DEVELOPING STUDENT OUTCOMES FOR ENVIRONMENTAL LITERACY IN K-12 EDUCATION

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NOTE FOR READERS - This document represents our latest thinking on bridging differences in language and practice between environmental education and formal K-12 education as viewed through the lens of environmental literacy. We recommend using this document as a tool for developing student outcomes but know that this is still a work in progress. Feedback on this document is welcome and encouraged. If you have feedback, please contact the NOAA Bay Watershed Education and Training program at: bwet.program@noaa.gov.

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OVERVIEW

Environmental education has been a valued focus for educators in a variety of learning contexts for decades. However, despite persistent efforts by environmental education stakeholders, many school districts have yet to formally integrate it into formal curriculum at the school-district level. In an attempt to improve this integration, we explored the ways in which the goals for student learning within environmental education and formal education cohere and the ways in which they might be misaligned. This document unifies different ideas about what counts as knowledge, pedagogical practices, and holistic education goals that are prioritized by environmental education stakeholders and those of K-12 education into a set of student outcomes.

For the purposes of this document, we define environmental education as a practice for developing attitudes, values, skills, motivation, knowledge, and actions to solve environmental problems. In addition, environmental education provides individuals and groups with opportunities to gain knowledge and take conservation actions, ideally while exploring the natural world. Further, we define environmental literacy as a set of abilities to interpret, communicate, and use environmental ideas, anticipate, and predict the effects of human activities, and to adapt and adjust behaviors in response to environmental information. Being environmentally literate requires a deep understanding of Earth's systems, their interdependence, resilience, and human impacts upon them. In this way, environmental literacy is fundamentally linked to learning, education, and science education specifically. Environmental education and environmental literacy are not only necessary for human sustainability but are also appropriate as a goal of formal schooling.

This approach to student outcomes is informed by a half-century of environmental education practice and research in formal and informal spaces. It offers a shared language for student outcomes that may be used to guide the planning, implementation, and evaluation of environmental education activities in formal instructional settings.

Where relevant, the outcomes in this document have been informed by, modeled after, and aligned with the language and goals of standards-based frameworks for K-12 education including the [Next Generation Science Standards](#) (NGSS) and the learning indicators of dimensions of social studies outlined by the [College Career and Civic Life Framework (C3) for Social Studies Standards.](#) As such, our intention was to facilitate the articulation of environmental education student outcomes in ways that align with formal academic goals. They have also been informed and shaped by frameworks put forth by professional non-formal education such as [Principles for Ocean and Climate Literacies.](#)

WHY ENVIRONMENTAL LITERACY?

Environmental education often serves as a catchall term and is sometimes used synonymously with outdoor education. The term environmental education can mean activities, pedagogical approaches, and/or outcomes. This document focuses specifically on environmental literacy as a goal of environmental education. We developed this document as a series of environmental literacy outcomes that could be achieved through Meaningful Watershed Educational Experiences (MWEEs), a unique approach to environmental education programming that utilizes elements of project-based learning with both in-classroom and outdoor learning experiences. MWEEs engage students in active investigations into local environmental issues and culminate in students taking action to address the problems they identified and explored.

The environmental literacy outcomes in this document could also be effectively achieved through a variety of types of environmental education programing and pedagogies (e.g. place-based learning) that utilize any of a variety of instructional strategies including outdoor field experiences, in-classroom work, stewardship activities, laboratory exercises, online simulations, and more.

The focus on environmental literacy is also important for alignment with formal academic goals. Developing and advancing a variety of literacies is widely considered a top responsibility of schooling and the outcomes within the document have been developed to align specifically with established standards and indicators of student achievement in formal contexts.

HOW DO MWEES SUPPORT ENVIRONMENTAL LITERACY?

Meaningful Watershed Educational Experiences (MWEEs) represent one approach to environmental literacy education. MWEEs seek to increase understanding and stewardship of watersheds and related ocean, coastal, riverine, and estuarine ecosystems through learner-centered investigations of local environmental issues. Students use the understanding they develop in their investigations to plan and implement informed stewardship actions that address these issues.

In many regions, systemic integration is a programmatic goal of MWEEs. The intention is that entire populations of students in targeted grade levels or courses all have equal access to participation in MWEEs. Through integration, MWEEs are not merely added to programs as additional or 'extra' lessons or units, they are part of the standard curriculum that all teachers provide for all students. The MWEE thus becomes the pedagogical approach and content focus for supporting students to meet the academic standards and/or learning objectives for the curricular unit. The success of systemic MWEEs depends on support from multiple community stakeholders including district-level curriculum supervisors, administrators, and teachers. They also often benefit from the support of community partners including non-formal education providers, state departments of natural resources, and others. In order to establish and maintain support, MWEE programs must be able to clearly and adequately demonstrate their value for supporting school goals. To find out more about MWEEs and the MWEE educational framework, visit: www.noaa.gov/office-education/bwet.

As noted above, student outcomes for environmental education experiences like MWEEs that align with standards for student achievement utilized by school systems can be a productive way to evaluate and communicate the impact of those experiences in ways that increase buy-in and thus sustainable implementation with target school audiences.

WHO SHOULD USE THIS STUDENT OUTCOMES DOCUMENT?

We designed this document for formal and non-formal educators who are developing and implementing environmental education programming with K-12 students. It can serve as a guidepost for environmental education providers in both formal and non-formal contexts as they develop their program activities and evaluation plans for students in grades K-12. Users are encouraged to employ the outcomes as written if they seem relevant to their work or to modify and adapt the outcomes to meet the specific needs of their programs.

