

TOWARDS CULTURALLY RESPONSIVE & DECOLONIZED PLACE-BASED
ENVIRONMENTAL SCIENCE EDUCATION

by

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"To exist, humanly, is to name the world." (Freire, 2000, p. 88)

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CHAPTER ONE

INTRODUCTION & BACKGROUND

Context of the Study

I have often said that I have been a great benefactor of teachers who chose to think outside the box and immerse students fully in the environments they were studying. Place has always been a vessel of learning for me. Growing up near the Great Lakes, my early science education was shaped by the cultural and natural history of Lake Michigan. I attended a public multi-age charter school where entire units in poetry, mathematics, and science were rooted in a schoolyard prairie. Learning unfolded through time spent outside, observation, and the changing of seasons rather than in a classroom.

As I continued my education, place-based learning became central to how I understood science and the world. In high school, I attended Conserve School, a semester-long environmental science boarding program, where we canoed nearby wilderness areas while reading *Undaunted Courage* and spent extended time learning outdoors. Later, my studies took me across many landscapes. I tracked elephants and zebras alongside San bushmen in Botswana while studying human wildlife conflict. I circumnavigated Lake Superior by voyageur canoe while studying geology. I mist-netted birds along the Beagle Channel in southern Chile and read *The Snow Leopard* in the Himalayas. Across these experiences, place has functioned not as a backdrop for learning, but as an active teacher.

These experiences have strongly informed my work as an educator. I have taught students from tribal reservations, where land, history, and cultural knowledge are inseparable from learning. I have also taught in urban and highly stratified environments and now live and work in New York City. Moving between these contexts has made visible the inequities embedded in environmental and science education. Environmental learning remains one of the most privileged spaces in education. Inequitable access to school greening and nearby natural environments reinforces broader educational disparities, limiting opportunities for place-based and environmental learning among historically underserved students (Baró et al., 2021). Access to nature-based learning and environmental science programming often mirrors broader patterns of segregation and exclusion. Many students, especially those from Indigenous communities, communities of color, and urban environments, are either excluded from such learning or encounter it through narratives that erase their community's histories and relationships to land.

As an educator working across these contexts, decolonizing and desegregating environmental science education has become a central focus of my practice. I am increasingly interested in how science learning can move beyond colonial assumptions of land as empty, apolitical space and instead recognize land as inhabited and relational. When students are invited to bring their own cultural relationships to place into science learning, they are more likely to engage deeply and see themselves as capable scientific thinkers (Abrica et al., 2024). This suggests that environmental science education is most meaningful when it positions diverse ways of knowing, lived experiences, and community relationships to land as assets rather than barriers to scientific learning.

The purpose of this Educational Scholarship project is to explore how culturally responsive, place-based approaches can inform the design of environmental science instruction that honors Indigenous sovereignty, recognizes diverse relationships to land and community, and is relevant to learners across both Indigenous and urban educational contexts. This project synthesizes research on place-based education, culturally responsive pedagogy, Indigenous scholarship and Traditional Ecological Knowledge (TEK), urban environmental education, and environmental science instruction to identify instructional strategies that foster environmental literacy, support equitable participation in science learning, and position students' cultural knowledge and lived experiences as valuable foundations for scientific sensemaking.

Focus Question

How can place-based environmental science education be designed in culturally responsive ways that honor diverse relationships to land and community?

Sub-Questions

What instructional strategies support the integration of Traditional Ecological Knowledge and Western science within environmental science learning?

How can field-based and nontraditional learning environments support NGSS-aligned science instruction while advancing equity and inclusion?

Support Team

This project was supported by a collaborative network of mentors, educators, and peers. Dr. Walt Woolbaugh, my MSSE faculty advisor, provided guidance in refining the project's scope and supporting the shift toward a literature-based scholarship. Dr. Kate Solberg served as my science reader and contributed expertise in science education and curriculum design, helping ensure the project remained grounded. Dr. Jon Graves supported this work through instruction and mentorship that extended across multiple learning contexts, from Montana landscapes to field-based study in the high Himalayas, shaping my understanding of place as a central component of science learning. Dr. Christine Stanton, a scholar of decolonized education at Montana State University, contributed critical perspectives on equity, decolonization, and culturally responsive pedagogies, which informed the framing of this study. In addition, environmental and science educators working in place-based and community-based settings across the country offered feedback on early drafts. Peers in the MSSE program participated in structured review processes.

CHAPTER TWO

CONCEPTUAL FRAMEWORK

Place-Based Education in Science Learning

Place-based education (PBE) situates learning in the local environments, communities, and ecological systems where students live. In science education, PBE has been shown to support deeper sensemaking by grounding abstract concepts in concrete, observable phenomena (Gruenewald, 2003). When students engage with local watersheds, species, seasonal changes, and land-use histories, scientific inquiry becomes tangible and relevant. Research in place-based science education suggests that students demonstrate increased engagement, motivation, and conceptual understanding when instruction begins with familiar contexts rather than broad and decontextualized examples (Kinslow, 2019).

PBE aligns strongly with the Next Generation Science Standards, which emphasize learning through phenomena, scientific practices, and crosscutting concepts (NGSS Lead States, 2013). Investigations of local environmental systems naturally invite students to ask questions, collect and interpret data, recognize patterns, and construct explanations. In this way, PBE could be seen as supporting three-dimensional science learning while allowing students to draw on their lived experiences and community knowledge (Science in the City, 2020).

Many scholars caution, however, that PBE is not inherently equitable. Without attention to history, power, and representation, place-based learning can reproduce dominant narratives that frame land as empty or neutral (McLean, 2013). This project, therefore, treats PBE as an

approach that is most effective when paired with culturally responsive and decolonizing practices.

Culturally Responsive Pedagogy and Science Education

Culturally responsive pedagogy emphasizes the importance of designing instruction that affirms students' identities, builds on cultural assets, and supports deep cognitive engagement (Hammond, 2015). In science education, this includes recognizing that students bring valuable knowledge, practices, and ways of reasoning shaped by their communities and lived experiences. When instruction fails to connect with these resources, students may disengage or perceive science as inaccessible (Ladson-Billings, 1995).

Science in the City documents how science classrooms often privilege narrow norms of participation, communication, and reasoning that implicitly define who is seen as a “good” science student. When Western science is positioned as the only legitimate way of knowing, students whose cultural practices, language, or ways of reasoning differ from dominant norms are more likely to be marginalized or disengage from the subject altogether (Brown, 2019). Culturally responsive science instruction broadens what counts as scientific sensemaking and expands who is recognized as a scientist, supporting more equitable participation in science learning.

