

Sample Scope and Sequence for California EP&Cs

Strategies for Satisfying the California Science Framework Requirements for Teaching California's Environmental Principles and Concepts in Conjunction with the Next Generation Science Standards*

Created by State Education and Environment Roundtable
in collaboration with Ten Strands

PURPOSE

Created for publishers submitting to California's 2018 Science Adoption, to demonstrate a Scope and Sequence for California's Environmental Principles and Concepts (EP&Cs) based on Appendix 2 of the 2016 Science Curriculum Framework adopted by the State Board of Education

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Introduction—Category 1 Requirements

With the 2016 adoption of a new Science Framework, California’s State Board of Education (SBE) required that adopted materials must align with California’s Next Generation Science Standards (CA NGSS) and include instructional content based upon California’s Environmental Principles and Concepts (EP&Cs).

This Scope and Sequence document provides examples of potential learning outcomes to demonstrate to publishers how the CA NGSS and EP&Cs can be integrated into instructional materials and activities and taught simultaneously with the three dimensions of the CA NGSS, thereby meeting the State Board’s Category 1 requirement for both.

Publishers will first read about the EP&Cs in the Science Framework where they are covered in the overview and in each grade-level chapter. Also, Appendix 2 of the Framework offers a wide range of examples that connect the EP&Cs to the CA NGSS.

In addition to the Framework, two-grade level Exemplars have been developed to demonstrate how the EP&Cs can be integrated into CA instructional materials. The first is a Grade 4 Exemplar and the second is a Grade 6-7 Exemplar. Both were shared at the CDE publisher briefing on August 29, 2017 and are available from the California Department of Education.

This document, a complement to the Framework and the Exemplars, provides an example Scope and Sequence for each grade Kindergarten-5th Grade, and for Middle and High School based on Appendix 2. It offers detailed statements of potential learning outcomes that connect the EP&Cs to Disciplinary Core Ideas (DCI’s) and Performance Expectations (PE’s). An excerpt from Appendix 2 connecting grade level DCI’s to the best-fit EP&Cs follows each grade-level.

Please contact Dr. Gerald Lieberman (gerald@seer.org) with questions.

Beyond the Three-Dimensions

Chapter 13 of California’s *2016 Science Framework* states that, “All criteria statements in Category 1 must be met for a program to be adopted. The criteria for Category 1 must be met in the core resources or via the primary means of instruction, rather than in ancillary components.”

As described throughout the framework, the SBE calls for instruction that goes well beyond the three dimensions represented by the Disciplinary Core Ideas, Crosscutting Concepts, and Science and Engineering Practices. The framework calls for an “Explicit focus on Environmental Principles and Concepts... that every student in the state should learn and be able to apply.”

Specifically, in Chapter 13 under Category 1: Alignment with the CA NGSS Three-Dimensional Learning, California’s *2016 Science Framework* states that:

All programs must include the following features:... Instructional resources, where appropriate, examine humanity’s place in ecological systems and the necessity for the protection of the environment (EC Section 60041). Resources include instructional content based upon the Environmental Principles and Concepts developed by the California Environmental Protection Agency and adopted by the SBE (Public Resources Code Section 71301) in context and aligned to the CA NGSS, as exemplified in Appendix 2 (2016 Science Framework). [Emphasis added.]

The *Framework* states that, to be adopted, resources must meet Category 1: Alignment with CA NGSS Three-Dimensional Learning, in full, **including the EP&Cs**.

California’s Environmental Principles and Concepts (EP&Cs)

As stated above, Category 1 requires that California’s Environmental Principles and Concepts (see Table 1 below) be incorporated into instructional materials. *2016 Science Framework* Chapter 1: Overview of the California Next Generation Science Standards introduces the role of the EP&Cs in California science education:

While the three dimensions are a major part of the CA NGSS, the standards are based on principles that go beyond these three dimensions. Teachers must be mindful of these other considerations, including principles of environmental literacy, engineering design, the nature of science... twenty-first century skills, and integrating science with California’s other standards...

*For many decades, California has been a national leader in educating students about the environment, and now more than ever, the state recognizes that environmental literacy is crucial to sustaining the economic and environmental well-being of all Californians... **Environmental literacy means more than knowing environmental content; it also encompasses civic engagement and community involvement in diverse settings.** Going beyond the walls of the classroom, environmental literacy can be developed through investigations on campus, in the local community, on the schoolyard, at nature centers and outdoor schools, as well as in the rich and diverse natural landscapes: found throughout California...*

*To help fulfill this goal, the California State Board of Education (SBE) approved a framework guideline that **calls for the Environmental Principles and Concepts (EP&Cs) to be incorporated into relevant subject matter frameworks, including science.** [Emphasis added.]*

The *2016 Science Framework* further calls for an explicit focus on California’s EP&Cs:

*A direct understanding of the connections between humans and the natural world prepares students to address the environmental challenges of today and of the future, to mitigate and prepare for natural hazards, and to interact in a responsible and sustainable manner with the natural systems that support all life. **California has identified several critical understandings, called the Environmental Principles and Concepts (EP&Cs; Table 1), that every student in the state should learn and be able to apply.** The State Board of Education (SBE) officially adopted the EP&Cs in 2004 and **they are an important piece of the curricular expectations for all California students.** [Emphasis added.]*

The commitment of the State Board of Education to the EP&Cs as an integral part of its curricular expectations is further demonstrated by their inclusion in the *2016 History-Social Science Framework* and SBE’s requirement that they be incorporated in the *Health Framework* (currently under development).

Appendix 2 of the *2016 Science Framework* presents examples of alignments by grade among the EP&Cs, Performance Expectations, Science and Engineering Practices, Disciplinary Core Ideas, and Crosscutting Concepts. Instructional materials that address the Performance Expectations are not sufficient; instruction *must* focus on Three-Dimensional Learning and the EP&Cs.

Table 1: California’s Adopted Environmental Principles and Concepts

<p>Principle I—The continuation and health of individual human lives and of human communities and societies depend on the health of the natural systems that provide essential goods and ecosystem services.</p>
<p>Concept a. The goods produced by natural systems are essential to human life and to the functioning of our economies and cultures.</p>
<p>Concept b. The ecosystem services provided by natural systems are essential to human life and to the functioning of our economies and cultures.</p>
<p>Concept c. The quality, quantity and reliability of the goods and ecosystem services provided by natural systems are directly affected by the health of those systems.</p>

Principle II—The long-term functioning and health of terrestrial, freshwater, coastal and marine ecosystems are influenced by their relationships with human society.

Concept a. Direct and indirect changes to natural systems due to the growth of human populations and their consumption rates influence the geographic extent, composition, biological diversity, and viability of natural systems.

Concept b. Methods used to extract, harvest, transport and consume natural resources influence the geographic extent, composition, biological diversity, and viability of natural systems.

Concept c. The expansion and operation of human communities influences the geographic extent, composition, biological diversity, and viability of natural systems.

Concept d. The legal, economic and political systems that govern the use and management of natural systems directly influence the geographic extent, composition, biological diversity, and viability of natural systems.

Principle III—Natural systems proceed through cycles that humans depend upon, benefit from, and can alter.

Concept a. Natural systems proceed through cycles and processes that are required for their functioning.

Concept b. Human practices depend upon and benefit from the cycles and processes that operate within natural systems.

Concept c. Human practices can alter the cycles and processes that operate within natural systems.

Principle IV—The exchange of matter between natural systems and human societies affects the long-term functioning of both.

Concept a. The effects of human activities on natural systems are directly related to the quantities of resources consumed and to the quantity and characteristics of the resulting byproducts.

Concept b. The byproducts of human activity are not readily prevented from entering natural systems and may be beneficial, neutral, or detrimental in their effect.

Concept c. The capacity of natural systems to adjust to human-caused alterations depends on the nature of the system as well as the scope, scale, and duration of the activity and the nature of its byproducts.

Principle V—Decisions affecting resources and natural systems are based on a wide range of considerations and decision-making processes.

Concept a. The spectrum of what is considered in making decisions about resources and natural systems and how those factors influence decisions.

Concept b. The process of making decisions about resources and natural systems, and how the assessment of **social**, economic, political, and environmental factors has changed over time.