Non-Formal Educators

Educators and professionals working outside (or alongside) formal academic learning contexts may find this document useful for environmental education programming they are developing for K-12 students. It can help ensure that their goals for environmental knowledge, responsibility, engagement, and 21st Century skills are met while targeting the outcomes of the formal curricular programs into which their programming will be integrated. Environmental education programs that do not purposefully and productively connect their goals to established curricular program outcomes risk being considered 'extra' or unnecessary by teachers, school administrators, and others focused on formal education. Schools may be more likely to sustain environmental education programs that include student outcomes that align with academic standards. Further, given that the outcomes in this document are aligned with formal standards, they are able to communicate the value of environmental education experiences for meeting academic goals.

Environmental education program designers are encouraged to explore the learning outcomes below and select those that:

- Most closely align with the targeted outcomes of planned activities, and/or

- Are associated with the academic standards the environmental education programming must support.

Designers are encouraged to either use the outcomes in their current form or modify them as needed in order to ensure that the outcomes meet the unique needs of the environmental education program.

Formal Educators

Educators and professionals working within formal academic learning contexts may find this document useful for identifying, and convincingly communicating, the ways that environmental education programming can be substantively integrated into formal instruction. For example, classroom teachers may wish to integrate field-based learning experiences, which can be particularly productive for learning because they allow students to apply classroom-based learning in authentic contexts, into their instructional programs. This document could help those educators demonstrate that student learning outcomes – related to their curriculum – are positively impacted by such activities.

HOW COULD WE EXTEND THIS APPROACH?

This document currently focuses on outcomes related to knowledge, skills, competencies, dispositions, and practices relevant to science, social studies, stewardship, and general student engagement. We recognize that there are productive opportunities to enhance this document with the inclusion of additional areas of focus to further demonstrate the power of environmental literacy education approaches like MWEEs for meeting the dynamic needs of 21st century education. For example, we encourage curriculum designers to explore enhancements regarding culturally responsive pedagogies; social and environmental justice; diversity; equity; and anti-bias education. The *Critical Practices* and *Social Justice Standards* put forth by Learning for Justice, a project of the Southern Poverty Law Center, may be a productive resource for developing relevant student outcomes within environmental literacy education. These resources emphasize learning outcomes specifically related to identity, diversity, justice, and individual and collective action related to reducing prejudice. The *Critical Practices* specifically emphasize family and community engagement, which includes culturally sensitive communication, the inclusion of family and community wisdom, increased connections among families, the use of local resources, and engagement with community issues and problems. Other enhancements might include notions of environmental or science identity. We envision this document as a tool into which many other dimensions can be incorporated.

HOW IS THIS APPROACH TO STUDENT OUTCOMES STRUCTURED?

Our student outcomes approach provides a way of thinking about, describing, and planning for environmental literacy education in a way that unites modern perspectives on the importance of active student agency in science with prominent elements of definitions, guidelines, and goals for environmental education that have been used over the last several decades. At the highest, or broadest, conceptual level, we operationalize environmental literacy through **four primary dimensions:**

• **Environmental Knowledge**

• **Environmentally Responsible Behavior**

• **Attitudes & Dispositions**

• **Environmental Literacy Skills & Disciplinary Practices**

The next tier features **categories** that further refine and define each of the four dimensions.

Finally, we offer a comprehensive list of observable and measurable **sample student outcomes** related to each dimension, broken down by grade-band where possible, and aligned with formal academic standards.

The document takes a holistic approach to environmental literacy education in which educational programming targets elements of all four dimensions.

The following table provides an overview of the four dimensions of environmental literacy through which the student outcomes are organized. It includes a brief description of each dimension and then lists the categories into which each dimension is broken down.

In the sections that follow, you will find more information about each dimension and its categories. You will also find a series of tables that articulate concepts of environmental literacy by grade-band related to each category of the dimensions. These grade-appropriate concepts are derived from a broad array of research studies in both science education and environmental education.

For each dimension there are a subset of categories and associated student learning outcomes.

TABLE 1: *Student Outcomes for Environmental Literacy Overview Chart*

Dimension of Environmental Literacy	Description	Categories	
Environmental Knowledge	The core ideas relevant to environmental literacy. These outcomes focus on understanding the complex, dynamic nature of life-sustaining systems and human impacts on them.	Natural Resources Human Impacts on Earth's Systems Earth Materials & Systems Interdependent Relationships in Ecosystems	Cycles of Matter & Energy Transfer in Ecosystems Ecosystems: Dynamics, Functioning & Resilience Biodiversity & Humans Weather, Climate & Global Climate Change
Environmentally Responsible Behavior	The competencies, abilities, and actions relevant to making informed decisions and taking action to mitigate the negative impacts of human activities on Earth's systems.	Communicating & Critiquing Conclusions	Identifying & Evaluating Solutions Taking Informed Action
Attitudes & Dispositions	The qualities, habits, views, beliefs, judgments, and ways of thinking that are connected to individuals' abilities to make sense of environmental issues and to take action to preserve and protect earth's systems.	Interest & Curiosity Personal Impact/ Self-awareness	Self-Efficacy
Environmental Literacy Skills & Disciplinary Practices	A broad set of knowledge, skills, competencies, traits, and practices related to environmental literacy that are important for success in post-secondary education, careers, and society.	**Skills:** Critical Thinking Communication **Practices:** Asking Questions & Defining Problems Developing & Using Models Planning & Carrying out investigations	Creativity Collaboration Problem-Solving Analyzing & Interpreting Data Constructing Explanations & Designing Solutions Engaging in Argument from Evidence

THE FOUR DIMENSIONS OF THE STUDENT OUTCOMES

ENVIRONMENTAL KNOWLEDGE DIMENSION

In this document, environmental knowledge refers to a set of **core ideas** that outline the knowledge and conceptual understanding required for environmental literacy. Knowledge is a critical tool for understanding and investigating environmental and sustainability issues as well as providing a foundation for decision-making and problem-solving. As a dimension of environmental literacy in our approach, **Environmental Knowledge** represents the cognitive elements of environmental literacy.