Hammond's foundational research further demonstrates that culturally responsive teaching supports cognitive development by connecting new content to existing mental models and reducing unnecessary barriers to learning (Hammond, 2015). When students see their cultural

experiences reflected in instruction, they are more able to engage in productive struggle and persist through complex problem-solving. These principles are foundational to this project's approach to environmental science curriculum design.

Traditional Ecological Knowledge and Western Science Integration

Traditional Ecological Knowledge (TEK) refers to Indigenous and community-based knowledge systems developed through long-term relationships with land, water, and ecosystems (Kimmerer, 2002). TEK includes detailed observations of ecological patterns, species behavior, seasonal change, and systems dynamics that parallel scientific practices such as data collection, analysis, and inference.

Integrating TEK with Western science supports both equity and disciplinary rigor in environmental science education (Bang et al., 2014). This integration allows Indigenous students to see their knowledge systems valued within science classrooms and helps non-Indigenous students recognize that scientific understanding is shaped by culture, history, and place (Kimmerer, 2013). Scholars emphasize that TEK should be positioned as complementary to Western science rather than as anecdotal enrichment (Bang et al., 2014). No one way of knowing should take precedence over another, and allowing space for diverse ways of being can serve to strengthen our students and the science they produce. Additionally, indigenous knowledge is not merely a commodity for Western science to draw from.

The language used to describe TEK closely mirrors that of NGSS practices and crosscutting concepts. Concepts such as patterns, cause and effect, systems, structure and function, and

stability and change are deeply embedded in TEK knowledge systems (Kimmerer, 2002). Making these connections explicit provides educators with a powerful framework for designing NGSS-aligned instruction that honors multiple ways of knowing.

Decolonizing and Desegregating Environmental Science Education

Many scholars and environmental historians argue that colonization has been a major driver of environmental degradation through land dispossession, resource extraction, forced displacement, and the suppression of Indigenous land stewardship practices, contributing to biodiversity loss, deforestation, and long-term ecological instability. Decolonizing and desegregating environmental science education requires examining how colonial histories, racialized power structures, and segregation continue to shape access to environmental learning spaces. Decolonizing education challenges how certain knowledge systems have been prioritized through colonial processes, while desegregating education draws attention to who has historically been included or excluded from environmental and science learning opportunities (Wilson, 2018). Together, these perspectives highlight that inequities in environmental science education are structurally produced rather than incidental.

Research shows that environmental education frequently reproduces narratives of land as empty, apolitical, and detached from Indigenous presence and ongoing stewardship (McLean, 2013). These narratives normalize environmental learning as a white and privileged space and obscure the colonial violence that made such access possible. As a result, many students, particularly Indigenous students, students of color, and learners in urban contexts, are positioned as outsiders

to environmental science and conservation work. These patterns persist even as environmental education increasingly adopts experiential and place-based approaches.

Desegregating environmental science education also requires attention to disproportionate access to outdoor learning opportunities. Schools and programs serving predominantly white or higher-income communities are more likely to offer sustained, immersive environmental science instruction, while marginalized communities often encounter limited or fragmented exposure (Gruenewald, 2003). When access does occur, instruction may fail to reflect students' cultural histories or relationships to land, which further reinforces exclusion from scientific identity formation.

Decolonizing pedagogical approaches challenge these patterns by reframing land as relational, storied, and culturally situated rather than as a neutral backdrop for scientific investigation (Bang et al., 2014). Integrating TEK alongside Western science affirms that rigorous scientific understanding exists within multiple epistemological traditions (Kimmerer, 2002). This integration enables students to recognize science as a human endeavor shaped by culture, ethics, and place, rather than as abstract and exclusionary. By critically examining whose knowledge is centered, whose access is prioritized, and how learning environments are structured, educators can design science instruction that is more equitable and responsive to the diverse communities it serves.

Synthesis and Application to Instructional Design

Together, place-based education, culturally responsive pedagogy, TEK integration, and decolonizing frameworks form the conceptual foundation for this project. These perspectives converge on the need for environmental science instruction that is contextual, relational, and inclusive, emphasizing learning as both a cognitive and socio-cultural process (Bang et al., 2014; Hammond, 2015). Instruction grounded in local phenomena invites students to engage in authentic scientific sensemaking while drawing on their lived experiences, community knowledge, and relationships to place. Such approaches align with the Next Generation Science Standards, which prioritize inquiry, phenomena-based learning, and the integration of science practices with disciplinary ideas (NGSS Lead States, 2013).

This framework supports instructional designs that position students as active participants in knowledge construction through inquiry anchored in community contexts and local landscapes. The Place-based Triangle and Prism (Figure 1) articulated by Teton Science Schools emphasize the dynamic relationship among learners, educators, and place, highlighting how learning is shaped by social relationships, ecological contexts, and reflective practice. When environmental science instruction is organized around this model, students have more opportunities to engage collaboratively in meaning-making, using local environments as sites for observation, questioning, and explanation, while connecting those experiences to broader scientific concepts and standards.

Culturally responsive scaffolds further strengthen this design by supporting reflection, relevance, and ethical engagement. The Four R's framework of Respect, Relevance, Reciprocity, and

Responsibility provides a structure for guiding student inquiry and reflection, encouraging learners to examine their positionality, relationships to land, and responsibilities within ecological systems (Kirkness and Barnhardt, 2001). Story work, narrative inquiry, and reflection prompts invite students to connect personal and cultural knowledge to scientific investigation, while the intentional integration of Traditional Ecological Knowledge alongside Western science affirms multiple epistemological traditions within the science classroom (Kimmerer, 2002).

