# California Grade 4
# EP&Cs Exemplar Lesson Series

## 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 how California's Environmental Principles and Concepts (EP&Cs) can be integrated into California NGSS Instructional Materials

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# Contents

# Introduction—Category 1 Requirements

This document provides an exemplar lesson series for publishers that demonstrates how one might create instructional materials that meet California's rigorous requirements for science instructional materials. 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 document provides a model intended 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.

The exemplar lesson series presented conforms with the three "Instructional Strategies for Sequencing Lessons" identified in the CA Science Framework: the 5E Instructional Cycle, Problem-Based Learning, and Outdoor and Environmental Learning Experiences. Detailed descriptions of these three strategies are included in California's *2016 Science Framework* in Chapter 11: Instructional Strategies for CA NGSS Teaching and Learning in the Twenty-first Century.

## *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

| | |
|---|---|
| **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. | |
| **Concept a.** | The goods produced by natural systems are essential to human life and to the functioning of our economies and cultures. |
| **Concept b.** | The ecosystem services provided by natural systems are essential to human life and to the functioning of our economies and cultures. |
| **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. |

**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.

The glossary presented in Appendix A provides an introduction to key words and terms that are essential to understanding these Environmental Principles and Concepts.

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.

## Table 2: Examples of Instructional Connections Between the EP&Cs and the CA NGSS

| EP&C | CA NGSS |
|---|---|
| **Principle I**<br>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. | LS4.D: Biodiversity and Humans<br>"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." |
| **Principle V**<br>Decisions affecting resources and natural systems are based on a wide range of considerations and decision-making processes. | ETS1.B Developing Possible Solutions<br>"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." |

## *Instructional Focus of this Exemplar*

This Exemplar specifically relates to the Grade 4 three-dimensional content within:

- **4-LS1: From Molecules to Organisms: Structures and Processes**
  - 4-LS1-1: Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.
- **3–5-ETS1: Engineering Design**
  - 3–5-ETS1-1: Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

From the perspective of the Category 1 requirement for incorporating the EP&Cs into California instructional materials, as exemplified in Appendix 2 of the *2016 Science Framework*, instruction needs to go beyond the "basics" of the three-dimensional content encompassed in Performance Expectation 4-LS1-1. High quality instructional materials should also address these concepts:

1. Plants and animals live in natural systems where they obtain all the resources required for their growth, survival, behavior, and reproduction.
2. The interactions and interdependence of the components of natural systems and their interactions with human social systems can affect the availability of the resources plants and animals need for growth, survival, behavior, and reproduction.
3. There is a direct connection between the natural systems where organisms live and their internal and external structures.
4. In addition to influencing the growth, survival, behavior, and reproduction of plants and animals, human social systems can affect where those organisms live, how many there are, the types of organisms that live in an area, and the viability of the natural system itself.
5. If the plants and animals in a natural system are affected by a human social system, the natural system may no longer provide ecosystem goods and services (resources) that humans need and use for survival.
6. Criteria and constraints for engineering design solutions should take into account the spectrum of considerations and decision-making factors that can influence the availability of resources and the viability of natural systems.

Appendix 2 of the *2016 Science Framework* identifies these examples of specific connections to the Disciplinary Core Ideas:

**4-LS1: From Molecules to Organisms: Structures and Processes** and **California's EP&Cs:**

As students learn that "Plants and animals have both internal and external structures that serve various functions in growth, survival, behavior, and reproduction" **(LS1.A)**, they should be developing an understanding:

"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" **(Principle II Concept a)**

and

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

and

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

**4-ESS3: Earth and Human Activity** and **California's EP&Cs:**

As students learn that "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" (**ESS3.A**), they should be developing an understanding:

"that the goods produced by natural systems are essential to human life and to the functioning of our economies and cultures" **(Principle I Concept a)**

**3-5 ETS1: Engineering Design** can be integrated into opportunities for students to apply what they are learning in connection with **3-5-ETS1-1** and **California's EP&Cs:**

As students recognize that "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." **(ETS1.A: Defining and Delimiting Engineering Problems)** And, that "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" **(ETS1.B: Developing Possible Solutions)**, they "should be developing an understanding of:

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

## *Learning Objectives and Direct Connections to the EP&Cs for this Exemplar*

### *Lesson Series 1: Structures and Functions in the Local Environment*

**Learning Objective**

Students explain that the internal and external structures of plants and animals (including humans) function in the natural systems, where they live, to provide them with the resources they need for growth, survival, behavior, and reproduction.

**Direct Connections to EP&Cs**

This lesson exemplifies the integration of California's **EP&C II.a.** with the CA NGSS three-dimensional content through a student investigation of plants and animals on campus and in the local neighborhood. It also explores the role of external and internal structures in their growth, survival, behavior, and reproduction.

**CA NGSS Three-Dimensional Content**

DCI: LS1.A Structure and Function
SEP: Planning and Carrying Out Investigations

### *Lesson Series 2: Influencing Natural Systems through Human Activities*

**Learning Objective**

Students describe how human activities cause changes to natural systems and influence the organisms that live there.

**Direct Connections to EP&Cs**

This lesson exemplifies the integration of California's **EP&C II.a.** with the CA NGSS three-dimensional content through a student investigation of the interactions of natural and human social systems, and how human activities influence organisms in natural systems. This is a precursor to investigating how human-caused changes to natural systems influence the functioning of internal and external structures in the growth, survival, behavior, and reproduction of organisms.

**CA NGSS Three-Dimensional Content**

DCI: LS1.A Structure and Function
CCCs: Cause and Effect; Systems and System Models
SEP: Engaging in Argument from Evidence

### *Lesson Series 3: Plants and Animals Surviving Changes in Natural Systems*

**Learning Objective**

Students discuss how changes to natural systems can influence the functions of internal and external structures in the growth, survival, behavior, and reproduction of plants and animals (including humans).

**Direct Connections to EP&Cs**

This lesson exemplifies the integration of California's **EP&C II.a.** with the CA NGSS three-dimensional content through a student investigation of the effects of human-caused changes

on ecosystems and the functioning of the internal and external structures of plants and animals in their survival, growth, behavior, and reproduction.