In Appendix 2, the *2016 Science Framework* provides diverse examples of how teachers can make connections between the EP&Cs and all three dimensions of the CA NGSS, “by focusing instruction on the environment of their local community and the issues that it faces.” Table 2 shows examples of these connections.

Elementary School Science Scope and Sequence

Kindergarten Learning Outcomes

Detailed Examples of Learning Outcomes Connecting EP&Cs–DCIs–PEs

- *Humans need food in order to live and grow; they obtain their food from plants and/or animals that depend on healthy natural systems. (EP&C: I.a.) (DCI: LS1.C) (PE: K-LS1-1)*
- *Humans use natural resources for everything they do. (EP&C: I.a.) (DCI: ESS3.A) (PE: K-ESS3-1)*
- *Things humans do to live comfortably (for example, materials and products they use in their daily lives) can affect the world around them, including the health of the places (habitats) where plants and animals live. (EP&C: II.a.) (DCIs: ESS2.E; ESS3.C) (PEs: K-ESS2-2; K-ESS3-3)*
- *Humanity’s effects on the environment can influence the amounts of important resources available to humans, such as food, clean air, and water. (EP&C: I.c.) (DCIs: ESS3.C; LS1.C) (PEs: K-ESS3-3; K-LS1-1)*
- *There are many different considerations when making decisions about human activities that can affect natural systems. (EP&C: V.a.) (DCI: ETS1.A) (PE: K-2-ETS1-1)*
- *Humans can make choices about how to reduce their impacts on other living things and natural systems on land, water, and air (atmosphere). (EP&C: V.a.) (DCI: ETS1.A) (PE: K-2-ETS1-1)*

Source Material from 2016 California Science Framework Appendix 2

LS1 From Molecules to Organisms: Structures and Processes

Disciplinary Core Ideas

As students learn that:

LS1.C: Organization for Matter and Energy Flow in Organisms “All animals need food in order to live and grow; they obtain their food from plants or from other animals; and plants need water and light to live and grow. (K-LS1-1)”

Environmental Principle and Concept(s)

Students should be developing an understanding:

Principle I Concept a: “that the goods produced by natural systems are essential to human life and to the functioning of our economies and cultures.” (LS1.C)

Principle II Concept a: “that direct and indirect changes to natural systems due to the growth of human populations and their consumption rates influence the geographic extent, composition, biological diversity, and viability of natural systems.” (LS1.C)

K-ESS2 Earth’s Systems

Disciplinary Core Ideas

As students learn that:

ESS2.E: Biogeology “Plants and animals can change their environment. (K-ESS2-2)”

Secondary DCI(s)

ESS3.C: Human Impacts on Earth Systems “Things people do to live comfortably can affect the world around them, but they can make choices that reduce their impacts on the land, water, air, and other living things. (secondary to K-ESS2-2)”

Environmental Principle and Concept(s)

Students should be developing an understanding:

Principle I Concept c: “that the quality, quantity and reliability of the goods and ecosystem services provided by natural systems are directly affected by the health of those systems.” (ESS2.E)

Principle II Concept a: “that direct and indirect changes to natural systems due to the growth of human populations and their consumption rates influence the geographic extent, composition, biological diversity, and viability of natural systems.” (ESS3.C)

ESS3 Earth and Human Activity

Disciplinary Core Ideas

As students learn that:

ESS3.A: Natural Resources “... Humans use natural resources for everything they do. (K-ESS3-1)”

ESS3.C: Human Impacts on Earth Systems “Things people do to live comfortably can affect the world around them. (K-ESS3-3)”

Secondary DCI(s)

ETS1.A: Defining and Delimiting an Engineering Problem “Asking questions, making observations, and gathering information are helpful in thinking about problems. (secondary to K-ESS3-2)”

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. (secondary to K-ESS3-3)”

Environmental Principle and Concept(s)

Students should be developing an understanding:

Principle I Concept c: “that the quality, quantity and reliability of the goods and ecosystem services provided by natural systems are directly affected by the health of those systems.” (ESS3.A)

Principle II Concept a: “that direct and indirect changes to natural systems due to the growth of human populations and their consumption rates influence the geographic extent, composition, biological diversity, and viability of natural systems.” (ESS3.C)

K-2-ETS1 Engineering Design

Disciplinary Core Ideas

As students discover that:

ETS1.A: Defining and Delimiting Engineering Problems “A situation people want to change or create can be approached as a problem to be solved through engineering. (K-2-ETS1-1)”

ETS1.A “Asking questions, making observations, and gathering information are helpful in thinking about problems. (K-2-ETS1-1)”

ETS1.A “Before beginning to design a solution, it is important to clearly understand the problem. (K-2-ETS1-1)”

Environmental Principle and Concept(s)

Students should be developing an understanding of:

Principle V Concept a: “the spectrum of what is considered in making decisions about resources and natural systems and how those factors influence decisions.” (ETS1.A)

First Grade Learning Outcomes

Detailed Examples of Learning Outcomes Connecting EP&Cs–DCIs–PEs

- *Changes to natural systems, caused by humans, can influence how plants and animals use their different body parts to help them survive and grow. (EP&C: II.a.) (DCI: LS1.A) (PE: 1-LS1-1)*
- *Human activities cause changes to natural systems. (EP&C: II.a.) (DCI: LS1.A) (PE: 1-LS1-1)*
- *Human-caused changes to natural systems affect the places (habitats) where plants and animals live and get everything they need to survive and grow. (EP&C: II.a.) (DCI: LS1.A) (PE: 1-LS1-1)*
- *Human activities that change habitats influence which plants and animals can live in a particular area. (EP&C: II.a.) (DCI: LS1.A) (PE: 1-LS1-1)*
- *There are many different considerations when making choices and decisions about human activities that can cause changes to natural systems. (EP&C: V.a.) (DCI: ETS1.A) (PE: K-2-ETS1-1)*
- *Decisions about human activities should consider (ask questions and make observations about) how changes to the natural system will affect the plants and animals that live there, as well as the habitats themselves. (EP&C: V.a.) (DCI: ETS1.A) (PE: K-2-ETS1-1)*

Source Material from 2016 California Science Framework Appendix 2

LS1 From Molecules to Organisms: Structures and Processes

Disciplinary Core Ideas

As students learn that:

LS1.A: Structure and Function “All organisms have external parts. Different animals use their body parts in different ways to see, hear, grasp objects, protect themselves, move from place to place, and seek, find, and take in food, water and air. Plants also have different parts (roots, stems, leaves, flowers, fruits) that help them survive and grow. (1-LS1-1)”

Environmental Principle and Concept(s)

Students should be developing an understanding:

Principle II Concept a: “that direct and indirect changes to natural systems due to the growth of human populations and their consumption rates influence the geographic extent, composition, biological diversity, and viability of natural systems.” (LS1.A)

K-2-ETS1 Engineering Design

Disciplinary Core Ideas

As students discover that:

ETS1.A: Defining and Delimiting Engineering Problems “Asking questions, making observations, and gathering information are helpful in thinking about problems. (K-2-ETS1-1)”

Environmental Principle and Concept(s)

Students should be developing an understanding of:

Principle V Concept a: “the spectrum of what is considered in making decisions about resources and natural systems and how those factors influence decisions.” (ETS1.A)

Second Grade Learning Outcomes

Detailed Examples of Learning Outcomes Connecting EP&Cs–DCIs–PEs

- *Changes to natural systems, resulting from human activities, affect the places (habitats) where plants live, as well as the animals they depend upon for pollination and moving around their seeds. (EP&C: II.a.) (DCI: LS2.A) (PEs: 2-LS2-2; 2-LS2-2)*
- *Human-caused changes to natural systems (habitats) affect the kinds of living things that can survive in an area. (EP&C: II.a.) (DCI: LS4.D) (PE: 2-LS4-1)*
- *Substantial human-caused changes to a natural system can result in some species of plants and animals dying or moving away, sometimes causing their complete disappearance from a region. (EP&C: II.a.) (DCI: LS4.D) (PE: 2-LS4-1)*
- *When designing and choosing a solution to a problem, it is necessary to fully understand how a particular solution might affect the associated natural systems. (EP&C: V.a.) (DCI: ETS1.A) (PE: K-2-ETS1-1)*
- *Decisions about human activities should consider (ask questions and make observations about) how changes to the natural system will affect the plants and animals that live there, as well as the habitats themselves. (EP&C: V.a.) (DCI: ETS1.A) (PE: K-2-ETS1-1)*

