ARKANSAS

K-12 SCIENCE STANDARDS

EDUCATION FOR A NEW GENERATION

Environmental Science

2016

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Notes:

1. Student Performance Expectations (PEs) may be taught in any sequence or grouping within a grade level. Several PEs are described as being "partially addressed in this course" because the same PE is revisited in a subsequent course during which that PE is fully addressed.
2. An asterisk (*) indicates an engineering connection to a practice, core idea, or crosscutting concept.
3. The Clarification Statements are examples and additional guidance for the instructor. AR indicates Arkansas-specific Clarification Statements.
4. The Assessment Boundaries delineate content that may be taught but not assessed in large-scale assessments. AR indicates Arkansas-specific Assessment Boundaries.
5. The section entitled "foundation boxes" is reproduced verbatim from *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*. Integrated and reprinted with permission from the National Academy of Sciences.
6. The examples given (e.g.,) are suggestions for the instructor.
7. Throughout this document, connections are provided to the nature of science as defined by *A Framework for K-12 Science Education* (NRC 2012).
8. Throughout this document, connections are provided to Engineering, Technology, and Applications of Science as defined by *A Framework for K-12 Science Education* (NRC 2012).
9. Each set of PEs lists connections to other disciplinary core ideas (DCIs) within the Arkansas K-12 Science Standards and to the Arkansas English Language Arts Standards, Arkansas Disciplinary Literacy Standards, and the Arkansas Mathematics Standards.

Arkansas K-12 Science Standards Overview

The Arkansas K-12 Science Standards are based on *A Framework for K-12 Science Education* (NRC 2012) and are meant to reflect a new vision for science education. The following conceptual shifts reflect what is new about these science standards. The Arkansas K-12 Science Standards

- reflect science as it is practiced and experienced in the real world,
- build logically from Kindergarten through Grade 12,
- focus on deeper understanding as well as application of content,
- integrate practices, crosscutting concepts, and core ideas, and
- make explicit connections to literacy and math.

As part of teaching the Arkansas K-12 Science Standards, it will be important to instruct and guide students in adopting appropriate safety precautions for their student-directed science investigations. Reducing risk and preventing accidents in science classrooms begin with planning. The following four steps are recommended in carrying out a hazard and risk assessment for any planned lab investigation:

1) Identify all hazards. Hazards may be physical, chemical, health, or environmental.
2) Evaluate the type of risk associated with each hazard.
3) Write the procedure and all necessary safety precautions in such a way as to eliminate or reduce the risk associated with each hazard.
4) Prepare for any emergency that might arise in spite of all of the required safety precautions.

According to Arkansas Code Annotated § 6-10-113 (2012) for eye protection, every student and teacher in public schools participating in any chemical or combined chemical-physical laboratories involving caustic or explosive chemicals or hot liquids or solids is required to wear industrial-quality eye protective devices (eye goggles) at all times while participating in science investigations.

The Arkansas K-12 Science Standards outline the knowledge and science and engineering practices that all students should learn by the end of high school. The standards are three-dimensional because each student performance expectation engages students at the nexus of the following three dimensions:

- Dimension 1 describes scientific and engineering practices.
- Dimension 2 describes crosscutting concepts, overarching science concepts that apply across science disciplines.
- Dimension 3 describes core ideas in the science disciplines.

Science and Engineering Practices

The eight practices describe what scientists use to investigate and build models and theories of the world around them or that engineers use as they build and design systems. The practices are essential for all students to learn and are as follows:

1. Asking questions (for science) and defining problems (for engineering)

2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations (for science) and designing solutions (for engineering)
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

Crosscutting Concepts

The seven crosscutting concepts bridge disciplinary boundaries and unit core ideas throughout the fields of science and engineering. Their purpose is to help students deepen their understanding of the disciplinary core ideas, and develop a coherent, and scientifically based view of the world. The seven crosscutting concepts are as follows:

1. *Patterns*- Observed patterns of forms and events guide organization and classification, and prompt questions about relationships and the factors that influence them.
2. *Cause and effect- Mechanism and explanation*. Events have causes, sometimes simple, sometimes multifaceted. A major activity of science is investigating and explaining causal relationships and the mechanisms by which they are mediated. Such mechanisms can then be tested across given contexts and used to predict and explain events in new contexts.
3. *Scale, proportion, and quantity*- In considering phenomena, it is critical to recognize what is relevant at different measures of size, time, and energy and to recognize how changes in scale, proportion, or quantity affect a system's structure or performance.
4. *Systems and system models*- Defining the system under study—specifying its boundaries and making explicit a model of that system—provides tools for understanding and testing ideas that are applicable throughout science and engineering.
5. *Energy and matter: Flows, cycles, and conservation*- Tracking fluxes of energy and matter into, out of, and within systems helps one understand the systems' possibilities and limitations.
6. *Structure and function*- The way in which an object or living thing is shaped and its substructure determines many of its properties and functions.
7. *Stability and change*- For natural and built systems alike, conditions of stability and determinants of rates of change or evolution of a system are critical elements of study.

Disciplinary Core Ideas

The disciplinary core ideas describe the content that occurs at each grade or course. The Arkansas K-12 Science Standards focus on a limited number of core ideas in science and engineering both within and across the disciplines and are built on the notion of learning as a developmental progression. The Disciplinary Core Ideas are grouped into the following domains:

- Physical Science (PS)
- Life Science (LS)
- Earth and Space Science (ESS)
- Engineering, Technology and Applications of Science (ETS)

Connections to the Arkansas English Language Arts Standards

Evidence-based reasoning is the foundation of good scientific practice. The Arkansas K-12 Science Standards incorporate reasoning skills used in language arts to help students improve mastery and understanding in all three disciplines. The Arkansas K-8 Science Committee made every effort to align grade-by-grade with the English language arts (ELA) standards so concepts support what students are learning in their entire curriculum. Connections to specific ELA standards are listed for each student performance expectation, giving teachers a blueprint for building comprehensive cross-disciplinary lessons.