**CA NGSS Three-Dimensional Content**

DCIs: LS1.A Structure and Function; ESS3.A: Natural Resources
CCCs: Cause and Effect; Systems and System Models
SEPs: Engaging in Argument from Evidence and Planning; Carrying Out Investigations

## *Lesson Series 4: Criteria and Constraints*

**Learning Objective**

Students establish criteria and examine constraints for determining and comparing the success of alternative design solutions to minimize the influence of human activities on natural systems.

**Direct Connections to EP&Cs**

This lesson exemplifies the integration of California's **EP&Cs V.a., I.a., and II.a.** with the CA NGSS three-dimensional content through an engineering design process in which students develop and evaluate criteria and constraints for alternative engineering design solutions to a problem on campus or in the local neighborhood. This problem focuses on the effects human activities have on plants, animals, and natural systems. Students also learn about some of the considerations related to decisions about natural systems.

**CA NGSS Three-Dimensional Content**

DCIs: ETS1.A Defining and Delimiting Engineering Problems; ETS1.B Developing Possible Solutions; LS1.A Structure and Function
CCC: Cause and Effect
SEP: Asking Questions and Defining Problems

Appendices B, C, and D of this document present further details about connections to CA NGSS, Common Core State Standards, and the EEI Model Curriculum:

**Appendix B:** Connections to the EP&Cs Identified in Appendix 2 of California's *2016 Science Framework* for the PEs, DCIs, CCCs, and SEPs

**Appendix C:** California Common Core State Standards Connections in Exemplar

**Appendix D:** Instructional Resources Curriculum that Can be Used to Support Implementation—identifies instructional resources from California's Education and the Environment Initiative (EEI) model curriculum which may be used by teachers in conjunction with this Exemplar.

## *Lesson Series 1: Structures and Functions in the Local Environment*

**Learning Objective**

Students explain that the internal and external structures of plants and animals (including humans) function in the natural systems, where they live, to provide them with the resources they need for growth, survival, behavior, and reproduction.

**Direct Connections to EP&Cs**

This lesson exemplifies the integration of California's **EP&C II.a.** with the CA NGSS three-dimensional content through a student investigation of plants and animals on campus and in the local neighborhood. It also explores the role of external and internal structures in their growth, survival, behavior, and reproduction.

Environmental topics and issues comply with one of the three Key Instructional Shifts identified in the 2016 Science Framework. "CA NGSS instruction is:… Relevant to local communities and student interests." (*California Science Framework, Chapter 1 Overview of the CA NGSS*)

**CA NGSS Three-Dimensional Content**

DCI: LS1.A Structure and Function
SEP: Planning and Carrying Out Investigations

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## Procedures

### Engage and Explore:

1. Display a photo or specimen of a plant and animal with obvious external features and focus students' attention on those features. Explain that today they will investigate the campus and local neighborhood to search for examples of plants and animals that live in or visit these areas.

   Ask students about the types of information they think it is important for them to gather as they investigate the plants and animals that live on or visit the campus and local neighborhood. If the class discussion leads to an appropriate list of data, make it into a class chart. If they are just learning about planning investigations, introduce **External Structures: Observation of Local Plants and Animals (Chart 1)** and have students copy it into their science notebooks. Review the column labels on the chart to focus their exploration and explain that they will use the chart to record their findings.

This lesson series begins with an outdoor environmental learning experience that introduces the external structures of plants and animals and the role of external structures in growth, survival, behavior, and reproduction (**LS1.A**) Students will investigate plants and animals on campus and in the local neighborhood identifying where they are observed, their external structures, and, how the external structures are used. It thereby introduces them to some of the key ideas within **EP&Cs 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.

*Chart 1: External Structures: Observation of Local Plants and Animals*

| Organisms (plants or animals) | Where Seen | What the plant or animal is doing | External structures | Use of external structures |
|---|---|---|---|---|
| Identify or describe | Identify or describe | Describe | Identify, describe, or draw observed external structures e.g., ears, eyes, tails, branches, leaves, roots, etc. | How does each external structure help the plant or animal grow and survive |
| Example | | | | |
| Gray squirrel | Tree on campus | Climbing from branch to branch and eating an acorn | Long bushy tail, large eyes, sharp teeth, pointed sharp claws, whiskers, nose | I think that the tail might help it walk on the high branches. The sharp teeth help it open the acorns it eats. The claws help it climb trees. |
| | | | | |
| | | | | |

2. Remind students of your rules for working outside on the campus and in the local neighborhood. Organize them into small teams for exploring the campus and neighborhood, and have them record their observations in their science notebooks.

> "Outdoor and environmental learning experiences are powerful tools for implementing key instructional shifts required by the CA NGSS and California's Environmental Principles and Concepts (EP&Cs)." (*California Science Framework, Chapter 11 Instructional Strategies for CA NGSS Teaching and Learning in the Twenty-first Century*)

   When students return to the classroom, have each team share their findings about one plant or animal. Give students time to complete any missing portions of **External Structures: Observation of Local Plants and Animals (Chart 1)**, by adding information from other observations they made or that other teams reported.

3. Explain that the students will be working in their teams to choose and present one of the plants or animals they have observed. Lead a class discussion about the types of information they should share regarding their organism and its external structures and functions.

4. Guide the students to develop a few class questions about the external structures of organisms and the role of those structures in the growth, survival, behavior, and reproduction of the organisms. For example:

   - Where did they see the organism (plant or animal)?
   - Why do they think it was in that specific place? (Location has the resources it needs to grow and survive.)
   - What external structures did they observe?

- How do the external structures they saw help the organism grow and survive?
- What functions do the external structures play in the growth, survival, behavior, or reproduction of the organism?

### Explain:

5. Have each team prepare a poster of their organism showing the place they observed it, the external structures they observed, a description of one or more of the external structures, and describing the role each structure plays in the growth, survival, behavior, or reproduction of the organism. Explain that they will be sharing their posters during a Gallery Walk. (*Note*: keep the posters on the wall for later use during this lesson series.)
6. Following the Gallery Walk, ask one or two teams to make a short presentation of their posters that addresses the class' questions based on their observations in **External Structures: Observation of Local Plants and Animals (Chart 1)**.
7. Following these presentations, lead a class discussion by asking, "Why were the organisms in the specific locations where you saw them?" (For example: The places we saw them had the food and water they need to grow and survive.)