Source Material from 2016 California Science Framework Appendix 2

LS2 Ecosystems: Interactions, Energy, and Dynamics

Disciplinary Core Ideas

As students learn that:

LS2.A: Interdependent Relationships in Ecosystems “Plants depend on water and light to grow. (2-LS2-1)”

LS2.A “Plants depend on animals for pollination or to move their seeds around. (2-LS2-2)”

Secondary DCI(s)

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. (secondary to 2-LS2-2)”

Environmental Principle and Concept(s)

Students should be developing an understanding:

Principle II Concept a: “that direct and indirect changes to natural systems due to the growth of human populations and their consumption rates influence the geographic extent, composition, biological diversity, and viability of natural systems.” (LS2.A)

Principle V Concept a: “the spectrum of what is considered in making decisions about resources and natural systems and how those factors influence decisions.” (ETS1.B)

LS4 Biological Evolution: Unity and Diversity

Disciplinary Core Ideas

As students learn that:

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)”

Environmental Principle and Concept(s)

Students should be developing an understanding:

Principle II Concept a: “that direct and indirect changes to natural systems due to the growth of human populations and their consumption rates influence the geographic extent, composition, biological diversity, and viability of natural systems.” (LS.B)

K-2-ETS1 Engineering Design

Disciplinary Core Ideas

As students discover that:

ETS1.A: Defining and Delimiting Engineering Problems “Asking questions, making observations, and gathering information are helpful in thinking about problems...” (K-2-ETS1-1)

ETS1.A: Defining and Delimiting Engineering Problems “Before beginning to design a solution it is important to clearly understand the problem.” (K-2-ETS1-1)

Environmental Principle and Concept(s)

Students should be developing an understanding of:

Principle V Concept a: “the spectrum of what is considered in making decisions about resources and natural systems and how those factors influence decisions.” (ETS1.A)

Third Grade Learning Outcomes

Detailed Examples of Learning Outcomes Connecting EP&Cs–DCIs–PEs

- *The functioning of natural systems depends on the characteristic behaviors of animals and the life cycles of both plants and animals. (EP&C: III.a.) (DCI: LS1.B) (PE: 3-LS1-1)*
- *Humans depend on and benefit from the diverse life cycles of plants and animals. (EP&C: III.b.) (DCI: LS1.B) (PE: 3-LS1-1)*
- *Human activities (e.g., methods for obtaining natural resources, means and quantities of resource consumption, development of human communities due to population growth) can alter the cycles that occur in natural systems, including the life cycles of plants and animals. (EP&C: III.c.) (DCI: LS1.B) (PE: 3-LS1-1)*
- *Changes to natural systems resulting from human activities can affect the characteristics (e.g., diet, growth patterns) of an organism’s interactions with the environment, as well as the inherited traits that organisms develop. (EP&C: II.a.) (DCIs: LS3.B; LS3.A) (PE: 3-LS3-2)*
- *Human-caused changes to natural systems (habitats) affect both the number of each kind (species) of organism, and which kinds survive well in a particular area. (EP&Cs: II.a.; II.b.; II.c.) (DCIs: LS4.C; LS4.D) (PEs: 3-LS4-3; 3-LS4-4)*
- *Substantial human-caused changes to a natural system (habitat) can result in some species of plants and animals dying or moving away, sometimes causing their complete disappearance from a region and other species replacing them in the transformed environment. (EP&Cs: II.a.; II.b.; II.c.) (DCI: LS2.C) (PE: 3-LS4-4)*
- *There are many different factors to consider when making choices and decisions about human activities that can cause changes to natural systems. (EP&C: V.a.) (DCI: ETS1.A) (PE: 3-5-ETS1-1)*
- *When comparing different proposals for solutions to a problem, potential impacts on natural systems should be taken into consideration during the process of developing and considering criteria for success and project constraints. (EP&C: V.a.) (DCI: ETS1.A) (PE: 3-5-ETS1-1)*

Source Material from 2016 California Science Framework Appendix 2

LS1 From Molecules to Organisms: Structures and Processes

Disciplinary Core Ideas

As students learn that:

LS1.B: Growth and Development of Organisms “Reproduction is essential to the continued existence of every kind of organism. Plants and animals have unique and diverse life cycle. (3-LS1-1)”

Environmental Principle and Concept(s)

Students should be developing an understanding:

Principle III Concept a: “that natural systems proceed through cycles and processes that are required for their functioning.” (LS1.B)

Principle III Concept b: “that human practices depend upon and benefit from the cycles and processes that operate within natural systems.” (LS1.B)

Principle III Concept c: “that human practices can alter the cycles and processes that operate within natural systems.” (LS1.B)

LS3 Heredity: Inheritance and Variation of Traits

Disciplinary Core Ideas

As students learn that:

LS3.A: Inheritance of Traits “Other characteristics result from individuals’ interactions with the environment, which can range from diet to learning, that many characteristics involve both inheritance and environment. (3-LS3-2)”

LS3.B: Variation of Traits “The environment also affects the traits that an organism develops. (3-LS3-2)”

Environmental Principle and Concept(s)

Students should be developing an understanding:

Principle II Concept a: “that direct and indirect changes to natural systems due to the growth of human populations and their consumption rates influence the geographic extent, composition, biological diversity, and viability of natural systems.” (LS3.A; LS3.B)

LS4 Biological Evolution: Unity and Diversity

Disciplinary Core Ideas

As students learn that:

LS4.C: Adaptation “For any particular environment, some kinds of organisms survive well, some survive less well. (3-LS4-3)”

LS4.D: Biodiversity and Humans “Populations live in a variety of habitats, and change in those habitats affects the organisms living there. (3-LS4-4)”

Secondary DCI(s)

LS2.C: Ecosystem Dynamics, Functioning, and Resilience “When the environment changes in ways that affect a place’s physical characteristics, temperature, or availability of resources, some organisms survive and reproduce, others move to new locations, yet others move into the transformed environment, and some die. (secondary to 3-LS4-4)”

Environmental Principle and Concept(s)

Students should be developing an understanding:

Principle II Concept a: “that direct and indirect changes to natural systems due to the growth of human populations and their consumption rates influence the geographic extent, composition, biological diversity, and viability of natural systems.” (LS4.C; LS4.D; LS2.C)

Principle II Concept b: “that methods used to extract, harvest, transport and consume natural resources influence the geographic extent, composition, biological diversity, and viability of natural systems.” (LS4.C; LS4.D; LS2.C)

Principle II Concept c: “that the expansion and operation of human communities influences the geographic extent, composition, biological diversity, and viability of natural systems.” (LS4.C; LS4.D; LS2.C)

3-5 Engineering Design

Disciplinary Core Ideas

As students discover that:

ETS1.A: Defining and Delimiting Engineering Problems "... Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. (3-5-ETS1-1)"

Environmental Principle and Concept(s)

Students should be developing an understanding of:

Principle V Concept a: "the spectrum of what is considered in making decisions about resources and natural systems and how those factors influence decisions." (ETS1.A)

Fourth Grade Learning Outcomes

Detailed Examples of Learning Outcomes Connecting EP&Cs–DCIs–PEs

- *Plants and animals (including humans) have internal and external structures with which they obtain resources from natural systems to support their growth, survival, behavior, and reproduction. (EP&Cs: II.a.; II.b.; II.c.) (DCI: LS1.A) (PE: 4-LS1-1)*
- *Human-caused changes to natural systems can influence how an organism’s internal and external structures function for growth, survival, behavior, and reproduction. (EP&Cs: II.a.; II.b.; II.c.) (DCI: LS1.A) (PE: 4-LS1-1)*
- *The ecosystem goods obtained from natural systems, such as energy and fuels, are essential to human life and to the functioning of our economies and cultures. (EP&C: I.a.) (DCI: ESS3.A) (PE: 4-ESS3-1)*
- *Decisions about the methods used to obtain natural resources, and choices about using renewable or nonrenewable energy and fuels, affect natural systems and the organisms that depend upon them. (EP&C: II.b.) (DCI: ESS3.A) (PE: 4-ESS3-1)*
- *There are many different factors to consider when making choices and decisions about human activities that can cause changes to natural systems. (EP&C: V.a.) (DCI: ETS1.A) (PE: 3-5-ETS1-1)*
- *When comparing different proposals for possible solutions to a problem, potential impacts on natural systems should be taken into consideration during the process of developing and considering criteria for success and project constraints. (EP&C: V.a.) (DCI: ETS1.A) (PE: 3-5-ETS1-1)*