The intersections between Arkansas K-12 Science Standards and Arkansas ELA Standards teach students to analyze data, model concepts, and strategically use tools through productive talk and shared activity. Reading in science requires an appreciation of the norms and conventions of the discipline of science, including understanding the nature of evidence used, an attention to precision and detail, and the capacity to make and assess intricate arguments, synthesize complex information, and follow detailed procedures and accounts of events and concepts. These practice-based standards help teachers foster a classroom culture where students think and reason together, connecting around the subject matter and core ideas.

Connections to the Arkansas Disciplinary Literacy Standards

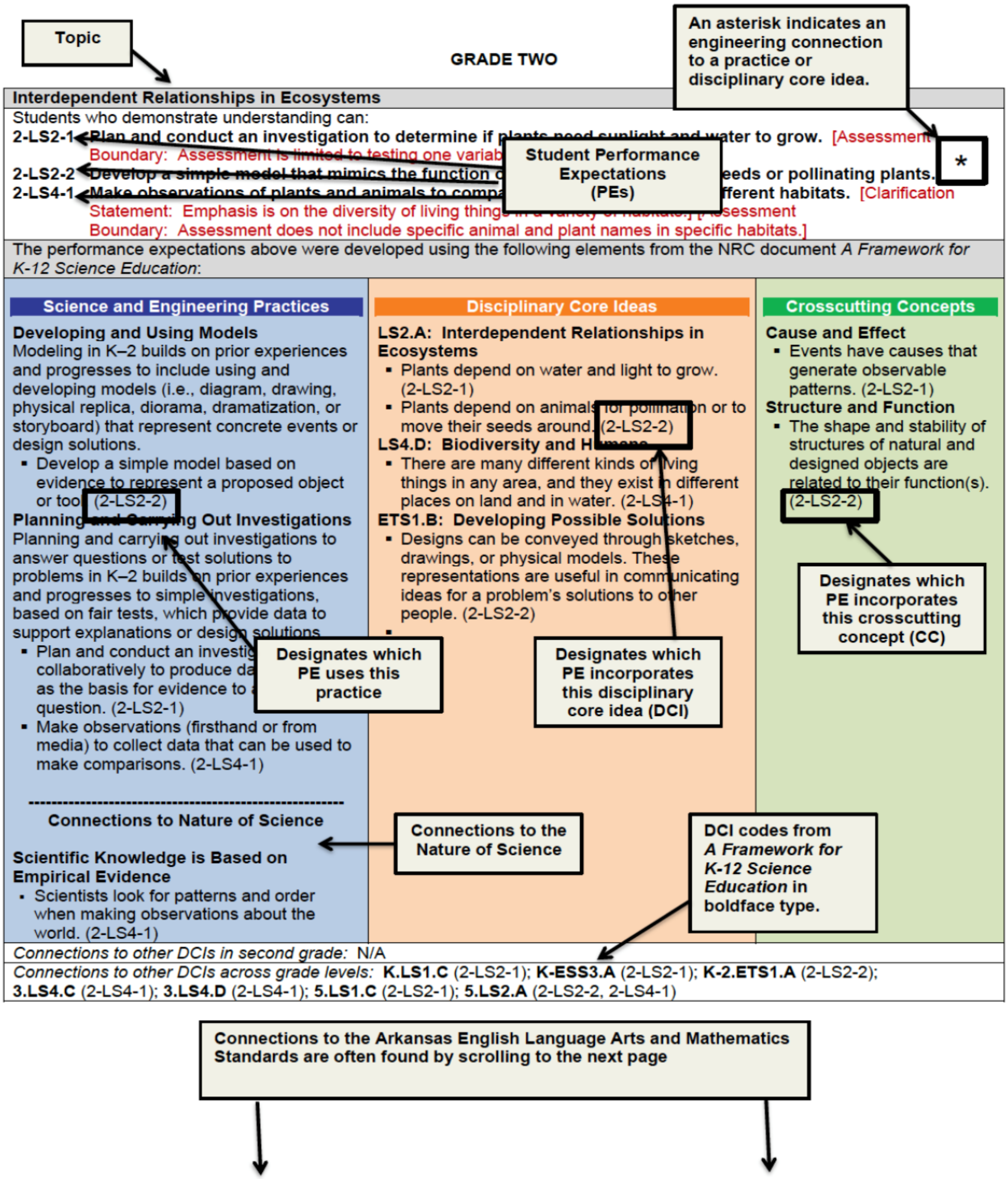
Reading is critical to building knowledge in science. College and career ready reading in science requires an appreciation of the norms and conventions of each discipline, such as the kinds of evidence used in science; an understanding of domain-specific words and phrases; an attention to precise details; and the capacity to evaluate intricate arguments, synthesize complex information, and follow detailed descriptions of events and concepts. When reading scientific and technical texts, students need to be able to gain knowledge from challenging texts that often make extensive use of elaborate diagrams and data to convey information and illustrate concepts. Students must be able to read complex informational texts in science with independence and confidence because the vast majority of reading in college and workforce training programs will be sophisticated nonfiction.

For students, writing is a key means of asserting and defending claims, showing what they know about science, and conveying what they have experienced, imagined, thought, and felt. To be college and career ready writers, students must take task, purpose, and audience into careful consideration, choosing words, information, structures, and formats deliberately. They need to be able to use technology strategically when creating, refining, and collaborating on writing. They have to become adept at gathering information, evaluating sources, and citing material accurately, reporting finds from their research and analysis of sources in a clear and cogent manner. They must have the flexibility, concentration, and fluency to produce high-quality first-draft text under a tight deadline and the capacity to revisit and make improvements to a piece of writing over multiple drafts when circumstances encourage or require it.

Connections to the Arkansas Mathematics Standards

Science is a quantitative discipline, so it is important for educators to ensure that students’ science learning coheres well with their understanding of mathematics. To achieve this alignment, the Arkansas K-12 Science Committee made every effort to ensure that the mathematics standards do not outpace or misalign to the grade-by-grade science standards. Connections to specific math standards are listed for each student performance expectation, giving teachers a blueprint for building comprehensive cross-disciplinary lessons.