   Record students' ideas on the board and have them record their ideas in their science notebooks.
8. Ask, "In addition to the external structures we have been observing and discussing, what types of internal structures do plants and animals have to support their survival, growth, behavior, and reproduction?" Facilitate a class discussion and make notes on the board. (For example, heart, stomach, lung, brain, reproductive organs, veins, and seeds.)
9. Based on the list of internal parts identified by the students, decide if it is necessary to further explore internal structures and functions.
10. Ask students to choose one of the internal parts from either a plant or an animal and sketch it in their science notebooks.
11. Give students access to grade-appropriate primary source information that will allow them to research how their chosen internal structure functions and the role it serves in growth, survival, behavior, and reproduction. Ask them to add this information to the drawings in their science notebooks.
12. On the board, create **Roles of Internal Structures in Growth, Survival, Behavior, and Reproduction (Chart 2)**. As a class, complete Chart 2 based on the organisms that each student has drawn and written about.

*Chart 2: Roles of Internal Structures in Growth, Survival, Behavior, and Reproduction*

| Organism (plant or animal | Internal Structure | Function in Growth, Survival, Behavior, and Reproduction |
|---|---|---|
| Example | | |
| Mouse | Stomach | Breaks down and digests food to provide nutrients from what the mouse has eaten |
| | | |
| | | |

13. Facilitate a class discussion of all the distinct functions that internal structures play in plants and animals.
14. As homework, have students sketch one of the plants or animals they observed on campus, including one of its external structures and where they observed it. In addition, have them respond to the following prompts:
    - Describe where your plant or animal lives.
    - What resources does your plant or animal need for its growth, survival, behavior, and reproduction?
    - How do your plant's or animal's external structures help it survive and get the resources it needs?
    - What would happen to this organism if the natural system where it lives or visits are changed by human activities?
    - How might it affect the organism's ability to use its external structures for growth, survival, behavior, and reproduction?

These questions have students focus on the changes to natural systems that results from human activities influence organisms and may affect the functioning of the internal and external structures **(EP&Cs Principle II a, b, c)**.

15. Mention that in the next lesson series, students will discover the interactions between natural and human social systems, and investigate how changes caused by human activities can influence plant's and animal's growth, survival, behavior, and reproduction.

## *Lesson Series 2: Influencing Natural Systems through Human Activities*

**Learning Objective**

Students describe how human activities cause changes to natural systems and influence the organisms that live there.

**Direct Connections to EP&Cs**

This lesson exemplifies the integration of California's **EP&C II.a.** with the CA NGSS three-dimensional content through a student investigation of the interactions of natural and human social systems, and how human activities influence organisms in natural systems. This is a precursor to investigating how human-caused changes to natural systems influence the functioning of internal and external structures in the growth, survival, behavior, and reproduction of organisms.

**CA NGSS Three-Dimensional Content**

DCI: LS1.A Structure and Function
CCCs: Cause and Effect; Systems and System Models
SEP: Engaging in Argument from Evidence

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## Procedures

### Engage and Explore:

1. Display several common objects with multiple interconnected parts that "work together" (e.g., bicycle, flashlight, guitar), and ask students to identify the "parts" in each object (e.g., pedals, chains, batteries, strings, neck, etc.). Write the names of the objects on the board and leave space to write students' responses. Mention that the term "*components*" is another word for parts.

> This lesson introduces students to the concept of "system thinking" which is essential to developing an understanding of California's Environmental Principles and Concepts. This also parallels the ideas identified in the Crosscutting Concept of "Systems and System Models." The EP&Cs can provide students with concrete examples of the ideas represented in this Crosscutting Concept.

2. Divide the students into small teams and ask them to select one of the objects to explore. Then have the students list all the parts of their object in their science notebooks.
3. Next, have students describe and record the connections among the parts and how they work together. For example, the pedals connect to the bicycle chain; pushing the pedals moves the chain; moving the chain makes the wheel spin, etc. List their ideas on the board.
4. Facilitate a class discussion asking, "If we removed one or more of the parts from your object, would it still work?" Guide students to the conclusion that the parts must work together if the object (a system) is going to function.
5. In their science notebooks, have students respond to the question, "Which parts of our object could we remove before it would stop working?" (For example, removing a bicycle wheel would stop it from moving, but if we removed the chain it could still roll down a hill.)

### Explain:

6. Mention that the objects they have been examining are examples of systems. Have students share their ideas about the meaning of the term "*system"* and then develop a class definition together. For example, "A group of things that interact and influence each other, like ecosystems" or "a collection of parts, processes, and cycles that influence each other and interact so that they function as a whole." Have students add the class definition to their science notebooks.
7. Ask students if they can think of any systems other than the "mechanical" ones that they have been thinking about. If they do not do it on their own, suggest the idea of "natural systems" (e.g., ponds, rivers, human bodies, forest ecosystems) and "human social systems" (e.g., streets, buildings, playgrounds, cars and buses, city hall).
8. Explain that as a class they will walk around campus (and the local area if possible) to observe examples of natural and human social systems. To prepare and engage students in a mapping activity, ask: "Where on campus can we find natural systems in which plants and animals might be living?" "Why are these plants and animals living in these particular areas?" "What external structures can we see on these plants and animals?" and "Are there any connections/interactions (patterns) between the locations where they live and their external structures?"
9. Have students write the four questions in their science notebooks and ask the teams to think about the steps they will need to take to find answers. Have several teams share their questions and plans for the mapping activity.
10. In preparation for this activity, have students sketch a basic map of the school campus or local neighborhood in their science notebooks. Explain that as they explore, they should draw and label the places where they observe plants and animals as well as other components of the natural systems (e.g., soil, water, rocks, roots, trees, tree trunks, flowers, insects, birds, and squirrels) and human social systems (e.g., sidewalks, parking lots, school buildings, playgrounds, etc.).
11. When the class has reconvened, create **Local Natural and Human Social Systems (Chart 3)** on the board and have students copy the chart into their science notebooks.

    Working in teams, have them complete Chart 3 based on the observations and notes they made on their maps.