Source Material from 2016 California Science Framework Appendix 2

LS1 From Molecules to Organisms: Structures and Processes

Disciplinary Core Ideas

As students learn that:

LS1.A: Structure and Function “Plants and animals have both internal and external structures that serve various functions in growth, survival, behavior, and reproduction. (4-LS1-1)”

Environmental Principle and Concept(s)

Students should be developing an understanding:

Principle II Concept a: “that direct and indirect changes to natural systems due to the growth of human populations and their consumption rates influence the geographic extent, composition, biological diversity, and viability of natural systems.” (LS1.A)

Principle II Concept b: “that methods used to extract, harvest, transport and consume natural resources influence the geographic extent, composition, biological diversity, and viability of natural systems.” (LS1.A)

Principle II Concept c: “that the expansion and operation of human communities influences the geographic extent, composition, biological diversity, and viability of natural systems.” (LS1.A)

ESS3 Earth and Human Activity

Disciplinary Core Ideas

As students learn that:

ESS3.A: Natural Resources “Energy and fuels that humans use are derived from natural sources, and their use affects the environment in multiple ways,” and that some resources are renewable over time, and others are not. (4-ESS3-1)”

Secondary DCI(s)

ETS1.B: Designing Solutions to Engineering Problems “Testing a solution involves investigating how well it performs under a range of likely conditions. (secondary to 4-ESS3-2)”

Environmental Principle and Concept(s)

Students should be developing an understanding:

Principle I Concept a: “that the goods produced by natural systems are essential to human life and to the functioning of our economies and cultures.” (ESS3.A)

3-5 Engineering Design

Disciplinary Core Ideas

As students discover that:

ETS1.A: Defining and Delimiting Engineering Problems “Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. (3-5-ETS1-1)”

Environmental Principle and Concept(s)

Students should be developing an understanding of:

Principle V Concept a: “the spectrum of what is considered in making decisions about resources and natural systems and how those factors influence decisions.” (ETS1.A)

Fifth Grade Learning Outcomes

Detailed Examples of Learning Outcomes Connecting EP&Cs–DCIs–PEs

- *The byproducts of human activities, such as manufacturing, energy production, and agriculture, cause changes to natural systems that influence the materials plants need for growth, including air and water. (EP&C: IV.a.) (DCI: LS1.C) (PE: 5-LS1-1)*
- *Human practices, such as mining, manufacturing, land management, energy production, and the introduction of nonnative species, can alter natural systems. These practices affect many cycles and processes including decomposition, soil formation, erosion, and food webs, thereby changing the balance within an ecosystem, the stability of the web of life, and the overall health of the ecosystem. (EP&Cs: III.a.; III.c.) (DCI: LS2.A) (PE: 5-LS2-1)*
- *The byproducts of human activity are not readily prevented from entering natural systems, and can alter cycles as matter moves between the air and soil and among plants, animals, and microbes. (EP&C: IV.b.) (DCI: LS2.B) (PE: 5-LS2-1)*
- *Humans depend on and benefit from the cycles and processes that occur as Earth’s major natural systems (biosphere, hydrosphere, atmosphere, and geosphere) interact through water, carbon, and nitrogen cycles, and processes like decomposition, and erosion. (EP&Cs: III.a.; III.b.) (DCI: ESS2.A) (PE: 5-ESS2-1)*
- *Human activities and practices can influence the cycles and processes that occur in Earth’s major natural systems (e.g., changes to the atmosphere resulting from burning fossil fuels and sending heat-trapping gases into the atmosphere). (EP&C: III.c.) (DCI: ESS2.A) (PE: 5-ESS2-1)*
- *The effects of human activities (agriculture, industry, and everyday life) on natural systems can vary depending on the ways resources are obtained and consumed. These activities can have major effects such as, altering water quality and quantity in streams; releasing pollutants into the air; and, removing native vegetation. (EP&C: II.a.; II.b.) (DCI: ESS3.C) (PE: 5-ESS3-1)*
- *The expansion of human communities due to population growth, can result in the destruction of natural habitats, changes to the numbers and kinds of organisms living in an area (biological diversity), and the viability of ecosystems. (EP&C: II.c.) (DCI: ESS3.C) (PE: 5-ESS3-1)*
- *Individuals and communities are making decisions to do things that help protect Earth’s resources and natural systems, as well as the organisms that depend on those systems for survival. (EP&C: V.a.) (DCI: ESS3.C) (PE: 5-ESS3-1)*
- *The energy released from food is essential to human life and to the functioning of our economies and cultures, as are many other ecosystem goods and services from natural systems. (EP&Cs: I.a.; I.b.) (DCI: PS3.D) (PE: 5-PS3-1)*
- *Research on a problem should be carried out before designing a solution including determining potential impacts on natural systems. Testing of design solutions should investigate potential impacts on natural systems. (EP&C: V.a.) (DCI: ETS1.B) (PE: 3-5-ETS1-2)*
- *Different solutions need to be tested in order to determine which of them best solves the problem, given criteria which take into account potential impacts on natural systems. (EP&C: V.a.) (DCI: ETS1.C) (PE: 3-5-ETS1-3)*
- *Communications about proposed solutions should address potential impacts on natural systems. (EP&C V.a.) (DCI: ETS1.B) (PE: 3-5-ETS1-2)*

Source Material from 2016 California Science Framework Appendix 2

LS1 From Molecules to Organisms: Structures and Processes

Disciplinary Core Ideas

As students learn that:

LS1.C: Organization for Matter and Energy Flow in Organisms “Plants acquire their material for growth chiefly from air and water. (5-LS1-1)”

Environmental Principle and Concept(s)

Students should be developing an understanding:

Principle IV Concept a: “that the effects of human activities on natural systems are directly related to the quantities of resources consumed and to the quantity and characteristics of the resulting byproducts.” (LS1.C)

LS2 Ecosystems: Interactions, Energy, and Dynamics

Disciplinary Core Ideas

As students learn that:

LS2.A: Interdependent Relationships in Ecosystems “The food of almost any kind of animal can be traced back to plants; organisms are related in 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 (both plants or plants parts and animals) and therefore operate as ‘decomposers;’ decomposition eventually restores (recycles) some materials back to the soil; organisms can survive only in environments in which their particular 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. (5-LS2-1)”

LS2.B: Cycles of Matter and Energy Transfer in Ecosystems “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. (5-LS2-1)”

Environmental Principle and Concept(s)

Students should be developing an understanding:

Principle IV Concept a: “that the effects of human activities on natural systems are directly related to the quantities of resources consumed and to the quantity and characteristics of the resulting byproducts.” (LS2.A; LS2.B)

Principle IV Concept b: “that the byproducts of human activity are not readily prevented from entering natural systems and may be beneficial, neutral, or detrimental in their effect.” (LS2.A; LS2.B)

Principle III Concept a: “that natural systems proceed through cycles and processes that are required for their functioning; and that human practices can alter the cycles and processes that operate within natural systems.” (LS2.A; LS2.B)

Principle III Concept c: “that human practices can alter the cycles and processes that operate within natural systems.” (LS2.A; LS2.B)

ESS2 Earth's Systems

Disciplinary Core Ideas

As students discover that:

ESS2.A: Earth Materials and Systems “Earth’s major systems are the geosphere, the hydrosphere, the atmosphere, and the biosphere,” “these systems interact in multiple ways to affect Earth’s surface materials and processes,” “the ocean supports a variety of ecosystems and organisms, shapes: landforms, and influences climate,” and that “winds and clouds in the atmosphere interact with the landforms to determine patterns of weather. (5-ESS2-1)”

Environmental Principle and Concept(s)

Students should be developing an understanding of:

Principle III Concept a: “natural systems proceed through cycles and processes that are required for their functioning.” (ESS2.A)

Principle III Concept b: “human practices depend upon and benefit from the cycles and processes that operate within natural systems.”