How to Read
Arkansas K-12 Science



GRADE TWO

Interdependent Relationships in Ecosystems

Students who demonstrate understanding can:

2-LS2-1 Plan and conduct an investigation to determine if plants need sunlight and water to grow. [Assessment Boundary: Assessment is limited to testing one variab…

2-LS2-2 Develop a simple model that mimics the function o… …eeds or pollinating plants.*

2-LS4-1 Make observations of plants and animals to compa… …fferent habitats. [Clarification Statement: Emphasis is on the diversity of living thing… …] [Assessment Boundary: Assessment does not include specific animal and plant names in specific habitats.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in K–2 builds on prior experiences and progresses to include using and developing models (i.e., diagram, drawing, physical replica, diorama, dramatization, or storyboard) that represent concrete events or design solutions. ▪ Develop a simple model based on evidence to represent a proposed object or tool. (2-LS2-2) **Planning and Carrying Out Investigations** Planning and carrying out investigations to answer questions or test solutions to problems in K–2 builds on prior experiences and progresses to simple investigations, based on fair tests, which provide data to support explanations or design solutions. ▪ Plan and conduct an investig… collaboratively to produce da… as the basis for evidence to a… question. (2-LS2-1) ▪ Make observations (firsthand or from media) to collect data that can be used to make comparisons. (2-LS4-1) --- **Connections to Nature of Science** **Scientific Knowledge is Based on Empirical Evidence** ▪ Scientists look for patterns and order when making observations about the world. (2-LS4-1)	**LS2.A: Interdependent Relationships in Ecosystems** ▪ Plants depend on water and light to grow. (2-LS2-1) ▪ Plants depend on animals for pollination or to move their seeds around. (2-LS2-2) **LS4.D: Biodiversity and Humans** ▪ There are many different kinds of living things in any area, and they exist in different places on land and in water. (2-LS4-1) **ETS1.B: Developing Possible Solutions** ▪ Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem's solutions to other people. (2-LS2-2) ▪	**Cause and Effect** ▪ Events have causes that generate observable patterns. (2-LS2-1) **Structure and Function** ▪ The shape and stability of structures of natural and designed objects are related to their function(s). (2-LS2-2)

Connections to other DCIs in second grade: N/A

Connections to other DCIs across grade levels: **K.LS1.C** (2-LS2-1); **K-ESS3.A** (2-LS2-1); **K-2.ETS1.A** (2-LS2-2); **3.LS4.C** (2-LS4-1); **3.LS4.D** (2-LS4-1); **5.LS1.C** (2-LS2-1); **5.LS2.A** (2-LS2-2, 2-LS4-1)

Environmental Science Learning Progression Chart

Topic 1: Systems	Topic 2: Energy	Topic 3: Populations	Topic 4: Sustainability
AR EVS-ESS2-2	AR EVS-PS3-1	AR EVS-LS2-1	AR EVS-ESS3-1
AR EVS-ESS2-3	AR EVS-PS3-2	AR EVS-LS2-2	AR EVS-ESS3-2
AR EVS-ESS2-5	AR EVS-PS3-3	AR EVS-LS2-6	AR EVS-ESS3-3
AR EVS-ESS2-6	AR EVS-PS3-4	AR EVS-LS2-8	AR EVS-ESS3-4
AR EVS-ESS3-5	AR EVS-ESS2-4	AR EVS3-ETS1-3	AR EVS-ESS3-6
AR EVS1-ETS1-1	AR EVS2-ETS1-2		AR EVS-LS2-7
			AR EVS-LS4-6
			AR EVS4-ETS1-3

Arkansas Clarification Statements (AR)

Environmental Science Course Overview

(Course code 424020)

Environmental science is an integrated science course that continues to develop conceptual understanding of the interactions in Earth science, physical science, and life science systems. The standards for environmental science engage students in the core ideas, scientific and engineering practices, and crosscutting concepts to support the development of knowledge that can be applied to understanding, explaining, and improving human interactions with Earth systems and resources. There are strong connections to mathematical practices of analyzing and interpreting data with creating mathematical and computational models. Teachers with any secondary science license (including an Earth science endorsement) are able to teach this course. Students will earn 1 Core requirement/career focus credit.

Students in environmental science develop understanding of key concepts that help them make sense of the interactions between Earth science, physical science, and life science. The ideas are building upon students' understanding of disciplinary ideas, science and engineering practices, and crosscutting concepts from earlier grades and previous high school science courses. There are four topics in environmental science: (1) Systems, (2) Energy, (3) Populations, and (4) Sustainability. The performance expectations in environmental science blend core ideas with scientific and engineering practices and crosscutting concepts to support students in developing usable knowledge that can be applied to understanding, explaining, and improving human interactions with Earth systems and resources. The performance expectations reflect the aspects of environmental science with an emphasis on using engineering and technology concepts to design solutions to challenges facing human society. While the performance expectations indicate particular practices to address specific disciplinary core ideas, it is recommended that teachers include a variety of practices and strategies in their instruction.

Connections with other science disciplines help high school students develop these capabilities in various contexts. For example, in biology students design, evaluate, and refine a solutions for reducing human impact on the environment (BI-LS2-7) and to create or revise a simulation to test solutions for mitigating adverse impacts of human activity on biodiversity (BI-LS4-6). In Earth science students apply their engineering capabilities to reduce human impacts on Earth systems, and improve social and environmental cost-benefit ratios (E-ESS3-2, E-ESS3-4).

Additionally, it should be noted that the environmental science standards are not intended to be used as curriculum. Instead, the standards are the minimum that students should know and be able to do. Therefore, teachers should continue to differentiate for the needs of their students by adding depth and additional rigor.

Students in environmental science also continue their ability to develop possible solutions for major global problems with engineering design challenges. At the high school level, students are expected to engage with major global issues at the interface of science, technology, society and the environment, and to bring to light the kinds of analytical and strategic thinking that prior training and increased maturity make possible. As in prior levels, these capabilities can be thought of in three stages:

- **Defining the problem** at the high school level requires both qualitative and quantitative analysis. For example, the need to provide food and fresh water for future generations comes into sharp focus when considering the speed at which the world population is growing and conditions in countries that have experienced famine. While high school students are not expected to solve these challenges, they are expected to begin thinking about them as problems that can be addressed, at least in part, through engineering.
- **Developing possible solutions** for major global problems begins by breaking them down into smaller problems that can be tackled with engineering methods. To evaluate potential solutions, students are expected to not only consider a wide range of criteria but to also recognize that criteria needs to be prioritized. For example, public safety or environmental protection may be more important than cost or even functionality. Decisions on priorities can then guide tradeoff choices.