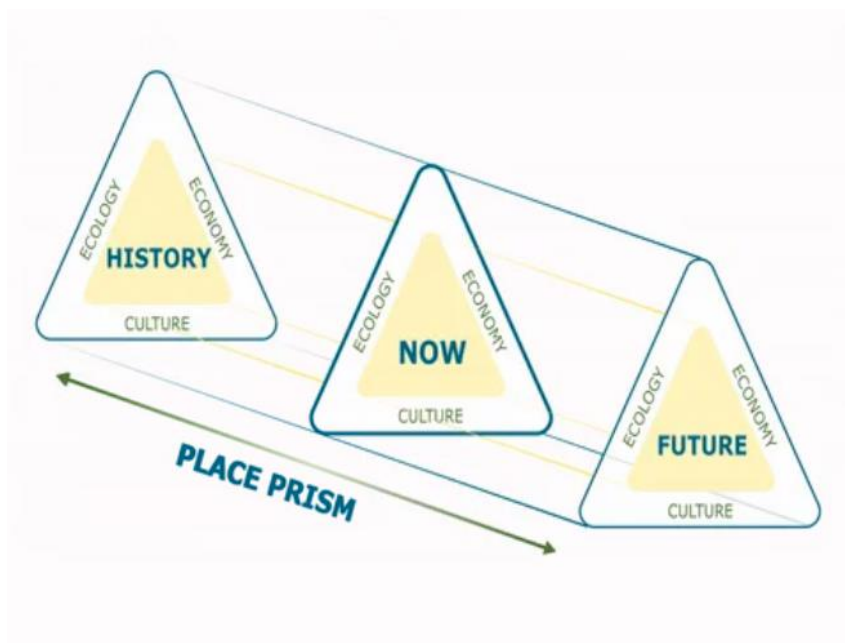


Figure 1. Place-based learning prism from Teton Science Schools.

Collectively, this conceptual framework guides the instructional strategies examined in the following section and informs the curriculum design principles proposed in this study. By centering student-centered inquiry, community knowledge, and reflective practices, educators can design environmental science learning experiences that maintain disciplinary rigor while advancing equity, relevance, and engagement. Grounding science learning in the place where the

learning is occurring positions environmental education not only as a site of knowledge acquisition, but also as a space for cultivating environmental literacy.

CHAPTER THREE

INSTRUCTIONAL STRATEGIES

Learning Cycle and Student-Centered Inquiry

The instructional strategies draw on the 5E learning cycle as an organizing structure, while maintaining flexibility to accommodate place-based and culturally responsive instruction. Engagement occurs through encounters with local phenomena and guiding questions rooted in students' environments. During exploration, students interact directly with place through field observation, mapping, sampling, or documentation using multiple modalities such as drawing, writing, photography, and discussion.

Explanation is treated as a collaborative process in which students construct meaning together, integrating data, personal observation, and peer dialogue. Educator input during this phase focuses on introducing scientific language and disciplinary concepts after students have established their own explanatory frameworks. Elaboration extends learning by inviting students to apply ideas to new contexts or compare their local observations with regional or global patterns. Evaluation emphasizes reflection and sensemaking rather than mastery of isolated facts, allowing students to demonstrate understanding through multiple forms of expression. This approach positions students as capable sense makers and recognizes that deep understanding often emerges through iteration, dialogue, and reflection rather than linear progression, memorization, and test taking.

Place-Based Triangle and Prism in Practice

Instructional strategies are informed by the Place-Based Triangle and Prism developed by Teton Science Schools, which emphasize the interdependence of learners, educators, and place.

Lessons are designed with attention to the relationships among these elements, recognizing that learning is shaped by who students are, where learning occurs, and how educators mediate those interactions.

Educators act as facilitators who help students uncover scientific meaning already present in place, rather than as sole sources of knowledge. Place functions as a co-teacher, offering opportunities for wonder, uncertainty, and inquiry. Reflection is embedded throughout instruction, supporting both students and educators in examining how their experiences, identities, and assumptions influence learning. This structure reinforces the idea that science learning is relational and context dependent.

Culturally Responsive Scaffolding, Decolonized, Desegregating Environmental Science

Instruction in this project integrates culturally responsive pedagogy, the Four R's framework, and decolonizing approaches to environmental science education. Learning is designed to support access, engagement, and ethical participation by honoring students' cultural identities, community knowledge, and relationships to place. Respect and relevance are enacted by positioning students lived experiences as assets and anchoring science learning in local ecological and social contexts.

Reciprocity and responsibility guide collaborative inquiry and reflection, encouraging students to consider their roles within ecological systems and their obligations to land, community, and future generations. Reflection prompts support examination of positionality and how identity shapes scientific questioning and explanation.

Traditional Ecological Knowledge is integrated alongside Western science as a parallel and rigorous knowledge system grounded in long-term observation and stewardship. Instruction highlights shared scientific practices and NGSS crosscutting concepts while situating TEK within its cultural and geographic context. Students compare knowledge systems to deepen critical thinking and recognize science as culturally situated. This approach also decolonizes and desegregates environmental science education by affirming learning in everyday, urban, and culturally significant environments. By challenging narratives that frame environmental learning as neutral or exclusive, instruction broadens participation and supports equitable access to meaningful science learning.

CHAPTER FOUR

LESSON FRAMEWORKS

The instructional examples in this project are designed as curriculum and lesson frameworks rather than standalone activities. Each framework is intentionally aligned with the Next Generation Science Standards, particularly the emphasis on learning through phenomena, scientific practices, and crosscutting concepts. These lessons are adaptable across grade levels and learning environments while maintaining coherence with NGSS expectations for sensemaking, evidence-based reasoning, and systems thinking.

A multi-lesson sequence integrating mapping, language, community knowledge, systems thinking, and civic action through creative and scientific practices.

1. Mapping Place and Discovering Place-based Relation

This lesson framework uses map interpretation and mapmaking to support spatial reasoning and systems thinking. Students analyze multiple types of maps, including topographic, political, and community-based representations, to examine how environments are organized and interpreted. They label features that are personally, culturally, or ecologically meaningful, such as waterways, green spaces, transportation routes, or sites tied to community use.

Students then create their own community maps, making decisions about what to include or exclude. This process supports NGSS practices such as developing and using models and analyzing and interpreting data, while crosscutting concepts like patterns and systems become

visible. Mapping is positioned as both a scientific and cultural practice, revealing how knowledge and power shape environmental representations.

Recommended Time: 1–2 class periods (60–90 min each)

Learning Objectives

- Analyze and compare different types of maps
- Identify patterns and relationships within environmental systems and your local community
- Develop a map as a model representing a place
- Evaluate how perspective, culture, and power influence what is represented

NGSS Alignment:

- HS-ESS2-2
 - o Students analyze maps to identify relationships between Earth systems (e.g., water, landforms) and human systems.
- HS-ESS3-1
 - o Students use map evidence to explain how environmental features influence human activity (e.g., settlement, transportation).