*Chart 3: Local Natural and Human Social Systems*

| Natural Systems and Components | Human Social Systems and Components |
|---|---|
| Example | Example |
| Creek behind the school<br>soil, water, rocks, fish, frogs, insects, birds, cattails, shrubs | Small Creek Elementary<br>sidewalks, parking lots, school buildings, playgrounds, students, teachers, custodians, principal, parents, bus drivers |
| | |
| | |

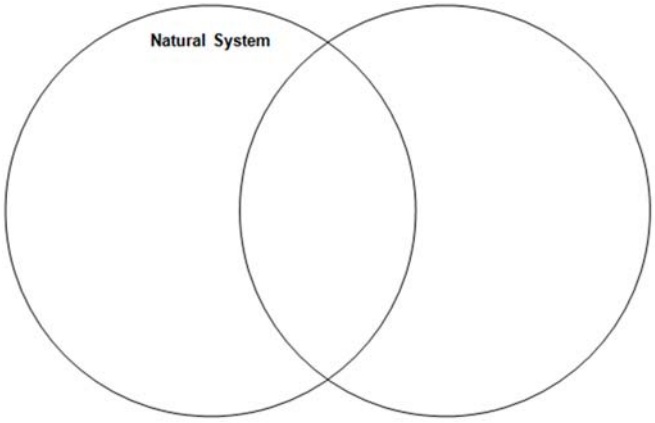
12. Working together, develop a class definition of the term "*natural systems*." For example, "The parts, processes, and cycles in an environment and the interactions among plants, animals, and other organisms with their environment." Have students add the class definition to their science notebooks.

## Explain and Elaborate:

13. On the board, draw two circles **Venn Diagram of Natural and Human Social Systems (Chart 4)** and have the students copy it into their science notebooks. Have each team make a large Venn diagram on a piece of flipchart paper.
14. Label the left-hand circle "**Natural System**" and leave the other unlabeled.

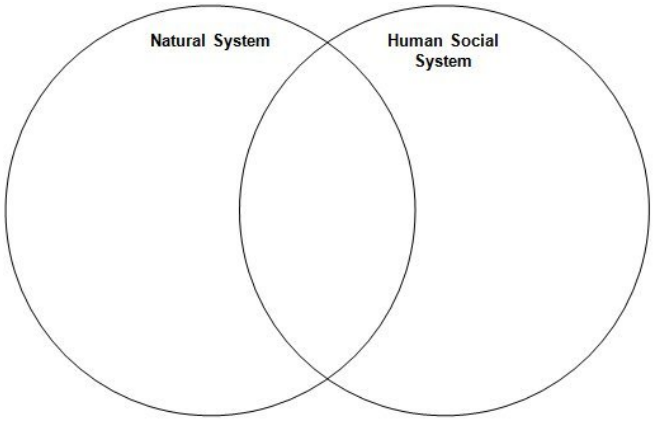
This section begins to build students' learning about the interactions between natural systems and human social systems. It starts by having them explore the components of the systems and the interactions among those components. In Step 23, students begin to explore the interactions between the natural systems and human social systems, building their knowledge about **EP&Cs 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.

*Chart 4: Venn Diagram of Natural and Human Social Systems*



15. As a team, have students write the natural system components they mapped into the natural system circle. For example, soil, water, rocks, plants (roots, trees, tree trunks, flowers), and animals (insects, birds, and squirrels).
16. On their Venn diagrams, within the natural system circle, have students draw arrows showing connections/interactions between the natural system components. For example, plants rooted in soil, insects and birds (birds catching insects as food), trees and squirrels (squirrels use trees as homes, sources of food, and for protection to escape predators).
17. Discuss the connections and interactions among the components of the natural systems as a class.
18. Review the concept of "*human social systems*," defined as "the components and processes of human communities and societies that support individuals and teams of people, such as education (school), social, economic, political, legal, transportation, and communications systems." Discuss school as a human social system and ask students to identify some of the components of the school system (e.g., teachers, students, school buildings, sidewalks, playgrounds, parking lots, etc.).
19. Ask teams to review the human social systems components they have already included on their maps and share them with the class.
20. Label the right-hand circle on **Venn Diagram of Natural and Human Social Systems (Chart 4)** with "**Human Social System**" and have students to do the same.

*Chart 4: Venn Diagram of Natural and Human Social Systems*

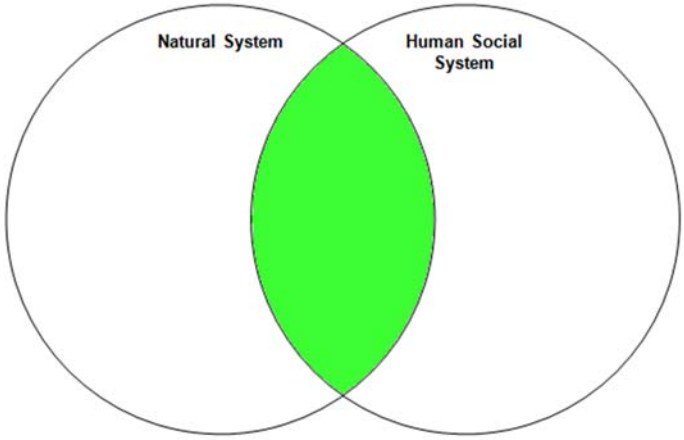



21. Have students add the human social system components from their maps into the appropriate circle on **Venn Diagram of Natural and Human Social Systems (Chart 4)**.
22. Ask students to draw arrows illustrating connections/interactions among the components of the human social system (e.g., teachers, students, and school buildings; students and sidewalks; students and playgrounds; parents' cars and parking lots).
23. Working in teams, have students identify some interactions between the natural system and the human social system (e.g., students affect animals [insects, birds, and squirrels] and plants [roots, trees, tree trunks, flowers]; sidewalks and asphalt affect soil, plants, roots, animals, and water; school buildings affect soil, trees, animals, and water).

24. Have students record their observation about the interactions in the intersection of circles on the flipchart with their **Venn Diagram of Natural and Human Social Systems (Chart 4)**. Post the Venn diagrams on the wall and ask each team to discuss another team's diagram and suggest additional interactions.

This series of activities involves students in investigating the types of interactions between natural systems and human social systems, preparing them to examine how the changes to natural systems on campus caused by human activities affect where plants and animals live, grow, and survive. **(EP&Cs Principle II Concept a)**

*Chart 4: Venn Diagram of Natural and Human Social Systems*




## Elaborate:

25. Have students return to their own Venn diagrams, select at least four interactions between natural and human social systems, and record them in their science notebooks.