- **Improving designs** at the high school level may involve sophisticated methods, such as using computer simulations to model proposed solutions. Students are expected to use such methods to take into account a range of criteria and constraints, anticipate possible societal and environmental impacts, and test the validity of their simulations by comparison to the real world.

Environmental Science Topics Overview

The performance expectations in **Topic 1: Systems** help students answer the question:

- How do Earth's major systems interact?

Students examine data to develop models to analyze and determine explanations for changes in Earth systems that took place in the past and are occurring in the present. Students will use this information/evidence to inform how Earth's systems interact and may undergo change in the future. Students investigate water including its properties, unique role in earth systems, and intricate support of various life forms. Students use quantitative models specifically to illustrate the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere. Students argue from evidence relating the simultaneous co-evolution of systems to life on our planet. Engineering and technology play a large role within this topic for obtaining and analyzing data as well as aiding in the development of models.

The performance expectations in **Topic 2: Energy** help students answer the question:

- How is energy transferred and conserved within Earth's systems?

Students design investigations to provide evidence of the transfer of energy in closed systems, develop models to illustrate and explain energy on a macroscopic level and how this energy is associated with both the motion and position of particles. Students create computational models to calculate the changes in the energy of a system when selected components are manipulated. Students engage in the engineering process to design, build, and refine a device that, given constraints, converts one form of energy into another form of energy. Technology plays a role in obtaining data and applying evidence to the development of models that explain the phenomena associated with energy.

The performance expectations in **Topic 3: Populations** help students answer the question:

- How do organisms interact with components of living and nonliving environments to obtain matter and energy?

Students engage in the use of mathematical or computational representations to support and revise explanations based on evidence regarding factors that affect carrying capacity, biodiversity, and populations of ecosystems at different scales. Students evaluate evidence to understand the role of group behavior on individual and species ability to survive and reproduce. Following the example of professional scientists, students evaluate claims, evidence, and reasoning regarding the complexities of the interactions that occur in ecosystems. Students explore how any change in conditions can impact an ecosystem. Engineering and technology play a role in obtaining relevant data and creating mathematical and computational representations to support scientific arguments.

The performance expectations in **Topic 4: Sustainability** help students answer these questions:

- How do Earth's surface processes and human activities affect each other?
- How do humans depend on Earth's resources?

Students construct explanations based on evidence for how the availability of natural resources, the existence of natural hazards, and changes in climate have influenced human activity. Students evaluate competing design solutions related to the management and utilization of natural resources and energy. Students use or create computational simulations to illustrate the relationships among Earth's systems and to determine how relationships are being modified due to human activity. Students explore and analyze the management of natural resources, the sustainability of human populations, and biodiversity. Students design, evaluate, and refine solutions for reducing the impacts of human activities on the environment and biodiversity.

Environmental Science

Topic 1: Systems

Students who demonstrate understanding can:

EVS-ESS2-2 **Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems.** [AR Clarification Statement: Emphasis is on organizing Arkansas-specific geoscience data indicating impacts on wildlife and humans as a result of hurricanes, Polar jet stream activity, wildfires, and sinkholes.]

EVS-ESS2-3 **Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection.** [AR Clarification Statement: Emphasis is on multi-dimensional models of Earth systems, which are associated with plate tectonics processes affecting near Earth surface and interactions among Earth's spheres (bio-, hydro-, atmo-, geo-). Examples of plate tectonics on modern land formation could include heated water in Hot Springs, AR; the Hawaii volcanic chemical and particulate air pollution (vog); rock formations represent paleo-environments and are mined resources in Arkansas.]

EVS-ESS2-5 **Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.** [AR Clarification Statement: Emphasis is on mechanical and chemical investigations with water and a variety of solid materials to provide the evidence for connections between the hydrologic cycle and system interactions commonly known as the rock cycle. Examples of mechanical investigations could include stream transportation and deposition, erosion rates vary related to soil composition and moisture content, or freeze/thaw cycle. Examples of chemical investigations could include chemical weathering and recrystallization by testing the solubility of different materials, and collecting/analyzing water quality data through public data sets (USGS). Arkansas specific investigations could include karst terrain (Blanchard Caverns) and Mississippi River and its tributaries (river channel shape and river water pollution).]

EVS-ESS2-6 **Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.** [AR Clarification Statement: Emphasis is on modeling biogeochemical cycles that include the cycling of carbon through the ocean, atmosphere, rock cycle, and biosphere. Arkansas topics could include agriculture (burning of hydrocarbons, use of natural resources), and energy-related industries including transportation.]

EVS-ESS3-5 **Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems.** [AR Clarification Statement: Examples of evidence, for both data and climate model outputs, are for climate changes (precipitation and temperature) and their associated impacts (sea level, glacial ice volumes, or atmosphere and ocean composition).] [Assessment Boundary: Assessment is limited to one example of a climate change and its associated impacts.]