Principle III Concept c: “human practices can alter the cycles and processes that operate within natural systems.” (ESS2.A)

ESS3 Earth and Human Activity

Disciplinary Core Ideas

As students discover that:

ESS3.C: Human Impacts on Earth Systems “Human activities in agriculture, industry, and everyday life have had major effects on the land, vegetation, streams, ocean, air, and even outer space, but individuals and communities are doing things to help protect Earth’s resources and environments. (5-ESS3-1)”

Environmental Principle and Concept(s)

Students should be developing an understanding of:

Principle II Concept a: “that direct and indirect changes to natural systems due to the growth of human populations and their consumption rates influence the geographic extent, composition, biological diversity, and viability of natural systems.” (ESS3.C)

Principle II Concept b: “that methods used to extract, harvest, transport and consume natural resources influence the geographic extent, composition, biological diversity, and viability of natural systems.” (ESS3.C)

Principle II Concept c: “that the expansion and operation of human communities influences the geographic extent, composition, biological diversity, and viability of natural systems.” (ESS3.C)

PS3 Energy

Disciplinary Core Ideas

As students discover that:

PS3.D: Energy in Chemical Processes and Everyday Life “The energy released [from] food was once energy from the sun that was captured by plants in the chemical process that forms plant matter (from air and water). (5-PS3-1)”

Secondary DCI(s)

LS1.C: Organization for Matter and Energy Flow in Organisms “Food provides animals with the materials they need for body repair and growth and the energy they need to maintain body warmth and for motion. (secondary to 5-PS3-1)”

Environmental Principle and Concept(s)

Students should be developing an understanding of:

Principle II Concept a: “that direct and indirect changes to natural systems due to the growth of human populations and their consumption rates influence the geographic extent, composition, biological diversity, and viability of natural systems.” (PS3.D)

Principle I Concept a: “the goods produced by natural systems are essential to human life and to the functioning of our economies and cultures.” (PS3.D)

Principle I Concept b: “the ecosystem services provided by natural systems are essential to human life and to the functioning of our economies and cultures.” (PS3.D)

3-5 Engineering Design

Disciplinary Core Ideas

As students discover that:

ETS1.C: Optimizing the Design Solution “Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints. (3-5-ETS1-3)”

ETS1.B: Developing Possible Solutions “Research on a problem should be carried out before beginning to design a solution. Testing a solution involves investigating how well it performs under a range of likely conditions. (3-5-ETS1-2)”

ETS1.B “At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs. (3-5-ETS1-2)”

Environmental Principle and Concept(s)

Students should be developing an understanding of:

Principle V Concept a: “the spectrum of what is considered in making decisions about resources and natural systems and how those factors influence decisions.” (ETS1.C; ETS1.B)

Middle School Science Scope and Sequence

Life Sciences Learning Outcomes

Detailed Examples of Learning Outcomes Connecting EP&Cs–DCIs–PEs

- *The expansion of human communities due to population growth can influence the characteristic behaviors of animals (e.g., a species may see a decrease in the odds successful reproduction if nesting and migration patterns are affected). (EP&C: II.c.) (DCI: LS1.B) (PE: MS-LS1-4)*
- *The byproducts of human activity are not readily prevented from entering natural systems and causing changes to local conditions that affect the growth of plants, resulting from the introduction chemicals, waste products, or other materials. (EP&C: IV.b.) (DCI: LS1.B) (PE: MS-LS1-5)*
- *Human practices (e.g., methods used to extract, harvest, transport and consume natural resources) and the legal, economic and political systems that govern them influence the geographic extent, composition, biological diversity, and viability of natural systems. This causes direct changes to the organisms and populations of organisms that live there, including their environmental interactions with both other living things and with nonliving factors. (EP&C: II.b.; II.d.) (DCI: LS2.A) (PE: MS-LS2-1)*
- *Humans depend on and benefit from the cycles and processes associated with the repeated cycling of matter between living and nonliving parts of ecosystems. (EP&Cs: III.b.; III.a.) (DCI: LS2.B) (PE: MS-LS2-3)*
- *Human activities and practices can alter the cycles and processes in natural systems, disrupting physical and biological components of ecosystems, and causing shifts in populations of organisms. (EP&C: III.c.) (DCI: LS2.C) (PE: MS-LS2-4)*
- *Human activities cause direct and indirect changes to environmental conditions in natural systems. (EP&C: II.c.) (DCIs: LS4.C; LS4.B) (PEs: MS-L4-6; MS-LS4-4)*
- *Human-caused changes to environmental conditions in natural systems occur at rates that can cause species to die or move away, rather than allowing multiple generations during which a population might otherwise adapt to the changing conditions. (EP&C: II.c.) (DCIs: LS4.C; LS4.B) (PEs: MS-L4-6; MS-LS4-4)*

Source Material from 2016 California Science Framework Appendix 2

LS1 From Molecules to Organisms: Structures and Processes

Disciplinary Core Ideas

As students learn that:

LS1.B: Growth and Development of Organisms “Animals engage in characteristic behaviors that increase the odds of reproduction. (MS-LS1-4)”

LS1.B: “Genetic factors as well as local conditions affect the growth of the adult plant. (MS-LS1-5)”

Environmental Principle and Concept(s)

Students should be developing an understanding:

Principle II Concept c: “that the expansion and operation of human communities influences the geographic extent, composition, biological diversity, and viability of natural systems.” (LS1.B)

Principle IV Concept b: “that the byproducts of human activity are not readily prevented from entering natural systems and may be beneficial, neutral, or detrimental in their effect.” (LS1.B)

LS2 Ecosystems: Interactions, Energy, and Dynamics

Disciplinary Core Ideas

As students learn that:

LS2.A: Interdependent Relationships in Ecosystems “Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors. (MS-LS2-1) ***Supplemental DCI PS1.B”

LS2.B: Cycle of Matter and Energy Transfer in Ecosystems “... Transfers of matter into and out of the physical environment occur at every level... The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem. (MS-LS2-3) ***Supplemental DCI PS1.B, ESS2.A”

LS2.C: Ecosystem Dynamics, Functioning, and Resilience “... Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations. (MS-LS2-4)”

Secondary DCI(s)

LS4.D: Biodiversity and Humans “Changes in biodiversity can influence humans’ resources, such as food, energy, and medicines, as well as ecosystem services that humans rely on—for example, water purification and recycling. (secondary to MS-LS2-5)”

ETS1.B: Developing Possible Solutions “There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (secondary to MS-LS2-5)”

Environmental Principle and Concept(s)

Students should be developing an understanding:

Principle I Concept c: “that the quality, quantity and reliability of the goods and ecosystem services provided by natural systems are directly affected by the health of those systems.” (LS4.D)

Principle II Concept b: “that methods used to extract, harvest, transport and consume natural resources influence the geographic extent, composition, biological diversity, and viability of natural systems.” (LS2.A)

Principle II Concept d: “that the legal, economic and political systems that govern the use and management of natural systems directly influence the geographic extent, composition, biological diversity, and viability of natural systems.” (LS2.A)

Principle III Concept a: “natural systems proceed through cycles and processes that are required for their functioning.” (LS2.B and LS2.C)

Principle III Concept b: “human practices depend upon and benefit from the cycles and processes that operate within natural systems.” (LS2.B)

Principle III Concept c: “human practices can alter the cycles and processes that operate within natural systems.” (LS2.B)

Principle IV Concept c: “that the capacity of natural systems to adjust to human-caused alterations depends on the nature of the system as well as the scope, scale, and duration of the activity and the nature of its byproducts.” (LS2.C)

Principle V Concept a: “the spectrum of what is considered in making decisions about resources and natural systems and how those factors influence decisions.” (ETS1.B)

LS4 Biological Evolution: Unity and Diversity

Disciplinary Core Ideas

As students learn that:

LS4.C: Adaptation “Adaptation by natural selection acting over generations is one important process by which species change over time in response to changes in environmental conditions. Traits that support successful survival and reproduction in the new environment become more common; those that do not become less common. Thus, the distribution of traits in a population changes. (MS-LS4-6)”

LS4.B: Natural Selection “Natural selection leads to the predominance of certain traits in a population, and the suppression of others. (MS-LS4-4)”

