scientist.

Audience: The target audience are the school community, your classmates, and your family.

Situation: You are presenting what you have learned about trees, climate, and culture.

Product: The product of this activity is one of the three project options below.

Option 1: Poster Presentation – "My Tree's Life Story"

Description: Create a colorful poster that tells the story of a tree through visuals, graphs, and storytelling. Your Poster Must Include:

- A line graph showing tree ring growth over 10 years (label key years).
- At least one ratio comparing two years of growth (explain what it shows).
- A paragraph reflection connecting your tree's story to a Diné teaching (e.g., Hózhó).
- Illustrations or visuals showing the tree's surroundings, seasons, or changes.

Option 2: Digital Slide Deck – "If Trees Could Talk"

Description: Use Google Slides or PowerPoint to create a digital presentation that weaves math, science, and cultural insights. Your Slide Deck Must Include:

- Title slide and introduction.
- A slide with a line or bar graph showing tree growth (with labels).
- A slide with 2-3 ratio comparisons and what they might reveal about climate change.
- A slide that connects tree growth patterns to a traditional Diné story or teaching.
- Final slide with a personal reflection: "What did I learn from this tree?"

Option 3: Oral Storytelling with Visual Aids – "The Tree Speaks"

Description: Prepare a short oral presentation where you tell the story of your tree as if it could speak. Use visuals to support your storytelling. Your Presentation Must Include:

- A visual aid (e.g., printed graph, drawing, or map).
- Description of growth years and years of struggle (using math terms like ratios).
- A storytelling connection to Diné culture or a personal/family experience.
- A reflection: "What can this tree teach us about balance and change?"

Standards: Diné - (1) Analyze the use of oral tradition as a source of Diné knowledge and history.

(2) Recognize the Diné philosophy of Sa'ah Naagháí Bik'eh Hózhóón (a belief system that guides harmonious living) and how it applies to daily life and balance with nature.

(3) Demonstrate responsibility, respect, and connection to living beings and the natural world.

(4) Apply Diné ways of knowing to understand weather, climate, and seasonal changes.

Reflection Prompt: What is one thing the tree taught you about balance, change, or listening?

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