EVS1-ETS1-1 **Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.** [AR Clarification Statement: Qualitative and quantitative constraints can be used to analyze a major global challenge. Examples could include water quality with relation to biosphere, atmosphere, cryosphere, and geosphere.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their	**ESS2.A: Earth Materials and Systems** ▪ Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. (EVS-ESS2-2) ▪ Evidence from deep probes and seismic waves, reconstructions of	**Energy and Matter** ▪ The total amount of energy and matter in closed systems is conserved. (EVS-ESS2-6)

components in the natural and designed world(s). ▪ Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (EVS-ESS2-3, EVS-ESS2-6) **Planning and Carrying Out Investigations** Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models. ▪ Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (EVS-ESS2-5) **Analyzing and Interpreting Data** Analyzing data in 9–12 builds on K–8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. ▪ Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. (EVS-ESS2-2) **Asking Questions and Defining Problems** Asking questions and defining problems in 9–12 builds on K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations.	historical changes in Earth's surface and its magnetic field, and an understanding of physical and chemical processes lead to a model of Earth with a hot but solid inner core, a liquid outer core, a solid mantle and crust. Motions of the mantle and its plates occur primarily through thermal convection, which involves the cycling of matter due to the outward flow of energy from Earth's interior and gravitational movement of denser materials toward the interior. (EVS-ESS2-3) **ESS2.B: Plate Tectonics and Large-Scale System Interactions** ▪ The radioactive decay of unstable isotopes continually generates new energy within Earth's crust and mantle, providing the primary source of the heat that drives mantle convection. Plate tectonics can be viewed as the surface expression of mantle convection. (EVS-ESS2-3) **ESS2.C: The Roles of Water in Earth's Surface Processes** ▪ The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks. (EVS-ESS2-5) **ESS2.D: Weather and Climate** ▪ 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. (EVS-ESS2-2) ▪ Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. (EVS-ESS2-6)	▪ Energy drives the cycling of matter within and between systems. (EVS-ESS2-3) **Structure and Function** ▪ The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials. (EVS-ESS2-5) **Stability and Change** ▪ Feedback (negative or positive) can stabilize or destabilize a system. (EVS-ESS2-2) **---------------------------------------** ***Connections to Engineering, Technology, and Applications of Science*** **Interdependence of Science, Engineering, and Technology** ▪ Science and engineering complement each other in the cycle known as research and development (R&D). Many R&D projects may involve scientists, engineers, and others with wide ranges of expertise. (EVS-ESS2-3) **Influence of Engineering, Technology, and Science on Society and the Natural World** ▪ New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology. (EVS-ESS2-2, EVS1-ETS1-1, EVS1-ETS1-3)

▪ Analyze complex real-world problems by specifying criteria and constraints for successful solutions. (EVS1-ETS1-1) **Constructing Explanations and Designing Solutions** Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles and theories. ▪ Evaluate a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (EVS1-ETS1-3) -- ***Connections to Nature of Science*** **Scientific Knowledge is Based on Empirical Evidence** ▪ Science knowledge is based on empirical evidence. (EVS-ESS2-3) ▪ Science disciplines share common rules of evidence used to evaluate explanations about natural systems. (EVS-ESS2-3) ▪ Science includes the process of coordinating patterns of evidence with current theory. (EVS-ESS2-3)	▪ Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate. (EVS-ESS2-6) **PS4.A: Wave Properties** ▪ Geologists use seismic waves and their reflection at interfaces between layers to probe structures deep in the planet. (EVS-ESS2-3) **ETS1.A: Defining and Delimiting Engineering Problems** ▪ Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (EVS1-ETS1-1) ▪ Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities. (EVS1-ETS1-1) **ETS1.B: Developing Possible Solutions** ▪ When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. (EVS1-ETS1-3)	

Connections to the Arkansas Disciplinary Literacy Standards:

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (EVS-ESS2-2, EVS-ESS2-3)

RST.11-12.2 Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms. (EVS-ESS2-2)

RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (EVS1-ETS1-1, EVS1-ETS1-3)

RST.11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (EVS1-ETS1-1, EVS1-ETS1-3)

RST.11-12.9	Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. (EVS1-ETS1-1, EVS1-ETS1-3)
WHST.9-12.7	Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (EVS-ESS2-5)
Connections to the Arkansas English Language Arts Standards:	
SL.11-12.5	Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (EVS-ESS2-3)
Connections to the Arkansas Mathematics Standards:	
MP.2	Reason abstractly and quantitatively. (EVS-ESS2-2, EVS-ESS2-3, EVS-ESS2-6, EVS1-ETS1-1, EVS-ETS1-3)
MP.4	Model with mathematics.(EVS-ESS2-3, EVS-ESS2-6, EVS1-ETS1-1, EVS1-ETS1-3)
HSN.Q.A.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (EVS-ESS2-2, EVS-ESS2-3, EVS-ESS2-6)
HSN.Q.A.2	Define appropriate quantities for the purpose of descriptive modeling. (EVS-ESS2-3, EVS-ESS2-6)
HSN.Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (EVS-ESS2-2, EVS-ESS2-3, EVS-ESS2-5, EVS-ESS2-6)

Environmental Science

Topic 2: Energy

Students who demonstrate understanding can:

EVS-PS3-1 **Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.** [AR Clarification Statement: Examples of mathematical expressions could include modeling of thermal energy (heat flow in aquatic systems) and gravitational energy (sediment-related pollutants such as turbidity).]

EVS-PS3-2 **Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative positions of particles (objects).** [AR Clarification Statement: Examples of phenomena at the macroscopic scale could include any fluid (wind, water) interacting with an engineered or natural surface, biomass and air masses as they relate to weather patterns. Models could include diagrams, drawings, descriptions, and computer simulations.]

EVS-PS3-3 **Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.*** [AR Clarification Statement: Emphasis is on both qualitative and quantitative evaluations of devices. Examples of devices could include wind turbines and biomass composting. Constraints could include efficiency of potential societal impact, engineering parameters, and economic feasibility.]

EVS-PS3-4 **Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).** [AR Clarification Statement: Emphasis is on analyzing data and using mathematical thinking to describe energy changes both quantitatively and conceptually. Examples of investigations could include balancing thermal input and output from systems such as coal-fueled power plants, natural gas mining, cooling towers, and insulating factors.]

EVS-ESS2-4 **Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.** [AR Clarification Statement: Emphasis is on the interactions between atmosphere and hydrosphere (ocean currents, weather patterns) on human activity and the environment. Examples of the causes of climate change differ by timescale, over 1-10 years: drought/non-drought trends (NOAA data); 10-100s of years: consequences of industrialization and geological events such as volcanic eruptions and glacial changes resulting in solar reflectivity; 1-100s of thousands of years: deep ocean circulation; 1-100s of millions of years: tectonic plate movement of the land masses.]