Environmental Principle and Concept(s)

Students should be developing an understanding:

Principle II Concept a: “direct and indirect changes to natural systems due to the growth of human populations and their consumption rates influence the geographic extent, composition, biological diversity, and viability of natural systems.” (LS4.C; LS4.B)

Principle II Concept c: “the expansion and operation of human communities influences the geographic extent, composition, biological diversity, and viability of natural systems.” (LS4.C; LS4.B)

Earth and Space Sciences Learning Outcomes

Detailed Examples of Learning Outcomes Connecting EP&Cs–DCIs–PEs

- *Human lives, communities, and societies, and activities (e.g., agriculture, fisheries, and industry) depend on and benefit from water as it continually cycles among land, ocean, and atmosphere. (EP&Cs: III.b.; III.a; I.a.; I.b.; I.c.) (DCI: ESS2.C) (PEs: MS-ESS2-4)*
- *Human practices (e.g., building dams and reservoirs, and increasing the quantity of impervious surfaces through urbanization) and the legal, economic and political systems that govern them influence can alter the complex patterns of water movement among Earth’s major natural systems (biosphere, hydrosphere, atmosphere, and geosphere). (EP&C: III.c.; II.b.) (DCI: ESS2.C) (PE: MS-ESS2-5)*
- *The quality, quantity, and reliability of the ecosystem goods and services humans obtain from Earth’s land, ocean, atmosphere, and biosphere are directly affected by the health of those natural systems. (EP&C: I.c.) (DCI: ESS3.A) (PE: MS-ESS3-1)*
- *The health, viability, and biological diversity of natural systems on which humans depend are directly affected by human population growth, human activities, and per-capita consumption of ecosystem goods and services, as well as the operation of human communities. (EP&Cs: II.c.; I.c.) (DCI: ESS3.C; LS4.D) (PEs: MS-ESS3-4; MS-LS2-5)*

Source Material from 2016 California Science Framework Appendix 2

ESS2 Earth's Systems

Disciplinary Core Ideas

As students learn that:

ESS2.C: The Roles of Water in Earth's Surface Processes "Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, and precipitation, as well as downhill flows on land. (MS-ESS2-4) ***Supplemental DCI PS1.A"

ESS2.C: "The complex patterns of the changes and the movement of water in the atmosphere, determined by winds, landforms, and ocean temperatures and currents, are major determinants of local weather patterns. (MS-ESS2-5)"

ESS2.C: "Global movements of water and its changes in form are propelled by sunlight and gravity. (MS-ESS2-4)"

Environmental Principle and Concept(s)

Students should be developing an understanding:

Principle III Concept a: "that natural systems proceed through cycles and processes that are required for their functioning." (ESS2.C)

Principle III Concept b: "that human practices depend upon and benefit from the cycles and processes that operate within natural systems." (ESS2.C)

Principle III Concept c: "that human practices can alter the cycles and processes that operate within natural systems." (ESS2.C)

Principle II Concept d: "that the legal, economic and political systems that govern the use and management of natural systems directly influence the geographic extent, composition, biological diversity, and viability of natural systems." (ESS2.C)

ESS3 Earth and Human Activity

Disciplinary Core Ideas

As students learn that:

ESS3.A: Natural Resources "Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources; minerals, fresh water, and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes; and that these resources are distributed unevenly around the planet as a result of past geologic processes. (MS-ESS3-1)"

ESS3.C: Human Impacts on Earth Systems "Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise. (MS-ESS3-4)"

ESS3.B: Natural Hazards "Mapping the history of natural hazards in a region, combined with an understanding of related geologic forces can help forecast the locations and likelihoods of future events. (MS-ESS3-2)"

Environmental Principle and Concept(s)

Students should be developing an understanding:

Principle I Concept c: "that the quality, quantity and reliability of the goods and ecosystem services provided by natural systems are directly affected by the health of those systems." (ESS3.A and ESS3.B)

Principle II Concept c: "that the expansion and operation of human communities influences the geographic extent, composition, biological diversity, and viability of natural systems." (ESS3.C)

Physical Sciences Learning Outcomes

Detailed Examples of Learning Outcomes Connecting EP&Cs–DCIs–PEs

- *Some chemical reactions produce new substances that have different properties from the original substances (e.g., greater toxicity) which, when they enter natural systems, can affect plants and animals (including humans). (EP&C: II.b.) (DCI: PS1.B) (PE: MS-PS1-3)*
- *The heat produced as a byproduct of many human activities (e.g., energy production, manufacturing) causes changes to terrestrial, freshwater, coastal, and marine ecosystems, influencing the ecosystems' long-term functioning and the survival of the organisms that depend on them. (EP&Cs: IV.a.; IV.c.) (DCI: PS3.B) (PE: MS-PS3-4; MS-PS3-5)*

Source Material from 2016 California Science Framework Appendix 2

PS1 Matter and its Interactions

Disciplinary Core Ideas

As students learn that:

PS1.B: Chemical Reactions Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. (MS-PS1-3)

***Supplemental DCI ESS3.C, LS4.D**

Environmental Principle and Concept(s)

Students should be developing an understanding:

Principle II Concept b: “that methods used to extract, harvest, transport and consume natural resources influence the geographic extent, composition, biological diversity, and viability of natural systems.” (PS1.B)

PS3 Energy

Disciplinary Core Ideas

As students learn that:

PS3.B: Conservation of Energy and Energy Transfer “the amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the environment. (MS-PS3-4)”

PS3.B: “when the motion energy of an object changes, there is inevitably some other change in energy at the same time. (MS-PS3–5)”

Secondary DCI(s)

ETS1.A: Defining and Delimiting an Engineering Problem “The more precisely a design task’s criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that is likely to limit possible solutions. (secondary to MS-PS3-3)”

Environmental Principle and Concept(s)

Students should be developing an understanding:

Principle IV Concept a: “that the effects of human activities on natural systems are directly related to the quantities of resources consumed and to the quantity and characteristics of the resulting byproducts.” (PS3.B)

Principle IV Concept c: “that the capacity of natural systems to adjust to human-caused alterations depends on the nature of the system as well as the scope, scale, and duration of the activity and the nature of its byproducts.” (PS3.B)

Engineering Design Learning Outcomes

Detailed Examples of Learning Outcomes Connecting EP&Cs–DCIs–PEs

- *Systematic processes for evaluating possible solutions, and the legal, economic and political systems that govern them, should consider criteria for success and project constraints that account for potential impacts on natural systems. (EP&C: V.a.) (DCI: ETS1.B) (PE: MS-ETS1-2)*

Source Material from 2016 California Science Framework Appendix 2

MS-ETS1 Engineering Design

Disciplinary Core Ideas

As students discover that:

ETS1.B: Developing Possible Solutions “There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (MS-ETS1-3)”

Environmental Principle and Concept(s)

Students should be developing an understanding of:

Principle V Concept a: “the spectrum of what is considered in making decisions about resources and natural systems and how those factors influence decisions.” (ETS1.B)

Principle II Concept d: “that the legal, economic and political systems that govern the use and management of natural systems directly influence the geographic extent, composition, biological diversity, and viability of natural systems.” (ETS1.B)