Environmental knowledge is presented here as progressing developmentally across grade bands. The eight categories detailed below reflect the goals and priorities articulated by stakeholders and educators in environmental fields. They are not exhaustive. Many environmental education activities support understanding in more than one of these content areas.

The language of the **Environmental Knowledge** dimension has been informed by, and modeled after, the ways that these ideas are articulated in the Framework for K-12 Science Education, the NGSS, and the C3 for Social Studies Standards. These formal frameworks prioritize having students actively make sense of conceptual ideas instead of restating isolated facts. Thus, rather than noting that students will simply "know," "recognize," or "understand" facts or definitions, these frameworks

communicate learning outcomes in ways that require students to actively understand core ideas through practice. To mirror this approach to articulating student outcomes, the **Environmental Knowledge** dimension of our approach to student outcomes presents core ideas related to categories of environmental knowledge (as opposed to discrete facts) with language that encourages environmental education program designers to develop outcomes that allow opportunities for students to express their understanding of these ideas through participation in authentic disciplinary practices.

To facilitate this, the following statement precedes the core ideas of each category:

"Students will construct and demonstrate knowledge related to one or more of the following ideas."

Examples of demonstrating understanding through practice can include developing or using models to represent phenomena and communicate understandings, using evidence developed through environmental education experiences to construct explanations for phenomena, or evaluating the relative strength of data as evidence to support given claims.

Environmental Knowledge Student Outcomes

Dimension: Environmental Knowledge
Category: Natural Resources
Standards Alignment: NGSS: ESS3.A
Outcome: Students will engage in 21st Century skills and disciplinary practice(s) to construct and demonstrate knowledge related to the idea that:

Primary Grades (K-2)	Living things need resources from the environment and live in places that have what they need. Humans use natural resources for everything they do.
Elementary Grades (3-5)	Energy and fuels that humans use are derived from natural sources, and their use affects the environment in multiple ways. Some resources are renewable over time while others are not. Human uses of natural resources affect ecosystems (including watershed ecosystems) in multiple ways.
Middle Grades (6-8)	Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources. Natural resources are limited and many are not renewable or replaceable over human lifetimes. Human uses of natural resources affect ecosystems (including watershed ecosystems) in multiple ways.
High Grades (9-12)	Resource availability has guided the development of human society. All forms of energy production and resource extraction have associated costs and risks as well as benefits. Regulations and technologies can impact the effects of energy production and resource extraction.

Dimension: Environmental Knowledge

Category: Human Impacts on Ecosystems

Standards Alignment: C3: D2. Geo.8; NGSS: ESS3.A, ESS3.C

Outcome: Students will engage in 21st Century skills and disciplinary practice(s) to construct and demonstrate knowledge related to the idea that:

Primary Grades (K-2)	People use resources from the environment to meet their needs and wants.
	Our choices and activities affect the cultural and environmental characteristics of ecosystems (including watershed ecosystems) and impact living and nonliving things.
	People can make choices that reduce their impacts on the land, water, air, and other living things.
Elementary Grades (3-5)	Human activities in agriculture, industry, and everyday life have major effects on ecosystems.
Middle Grades (6-8)	Human activities have significantly altered Earth's ecosystems, which are all connected in the biosphere.
	Cultural patterns and economic decisions influence environments and the daily lives of people.
	There are connections between population increases, per-capita consumption, and human impacts on Earth's ecosystems (including watershed ecosystems).
High Grades (9-12)	Relationships and interactions within and between human systems and Earth's systems contribute to reciprocal influences that occur among them.
	The sustainability of human societies and biodiversity that supports them requires responsible resource management.
	Science, engineering, and technology play important roles in environmental protection.

Dimension: Environmental Knowledge

Category: Earth's Materials & Systems

Standards Alignment: NGSS ESS2.A; NOAA Ocean Literacy Principles 1, 2, 3, 4, 5, 6; Climate Literacy Principles 1, 2, 4, 6

Outcome: Students will engage in 21st Century skills and disciplinary practice(s) to construct and demonstrate knowledge related to the idea that:

Primary Grades (K-2)	Wind and water can change the shape of the land.
	Things that happen on land can affect water on Earth and the plants and animals that live there.
	The Earth has one big ocean with many features.
Elementary Grades (3-5)	Earth is a complex system of interacting subsystems.
	The major subsystems of Earth are the geosphere (solid and molten rock, soil, and sediments), the hydrosphere (water and ice), the atmosphere (air), and the biosphere (living things, including humans).
	The ocean is the largest part of the hydrosphere and is connected to major lakes, watersheds, and waterways because all major watersheds on Earth drain to the ocean.
	Rainfall helps to shape the land and affects the types of living things found in a region. Water, ice, wind, living organisms, and gravity break rocks, soils, and sediments into smaller particles and move them around.
	Rivers and streams transport nutrients, salts, sediments, and pollutants from watersheds to coastal estuaries and to the ocean.
	The ocean supports a variety of ecosystems and organisms, shapes landforms, and influences climate.

| Middle Grades (6-8) | All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems.

The energy that flows within and among Earth's systems is derived from the sun and Earth's hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth's materials and living organisms.

The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years.

Interactions between Earth's systems have shaped Earth's history and will determine its future.

The ocean provided and continues to provide water, oxygen, and nutrients, and moderates the climate needed for life to exist on Earth. |
|---|---|
| High Grades (9-12) | Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes.

The geologic recording shows that changes to global and regional climate can be caused by many factors, including human activities.

The ocean moderates the Earth's climate, influences our weather, and affects human health.