This lesson engages students in using maps as models to analyze spatial patterns and relationships between environmental and human systems, supporting evidence-based explanations about how places are organized and experienced.

- 1) Engage: Start by displaying 2–3 contrasting maps of the same place (e.g., topographic, subway/transit, political boundary map for your local community or an area you are

studying). Ask students to silently observe first, then discuss. Students should observe both natural (water, elevation, vegetation) and manmade systems (roads, buildings, boundaries) that are represented on the map.

- What information seems most important on each map?
- What might be missing?
- Who do you think each map was made for?
- What natural systems are present in your community (water, vegetation, landforms)?
- How do these systems interact with human systems like roads, buildings, or transportation?
- How do natural and human features interact?

Allow students time to engage with the different maps and notice how maps are used to express systems and functions of the community and land. It may be helpful to prompt students to find areas they know of, have memories with family at, or know as important landmarks. Challenge students to notice what systems have ownership over certain areas such as city, state, federal, private, etc., and if possible, journal or notate the maps with this information. This could be over a few minutes, or a whole class period if time allows.

- 2) Explore: Shift students from observing maps to beginning to think about their own local school, home, or special communities as a system that can be mapped. In small groups or individually, have students' brainstorm features that could be included in a community map. Encourage them to think across multiple systems:

- Natural systems (waterways, green spaces, elevation, vegetation)

- Human systems (roads, buildings, transportation networks)
- Cultural or community spaces (parks, gathering places, landmarks, places of personal or cultural significance)

Students should begin a rough sketch or outline of a community they know well. This can be their neighborhood, a park, their route to school, or another meaningful place. Include time for research, and additional resources to aid their discovery.

Students may use:

- Digital maps (e.g., satellite view, terrain view)
- Local or regional maps
- School or community knowledge
- Optional: conversations with family or peers

The goal is to build a foundation of knowledge that will inform their own map. Their maps may have utilitarian functions, such as highlighting the water treatment cycle in their area, or they may be more personal, such as featuring a skatepark, walking trails, or places of familial or cultural importance. Encourage students to begin thinking about what their map will emphasize or communicate.

- 3) Elaborate: Students use their research to create a detailed community map that communicates a clear idea about the place they are representing. They should move from notes and observations into a map that not only shows features, but makes an argument about how the community functions, who it serves, and what it values.

Students should first identify a focus or guiding idea for their map. This may be:

- A system (e.g., water access, transportation, food systems)

- A pattern (e.g., where people gather, where green space is located or missing)
- A perspective (e.g., youth experience, cultural landmarks, access and exclusion)

Maps should include evidence of:

- Natural system(s) (waterways, vegetation, landforms)
- Human system(s) (infrastructure, development, movement)
- Cultural/community features (landmarks, spaces of meaning)
- A clear legend and use of symbols to communicate information
- A system to show scale
- Indication of ownership or control where relevant (public, private, city, state, etc.)

Students should also produce a short, written statement that answers the following questions:

- What system or story is your map centered on?
- Who is this map for? Who might it leave out?
- Where do you see patterns of access, movement, or control?
- How do different systems (natural, human) interact in this space?

- 4) Explain: Once students have had sufficient worktime, pause student work and bring the class together to reflect on what they have discovered through their research. Use this time to connect their observations to the idea of maps as models that represent environmental systems, human relationships, and perspectives.

Build on student responses to highlight that maps are not neutral representations of place.

They are created by selecting, organizing, and emphasizing certain features over others.

These decisions are shaped by purpose, audience, and perspective.

Introduce the idea that maps can reflect power and access, as well as lived experience:

- Who typically creates maps?
- What kinds of places or knowledge are often included or excluded?
- How might a map look different if it were created from another perspective?

Build on student responses to highlight that maps can help us understand how environmental systems function and how human activity shapes those systems over time.

Extend thinking toward environmental impact and access:

- Are there areas where natural systems are protected, have been changed, or limited? Why might that be?
- Who has access to green space, clean water, or other environmental resources in this place?

Reinforce that maps are not neutral representations. They reflect choices about what to include and can highlight or obscure environmental relationships, access, and impact. Students are developing maps as models of interacting environmental and human systems, shaped by their research and development of sense of place.

- 5) Evaluate/Extend: Provide time for students to reflect on both their process and their final map.

Arrange a table, or gallery walk, where students can observe each other's work.

Encourage them to look for new perspectives on familiar places and patterns in how systems are represented across the class.

Students may leave brief feedback or respond to prompts such as:

- One environmental pattern I noticed...
- One way this map shows human impact...
- One question I have about this place...

Close by reinforcing that maps are tools for understanding environmental systems and for communicating how people interact with the natural world. By creating their own maps, students are analyzing and representing the relationships between land, resources, and community, developing a stronger sense of place and their own relationship to it.

2. Language, Landmarks, and Environmental Sensemaking

Building on the mapping work, this lesson framework explores the role of language in environmental observation and meaning-making. Drawing from Robert MacFarlane's *Landmarks*, students examine how words encode ecological processes, seasonal change, and relationships to place. Students investigate how naming practices shape attention and understanding, connecting linguistic diversity to scientific noticing and sensemaking.

Students extend this work by interviewing family members or community members about local place names, environmental terms, or expressions used to describe land, weather, or ecological change. These interviews position families and communities as knowledge holders and emphasize the relational nature of environmental understanding. Students then synthesize what

they learn by creating a collective class dictionary or glossary of place-based terms, which may include words from multiple languages, dialects, or cultural traditions.

This lesson aligns with NGSS science and engineering practices related to asking questions, constructing explanations, and communicating information. By linking language, observation, and empirical experience, students deepen their understanding of environmental phenomena while recognizing that scientific knowledge is shaped by culture, language, and place.

Incorporating multilingual perspectives affirms diverse identities and expands students' capacity to interpret and describe the natural world through multiple lenses.

Recommended Time: 1–2 class periods (60–90 min each)

Learning Objectives

- Analyze how language shapes environmental observation and understanding
- Identify connections between words, environmental features, and ecological processes
- Gather and synthesize community-based knowledge about place and environment
- Develop a shared glossary that represents environmental systems through multiple perspectives
- Evaluate how language, culture, and experience influence what is noticed, named, and understood in the natural world

NGSS Alignment:

- HS-ESS2-2
 - Students analyze maps to identify relationships between Earth systems (e.g., water, landforms) and human systems.
- HS-ESS3-5

- o Students analyze and communicate how human perspectives and values influence interactions with the environment, including how language reflects relationships to land and resources.
- HS-ESS3-4
 - o Students use community knowledge and observations to consider how understanding environmental systems can inform responses to environmental change.