26. Post the following questions on the board:

    - "How have human activities caused changes to natural systems on campus?"
    - "How have these changes affected where plants and animals live, grow, and survive?"

27. Have the teams discuss these questions in relation to the four interactions they selected. Based on their conversation, have teams identify whether and why they think these interactions will benefit, not affect, or cause harm to the natural system they are studying.

    Have the teams share their arguments with the class, including their evidence and conclusions. Ask, "Will most of the interactions between natural and human social systems benefit, not affect, or cause harm to the natural system?" On the board, make a list of the students' evidence and conclusions.

    Have students record their conclusions in their science notebooks and share with the class.

### Explain:

Students examine the direct connection between how the interactions between natural systems and human social systems and how human activities influence the natural systems. **(EP&Cs Principle II Concept a)**

28. Have teams create posters labeled, "**Changing Natural Systems on Our Campus**." The posters should include:
    - A small map of the campus indicating the area on which they focused.
    - A photo or drawing of what the area looks like now and what it looked like before the campus was built.
    - A Venn diagram showing the components of the natural and human social systems in the area.
    - In the intersection on the Venn diagram, a list of some interactions between the natural and the human social systems.
    - Initial ideas or drawings about how the human activities in the area might have affected the organisms living there.
29. When students have completed their posters, have them share with the class through a poster session.
30. Tell students that in Lesson Series 4, they will identify a problem caused by a change to one of the natural systems on campus. They will also design solutions to improve a natural system on campus or in the local neighborhood.

## *Lesson Series 3: Plants and Animals Surviving Changes in Natural Systems*

**Learning Objective**

Students discuss how changes to natural systems can influence the functions of internal and external structures in the growth, survival, behavior, and reproduction of plants and animals (including humans).

**Direct Connections to EP&Cs**

This lesson exemplifies the integration of California's **EP&C II.a.** with the CA NGSS three-dimensional content through a student investigation of the effects of human-caused changes on ecosystems and the functioning of the internal and external structures of plants and animals in their survival, growth, behavior, and reproduction.

Examining the impacts of human activities on the natural environment is a major component the CA NGSS that extends from Kindergarten through high school. There is a major emphasis on this content in ESS3 Earth and Human Activity. In addition, however, in some grades the impacts of human activities on natural and human social systems are also included in the domains of Life Sciences and Engineering Design.

**CA NGSS Three-Dimensional Content**

DCIs: LS1.A Structure and Function; ESS3.A: Natural Resources
CCCs: Cause and Effect; Systems and System Models
SEPs: Engaging in Argument from Evidence and Planning; Carrying Out Investigations

### Procedures

#### Engage and Explore:

1. Ask students to revisit the definition of "*natural systems*" on the board: the parts, processes, and cycles in an environment and the interactions among plants, animals, and other organisms with their environment.
2. Explain that today students will focus on "*ecosystems*," groups of living and nonliving things that are found together and affect each other. Post photos of a forest, river, desert, ocean, etc. on the board and ask students to think about examples of plants and animals that live in each. Have them share their examples:
    - Forest: birds, foxes, mice, trees, flowers, etc.
    - River: fish, birds, plants, insects, etc.
    - Desert: snakes, cactus, birds, mice, lizards, etc.
    - Ocean: fish, birds, plants, whales, dolphins, etc.
3. Divide students into teams and have each select two ecosystems from the pictures provided (e.g., forest and river). Then ask the teams to:

- Choose one plant and one animal that live in each ecosystem and select the corresponding information cards[1].
- Analyze the photographs and information on the cards and list some of the resources their plants and animals need for survival.
- Ask students, "How can you decide if a plant's or animal's external structures, adaptations, or behaviors would help them survive in the ecosystem where they live?"
- Have the teams review their photographs to identify and describe at least two external structures, adaptations, or behaviors and describe how they help their plants and animals survive in the ecosystem where they live.

4. Have students continue to work in teams to study the coastal salt marsh ecosystems found in California and gather evidence about what happens to the plants and animals living there when human activities cause significant environmental changes.

5. Post a large picture of a salt marsh and ask students to guess what kinds of plants and animals live there (e.g., salt marsh grass, birds, fish, crabs, etc.). Explain that coastal salt marshes are areas along the ocean which are periodically covered with shallow water by the tide. Ask students, "What might change in the salt marsh because of the varying water level?" and "How do you think these constant changes might affect the plants and animals living there?"

### Explain:

6. Distribute copies of *Sweetwater Marsh National Wildlife Refuge*[2], a grade-level reading about salt marshes, to each team.

   Read **Chapter 1: Meet the Marsh**.

   Have students read to gather evidence about how some plants and animals benefit from their external structures, adaptations, and/or behaviors to survive in a salt marsh. Remind students to record the evidence they find in their science notebooks. For example:

   - **Pickleweed**, a plant that grows along the edge of the marsh and is sometimes covered by salty water. It pushes salt from the water to the tip of its leaves. Late in fall, the leaves drop off. In this way, pickleweed can rid its body of a lot of salt.
   - **Round Stingray**, an animal that lives in the marsh and likes the warm water. It has adaptations that help it survive the salt and tides. The water in the stingray's body changes to stay just as salty as the marsh water. If the marsh water gets saltier, or less salty, the stingray flushes out much of its body water and takes in the water around it.

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[1] Information cards with grade-appropriate text and photos, e.g., http://www.calrecycle.ca.gov/eei/unitdocs/grade03/33cd/33cdic.pdf

[2] http://www.calrecycle.ca.gov/eei/unitdocs/grade03/33cd/33cdreader.pdf

Ask the teams to divide their flipchart paper into two halves and create **Plants and Animals Surviving Changes in the Salt Marsh (Chart 5)**. Have the teams label the top half of the chart, "How Some Plants and Animals Survive in a Salt Marsh" and make a sketch of one of the plants or animals they have read about. Teams should then list three facts describing how the organism can survive in the salt marsh. (*Note*: A sample completed version of this chart is provided later in this lesson series.)

Post the charts and have some teams share what they have learned about how the organism's external structure, adaptation, or behavior helps it to survive in a salty environment. Have students make notes and drawings about their plant or animal in their science notebooks.