EVS2-ETS1-2 **Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.** [AR Clarification Statement: Examples of solutions could include, designing and refining solutions using solar cells and energy recovery from waste practices. Examples of constraints could include use of renewable energy forms and efficiency modeling.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Using Mathematics and Computational Thinking Mathematical and computational thinking at the 9–12 level builds on K–8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Create a computational model or simulation of a phenomenon, designed device, process, or system. (EVS-PS3-1) **Developing and Using Models** Modeling in 9–12 builds on K–8 and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds. • Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system. (EVS-PS3-2) **Constructing Explanations and Designing Solutions** Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized	**PS3.A: Definitions of Energy** • Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms. (EVS-PS3-1, EVS-PS3-2) • At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. (EVS-PS3-2, EVS-PS3-3) • These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as a combination of energy associated with the motion of particles and energy associated with the configuration (relative position of the particles). In some cases the relative position energy can be thought of as stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space. (EVS-PS3-2) **PS3.B: Conservation of Energy and Energy Transfer** • Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system. (EVS-PS3-1) • Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. (EVS-PS3-1) • Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g. relative positions of charged	**Systems and System Models** • Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models. (EVS-PS3-1) • When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. (EVS-PS3-4) - ***Connections to Nature of Science*** **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** • Science assumes the universe is a vast single system in which basic laws are consistent. (EVS-PS3-1) **Energy and Matter** • Energy cannot be created or destroyed—only moves between one place and another place, between objects and/or fields, or between systems. (EVS-PS3-2) • Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. (EVS-PS3-3)

criteria, and tradeoff considerations. (EVS-PS3-3, EVS2-ETS1-2) **Planning and Carrying Out Investigations** Planning and carrying out investigations to answer questions or test solutions to problems in 9–12 builds on K–8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models. • Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (EVS-PS3-4)	particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior. (EVS-PS3-1) • The availability of energy limits what can occur in any system. (EVS-PS3-1) • Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. (EVS-PS3-4) • Uncontrolled systems always evolve toward more stable states—that is, toward more uniform energy distribution (e.g., water flows downhill, objects hotter than their surrounding environment cool down). (EVS-PS3-4) **PS3.D: Energy in Chemical Processes** • Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment. (EVS-PS3-3, EVS-PS3-4) **ETS1.A: Defining and Delimiting an Engineering Problem** • Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (EVS-PS3-3) **ETS1.C: Optimizing the Design Solution** • Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed. (EVS2-ETS1-2)	- ***Connections to Engineering, Technology, and Applications of Science*** **Influence of Science, Engineering and Technology on Society and the Natural World** • Modern civilization depends on major technological systems. Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks. (EVS-PS3-3)

Connections to the Arkansas Disciplinary Literacy Standards:

WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (EVS-PS3-3)

WHST.11-12.8 Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. (EVS-PS3-4)

WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research. (EVS-PS3-4)

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (EVS-PS3-4)

Connections to Arkansas English Language Arts Standards:

SL.11-12.5 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (EVS-PS3-1, EVS-PS3-2)

Connections to the Arkansas Mathematics Standards:

MP.2 Reason abstractly and quantitatively. (EVS-PS3-1, EVS-PS3-2, EVS-PS3-3, EVS-PS3-4)

MP.4 Model with mathematics. (EVS-PS3-1, EVS-PS3-2, EVS-PS3-3, EVS-PS3-4, EVS2-ETS1-2)

HSN.Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (EVS-PS3-1, EVS-PS3-3)

HSN.Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. (EVS-PS3-1, EVS-PS3-3)

HSN.Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (EVS-PS3-1, EVS-PS3-3)

Environmental Science

Topic 3: Populations

Students who demonstrate understanding can:

EVS-LS2-1 **Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.** [AR Clarification Statement: Emphasis is on Arkansas-specific biodiversity and nonbiodiversity, water habitats, and native vegetation. Evaluation techniques could include the use of quantitative analyses and comparison of the relationships among interdependent factors including boundaries, resources, climate, and competition. Arkansas examples could include predator/prey relationships (bass/feeder fish), biodiversity (cave systems and endangered species such as the Ozark Big-Eared bat), producer/consumer relationship (pine tree/Japanese beetle).]

EVS-LS2-2 **Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.** [AR Clarification Statement: Examples of mathematical representations could include finding the average, determining trends, and using graphical comparisons of multiple sets of data (Arkansas macroinvertebrates stream data).] [Assessment Boundary: Assessment is limited to provided data.]

EVS-LS2-6 **Evaluate claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.*** [AR Clarification Statement: Emphasis is on both ancient and modern conditions. Examples of changes in ecosystem conditions could include Arkansas habitat loss and its impact on the bobwhite population or fossil evidence of exosystems (leaf-margin analyses).]

EVS-LS2-8 **Evaluate evidence for the role of group behavior on individual and species' chances to survive and reproduce.** [AR Clarification Statement: Emphasis is on the relationship of human activity with the environment: (1) distinguishing between group and individual behavior, (2) identifying evidence supporting the outcomes of group behavior, and (3) developing logical and reasonable arguments based on evidence. Examples of group behaviors could include human population dynamics, ant or bee colonies, and copperhead mating behaviors.]

EVS3-ETS1-3 **Evaluate a solution to a complex real-world problem based on prioritized criteria and tradeoffs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.** [AR Clarification Statement: Solutions to complex real world issues could include Arkansas wildlife management practices and river management programs susceptible to natural hazards (e.g., erosion, flooding, tornadoes, and earthquakes).]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Using Mathematics and Computational Thinking Mathematical and computational thinking at the 9–12 level builds on K–8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple	**LS2.A: Interdependent Relationships in Ecosystems** • Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. These limits result from such factors as the availability of living and nonliving resources and from such challenges such as predation, competition, and disease. Organisms would have the capacity to produce populations of great size were it not for	**Scale, Proportion, and Quantity** • The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. (EVS-LS2-2) **Stability and Change** • Much of science deals with constructing explanations of how