- 1) Engage: Introduce to your students that the words we use to describe the natural world influence what we notice, remember, and understand. Share these quotes from nature writer

“Under pressure, Oxford University Press revealed a list of the entries it no longer felt to be relevant to a modern-day childhood. The deletions included acorn, adder, ash, beech, bluebell, buttercup, catkin, conker, cowslip, cygnet, dandelion, fern, hazel, heather, heron, ivy, kingfisher, lark, mistletoe, nectar, newt, otter, pasture and willow. The words introduced to the new edition included attachment, block-graph, blog, broadband, bullet-point, celebrity, chatroom, committee, cut-and-paste, MP3 player and voicemail.”

— **Robert Macfarlane, Landmarks**

“Meaning indifferent to the distinction between things. It is not, on the whole, that natural phenomena and entities themselves are disappearing; rather that there are fewer people able to name them, and that once they go unnamed they go to some degree unseen. Language deficit leads to attention deficit.” — **Robert Macfarlane, Landmarks**

“Without a name made in our mouths, an animal or a place struggles to find purchase in our minds or our hearts.”

— **Robert Macfarlane, Landmarks**

Provide students with the following questions, instruct them to journal any ideas for 5-10 minutes:

- What do you notice about the types of words being removed and added from the Oxford Junior Dictionary?
- What might be the impact of losing words for plants, animals, or landscapes?
- What does Macfarlane mean by “once they go unnamed, they go to some degree unseen”?
- How might language influence what we pay attention to in the environment?
- Can you think of a time when knowing the name of something changed how you saw it?

Allow students time to share and build on each other’s ideas. Guide them toward the idea that language shapes observation, and that naming is connected to noticing patterns, relationships, and changes in environmental systems.

- 2) Explore: Shift students from reflecting on language to beginning to generate and investigate their own place-based vocabulary. Frame this as an opportunity to notice how language connects to environmental systems and personal experience.

In small groups or individually, have students brainstorm words they already use to describe their local environment. Encourage them to think across different types of environmental observation:

- Weather and seasonal changes
- Landforms, water, and vegetation
- Sounds, textures, and movement
- Words used by family, friends, or community members

You may choose to provide time for research and observation to expand their word list. Students may:

- Revisit maps, notes, or places from the previous lesson
- Observe their immediate surroundings (schoolyard, neighborhood, or nearby green space)
- Use digital tools or local resources to identify environmental features
- Begin thinking about people they could speak with for additional language or knowledge

Prompt students to deepen their thinking:

- Are there multiple words for similar things? What might that suggest?
- Are there important aspects of your environment that don't have clear or commonly used names?
- What words feel specific to your community or experience?

3) Explain: Bring the class together to reflect on the language students generated and researched. Use this time to connect their observations to environmental science concepts and the role of language in shaping understanding. Highlight that language is a tool for scientific observation and communication. The words we use can help us notice details, identify patterns, and describe relationships within environmental systems. Extend thinking toward perspective and knowledge:

- Where do these words come from (school, family, culture, media)?
- Whose language is most often used in science?
- What knowledge might be overlooked when certain words or ways of describing the environment are missing?

Reinforce that expanding the language we use allows us to better understand environmental systems and include multiple ways of knowing.

4) Elaborate: Students extend their learning by gathering community-based language and synthesizing it into a shared resource that reflects both environmental science and lived experience.

Part 1: Community Interviews

Students develop and conduct brief interviews with family members, caregivers, or community members. Students should ask about:

- Local place names
- Words used to describe weather, seasons, or environmental change
- Expressions related to land, water, or daily environmental experience

Encourage students to seek out multiple perspectives where possible, including different languages, dialects, or generational knowledge.

Part 2: Class Glossary Creation

Students bring their findings back to class and contribute to a collective glossary or dictionary of place-based terms.

Each entry should include:

- The word or phrase
- A definition or explanation
- The environmental feature or process it describes
- The source (e.g., family member, language, community context)

Push students to go beyond simple definitions by identifying connections:

- What system does this term relate to (water, weather, vegetation, etc.)?
- What pattern or process does it help describe?
- Does this word reflect a particular relationship to the environment (use, care, observation)?

Encourage students to notice patterns across the class glossary:

- Are there multiple words for similar phenomena?
- What does this suggest about how people experience and understand this place?

The goal is for students to recognize that language can function as both scientific evidence and cultural knowledge, helping describe environmental systems in nuanced ways.

- 5) Extend/Evaluate: Language shapes how we observe and understand environmental systems. By expanding the words we use and value multiple ways of knowing, we deepen our ability to notice patterns, describe change, and make meaning of the natural world.

Students may respond in writing or discussion:

- How did your understanding of your environment change through this lesson?
- What environmental processes or patterns are better described using the words you collected?
- How did community knowledge contribute to your understanding?
- What environmental systems are most visible in your glossary? Which are less represented?
- Whose perspectives are included in your glossary? Whose might still be missing?
- How might scientists benefit from using more diverse languages and perspectives when studying the environment?

Optional: Share-Out or Display, Create a visible class glossary (poster, digital document, or printed booklet). Allow students time to read and engage with the collection. Students may respond in their notebooks to prompts such as:

- One word that changed how I see this place...
- One connection between language and environmental systems...

Community Knowledge and Climate Through Interviews

This lesson framework centers community knowledge as a critical source of evidence for understanding environmental and climate change. Students design and conduct interviews with family members, community elders, or local knowledge holders to explore observed changes in weather patterns, seasonal cycles, land use, or ecological conditions over time. Emphasis is placed on listening for patterns, timelines, and lived observations that connect personal experience to larger climate processes.

Students analyze interview responses alongside scientific data such as temperature records, precipitation trends, maps, or satellite imagery. Through comparison, students identify areas of alignment and divergence between qualitative and quantitative sources, supporting NGSS practices related to obtaining, evaluating, and communicating information as well as analyzing and interpreting data. This process reinforces that climate science relies on multiple forms of evidence, including long-term observation and community memory.