High School Science Scope and Sequence

Life Sciences Learning Outcomes

Detailed Examples of Learning Outcomes Connecting EP&Cs–DCIs–PEs

- *The growth of human populations and their consumption of living and nonliving resources influence the carrying capacities of ecosystems as well as their geographic extent, composition, biological diversity, and viability, thus influencing the abundance of species. (EP&C: II.a.) (DCI: LS2.A) (PEs: HS-LS2-1; HS-LS2-2)*
- *Anthropogenic changes, including habitat destruction, pollution, invasive species, overexploitation, and climate change, result from extracting, harvesting, transporting and consuming natural resources, and are directly related to the quantities of resources consumed by humans. These activities directly disrupt ecosystems and, over time, their byproducts enter natural systems thereby influencing the functioning and geographic extent, composition, biological diversity, and viability of ecosystems and threatening the survival of some species. (EP&Cs: II.b.; II.c.; IV.a.; IV.b.) (DCI: LS2.C) (PEs: HS-LS2-2; HS-LS2-6; HS-LS2-7)*
- *The scale and scope of anthropogenic changes, including pollution, waste management, and habitat destruction, are directly influenced by the legal, economic and political systems that govern them influence the functioning and geographic extent, composition, biological diversity, and viability of ecosystems and threatening the survival of some species. (EP&Cs: II.d.) (DCI: LS2.C) (PEs: HS-LS2-2; HS-LS2-6; HS-LS2-7)*
- *The byproducts of human activity that result from the expansion and operation of human communities and the use of natural resources, such as pollution and waste products, are not readily prevented from entering natural systems and, depending on the scope, scale, and duration of the activities, can affect the expression of traits and the probability of occurrences of traits in a population. (EP&Cs: IV.b.; IV.c.; III.a; III.c.) (DCI: LS3.B) (PE: HS-LS3-2)*
- *Direct and indirect changes to natural systems due to the growth of human populations and their consumption rates have 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. Species become extinct because they can no longer survive and reproduce in their altered environment. (EP&C: II.a.) (DCI: LS4.C) (PE: HS-LS4-5; HS-LS4-6; HS-LS2-7)*
- *Human activities are having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Therefore, the spectrum of what is considered in making decisions about natural systems and resources, and how those factors influence decisions, should take into account both sustaining biodiversity and ecosystem function, as well as human dependence on the living world for the resources and other benefits provided by biodiversity. (EP&Cs: V.a.; II.a.; II.b.; II.c.; I.a.; I.b; I.c.) (DCI: LS4.D) (PE: HS-LS4-6; HS-LS2-7)*

Source Material from 2016 California Science Framework Appendix 2

HS-LS2 Ecosystems: Interactions, Energy, and Dynamics

Disciplinary Core Ideas

As students learn that:

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.”

LS2.A: “Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are finite. This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem. (HS-LS2-1),(HS-LS2-2)”

LS2.C: Ecosystem Dynamics, Functioning, and Resilience “... Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability. (HS-LS2-2), (HS-LS2-6)”

LS2.C: “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. (HS-LS2-7)”

Secondary DCI(s)

LS4.D: Biodiversity and Humans “Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction). (secondary to HS-LS2-7)”

LS4.D: “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.(secondary to HS-LS2-7) (Note: This Disciplinary Core Idea is also addressed by HS-LS4-6.)”

PS3.D: Energy in Chemical Processes “The main way that solar energy is captured and stored on Earth is through the complex chemical process known as photosynthesis. (secondary to HS-LS2-5)”

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. (secondary to HS-LS2-7)”

Environmental Principle and Concept(s)

Students should be developing an understanding:

Principle II Concept a: “that direct and indirect changes to natural systems due to the growth of human populations and their consumption rates influence the geographic extent, composition, biological diversity, and viability of natural systems.” (LS2.A; LS2.C; LS4.D)

Principle II Concept b: “that methods used to extract, harvest, transport and consume natural resources influence the geographic extent, composition, biological diversity, and viability of natural systems.” (LS2.C)

Principle II Concept c: “that the expansion and operation of human communities influences the geographic extent, composition, biological diversity, and viability of natural systems.” (LS2.C; LS4.D)

Principle II Concept d: “that the legal, economic and political systems that govern the use and management of natural systems directly influence the geographic extent, composition, biological diversity, and viability of natural systems.” (LS2.C; LS4.D)

Principle IV Concept a: “that the effects of human activities on natural systems are directly related to the quantities of resources consumed and to the quantity and characteristics of the resulting byproducts.” (LS2.C; LS4.D)

Principle IV Concept b: “that the byproducts of human activity are not readily prevented from entering natural systems and may be beneficial, neutral, or detrimental in their effect.” (LS2.C; LS4.D)

Principle IV Concept c: “that the capacity of natural systems to adjust to human-caused alterations depends on the nature of the system as well as the scope, scale, and duration of the activity and the nature of its byproducts.” (LS2.C; LS4.D)

HS-LS3 Heredity: Inheritance and Variation of Traits

Disciplinary Core Ideas

As students learn that:

LS3.B: Variation of Traits “Environmental factors can also cause mutations in genes, and viable mutations are inherited.” (HS-LS3-2)

LS3.B: “environmental factors also affect expression of traits, and hence affect the probability of occurrences of traits in a population, thus the variation and distribution of traits observed depends on both genetic and environmental factors. (HS-LS3-2)”

Environmental Principle and Concept(s)

Students should be developing an understanding:

Principle III Concept a: “that natural systems proceed through cycles and processes that are required for their functioning.” (LS3.B)

Principle III Concept c: “that human practices can alter the cycles and processes that operate within natural systems.” (LS3.B)

Principle IV Concept b: “that the byproducts of human activity are not readily prevented from entering natural systems and may be beneficial, neutral, or detrimental in their effect.” (LS3.B)

Principle IV Concept c: “that the capacity of natural systems to adjust to human-caused alterations depends on the nature of the system as well as the scope, scale, and duration of the activity and the nature of its byproducts.” (LS3.B)

HS-LS4 Biological Evolution: Unity and Diversity

Disciplinary Core Ideas

As students learn that:

LS4.C “Evolution is a consequence of the interaction of four factors: (1) the potential for a species to increase in number, (2) the genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for an environment’s limited supply of the resources that individuals need in order to survive and reproduce, and (4) the ensuing proliferation of those organisms that are better able to survive and reproduce in that environment. (HS-LS4-2)”

LS4.C “Adaptation also means that the distribution of traits in a population can change when conditions change. (HS-LS4-3)”

LS4.C “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. (HS-LS4-5), (HS-LS4-6)”

LS4.C “Species become extinct because they can no longer survive and reproduce in their altered environment. If members cannot adjust to change that is too fast or drastic, the opportunity for the species’ evolution is lost. (HS-LS4-5)”

LS4.D “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. (HS-LS4-6) (Note: This Disciplinary Core Idea is also addressed by HS-LS2-7.)”

Environmental Principle and Concept(s)

Students should be developing an understanding that:

Principle II Concept a: “direct and indirect changes to natural systems due to the growth of human populations and their consumption rates influence the geographic extent, composition, biological diversity, and viability of natural systems.” (LS4.C; LS4.D)

Principle II Concept b: “methods used to extract, harvest, transport and consume natural resources influence the geographic extent, composition, biological diversity, and viability of natural systems.” (LS4.C; LS4.D)

Principle II Concept c: “the expansion and operation of human communities influences the geographic extent, composition, biological diversity, and viability of natural systems.” (LS4.C; LS4.D)

Principle I Concept a: “the goods produced by natural systems are essential to human life and to the functioning of our economies and cultures.” (LS4.C; LS4.D)

Principle I Concept b: “the ecosystem services provided by natural systems are essential to human life and to the functioning of our economies and cultures.” (LS4.C; LS4.D)

Principle I Concept c: “the quality, quantity and reliability of the goods and ecosystem services provided by natural systems are directly affected by the health of those systems.” (LS4.C; LS4.D)

Principle V Concept a: “the spectrum of what is considered in making decisions about resources and natural systems and how those factors influence decisions.” (LS4.C; LS4.D)