The ocean provides food, medicines, and mineral and energy resources. It supports jobs and national economies, serves as a highway for transportation of goods and people, and plays a role in national security. |

Dimension: Environmental Knowledge

Category: Interdependent Relationships in Ecosystems

Standards Alignment: NGSS: LS2.A

Outcome: Students will engage in 21st Century skills and disciplinary practice(s) to construct and demonstrate knowledge related to the idea that:

Primary Grades (K-2)	Plants and animals need food, water, shelter, and light to grow.
Elementary Grades (3-5)	Organisms are interdependent through food webs in which some animals eat plants for food and other animals eat the animals that eat plants. Some organisms, such as fungi and bacteria, break down dead organisms, eventually restoring some materials back to the soil.
	Organisms can survive only in environments in which their needs are met.
	A healthy ecosystem is one in which multiple species of different types are each able to meet their needs in a relatively stable web of life.
	Newly introduced species can damage the balance of an ecosystem.
Middle Grades (6-8)	Organisms and populations of organisms in ecosystems are dependent on interactions with other living and nonliving things.
	In any ecosystem (including watershed ecosystems) organisms and populations may compete for limited resources.
	Growth of organisms and population increases are limited by access to resources.
High Grades (9-12)	Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations that the ecosystem can support.
	Carrying capacity limits within ecosystems result from such factors as the availability of living and nonliving resources and from such challenges such as predation, competition, and disease.

Dimension: Environmental Knowledge
Category: Cycles of Matter & Energy Transfer in Ecosystems
Standards Alignment: NGSS: LS2.B
Outcome: Students will engage in 21st Century skills and disciplinary practice(s) to construct and demonstrate knowledge related to the idea that:

Primary Grades (K-2)	Plants and animals need food, water, shelter, and light to grow.
Elementary Grades (3-5)	Matter cycles between the air and soil and among plants, animals, and microbes as these organisms live and die. Organisms obtain gases, and water, from the environment, and release waste matter (gas, liquid, or solid) back into the environment.
Middle Grades (6-8)	Food webs are models that demonstrate how matter and energy is transferred between producers, consumers, and decomposers as the three groups interact within an ecosystem. In any ecosystem (including watershed ecosystems) organisms and populations may compete for limited resources. Growth of organisms and population increases are limited by access to resources.
High Grades (9-12)	Photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life processes. Plants or algae form the lowest level of the food web. Only a small amount of the matter consumed at each level of the food web is transferred up to the next level. Therefore, there are generally fewer organisms at higher levels of a food web. At each link in an ecosystem, matter, and energy are conserved.

Dimension: Environmental Knowledge

Category: Dynamics, Functioning & Resilience of Ecosystems

Standards Alignment: NGSS: LS2.C

Outcome: Students will engage in 21st Century skills and disciplinary practice(s) to construct and demonstrate knowledge related to the idea that:

Primary Grades (K-2)	Changes to an environment can affect the plants and animals that live there.
Elementary Grades (3-5)	When the environment changes in ways that affect a place's physical characteristics, some organisms survive and reproduce, some move to new locations, some move into the transformed environment, and some die.
Middle Grades (6-8)	The characteristics of ecosystems can change over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in populations of living things. Biodiversity describes the variety of species found in ecosystems. An ecosystem's biodiversity is often used as a measure of its health.
High Grades (9-12)	A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. Extreme changes in conditions (including the size of any population of living things) can affect the functioning of ecosystems in terms of resources and habitat availability. Anthropogenic changes (induced by human activity) to the environment can disrupt an ecosystem.

Dimension: Environmental Knowledge
Category: Biodiversity & Humans
Standards Alignment: NGSS: LS2.D
Outcome: Students will engage in 21st Century skills and disciplinary practice(s) to construct and demonstrate knowledge related to the idea that:

Primary Grades (K-2)	There are many different kinds of living things in any area (including watersheds). Living things are found in different places on land and in water.
Elementary Grades (3-5)	Populations live in a variety of habitats (including those within a watershed) and changes to those habitats affects the organisms living there.
Middle Grades (6-8)	Changes in biodiversity can influence humans' resources, such as food, energy, and medicines, as well as ecosystem services that humans rely on.
High Grades (9-12)	Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction). Humans depend on Earth's systems for the resources and other benefits provided by biodiversity. But human activity is also having negative impacts on biodiversity. Sustaining biodiversity to maintain the functioning and productivity of ecosystems (including watershed ecosystems) is essential to supporting and enhancing life on Earth.

Dimension: Environmental Knowledge
Category: Weather, Climate & Global Climate Change
Standards Alignment: NGSS ESS2.D; NGSS ESS3.D; Climate Literacy Principles 2, 4, 5, 6
Outcome: Students will engage in 21st Century skills and disciplinary practice(s) to construct and demonstrate knowledge related to the idea that:

Primary Grades (K-2)	Sunlight can heat the land, ocean, and air on Earth.
	Weather is the combination of sunlight, wind, snow or rain, and temperature in a particular region at a particular time.
	People measure these conditions to describe and record the weather and to notice patterns over time.
Elementary Grades (3-5)	Weather is not the same thing as climate. Scientists record patterns of the weather across different times and areas so that they can make predictions about what kind of weather might happen next.
	Climate is not the same thing as weather. Climate describes a range of an area's typical weather conditions and the extent to which those conditions vary over years.
Middle Grades (6-8)	Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things.
	The ocean exerts a major influence on weather and climate by absorbing energy from the sun, releasing it over time, and globally redistributing it through ocean currents.