Recommended Time: 1–2 class periods (60–90 min each)

Learning Objectives

- Collect and analyze community-based observations about environmental and climate change
- Identify patterns and trends in qualitative data (interviews)
- Compare community knowledge with scientific data (e.g., temperature, precipitation, maps)
- Evaluate how different types of evidence contribute to understanding climate systems

- Explain how climate change is experienced and observed at a local scale

NGSS Alignment:

- HS-ESS3-5
 - o Students analyze and communicate how human perspectives and values influence interactions with the environment, including how language reflects relationships to land and resources.
- HS-ESS3-1
 - o Construct an explanation based on evidence of how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.

- 1) Engage: Introduce to your students that long-term observation of environmental patterns, known as phenological monitoring, can provide important evidence about climate and environmental change. Explain that scientists are not the only ones who collect this kind of data; individuals and communities around the world have been observing and recording environmental changes for generations.

Share the following examples of phenological observation:

- Video of Billy Barr monitoring Colorado Snowfall
- Graph tracking the blooming of Cherry Blossom Trees in Japan

Prompt students with the following questions:

- What do these examples have in common?
- Why might long-term observation be important for understanding environmental change?
- How are these observations similar to or different from data collected by scientists?
- What makes these observations useful or meaningful?

Give students time to share and build on each other's ideas. Guide them toward the understanding that consistent observation over time can reveal patterns in environmental systems, and that meaningful data can come from lived experience as well as formal scientific study.

- 2) Explore: Prepare your students to gather their own evidence about environmental and climate change. Frame this as an opportunity to investigate how people in their own communities have noticed changes over time.

Students will design interview questions to collect observations from family members, community elders, or other knowledge holders. Encourage students to focus on phenological observations, similar to the phenological observations introduced earlier.

Students should develop questions that explore:

- Changes in seasonal timing (e.g., earlier springs, later winters, shifting bloom times)
- Weather patterns (temperature, precipitation, storms)
- Changes in plant or animal behavior, species observed
- Land use changes, ownership, or environmental conditions over time

Students may work individually or in small groups to draft and revise interview questions, practice asking questions and following up for clarification, identify who they might interview.

Prompts to consider:

- How can you ask questions that help reveal change over time?
- What kinds of answers would help you identify patterns?
- How will you record and organize what you learn?

The goal is for students to prepare qualitative data that reflects long-term community-based environmental observations.

- 3) Explain: Bring the class together to host a discussion connecting interview data to environmental science and climate systems.

Introduce the idea that climate science relies on identifying patterns over time, and that these patterns can be observed in multiple ways:

- Instrument-based data (temperature records, precipitation measurements)
- Observational data (changes in seasons, snowfall, plant growth, animal behavior)

Highlight that both forms of data can help identify trends, but may differ in scale, precision, and perspective.

- What might observational data reveal that instruments do not?
- What might instruments capture that people might not notice?

Reinforce that students will use both forms of evidence to better understand environmental change.

- 4) Introduce to your students that they will now gather their own evidence of environmental and climate change by learning from people in their community. Explain that just like the examples they observed, individuals and communities often notice patterns over time through daily life, memory, and experience. These observations can provide valuable insight into environmental systems and change.

Explain that students will conduct interviews to collect this type of observational data.

Give students time to develop, revise, and practice their interview questions. Encourage them to focus on open-ended questions and to consider how they will record responses.

Students then conduct their interviews (outside of class time), listening for patterns, timelines, and repeated observations.

- 5) Extend: Your students that they will now analyze their interview data and compare it with scientific evidence to better understand environmental and climate systems. Explain that scientists often use multiple types of data to identify patterns and trends over time.

Students should organize and review their interview responses, looking for:

- Repeated observations across interviews
- Descriptions of change over time
- Patterns related to seasons, weather, or environmental conditions

- Next, students compare their findings with scientific data such as temperature records, precipitation trends, maps, or satellite imagery.

Prompt your students with the following questions:

- What patterns appear in your interview data?
- How do these patterns compare to scientific data?
- Where do the two sources align? Where do they differ?
- What might explain similarities or differences?

Give students time to analyze and discuss their findings. Guide them toward the understanding that environmental knowledge can be developed and communicated through many ways of knowing, including scientific measurement, long-term community observation, oral histories, cultural traditions, and Traditional Ecological Knowledge (TEK). Emphasize that people who work closely with environmental systems often develop deep observational knowledge over time, such as farmers noticing seasonal shifts, gardeners tracking soil and plant changes, fishers observing water conditions and species movement, or community members recognizing long-term changes in local weather patterns.

Encourage students to brainstorm additional perspectives and forms of environmental knowledge that may contribute to understanding environmental systems and climate change. Help students recognize that comparing multiple forms of evidence and lived experience can deepen scientific understanding and strengthen explanations of environmental change.

Environmental Case Study and Structured Dialogue

This lesson framework engages students in environmental case studies grounded in local or regional issues such as water access, land management, habitat protection, or climate adaptation. Students examine scientific data, historical context, and stakeholder perspectives, construct explanations, and assess trade-offs.

Learning culminates in a structured town hall style seminar in which students represent different stakeholder viewpoints. This format aligns with NGSS practices related to argumentation from evidence and communication, while emphasizing that science informs policy decisions but does not operate independently from social values and ethics.

Recommended Time: 1–2 class periods (60–90 min each)

Learning Objectives

- Collect and analyze community-based observations about environmental and climate change
- Identify patterns and trends in qualitative data (interviews)
- Compare community knowledge with scientific data (e.g., temperature, precipitation, maps)
- Evaluate how different types of evidence contribute to understanding climate systems
- Explain how climate change is experienced and observed at a local scale

NGSS Alignment:

- HS-ESS3-5
 - Students analyze and communicate how human perspectives and values influence interactions with the environment, including how language reflects relationships to land and resources.

- HS-ESS3-4
 - o Students use community knowledge and observations to consider how understanding environmental systems can inform responses to environmental change.
- 1) Engage: Frame for students that environmental decisions are often complex and involve both scientific evidence and human values. Explain that issues such as water access, land use, habitat protection, and climate adaptation require choices that affect both ecosystems and communities.

Present a local or regional environmental issue relevant to your students (e.g., water quality, development of green space, wildlife management, flooding, or climate adaptation efforts).

Provide a brief overview and any visuals or data that help frame the issue. When possible, include context about the land itself, including prior or ongoing relationships with Indigenous communities or historically marginalized groups.

Prompt students with the following questions:

- What is happening in this situation?
- Who might be affected by this issue?
- What environmental systems are involved?
- What questions do you have about this situation?