Earth and Space Sciences Learning Outcomes

Detailed Examples of Learning Outcomes Connecting EP&Cs–DCIs–PEs

- *Human activities and practices depend upon, benefit from, and can alter the cycles and processes that operate within natural systems, causing changes in the atmosphere that increase carbon dioxide concentrations and thus affect the global climate. (EP&Cs: III.b.; III.c.) (DCI: ESS2.D) (PEs: HS-ESS2-4; HS-ESS2-6)*
- *The byproducts of human activity are not readily prevented from entering natural systems and can result in changes like increased carbon dioxide concentrations which can affect the global climate. The capacity of the atmosphere and other natural systems to adjust to human-caused alterations depends on the scope, scale, and duration of the activity and the nature of the associated byproducts. (EP&Cs: IV.b.; IV.c.; III.a.) (DCI: ESS2.D) (PEs: HS-ESS2-6; HS-ESS2-4)*
- *Human practices, including the methods used to extract, harvest, transport and consume natural resources alter the cycles and processes that operate within natural systems, thereby influencing the geographic extent, composition, biological diversity, health, viability, and functioning of natural systems, directly and indirectly influencing the quality, quantity, and reliability of ecosystem goods and ecosystem services available from natural systems. (EP&Cs: II.b.; III.c.; I.c.) (DCI: ESS3.A) (PE: HS-ESS3-1; HS-ESS3-2)*
- *The size and growth of human populations, their consumption rates, and their migrations are directly affected by natural hazards and geologic events, and indirectly influenced by the effects of those hazards and events on the health and functioning of natural systems which consequently influence the availability and reliability of the ecosystem goods and ecosystem services they provide. (EP&Cs: II.a.; I.c.) (DCI: ESS3.B) (PE: HS-ESS3-1)*
- *The sustainability of human societies and the biodiversity that supports them requires responsible management based on decisions about natural systems that take into account the effects of those decisions on the health and functioning of natural systems, as well as the spectrum of social, economic, political, and other factors that influence both the natural systems and the human social systems on which they depend. (EP&Cs: I.c.; II.d.; V.a.; V.b.) (DCI: ESS3.C) (PE: HS-ESS3-3; HS-ESS3-4)*
- *The sustainability of human societies and the biodiversity that supports them is affected by the byproducts of human activity which are not readily prevented from entering natural systems and may be beneficial, neutral, or detrimental in their effect. (EP&Cs: IV.b.; IV.c.) (DCI: ESS3.C) (PE: HS-ESS3-3; HS-ESS3-4)*
- *The scope, scale, and duration of human activities, and the nature of resulting byproducts, influences the capacity of natural systems to adjust to human-caused alterations and directly influences biodiversity and the sustainability of human societies. (EP&Cs: IV.b.; IV.c.) (DCI: ESS3.C) (PE: HS-ESS3-3; HS-ESS3-4)*
- *Scientists and engineers can develop technologies that produce less pollution and waste, and diminish ecosystem degradation. Those solutions are, however, only likely to be implemented if the effects of pollution, waste, and ecosystem degradation are taken into account during decision-making processes, like social, economic, and political factors. (EP&Cs: I.c.; V.a.; V.b.) (DCI: ESS3.C; ETS1.B) (PE: HS-ESS3-3; HS-ESS3-4; HS-ETS1-3)*

Source Material from 2016 California Science Framework Appendix 2

HS-ESS2 Earth's Systems

Disciplinary Core Ideas

As students learn that:

ESS2.A: Earth Materials and Systems “Earth’s systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. (HS-ESS2-2)”

ESS2.A: “The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun’s energy output or Earth’s orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities. (HS-ESS2-4)”

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. (HS-ESS2-5)”

ESS2.D: Weather and Climate “Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. (HS-ESS2-6)”

ESS2.D: “Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate. (HS-ESS2-6) (HS-ESS2-4)”

Secondary DCI(s)

ESS1.B: Earth and the Solar System “Cyclical changes in the shape of Earth’s orbit around the sun, together with changes in the tilt of the planet’s axis of rotation, both occurring over hundreds of thousands of years, have altered the intensity and distribution of sunlight falling on the earth. These phenomena cause a cycle of ice ages and other gradual climate changes. (secondary to HS-ESS2-4)”

Environmental Principle and Concept(s)

Students should be developing an understanding:

Principle III Concept a: “that natural systems proceed through cycles and processes that are required for their functioning.” (ESS2.A; ESS2.C; ESS2.D)

Principle III Concept b: “that human practices depend upon and benefit from the cycles and processes that operate within natural systems.” (ESS2.D)

Principle III Concept c: “that human practices can alter the cycles and processes that operate within natural systems.” (ESS2.D)

Principle IV Concept b: “that the byproducts of human activity are not readily prevented from entering natural systems and may be beneficial, neutral, or detrimental in their effect.” (ESS2.D)

Principle IV Concept c: “that the capacity of natural systems to adjust to human-caused alterations depends on the nature of the system as well as the scope, scale, and duration of the activity and the nature of its byproducts.” (ESS2.D)

HS-ESS3 Earth and Human Activity

Disciplinary Core Ideas

As they learn that:

ESS3.A: Natural Resources “Resource availability has guided the development of human society. (HS-ESS3-1)”

“All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors. (HS-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. (HS-ESS3-1)”

ESS3.C: Human Impacts on Earth Systems “The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources. (HS-ESS3-3)”

“Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation. (HS-ESS3-4)”

Secondary DCI(s)

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. (secondary to HS-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. (secondary to HS-ESS3-2), (secondary HS-ESS3-4)"

Environmental Principle and Concept(s)

Students should be developing an understanding:

Principle I Concept c: "that the quality, quantity and reliability of the goods and ecosystem services provided by natural systems are directly affected by the health of those systems." (ESS3.A)

Principle II Concept a: "that direct and indirect changes to natural systems due to the growth of human populations and their consumption rates influence the geographic extent, composition, biological diversity, and viability of natural systems." (ESS3.C)

Principle II Concept b: "that methods used to extract, harvest, transport and consume natural resources influence the geographic extent, composition, biological diversity, and viability of natural systems." (ESS3.C)

Principle II Concept d: "that the legal, economic and political systems that govern the use and management of natural systems directly influence the geographic extent, composition, biological diversity, and viability of natural systems." (ESS3.C)

Principle III Concept c: "that human practices can alter the cycles and processes that operate within natural systems." (ESS3.C)

Principle IV Concept b: "that the byproducts of human activity are not readily prevented from entering natural systems and may be beneficial, neutral, or detrimental in their effect." (ESS3.C)

Principle IV Concept c: "that the capacity of natural systems to adjust to human-caused alterations depends on the nature of the system as well as the scope, scale, and duration of the activity and the nature of its byproducts." (ESS3.C)

Principle V Concept a: "the spectrum of what is considered in making decisions about resources and natural systems and how those factors influence decisions." (ESS3.C)

Principle V Concept b: "the process of making decisions about resources and natural systems, and how the assessment of social, economic, political, and environmental factors has changed over time." (ESS3.C)

Physical Sciences—Chemistry and Physics

In the 2016 California Science Framework, within both the three -and four-course models, there are several examples of how California’s Environmental Principles and Concepts can be reinforced when teaching Chemistry and Physics. The descriptions of a few of the instructional segments also identify potential connections to specific environmental principles.

Since these disciplines and connections were not incorporated into Appendix 2 of the Framework they are not included here.

Engineering Design Learning Outcomes

Detailed Examples of Learning Outcomes Connecting EP&Cs–DCIs–PEs

- *Established criteria and constraints should take into account potential impacts on natural systems and should be quantified to the extent possible and stated in such a way that one can tell if a given design meets minimizes those impacts. (EP&C: V.a.) (DCI: ETS1.A) (PE: HS-ETS1-1)*
- *Global challenges may have manifestations on natural systems and resources, social, economic, and political conditions in local communities, therefore engineering design solutions should take into account the full spectrum of these factors when evaluating and engineering design solutions. (EP&C: V.a.; II.d.) (DCI: ETS1.A; ETS1.B) (PE: HS-ETS1-1)*
- *Decisions about the priority of certain criteria over others (trade-offs) should assess social, economic, and political factors, with particular emphasis on environmental factors that can influence the long-term functioning of affected ecosystems and the survival of the organisms that depend on them. (EP&Cs: V.b.; V.a.; II.d.) (DCI: ETS1.C; ETS1.B) (PE: HS-ETS1-2; HS-ETS1-3)*

Source Material from 2016 California Science Framework Appendix 2

HS-ETS1 Engineering Design

Disciplinary Core Ideas

As students recognize that:

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. (HS-ETS1-1)

ETS1.A: 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. (HS-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. (HS-ETS1-3)”

ETS1.B: “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. (HS-ETS1-3)”

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. (HS-ETS1-2)”

Environmental Principle and Concept(s)

Students should be developing an understanding that:

Principle V Concept a: “the spectrum of what is considered in making decisions about resources and natural systems and how those factors influence decisions.” (ETS1.A; ETS1.B)

Principle V Concept b: “the process of making decisions about resources and natural systems, and how the assessment of social, economic, political, and environmental factors has changed over time.” (ETS1.A; ETS1.B)

Principle II Concept d: “that the legal, economic and political systems that govern the use and management of natural systems directly influence the geographic extent, composition, biological diversity, and viability of natural systems.” (ETS1.A; ETS1.B)