Middle Grades (6-8) (Con't)	Human activities are major factors in the current rise in Earth's mean surface temperature (global warming), which in turn has negative effects on Earth's life-sustaining systems (including watershed ecosystems). Reducing the level of climate change and reducing human vulnerability to whatever climate changes do occur depend on the understanding of climate science, engineering capabilities, and other kinds of knowledge.
High Grades (9-12)	Current models predict that, although future regional climate changes will be complex and varied, average global temperatures will continue to rise. The outcomes predicted by global climate models strongly depend on the amounts of human-generated greenhouse gases added to the atmosphere each year and by the ways in which these gases are absorbed by the ocean and biosphere. The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space. Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate. Though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict, and manage current and future impacts. Our understanding of the climate system is improved through observations, theoretical studies, and modeling. Important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities.

ENVIRONMENTALLY RESPONSIBLE BEHAVIOR DIMENSION

Environmentally responsible behavior refers to the active and outward expression of environmental literacy. It is sometimes referred to as "pro-environmental behavior," "environmentally significant behavior," "stewardship," and other terms. Here, **Environmentally Responsible Behaviors** are defined as intentional actions intended to, and that ultimately have, a positive impact on the environment. In addition, we believe that such behaviors should not be one-time events but should represent long-term patterns of behavior. The dimension of **Environmentally Responsible Behavior** is presented in terms of three categories: *Communicating & Critiquing Conclusions*, under which students formalize arguments, explanations, perspectives, and claims in support of protection of the environment; *Identifying*

& Evaluating Solutions, in which students identify and explore solutions to environmental issues or problems; and *Taking Informed Action*, in which students participate in activities or projects that support or protect the environment and through which students adapt and apply their understandings and points of view in active ways.

The three categories of **Environmentally Responsible Behavior** have been articulated through grade-band outcomes. This is because there are clear connections between these goals and student learning outcomes within formal frameworks for standards-based, K-12 education, which provide guidance for how such goals are approached across a student's K-12 experience (and beyond).

Environmentally Responsible Behavior Student Outcomes

Dimension: Environmentally Responsible Behaviors

Category: Communicating & Critiquing Conclusions

Standards Alignment: C3: D4; NGSS: ESS3.A, C; NGSS: ETS1.A, B, C

Outcome: Students will engage in and demonstrate environmentally responsible behavior when they:

Primary Grades (K-2)	Make and explain an argument about the importance of the responsible management of natural resources. Make and explain an argument about the importance of taking care of the environment.
Elementary Grades (3-5)	Use evidence to construct and communicate an idea and/or argument about the importance of minimizing the negative impacts of human activities on the environment. Use evidence to construct and communicate a claim about the relevance of responsible management of natural resources on the student's life and the lives of others.
Middle Grades (6-8)	Use evidence to construct, communicate, and critique claims about the importance of responsible management of natural resources OR about the importance of environmental protection. Use evidence to construct, communicate, and critique claims about the relevance of responsible management of natural resources or environmental protection to our lives.

Middle Grades (6-8) (Con't)	Evaluate the merits of solutions designed to respond to problems or issues related to the responsible management of natural resources OR environmental protection. Present adaptations of arguments and explanations about responsible management of natural resources, OR related environmental protection, on the environment to others to reach audiences and venues outside the classroom.
High Grades (9-12)	Construct, communicate, and critique claims (acknowledging strengths and limitations of the claims) about the importance of responsible management of natural resources, OR related to environmental protection, using precise, informed evidence. Construct, communicate, and critique claims (acknowledging strengths and limitations of the claims) about the relevance of responsible management of natural resources, OR environmental protection, on the student's life and the lives of others using precise, informed evidence. Evaluate solutions to problems related to the responsible management of natural resources, OR related to environmental protection, based on prioritized criteria and trade-offs that account for a range of constraints. Present adaptations of arguments and explanations about responsible management of natural resources, OR related to environmental protection, to others to reach audiences and venues outside the classroom.

Dimension: Environmentally Responsible Behaviors

Category: Identifying & Evaluating Solutions

Standards Alignment: ETS1-1, 1-2, 1-3

Outcome: Students will engage in and demonstrate environmentally responsible behavior when they:

Primary Grades (K-2)	Ask questions, make observations, and gather information to define a simple problem about a situation people want to change.
	Identify and/or describe a solution to an environmental problem, issue, or challenge.
	Explain why a given solution may work well to address an environmental problem, issue, or challenge.
	Explain why a given solution may *not* work well to address an environmental problem, issue, or challenge.
Elementary Grades (3-5)	Identify and/or describe multiple solutions to an environmental problem, issue, or challenge.
	Identify criteria for a successful solution and constraints for implementing a solution (or multiple solutions).
	Explain why a given solution may work well to address an environmental problem, issue, or challenge.
	Explain why a given solution may *not* work well to address an environmental problem, issue, or challenge.
Middle Grades (6-8)	Define the criteria and constraints of an environmental problem, issue, or challenge with sufficient precision to identify and describe a successful solution.
	Identify and describe scientific ideas and information that are relevant to solutions.
	Identify and describe the potential intended and unintended impacts of a solution on people and the natural environment.

Middle Grades (6-8) (Con't)	Use evidence to explain the merits and limitations of a given solution to an environmental problem, issue, or challenge. Systematically evaluate competing solutions for an environmental problem according to identified criteria and constraints.
High Grades (9-12)	Analyze environmental problems or challenges to specify qualitative and quantitative criteria and constraints for solutions. Identify and describe scientific ideas and information that are relevant to solutions. Identify and describe the potential intended and unintended impacts of a solution on people and the natural environment. Use evidence to explain the merits and limitations of a given solution to an environmental problem, issue, or challenge. Design a solution to a complex environmental problem by breaking it down into smaller, more manageable problems. Evaluate a solution to a complex environmental problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.