Give students time to share and build on each other's ideas. Guide them toward understanding that environmental issues involve interacting systems, stakeholders, and multiple perspectives.

- 2) Explore: Shift students into investigating the issue more deeply by examining different types of information and perspectives. Explain that understanding environmental challenges requires looking at scientific data alongside human experiences and priorities. Students should research and gather information about the case study, including:

- Scientific data (e.g., environmental measurements, maps, trends)
- Historical context (how the issue developed over time)
- Stakeholder perspectives (people or groups affected by or involved in the issue)

Prompt students with the following questions. Give students time to organize their findings and begin identifying patterns, conflicts, or trade-offs:

- What does scientific data show about this issue?
- How has this situation changed over time?
- Who is involved, and what might they value or prioritize?
- What environmental systems may be affected?

- 3) Explain: Frame for students that environmental decisions are not made in isolation, but are shaped by history, culture, power, and relationships to land. Explain that issues such as water access, land use, habitat protection, and climate adaptation often affect

communities differently, depending on who has access to resources, whose knowledge is recognized, and whose voices are included in decision-making.

Bring the class together to reflect on what students have learned through their research. Use this time to connect scientific evidence to decision-making and highlight how knowledge, power, and perspective shape environmental understanding.

Guide a discussion:

- What patterns or trends do you see in the data?
- What are the main challenges or conflicts in this issue?
- How do different stakeholders understand or experience this issue?
- Where do scientific data and lived experiences align or differ?

Highlight that environmental decision-making often involves trade-offs, and that these trade-offs are not always evenly distributed. Emphasize that science provides critical evidence, but decisions are also shaped by values, priorities, access to power, and historical context. Additional prompts for students to journal about:

- Whose knowledge is recognized as valid in this situation?
- What knowledge systems might be overlooked or undervalued?
- How might including more perspectives change how the issue is understood?

Reinforce that students will use both evidence and perspective to construct and communicate their ideas.

- 4) Elaborate: Explain that students will participate in a structured town hall to represent different stakeholder perspectives and propose responses to the environmental issue. Emphasize that their role is not only to present a position, but to consider how environmental decisions impact communities, systems, and future generations.

Assign or allow students to take on stakeholder roles. Each student or group should:

- Represent a specific perspective grounded in research
- Use scientific data and contextual knowledge to support their position
- Consider cultural, historical, and environmental relationships to the land
- Reflect on how power, access, and representation shape their stakeholder's position

Students should prepare by developing a clear position or claim, supporting evidence (scientific data, observations, historical context, community perspectives).

Consideration of trade-offs, including who benefits and who may be impacted

Prompt students with the following questions:

- What does your stakeholder value or prioritize?
- How does your stakeholder relate to the land or environment?
- What evidence supports your position?
- Who benefits from your proposal? Who might be impacted?
- What trade-offs are involved, and how are they distributed?

Students then participate in a structured town hall discussion, where they present their perspectives, respond to others, and engage in dialogue about possible solutions. Encourage respectful listening, questioning, and consideration of multiple viewpoints.

- 5) Extend: Frame for students that environmental decision-making often requires ongoing dialogue, reflection, and revision. Emphasize that solutions are rarely simple and often involve balancing competing needs and perspectives.

Students reflect on the town hall and consider possible paths forward for the issue. Prompt students with the following questions:

- What solutions were proposed during the discussion?
- What trade-offs were involved in these solutions?
- Were any compromises or shared understandings identified?
- How did different perspectives influence the conversation?
- What might a more equitable or inclusive solution look like?

Policy, Power, and Environmental Decision-Making

This framework explicitly examines the role of policy in shaping environmental systems and access to land. Students investigate who created foundational environmental policies such as the establishment of national parks, the Wilderness Act, and wildlife management doctrines.

Instruction emphasizes how scientific knowledge, political priorities, and cultural values intersected in the creation of these policies and whose voices were included or excluded.

Students analyze primary and secondary sources related to land policy alongside ecological consequences, such as species management outcomes or land use change. This supports NGSS practices of analyzing information and evaluating evidence while engaging the crosscutting concept of cause and effect across systems.

As a culminating task, students are invited to draft their own land or environmental doctrines. These may outline principles for conservation, access, stewardship, or environmental justice grounded in local context and scientific understanding. This exercise positions students as civic actors who use science to inform ethical decision-making, reinforcing that environmental science is inseparable from governance and responsibility.

Recommended Time: 2–3 class periods (60–90 min each)

Learning Objectives

- Analyze how environmental policies shape ecosystems, land use, and access to resources
- Evaluate how scientific knowledge, cultural values, and political priorities influence environmental decision-making
- Examine whose perspectives are included or excluded in the creation of environmental policy
- Interpret primary and secondary sources to understand environmental change over time
- Develop and justify a set of principles or a policy proposal grounded in scientific understanding and community context

NGSS Alignment:

- HS-ESS3-5

- o Students analyze and communicate how human perspectives and values influence interactions with the environment, including how language reflects relationships to land and resources.
- HS-ESS3-4
 - o Students use community knowledge and observations to consider how understanding environmental systems can inform responses to environmental change.
- 1. Engage: Frame for students that environmental policies shape how land is used, protected, and accessed, and that these decisions are influenced by scientific knowledge, cultural values, and systems of power. Provide context for foundational environmental policies such as the establishment of national parks, the Wilderness Act, and wildlife management practices. Situate these policies within their historical moment, including the social and political priorities that informed their creation and the communities that were impacted by them.

Students examine how these policies have influenced land use, conservation practices, and access to natural spaces, with attention to both intended outcomes and broader social and ecological consequences.

- 2. Explore: Students investigate a selected environmental policy or land management decision through the analysis of primary and secondary sources. These sources may include policy texts, historical documents, maps showing land use change, ecological data, and accounts from different communities.

This phase emphasizes building an understanding of how environmental systems have changed over time in response to policy decisions. Students examine evidence of ecological outcomes such as species management, habitat change, or resource distribution, alongside the historical and social context in which decisions were made.

Attention is given to multiple perspectives, including those of government agencies, environmental organizations, local communities, Indigenous communities, and industry stakeholders. Students begin to identify patterns, impacts, and tensions across sources, as well as gaps in representation or knowledge.

3. Explain: Class discussion and synthesis focus on connecting environmental policy decisions to observable changes in environmental systems. Students analyze cause-and-effect relationships, identifying how specific policies have shaped land, ecosystems, and access to resources over time.