7. On the next day, ask students to repeat the process as they continue reading *Sweetwater Marsh National Wildlife Refuge*.

   This introduces students to how human-caused changes to a natural system affect organisms and starts to develop their knowledge that not all that organisms respond in the same way. **(EP&Cs Principle II Concept a)**

   Read **Chapter 2: Changes to the Marsh** to learn about changes to the ecosystem and whether different organisms respond in the same way. Again, remind students to record their evidence about how changes to the ecosystem harm or benefit an organism that lives there, in their science notebooks.

   Have students label the lower half of Surviving Changes in the Salt Marsh (Chart 5) with "Responding to Change" and list several examples of changes humans have made to the salt marshes. Then students should describe how their organism was affected (harmed or helped) by changes to the marsh (e.g., changes to the salt marsh: dredging mud out of the bay so that big ships can pass through; development: building roads, dams, and levees to break apart the marsh; and, building power plants on the bay). For example:

   - **Pickleweed** was affected by people building roads, dams, and levees. These structures changed the flow of water in the marsh and the saltiness of the water. Though pickleweed is well-adapted to changes in salt water and tides, it cannot grow where there are roads, dams, and levees.
   - **Belding's savannah sparrows,** are endangered in California because buildings, roads, and levees have replaced pickleweed. Their habitat is disturbed by people and pets. The sparrows use pickleweed and other plants to make their nests and keep their eggs safe from water, even at high tide. Because there is less pickleweed fewer pairs of sparrows can build nests.

*Chart 5: Plants and Animals Surviving Changes in the Salt Marsh*

| How Some Plants and Animals Survive in a Salt Marsh |
|---|
| Pickleweed, is a plant that grows along the edge of the marsh.<br>• It can rid its body of a lot of salt.<br>• It pushes salt from the water to the tips of its leaves.<br>• Its leaves drop off in the fall. |
| **Responding to Change** |
| The pickleweed can survive when human activities change the marsh because is well-adapted to salt water and tides.<br>• It can grow with different levels of salt and tidal flow.<br>• It does not grow where there are roads, dams, and levees. |

Post completed charts on the wall and ask a few teams to share what they have learned about how their organism's external structure, adaptation, or behavior helped it to survive in a salty environment after human activities caused changes to the salt marsh.

### Elaborate:

8. Guide a discussion by asking students to provide evidence from the salt marsh as they respond to the statement, "Human activities change ecosystems in ways that affect the growth, survival, or behavior of some plants and animals."
9. Have students write an informational/explanatory piece, constructing their arguments with evidence and data gathered from *Sweetwater Marsh National Wildlife Refuge*, information recorded in their science notebooks, and class discussions. Provide them with the following writing prompt:

   "Plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction. Human activities can cause changes to the natural systems where these organisms live, and these changes can influence how the external structures help the plants and animals."
10. When students have completed their writing assignment, have them share their arguments through a class discussion, newsletter, or Gallery Walk.

### Engage:

11. In preparation for their work on an engineering design activity in the next lesson, ask students to read **Chapter 3: Restoring the Marsh** from *Sweetwater Marsh National Wildlife Refuge*. If necessary, work with students to define the term "*restore*" and then develop a class definition together. For example, "to help a natural system or habitat go back to the way it was before it was affected by human activities." Have students add the class definition to their science notebooks.

    This introduces students to the idea that the effects of human activities on natural systems are not all negative, but in some cases, may be beneficial or neutral **(EP&Cs Principle II)**.
12. As they read, ask them to identify and briefly describe, in their science notebooks, three ways that people are working to restore the health of Sweetwater Marsh. For example:

- Volunteers pulled out plants that did not belong there and planted native plants.
- People planted eelgrass and cordgrass to replace the non-native plants.
- People built nesting rafts to help protect the clapper rail nests.

Have students share their examples of ways people are working to restore Sweetwater Marsh and make notes in their science notebooks.

## *Lesson Series 4: Criteria and Constraints*

**Learning Objective**

Students establish criteria and examine constraints for determining and comparing the success of alternative design solutions to minimize the influence of human activities on natural systems.

**Direct Connections to EP&Cs**

This lesson exemplifies the integration of California's **EP&Cs V.a., I.a., and II.a.** with the CA NGSS three-dimensional content through an engineering design process in which students develop and evaluate criteria and constraints for alternative engineering design solutions to a problem on campus or in the local neighborhood. This problem focuses on the effects of human activities on plants, animals, and natural systems. Students also learn about some of the considerations related to decisions about natural systems.

**CA NGSS Three-Dimensional Content**

DCIs: ETS1.A Defining and Delimiting Engineering Problems; ETS1.B Developing Possible Solutions; LS1.A Structure and Function
CCC: Cause and Effect
SEP: Asking Questions and Defining Problems

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## Procedures

### Engage and Explore:

1. Have students review the charts, posters, and their science notebooks from the previous lessons:

   Lesson 1: Where plants, animals, natural systems, and human social systems are found on the campus and their major components.

   Lesson 2: Interactions between the components of natural systems and human social systems, how human activities can change natural systems, and the plants and animals that live on the campus.

   Lesson 3: How human-caused changes to natural systems can influence both the external structures of plants and animals and how they support their survival, growth, behavior, and reproduction.

2. Have students return to their "**Changing Natural Systems on Our Campus**" posters. Ask them to review their Venn diagrams (showing natural and human social system interactions), listings of interactions between these systems, and initial ideas or drawings about how human activities in the area might have affected the organisms living there.

3. Based on the information from their posters, have students consider the question:

"How do human-caused changes to the natural systems (plants and animals) on the campus and in the local neighborhood affect:

- students, teachers, staff, and parents?
- plants, animals, and natural systems on campus?"

This section begins to build students' recognition of how individual human lives, communities, and societies depend on natural systems for their survival. **(EP&Cs Principle I)** It thereby begins their exploration of how the effects of human activities on natural systems can directly and indirectly affect people. **(EP&Cs Principle I Concepts a, b, and c)**

Have students record their answers in their science notebooks and then discuss as a class and make a list on the board. For example: because all the trees are gone we do not get any shade when we play outside; because most of our campus is covered in asphalt, we don't see much soil, or plants and animals [insects, birds, and squirrels] near the school, so we don't go outside to do science. (*Note*: The responses from students will vary substantially depending on the campus and local neighborhood: some sites may have mainly asphalt with very few plants and animals, other sites may be compacted soil that gets muddy during rains and supports few plants or animals, others may have gardens, and yet others may be neighboring a local park.)