Dimension: Environmentally Responsible Behaviors

Category: Taking Informed Action

Standards Alignment: C3: D4.6, D4.7, D4.8; NGSS: ESS3.A, C, ETS1.A, B, C

Outcome: Students will engage in and demonstrate environmentally responsible behavior when they:

Primary Grades (K-2)	Identify and explain some ways in which people are trying to address problems related to the responsible management of natural resources. Identify ways that the student could (individually or collectively) take action to help address problems related to the responsible management of natural resources. Work collaboratively to plan and take action to respond to problems related to the responsible management of natural resources in their communities and/or local watersheds.
Elementary Grades (3-5)	Explain different strategies and approaches students and others could take to address problems related to resource management and predict possible challenges to and results of their actions. Work collaboratively to decide on, plan, and take action (including civic action) to respond to problems related to the responsible management of natural resources or environmental protection in their communities and/or local watersheds. Evaluate the success of their actions based on defined criteria. Develop plans to monitor and/or sustain the positive impacts of their actions on their communities and/or local watersheds.
Middle Grades (6-8)	Assess their individual and collective capacities to take action to address local, regional, and global problems. Work collaboratively to decide on, plan, and take action to respond to problems related to the responsible management of natural resources in their communities and/or local watersheds.

Middle Grades (6-8) (Con't)	Evaluate the success of their actions based on defined criteria. Develop and implement plans to monitor and/or sustain the positive impacts of their actions on their communities and/or local watersheds.
High Grades (9-12)	Use disciplinary and interdisciplinary lenses to understand the characteristics and causes of local, regional, and global problems; instances of such problems in multiple contexts; and challenges and opportunities faced by those trying to address these problems over time and across place. Assess options for individual and collective action to address local, regional, and global problems by engaging in self-reflection, strategy identification, and complex causal reasoning. Apply a range of deliberative and democratic strategies and procedures to make decisions and take action to respond to problems related to the responsible management of natural resources in their communities and/or local watersheds. Evaluate the success of their actions based on defined criteria. Develop and implement plans to monitor and/or sustain the positive impacts of their actions on their communities and/or local watersheds.

ATTITUDES & DISPOSITIONS DIMENSION

In the context of environmental education, the constructs of "attitudes" and "dispositions" are often viewed as being productive for enhancing and sustaining environmental literacy and environmental stewardship. The **Attitudes & Dispositions** dimension describes some of the affinities, inclinations, sentiments, orientations, and proclivities many environmental education researchers consider essential to the actions that are associated with being environmentally responsible individuals. When students exhibit these characteristics in ways that link to positive environmental outcomes, it can indicate that they possess a view of the environment that is in line with the goals of environmental literacy education. While these are legitimate goals for environmental education programs that have connections to environmental identities, and are not that different from students' attitudes and dispositions about science generally, it is not clear how progress toward these goals supports student achievement.

The outcomes within **Attitudes & Dispositions** have not been articulated in grade-level specific progressions because they are expressed differently by individuals of all ages. It may be valuable for future efforts in this field to attempt to determine how each of these attitudes and dispositions could be integrated with the other three environmental literacy dimensions. This list is also not exhaustive, and environmental education activities are likely to result in a variety of interconnected demonstrations of student attitudes and dispositions.

Attitudes & Dispositions Student Outcomes

Dimension: Attitudes & Dispositions

Category: Motivation & Intentions

Outcome (All Grade Levels): Students display and/or demonstrate the motivation and intentions typical of environmentally responsible individuals when they:

Willingly participate in learning activities.

Desire to succeed at learning tasks.

Show interest in learning more.

Willingly take further action.

Dimension: Attitudes & Dispositions

Category: Attention

Outcome (All Grade Levels): Students display and/or demonstrate the attention typical of environmentally responsible individuals when they:

Concentrate and focus on tasks.

Carefully listen and/or observe and/or watch.

Abide by directions and requests.

Dimension: Attitudes & Dispositions

Category: Interest & Curiosity

Outcome (All Grade Levels): Students display and/or demonstrate the interest and curiosity typical of environmentally responsible individuals when they:

Ask questions.

Test and/or apply new ideas.

Are inquisitive.

Desire to learn more.

Show interest in taking further action.

Dimension: Attitudes & Dispositions

Category: Optimism

Outcome (All Grade Levels): Students display and/or demonstrate optimism typical of environmentally responsible individuals when they:

Express hopefulness about outcomes of activities and/or about progress toward reaching goals.

Express confidence in the potential success of activities.

Reveal dispositions or tendencies to identify favorable elements of activities and actions.

Express expectations for positive outcomes.

Dimension: Attitudes & Dispositions

Category: Personal Impact & Self-awareness

Outcome (All Grade Levels): Students display and/or personal impact & self-awareness typical of environmentally responsible individuals when they:

Understand the impact of individual and collective choices on the health of the environment (including local watersheds).

Dimension: Attitudes & Dispositions

Category: Self-efficacy

Outcome (All Grade Levels): Students display and/or demonstrate self-efficacy typical of environmentally responsible individuals when they:

Understand and believe in one's own ability to achieve goals, influence others, affect change (individually and collectively).

Dimension: Attitudes & Dispositions

Category: Sensitivity

Outcome (All Grade Levels): Students display and/or demonstrate sensitivity typical of environmentally responsible individuals when they:

Express concern for the environment.

Espouse caring and positive feelings toward the environment.

ENVIRONMENTAL LITERACY SKILLS & DISCIPLINARY PRACTICES DIMENSION

The 21st century will continue to pose new demands on people to adapt their capabilities in an ever-changing landscape of challenges to the workforce, self-actualization, and global sustainability. Escalating impacts of human activities on Earth's life-sustaining systems demand that we prepare our students to employ skills like critical thinking and problem-solving and engage in authentic scientific practices, specifically environmental science, like interpreting models and analyzing data. These skills are wide-ranging and often grouped under the heading "21st Century Skills." Many environmental education programs are designed around these skills and practices and they are commonly identified as essential to modern K-12 education. Competencies within these skills and practices are important for environmental literacy and schools serve an important role helping students develop, apply, and strengthen them.