This phase highlights the intersection of scientific evidence with cultural values and political priorities. Students consider how different forms of knowledge were used, prioritized, or excluded in decision-making processes. Emphasis is placed on recognizing that environmental outcomes are not only the result of ecological processes, but also of human choices shaped by power and historical context.

4. Elaborate: Students take on the role of decision-makers by developing their own environmental doctrine or policy proposal. This work should be grounded in scientific understanding, community context, and meaningful ethical consideration.

Students design a set of principles or a policy that addresses an environmental issue relevant to their local or regional context. Their proposal integrates scientific evidence about environmental systems with consideration of cultural relationships to land, access to resources, and long-term sustainability.

Each proposal includes a clear statement of purpose, supporting evidence, and an explanation of potential impacts. Students consider how their policy addresses trade-offs, including ecological outcomes and social implications. Attention is given to issues of equity, access, and representation, with students reflecting on how their proposal responds to gaps or limitations identified in earlier policy examples. This phase positions students as active participants in environmental decision-making, using science as a tool to inform thoughtful and responsible action.

5. Extend: Students reflect on their written policy proposals in relation to existing environmental policies and consider how decisions are implemented and adapted over time. This phase emphasizes that environmental decision-making is an ongoing process that evolves as new evidence and perspectives emerge.

Students consider the challenges of translating ideas into action, including the role of governance, competing interests, and resource limitations. They examine how policies can be revised to better reflect environmental needs and community priorities, and how broader participation can influence more equitable outcomes.

Coherence Across Pedagogies and Frameworks

Across these lesson frameworks, NGSS alignment is maintained through a shared emphasis on phenomena-based inquiry, scientific practices, and crosscutting concepts. The frameworks foreground student-centered sensemaking while honoring diverse ways of knowing and lived relationships to place. Collectively, they demonstrate how environmental science curricula can be rigorous, culturally responsive, and attentive to issues of power, policy, and participation. These frameworks are intended to support educators in implementing environmental science instruction that connects disciplinary knowledge to community, culture, and civic engagement. By integrating mapping, language, interviews, case studies, and policy analysis, the curriculum positions students as informed scientific thinkers capable of engaging thoughtfully with environmental challenges and helps students blur the line between “scientist” and just plain human.

CHAPTER FIVE

VALUE: REASONING AND REFLECTION

Research consistently demonstrates that instructional approaches such as mapping, storytelling, interviews, dialogue, and community-based inquiry support core NGSS science and engineering practices, including constructing explanations, analyzing and interpreting data, engaging in argument from evidence, and communicating information. The literature further suggests that students are more likely to engage deeply in science learning when curriculum connects to their lived experiences, cultural knowledge, and relationships to place. Approaches that honor multiple ways of knowing, including Indigenous knowledge systems grounded in sovereignty, reciprocity, and long-standing relationships with land, can strengthen both scientific understanding and scientific identity particularly for students who come from backgrounds historically excluded or marginalized within environmental education and outdoor learning spaces. Together, these findings support the idea that rigorous environmental science instruction should not be separated from culture, history, language, community context, or Indigenous relationships to land, but instead grounded within them. While this project does not attempt to measure causal outcomes, it offers a research-informed and practice-based framework for designing environmental science instruction that is academically rigorous, reflective, and culturally responsive.

This work also reflects my own values and evolving philosophy as an educator. Throughout my experiences teaching science in classrooms, museums, field settings, and outdoor environments, I have repeatedly observed how students become more engaged when they can see

themselves, their families, and their communities reflected in the learning process. Too often, environmental education has been presented through exclusionary narratives that position science as detached from culture, emotion, or lived experience, while also privileging access to wilderness spaces historically shaped by colonialism, Indigenous dispossession, segregation, and environmental inequity. I believe environmental science education should instead help students understand that scientific observation already exists within their daily lives: in the noticing of changing seasons, in stories passed between generations, in neighborhood parks and waterways, and in the languages, communities use to describe the environments around them. Practices such as Zaretta Hammond's Culture Tree encourage students to reflect on the cultural identities, values, traditions, and experiences that shape how they make meaning, providing a starting point for connecting community knowledge and personal experience with scientific inquiry (Hammond, 2015).

The instructional frameworks proposed in this paper attempt to blur the line between 'doing science' and everyday human experience. By asking students to create community maps, conduct interviews about climate observations, analyze environmental policy, and engage in structured dialogue about land and stewardship, these lessons position students not simply as recipients of scientific knowledge, but as active participants in meaning-making and environmental decision-making. This approach values curiosity, reflection, and place-relational understanding alongside scientific evidence and analysis. It also encourages students to critically examine how power, policy, and historical exclusion shape relationships to land and access to environmental spaces.

For students, these approaches offer opportunities for increased relevance, agency, and meaningful participation in science learning. Students are invited to bring their identities, languages, histories, and observations into the classroom while simultaneously developing analytical and scientific reasoning skills. For educators, administrators, and community partners, the findings underscore the importance of curriculum design and professional learning that center place, equity, and community engagement rather than treating culture as supplemental to science instruction.

The lesson frameworks presented here are intentionally adaptable across both formal and informal educational settings. Although the specific environmental content and community contexts will vary by location, the broader principles of place-based inquiry, systems thinking, culturally responsive pedagogy, and community-centered environmental science remain widely applicable. Future work will involve piloting and revising selected frameworks, gathering educator and student feedback, and continuing to refine these approaches through collaborative practice. Ultimately, I hope this work contributes to environmental science education that is not only rigorous and standards-aligned, but also more personable, participatory, and connected to the realities of the communities' students call home.

Creating curricula and learning experiences that build environmentally literate learners is challenging and intimate work. It is also necessary work as our planet faces the increasing pressure of climate catastrophe. Children born today are projected to experience significantly more climate-related disasters than previous generations, including more heatwaves and several times more floods, droughts, and wildfires. It is our duty as science educators to prepare students

for the real-world problems they will face; this project suggests one framework teachers may use to approach these uncertain futures in their own classrooms. Meeting these challenges will require science education to recognize multiple knowledge systems, honor the expertise that already exists within students and their communities, and expand who is seen as belonging in science. By making space for honoring ongoing cultural knowledge and diverse ways of knowing alongside rigorous scientific inquiry, environmental education can better prepare students not only to understand a changing world, but to participate in shaping its future.

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