4. Facilitate a class discussion about one of the problems students identified. For example, how the asphalt on the playgrounds and parking lots has affected the soil, plants, roots, animals [insects, birds, and squirrels], and natural and human social systems. Make notes on the board about the plants and animals that are affected, the human social systems and activities, and the interactions of the systems.

Problem-Based Learning activities related to the environment "build on students' existing experience to learn about and solve real-world problems" (e.g., habitat restoration, energy consumption, and waste reduction). (*California Science Framework, Chapter 1 Overview of the CA NGSS*)

### Evaluate:

5. Explain that their next task will be to develop a solution to a problem caused by human changes on the campus or in the local neighborhood.

   In teams, ask students to select one of the problems they identified and write a description of it on **Evaluating Problem Solutions Based on Criteria and Constraints (Chart 6)** and in their science notebooks. (*Note:* A sample of this chart is provided later in this lesson series.)

This series of activities involves students in developing engineering design solutions for a local environmental problem that they have identified and studied, thereby applying and strengthening their understanding of the EP&Cs, engineering design, and the three-dimensional content in **4-LS1-1:** Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction; **3-5-ETS1-1**: Define a simple problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or costs; and, **3-5-ETS1-2**: 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

Based on their problem, have the teams brainstorm about the question, "What can we do on campus to decrease the effects of the human activities so that plants and animals will be able to survive, grow, and reproduce?" (For example: creating a school garden with plants that will attract insects and birds; cleaning up waste in the lunch area so the birds don't eat it and get sick.) Tell students to summarize their ideas and make notes in their science notebooks.

> Environmental topics and issues provide engaging opportunities for students to engage in Problem-Based Learning activities. These problems should engage them in solving challenging problems with real-world applications. "Problem-based learning (PBL) is particularly well suited to the CA NGSS" (*California Science Framework, Chapter 11 Instructional Strategies for CA NGSS Teaching and Learning in the Twenty-first Century*)

6. Explain that one of the basic ideas behind creating engineering design solutions is the need to develop a plan. However, before they develop their plans, students need to think of the criteria they will use to determine if their plan is a success and recognize the design's constraints (limits).

7. Tell students that once a problem has been identified and defined, even if it is a very simple problem, it is necessary to identify the criteria and constraints by which the success of a solution will be determined. To help them understand the idea of criteria, ask the teams to discuss the question, "How do you make decisions and choices?" Have them share their ideas and introduce them to the term "*criteria*" (the desired features of a solution).

   > This develops students' ability to analyze the diverse factors that influence the impacts of alternative engineering design solutions on environmental health, communities, and natural systems **(EP&Cs Principle V)**.

   Then have the teams consider the question, "What criteria should we use to decide which of our ideas to choose?" Remind students that, for this activity, their primary criterion should be based on developing a design solution that will minimize the effects of human activities on plants, animals, and natural systems. For example, as a result of this project, will the campus or the local neighborhood better support the survival of plants and animals, make the campus nicer, or decrease the environmental effects of human activities?

   Have the teams share their criteria and list them on the board, then allow the teams to make suggestions to each other and modify their lists of criteria. Facilitate a class discussion and have students agree on the criteria they will use to determine the potential success of proposed solutions. Add the agreed upon criteria to the box labeled "**Criteria** for considering the desired features of a proposed solution" on **Evaluating Problem Solutions Based on Criteria and Constraints (Chart 6).**

8. Ask, "What might prevent us from being successful with our proposed solutions?" Have students share their ideas, which may include: the materials needed, the time and costs of finishing the project, if students will be able to complete the project, and student safety. With their ideas on the board, introduce them to the term "*constraints*," (the things, like available materials and resources, that limit whether a project can be completed) and some examples such as materials, resources, time, money, safety concerns, and possible damage to the environment.

Facilitate a class discussion and agree on the constraints students will all take into account when reviewing their proposed solutions. For example: they will only have two days to complete their project, they can spend a maximum of $100, they can't release any chemicals or leave waste on campus, and they need to get their plans approved by the principal.

Add the agreed upon constraints to the box labeled "**Constraints** to take into account when designing possible solutions" on **Evaluating Problem Solutions Based on Criteria and Constraints (Chart 6).**

Have the teams review their proposed solutions for decreasing the effects of human activities on the natural systems around campus. Remind them that a key criterion is that their solutions must help plants and animals be better able to survive, grow, and reproduce, and that they make the campus nicer. The teams should write a description of their solution in the appropriate box on **Evaluating Problem Solutions Based on Criteria and Constraints (Chart 6).**

> Problem-Based Learning activities related to the environment "build on students' existing experience to learn about and solve real-world problems" (e.g., habitat restoration, energy consumption, and waste reduction). (*California Science Framework, Chapter 1 Overview of the CA NGSS*)

*Chart 6: Evaluating Problem Solutions Based on Criteria and Constraints*

| **Team Name:** | |
|---|---|
| **Description of problem:** | |
| **Criteria** for considering the desired features of a proposed solution: | **Constraints** to take into account when designing possible solutions: |
| **Description of the proposed solution:** | |

9. When teams have completed **Chart 6**, post their charts around the room.
10. Have teams walk around the classroom to review and discuss each of the proposals. Explain that, as they review the different proposals, they should consider two main things:
    - Can the proposal be successful within the identified constraints (materials, resources, time, money, safety concerns, and possible damage to the environment)?
    - Would the proposed solution satisfy the primary criterion of minimizing the effects of human activities on plants, animals, and natural systems on campus or in the local neighborhood? Does it meet the other criteria agreed upon by the class?
11. Tell students that they each get to vote for two proposed solutions that they think will be most successful and they would like to undertake as a class.
12. After the class has voted, facilitate a discussion and allow all students to make suggestions for improvement to the winning two proposals. Have the students who developed those proposals make any final adjustments to their plans.

13. If funding is available and the administration gives permission, allow students an opportunity to implement one or both of the plans and monitor the results of their engineering design solutions.