Environmental Literacy Skills: Many environmental education programs employ and advance a wide range of the skills included in this dimension. Students develop and use these skills in a variety of ways.

Disciplinary Practices: Many of the practices listed as categories within this dimension are featured in the NGSS. We adapted them to focus attention on the connections between K-12 education disciplinary practices and those often seen in environmental education programs and environmental literacy education.

The behaviors listed for each environmental literacy skill and disciplinary practice are not presented here as being grade-band specific, although there are progressive degrees of appropriate engagement and application of these skills and practices across grade levels. The characteristics of each skill and practice identified in the student outcomes tiers are examples of the ways that students might demonstrate these capabilities. We recognize that a student need not participate in every single characteristic in the list to demonstrate engagement in a particular skill or practice. Furthermore, a student may exhibit behaviors that seem to reflect characteristics of more than one skill or practice. The behaviors here are not exhaustive and it is recommended that environmental education program designers consult the NGSS and C3 for more detailed descriptions of the practices, including grade-band progressions.

Environmental Literacy Skills & Disciplinary Practices Student Outcomes

Dimension: Environmental Literacy Skills

Category: Critical Thinking

Outcome (All Grade Levels): Students will display and/or engage in critical thinking by:

Explaining an issue or problem.

Identifying and using evidence effectively.

Analyzing contexts.

Describing their own perspectives and those of others.

Drawing logical conclusions.

Making informed decisions.

Evaluating the success of solutions according to given criteria.

Determining the merit of claims based on available evidence.

Identifying and understanding biases.

Dimension: Environmental Literacy Skills

Category: Communication

Outcome (All Grade Levels): Students will display and/or engage in communication by:

Applying and synthesizing multiple perspectives.

Expressing ideas and information in a variety of ways.

Clearly articulating the connections between assumptions, situations, and ideas and how those connections can be changed.

Developing and sharing new ideas.

Dimension: Environmental Literacy Skills

Category: Creativity

Outcome (All Grade Levels): Students will display and/or engage in creativity by:

Thinking 'outside of the box' (generating ideas that are novel and useful).

Combining ideas in new or surprising ways.

Drawing from a wide variety of sources or disciplines.

Bending or breaking conventions or rules in ways that yield progress.

Dimension: Environmental Literacy Skills

Category: Collaboration

Outcome (All Grade Levels): Students will display and/or engage in collaboration by:

Working with others to identify and solve problems.

Demonstrating flexibility.

Motivating, supporting, and inspiring others.

Listening to other points of view.

Integrating ideas from team members.

Demonstrating accountability.

Setting, working toward, and achieving goals as a team.

Dimension: Environmental Literacy Skills

Category: Problem-Solving

Outcome (All Grade Levels): Students will display and/or engage in problem-solving by:

Clearly defining and redefining a problem.

Demonstrating a systematic approach to seeking solutions.

Researching relevant information.

Managing risks.

Making decisions.

Generating options.

Determining and evaluating constraints and criteria for success.

Evaluating the merits of solutions.

Implementing solutions.

Dimension: Disciplinary Practices

Category: Analyzing & Interpreting Data

Outcome (All Grade Levels): Students will display and/or engage in analyzing & interpreting data by:

Recording information (observations, measurements, thoughts, and ideas).

Using and sharing pictures, drawings, and/or writings of observations.

Using observations (firsthand or from media) to describe patterns and/or relationships in the natural and designed world(s) in order to answer scientific questions and solve problems.

Comparing predictions (based on prior experiences) to what occurred (observable events).

Constructing, analyzing, and/or interpreting graphical displays of data to reveal patterns that indicate relationships.

Analyzing and interpreting data to make sense of phenomena, using logical reasoning, physical, computational, or computer modeling, mathematics, and/or computation.

Comparing and contrasting data collected by different groups in order to discuss similarities and differences in their findings.

Analyzing data to refine a problem statement or the design of a proposed object, tool, or process.

Using data to evaluate and refine design solutions.

Dimension: Disciplinary Practices

Category: Planning & Carrying Out Investigations

Outcome (All Grade Levels): Students will display and/or engage in planning & carrying out investigations by:

- Collaboratively planning and conducting an investigation to produce data to serve as the basis for evidence to answer a question.

- Evaluating different ways of observing and/or measuring a phenomenon to determine which way can answer a question.

- Making observations (firsthand or from media) to collect data that can be used to make comparisons.

- Making predictions based on prior experiences.

- Selecting appropriate tools for collecting, recording, analyzing, and evaluating data.

- Evaluating the accuracy of various methods for collecting data.

- Collecting data to serve as the basis for evidence to answer scientific questions or test design solutions under a range of conditions.

Dimension: Disciplinary Practices

Category: Engaging in Argument from Evidence

Outcome (All Grade Levels): Students will display and/or engage in argument from evidence by:

- Identifying and constructing arguments that are supported by evidence.

- Distinguishing between explanations that account for all gathered evidence and those that do not.

- Analyzing why some evidence is relevant to a scientific question and some is not.

- Distinguishing among facts, reasoned judgment based on research findings, and speculation in an explanation.

- Distinguishing between opinions and evidence in one's own explanations.

- Listening actively to arguments to indicate agreement or disagreement based on evidence, and/or to retell the main points of the argument.

- Constructing an argument with evidence to support a claim.

- Making a claim about the merit of a solution to a problem by citing relevant evidence about how it meets the criteria and constraints of the problem.