computational simulations are created and used based on mathematical models of basic assumptions. • Use mathematical and/or computational representations of phenomena or design solutions to support and revise explanations. (EVS-LS2-1, EVS-LS2-2) **Engaging in Argument from Evidence** Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science. • Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments. (EVS-LS2-6, EVS-LS2-8) - ***Connections to Nature of Science*** **Scientific Knowledge is Open to Revision in Light of New Evidence** • Most scientific knowledge is quite durable, but is, in principle, subject to change based on new evidence and/or reinterpretation of existing evidence. (EVS-LS2-2) • Scientific argumentation is a mode of logical discourse used to clarify the strength of relationships between ideas and evidence that may result in revision of an explanation. (EVS-LS2-6, EVS-LS2-8)	the fact that environments and resources are finite. This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem. (EVS-LS2-1, EVS-LS2-2) **LS2.C: Ecosystem Dynamics, Functioning, and Resilience** • 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. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability. (EVS-LS2-2, EVS-LS2-6) **LS2.D: Social Interactions and Group Behavior** • Group behavior has evolved because membership can increase the chances of survival for individuals and their genetic relatives. (EVS-LS2-8) **ETS1.A: Defining and Delimiting an Engineering Problem** • Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (EVS-PS3-3)	things change and how they remain stable. (EVS-LS2-6) **Cause and Effect** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (EVS-LS2-8) - ***Connections to Engineering, Technology, and Applications of Science*** **Influence of Science, Engineering and Technology on Society and the Natural World** • Modern civilization depends on major technological systems. Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks. (EVS-PS3-3)

Connections to the Arkansas Disciplinary Literacy Standards:

RST.9 10.8 Assess the extent to which the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem. (EVS-LS2-6, EVS-LS2-8)

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (EVS-LS2-1, EVS-LS2-2, EVS-LS2-8)

RST.11.12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g. quantitative data, video, multimedia) in order to address a question or solve a problem. (EVS-LS2-6, EVS-LS2-8, EVS3-ETS1-3)

RST.11.12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (EVS-LS2-6, EVS-LS2-8, EVS3-ETS1-3)

Synthesize information from a range of sources (e.g. texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. (EVS3-ETS1-3)

WHST.9-12.2 Write informative/explanatory texts, including the narrations of historical events, scientific procedures/experiments, or technical processes. (EVS-LS2-1, EVS-LS2-2)

Connections to the Arkansas Mathematics Standards:

MP.2 Reason abstractly and quantitatively. (EVS-LS2-1, EVS-LS2-2, EVS-LS2-6, EVS3-ETS1-3)

MP.4 Model with mathematics. (EVS-LS2-1, EVS-LS2-2, EVS3-ETS1-3)

HSN.Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (EVS-LS2-1, EVS-LS2-2)

HSN.Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. (EVS-LS2-1)

HSN.Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (EVS-LS2-1)

HSS.ID.A.1 Represent data with plots on the real number line. (EVS-LS2-6)

HSS.IC.A.1 Recognize statistics as a process for making inferences about population parameters based on a random sample from that population. (EVS-LS2-6)

HSS.IC.B.6 Read and explain, in context, the validity of data from outside reports by: identifying the variables as quantitative or categorical; describing how the data was collected; indicating any potential biases or flaws; identifying inferences the author of the report made from sample data. (EVS-LS2-6)

Environmental Science

Topic 4: Sustainability
Students who demonstrate understanding can:

EVS-ESS3-1 **Construct an explanation based on evidence for how the availability of natural resources, occurrences of natural hazards, and changes in climate have influenced human activity.** [AR Clarification Statement: Emphasis is on sustainability of natural resources, extracting natural resources, and how human societies are economically impacted by these phenomena.]

EVS-ESS3-2 **Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.*** [AR Clarification Statement: Emphasis is on conservation, sustainability (e.g., recycling and reuse of resources), and minimizing impacts (e.g., Low Impact Design).]

EVS-ESS3-3 **Create a computational simulation to illustrate the relationships among the management of natural resources, the sustainability of human populations, and biodiversity.** [AR Clarification Statement: Emphasis is on Arkansas-specific management and conservation of, costs of implementation and regulation of, and land use of (agriculture, mining, recreation, and urbanization) natural resources.]

EVS-ESS3-4 **Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.*** [AR Clarification Statement: Examples of data on the impacts of human activities could include the sequencing of traffic lights, adding lanes to main traffic arteries, docking and dredging of waterways, transportation of goods to market, use of drones, and use of alternative energies.]

EVS-ESS3-6 **Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.** [AR Clarification Statement: Examples of evidence for both data and climate model outputs for climate changes and their associated impacts can be found at NOAA, National Weather Service and United States Geological Survey.]

EVS-LS2-7 **Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.*** [AR Clarification Statement: Emphasis in this course is on Arkansas-specific solutions. Examples of human activities can include land use (agriculture, forestry, recreation, industry); sustainable and nonsustainable practices (crop rotations, eradication of invasive species); and solution resources may include Low Impact Design (LID) or bioremediation (Faulkner County, AR; Gulf of Mexico hypoxia zone.)]

EVS-LS4-6 **Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.*** [AR Clarification Statement: Emphasis is on designing solutions for a proposed problem (e.g., microbead pollution, invasive species, effects of sedimentation on the Arkansas fatmucket, White-nose Syndrome affecting bat populations, and environmental pollution from hormones and antibiotics).]

EVS4-ETS1-3 **Evaluate a solution to a complex real-world problem based on prioritized criteria and tradeoffs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.** [AR Clarification Statement: Modeling complex real world problems using computer software could include simulating future population growth in terms of limited resources or evaluating water flow through different Earth and geoengineered materials.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions	**LS2.C: Ecosystem Dynamics, Functioning, and Resilience**	**Cause and Effect** • Empirical evidence is required to differentiate

Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific knowledge, principles, and theories.

- Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (EVS-ESS3-1)
- Design or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (EVS-ESS3-4, EVS-LS2-7)

Engaging in Argument from Evidence

Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about natural and designed world(s). Arguments may also come from current scientific or historical episodes in science.

- Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and logical arguments regarding relevant factors (e.g. economic, societal, environmental, ethical considerations). (EVS-ESS3-2)

Using Mathematics and Computational Thinking

Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using

- Moreover, anthropogenic changes (induced by human activity) in the environment—including habitat destruction, pollution, introduction of invasive species, overexploitation, and climate change—can disrupt an ecosystem and threaten the survival of some species. (EVS-LS2-7)

LS4.C: Adaptation

- Changes in the physical environment, whether naturally occurring or human induced, have thus contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline–and sometimes the extinction–of some species. (EVS-LS4-6)

LS4.D: Biodiversity and Humans

- Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction). (EVS-LS2-7)
- Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Thus sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value. (EVS-LS2-7, EVS-LS4-6)

ESS2.D: Weather and Climate

- 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. (EVS-ESS3-6)

between cause and correlation and make claims about specific causes and effects. (EVS-ESS3-1, EVS-LS4-6)

Stability and Change

- Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. (EVS-ESS3-3, EVS-ESS3-4)
- Much of science deals with constructing explanations of how things change and how they remain stable. (EVS-LS2-7)

Systems and System Models

- When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. (EVS-ESS3-6)

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Connections to Engineering, Technology, and Applications of Science

Influence of Science, Engineering, and Technology on Society and the Natural World

- Modern civilization depends on major technological systems. (EVS-ESS3-1, EVS-ESS3-3)
- Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks. (EVS-ESS3-2)

algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Create a computational model or simulation of a phenomenon, designed device, process, or system. (EVS-ESS3-3) • Use a computational representation of phenomena or design solutions to describe and/or support claims and/or explanations. (EVS-ESS3-6) • Create or revise a simulation of a phenomenon, designed device, process, or system. (EVS-LS4-6)	**ESS3.A: Natural Resources** • Resource availability has guided the development of human society. (EVS-ESS3-1, EVS-ESS3-2) **ESS3.B: Natural Hazards** • Natural hazards and other geologic events have shaped the course of human history; [they] have significantly altered the sizes of human populations and have driven human migrations. (EVS-ESS3-1) **ESS3.C: Human Impacts on Earth Systems** • Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation. (EVS-ESS3-3, EVS-ESS3-4) **ESS3.D: Global Climate Change** • Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities. (EVS-ESS3-6) **ETS1.B: Developing Possible Solutions** • When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. (EVS-ESS3-2, EVS-ESS3-4, EVS-LS4-6, EVS-LS2-7) • Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs. (EVS-LS4-6)	• Analysis of costs and benefits is a critical aspect of decisions about technology. (EVS-ESS3-2) • New technologies can have deep impacts on society and the environment, including some that were not anticipated. (EVS-ESS3-3) • Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks. (EVS-ESS3-4) - ***Connections to Nature of Science*** **Science Addresses Questions About the Natural and Material World** • Science and technology may raise ethical issues for which science, by itself, does not provide answers and solutions. • Science knowledge indicates what can happen in natural systems—not what should happen. The latter involves ethics, values, and human decisions about the use of knowledge. • Many decisions are not made using science alone, but rely on social and cultural contexts to resolve issues. (EVS-ESS3-2) **Science is a Human Endeavor** • Science is a result of human endeavors, imagination, and creativity. (EVS-ESS3-3)

Connections to the Arkansas Disciplinary Literacy Standards:

RST.9-10.8 Assess the extent to which the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem. (EVS-LS2-7)

RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g. quantitative data, video, multimedia) in order to address a question or solve a problem. (EVS-LS2-7)

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (EVS-ESS3-1, EVS-ESS3-4)

RST.11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (EVS-ESS3-2, EVS-ESS3-4, EVS-LS2-7)

WHST.9-12.2 Write informative/explanatory texts, including the narrations of historical events, scientific procedures/experiments, or technical processes. (EVS-ESS3-1)

WHST.9-12.5 Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. (EVS-LS4-6)

WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (EVS-LS4-6, EVS-LS2-7)

Connections to the Arkansas Mathematics Standards:

MP.2 Reason abstractly and quantitatively. (EVS-ESS3-1, EVS-ESS3-2, EVS-ESS3-3, EVS-ESS3-4, EVS-ESS3-6, EVS-LS2-7)

MP.4 Model with mathematics. (EVS-ESS3-3, EVS-ESS3-6)

HSN.Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (EVS-ESS3-1, EVS-ESS3-4, EVS-ESS3-6, EVS-LS2-7)

HSN.Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. (EVS-ESS3-1, EVS-ESS3-4, EVS-ESS3-6, EVS-LS2-7)

HSN.Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (EVS-ESS3-1, EVS-ESS3-4, EVS-ESS3-6, EVS-LS2-7)

Contributors

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Dr. Katherine Auld - Northwest Arkansas Community College	Steven Long – Rogers School District
Dr. Daniel Barth - University of Arkansas at Fayetteville	Chris Lynch – Black River Technical College
Angela Bassham – Salem School District	Jacki Marlin – Perryville School District
Allison Belcher – Little Rock School District	Monica Meadows – Pulaski County Special School District
Debbie Bilyeu – Arkansas AIMS	Patti Meeks – Hamburg School District
Tami Blair – Texarkana School District	Melissa Miller – Farmington School District
Stephen Brodie – University of Arkansas at Fort Smith STEM Center	Dr. Jim Musser – Arkansas Tech University
Stephanie Brown – Quitman School District	Nanette Nichols – Wilbur D. Mills AR Education Cooperative
Cindy Bunch – Manila School District	Dennis Pevey – eSTEM Public Charter School
Cindy Cardwell – Bentonville School District	Tami Philyaw – Smackover – Norphlet School District
Larry Cooper – Springdale School District	Kathy Prislovsky – Stuttgart School District
Sarah Croswell – Virtual Arkansas	Kathy Prophet – Springdale School District
Tami Eggensperger – Cabot School District	Rhonda Riggin – Booneville School District
Shelley Forbess – El Dorado School District	Will Squires – Caddo Hills School District
Kyla Gentry – Searcy School District	Tim Trawick – Conway School District
Jenna Gill – Siloam Springs School District	David Wentz – Pea Ridge School District
Douglas Hammon – Little Rock School District	Andrew Williams – University of Arkansas at Monticello
Keith Harris – University of Arkansas at Little Rock Partnership for STEM Education	Wendi J.W. Williams – Northwest Arkansas Community College
Leonda Holthoff – Star City School District	Cathy Wissehr – University of Arkansas at Fayetteville
Amanda Jones – Poyen School District	Diedra Young – Ridgway Christian High School, Pine Bluff