# Appendices

## *Appendix A: Key Words and Terms in California's EP&Cs*[3]

Biological diversity (biodiversity and species richness): A measure of the number of different species of organisms in a specific area, also used as a general description of species richness, ecosystem complexity, and genetic variation.

Byproduct: Something, such as waste materials or chemicals, produced when something else is manufactured or consumed.

Composition: The make-up of a natural system including the mixture of components (e.g., species) and relative numbers of those components.

Cultural system: The way of life defined by human communities and societies through their tangible objects, as well as their beliefs, behaviors, values, and traditions.

Economic factors: Considerations related to the production, distribution, and consumption of goods and services that affects outcomes.

Economic system: The means and methods a society uses to manage the production, distribution, exchange, and consumption of goods and services, including income, expenses, and labor.

Ecosystem goods: Tangible materials, such as timber and food, produced by natural systems, that are essential to human life, economies, and cultures.

Ecosystem services: The functions and processes that occur in natural systems, such as pollination, that support or produce ecosystem goods and help sustain human life, economies, and cultures.

Environmental management: Human practices that influence an ecosystem so that it produces particular goods and services that are useful to people.

Exchange of matter: Substances moving within and between systems, particularly human-social systems and natural systems.

Geographic extent (range): The area through which a species or ecosystem is naturally found.

Human activity: The full range of behaviors, actions, and practices of humans as individuals and as members of communities and societies.

Human practices: The ways individual people, communities, and societies do things, such as harvesting or extracting of materials, as well as producing and consuming goods and services from natural systems and human social systems.

Human social system: The functions, processes, and interactions among individuals, human communities, and societies including political, social, cultural, economic, and legal systems.

Legal system: The means and methods of establishing, interpreting, and enforcing laws.

Natural cycle: A regularly repeated event, or sequence of events, that occur in a natural system over time, e.g., carbon cycle, life cycles, nitrogen cycle, nutrient cycle, reproductive cycle, and water cycle.

Natural process: A generally sequential and interconnected series of related events, activities, or phenomena, e.g., decomposition, erosion, evaporation, photosynthesis, and pollination.

[3] Based primarily on the Glossary developed for the model curriculum developed for California Education and Environment Initiative.

Natural resources: Materials, such as water, minerals, energy, and soil, that people use from nature and natural systems, to produce food, and build shelters and other products.

Natural system: The interacting components, processes, and cycles within an environment, as well as the interactions among organisms and their environment.

Political factors: Considerations and aspects of decisions related to the operation of governments and political systems.

Political system: The means and methods by which governments are managed, including decision-making processes such as elections.

Social factors: Considerations and aspects of decisions related to the operation of human society and its members.

Systems: Groups of interacting components, processes, and cycles that form a complex whole, such as natural systems, political systems, and economic systems.

Viability of natural systems: The likelihood that the components, processes, and cycles in a natural system, such as an ecosystem, will continue to function over time.

## *Appendix B: Connections to the EP&Cs Identified in Appendix 2 of California's Science Curriculum Framework for the PEs, DCIs, CCCs, and SEPs*

The California Science Framework describes the state's Environmental Principles and Concepts (EP&Cs) as providing "a meaningful way to teach and amplify many of the ideas that are already embedded in the CA NGSS. Appendix 2 of this CA Science Framework presents diverse examples of the connections that can be made between the EP&Cs and instruction in the three dimensions of the CA NGSS."[4]

### *Performance Expectations (PEs)*

**4-LS1-1.** Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction. [Clarification Statement: Examples of structures could include thorns, stems, roots, colored petals, heart, stomach, lung, brain, and skin. **Each structure has specific functions within its associated system.] [Assessment Boundary: Assessment is limited to macroscopic structures within plant and animal systems.]

**4-ESS3-1.** Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment. [Clarification Statement: Examples of renewable energy resources could include wind energy, water behind dams, and sunlight; non-renewable energy resources are fossil fuels and fissile materials. Examples of environmental effects could include loss of habitat due to dams, loss of habitat due to surface mining, and air pollution from burning of fossil fuels.]

**3-5-ETS1-1.** Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

### *Disciplinary Core Ideas (DCIs)*

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)"

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)"

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)"

ETS1.B: Developing Possible Solutions: "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)"

[4] California's *Science Framework 2016*. Chapter 1 Overview of the California Next Generation Science Standards

### *Crosscutting Concepts (CCCs)*

Systems and System Models: A system can be described in terms of its components and their interactions. (4-LS1-1)

Cause and Effect: Cause and effect relationships are routinely identified and used to explain change. (4-ESS3-1)

Energy and Matter: Energy can be transferred in various ways and between objects.

Connections to Engineering, Technology, and Applications of Science: Influence of Engineering, Technology, and Science on Society and the Natural World: People's needs and wants change over time, as do their demands for new and improved technologies. (3-5-ETS1-1)

### *Science and Engineering Practices (SEPs)*

Planning and Carrying Out Investigations: Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon. (4-ESS2-1)

Engaging in Argument from Evidence: Construct an argument with evidence, data, and/or a model. (4-LS1-1)

Obtaining, Evaluating, and Communicating Information: Obtain and combine information from books and other reliable media to explain phenomena. (4-ESS3-1)

Asking Questions and Defining Problems: Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost. (3-5-ETS1-1)

### *Environmental Principles and Concepts (EP&Cs)*

Students should be developing an understanding that:

**Principle I Concept a:** "The goods produced by natural systems are essential to human life and to the functioning of our economies and cultures."

**Principle II Concept a:** "The 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."

**Principle V Concept a:** "There is a spectrum of what is considered in making decisions about resources and natural systems and how those factors influence decisions."

## *Appendix C: California Common Core State Standards Connections in Exemplar*

### *English Language Arts/Literacy*

**W.4.1.a–d** Write opinion pieces on topics or texts, supporting a point of view with reasons and information.

## *Appendix D: Instructional Resources Curriculum that Can be Used to Support Implementation*

These instructional resources from California's Education and the Environment Initiative (EEI) model curriculum may be used by teachers in conjunction with this Exemplar.

**Third Grade** *Structures for Survival in a Healthy Ecosystem*

**Third Grade** *Living Things in Changing Environments*

**Fourth Grade** *The Flow of Energy through Ecosystems*