Dimension: Disciplinary Practices

Category: Constructing Explanations & Designing Solutions

Outcome (All Grade Levels): Students will display and/or engage in constructing explanations & designing solutions by:

Recording information (observations, measurements, thoughts, and ideas).

Using information from observations (firsthand and from media) to construct an evidence-based account for natural and/or human-driven phenomena.

Using tools and/or materials to design and/or build a device that solves a specific problem or a solution to a specific problem.

Generating and/or comparing multiple solutions to a problem.

Constructing an explanation of observed relationships.

Using evidence (e.g., measurements, observations, patterns) to construct or support an explanation or design a solution to a problem.

Identifying the evidence that supports particular points in an explanation.

Applying scientific ideas to solve problems.

Generating and comparing multiple solutions to a problem based on how well they meet the criteria and constraints of the solution.

Dimension: Disciplinary Practices

Category: Developing & Using Models

Outcome (All Grade Levels): Students will display and/or engage in developing & using models by:

Developing and using models based on evidence to represent an object, tool, process, phenomenon, and/or event.

Distinguishing between the model and the actual object, tool, process, phenomenon, and/or event that the model represents.

Identifying limitations of models.

Developing or modifying a model - based on evidence – to match what happens if a variable or component of a system is changed.

Developing and/or using a model to predict and/or describe phenomena.

Developing a model to describe unobservable mechanisms.

Dimension: Disciplinary Practices

Category: Asking Questions & Defining Problems

Outcome (All Grade Levels): Students will display and/or engage in asking questions & defining problems by:

Asking questions based on observations to find more information about the natural and/or designed world(s).

Asking questions for clarification, to refine ideas or models, and/or to seek new information.

Asking and/or identifying questions that can be answered through investigations.

Defining and describing problems that warrant investigation and/or solution-seeking.

SUMMARY AND A VISION FOR THE FUTURE

At this stage, the student outcomes in this document would be appropriate and productive for use by formal and informal educators who endeavor to develop and implement environmental education programming with K-12 students. We encourage program and curriculum designers to use the outcomes as written, if they seem relevant to their work, or to modify and adapt the outcomes to meet the specific needs of their programs. Educators and professionals working within formal academic learning contexts may find our approach useful for identifying and articulating the ways that environmental education programming can be legitimately and productively integrated into formal instruction. Non-formal environmental education providers can use the outcomes to increase the likelihood that the ways they are approaching the design and subsequent evaluation of their programming will seem to "match" and fit into formal programs, thus communicating the value of the environmental education experiences for meeting academic goals through a "language" utilized by schools.

APPENDIX

DEVELOPING STUDENT OUTCOMES: A MWEE EXAMPLE

This document promotes a holistic approach to environmental literacy education in which education programming targets elements of all four dimensions. Stakeholders (including program designers and/or evaluators) looking to use our approach to help design and/or evaluate a MWEE or other environmental education program might first begin by deciding what it is that they want students to understand and be able to do better as a result of participating in the program. The next step is to work down the tiers of this document, deciding which categories of each dimension and which student outcomes best meet the goals of the program. Finally, stakeholders should make any appropriate "tweaks" or edits to make sure the outcomes are a productive fit.

The following represents an example set of student outcomes that were developed for a 5th grade MWEE.

EXAMPLE: *Developing environmental literacy student outcomes for a MWEE (5th grade)*

MWEE FOCUS: THE IMPORTANCE OF HEALTHY ECOSYSTEMS AND HOW WE CAN TAKE ACTION TO PROTECT OUR LOCAL WATERSHED

Dimension of Environmental Literacy	Targeted Categories	Student Outcomes
Environmental Knowledge	• Ecosystems: Dynamics, Functioning & Resilience • Human Impacts on Earth's Systems	*Students will:* • Construct and demonstrate knowledge related to the idea that when the environment changes in ways that affect a place's physical characteristics, some organisms survive and reproduce, some move to new locations, some move into the transformed environment, and some die. • Construct and demonstrate knowledge related to the idea that human activities in agriculture, industry, and everyday life have major effects on ecosystems.
Environmentally Responsible Behavior	• Communicating & Critiquing Conclusions • Identifying & Evaluating Solutions • Taking Informed Action	*Students will:* • Use evidence from the MWEE to construct and communicate an idea and/or argument about the importance of minimizing the negative impacts of human activities on the environment. • Identify and/or describe multiple solutions to an environmental problem, issue, or challenge. • Work collaboratively to decide on, plan, and take action (including civic action) to respond to problems related to the responsible management of natural resources or environmental protection in their communities and/or local watersheds. • Evaluate the success of their actions based on defined criteria. • Develop plans to monitor and/or sustain the positive impacts of their actions on their communities and/or local watersheds.

Dimension of Environmental Literacy	Targeted Categories	Student Outcomes
Attitudes & Dispositions	• Self-Efficacy • Sensitivity • Personal Impact & Self-Awareness	*Students will:* • Display and/or demonstrate understanding of and belief in one's own ability to achieve goals, influence others, affect change (individually and collectively). • Display and/or demonstrate understanding of the impact of individual and collective choices on the health of the environment (including local watersheds). • Display and/or demonstrate caring and positive feelings toward the environment.
Environmental Literacy Skills & Disciplinary Practices	**Skills:** • Collaboration • Problem-Solving **Practices:** • Analyzing & Interpreting Data • Developing & Using Models • Constructing Explanations & Designing Solutions	*Students will:* • Work with others to identify and solve problems. • Define a problem, research information related to solutions, evaluate the merits of a solution, and implement a solution. • Analyze and interpret data to make sense of phenomena, using logical reasoning. • Use information from observations (firsthand and from media) to construct an evidence-based account for natural and/or human-driven phenomena. • Develop and use models based on evidence to represent an object, tool, process, phenomenon, and/or event.

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