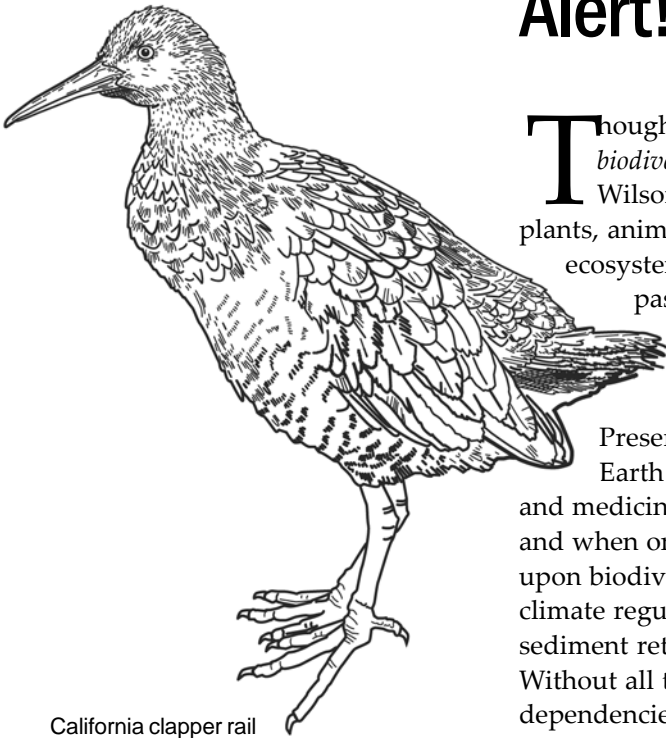# Chapter 7
Alert! Species in Danger

California clapper rail
Rallus longirostris obsoletus

New Words
biodiversity; ecosystem services; biome; rare, threatened, and endangered species; endemic species; adaptation

California Coastal Commission Areas of Critical Concern: Rare and Endangered Species, Wetlands

Relevant California Science Content Standards, Grade 7: Life Sciences (3.a,b,d,e)

Though the concept is as old as all creatures on Earth, the term *biodiversity* was first coined by Harvard ecologist Edward O. Wilson in 1988. Biodiversity is the full array of life on Earth: the plants, animals, microorganisms, and the natural communities, ecosystems, and landscapes that support them. Biodiversity encompasses the processes, both ecological and evolutionary, that allow life on Earth to adapt and evolve over time and changing environmental conditions.

Preserving aquatic and terrestrial biodiversity is critical to life on Earth—humans rely on wild biological resources for food, shelter, and medicines. Species depend upon each other in a variety of ways, and when one is eliminated, others may follow. People also depend upon biodiversity for *ecosystem services* such as waste assimilation, climate regulation, water supply and regulation, erosion control and sediment retention, soil formation, waste treatment, and pollination. Without all the species of the world, with their intricate interactions and dependencies that have taken sometimes millions of years to evolve, the world would be a different place. Though it is impossible to bring back extinct species, we can learn about how biodiversity works, how to protect rare and endangered species, and how to care for natural communities and ecosystems so they can support biodiversity.

Every species on Earth lives in a *biome*. Biomes are large, distinct areas of land or water that have a similar climate, soil, plants, and animals. Different biomes contain different habitats for plants and animals. The U.S. contains the widest spread of biome types, ranging from rain forest to Arctic tundra, of any country in the world. It also has the largest number of known species of any temperate country—200,000 or so, and new species are being discovered each year. However, over the years as our country has focused on economic and material gains, we have taken for granted, overlooked, and in many cases destroyed natural resources and native plant and animal species. California's wetlands, one of our most beautiful and productive biomes, have been hit particularly hard; we have lost 90 percent of our original wetlands, and many of the remaining wetlands are in danger of being harmed by nearby development. Another biome under attack is the intertidal zone; aggressive, invasive, nonnative species threaten to overcome some intertidal plants and animals.

Over geologic time, some species become extinct as others evolve, resulting in an array of biological diversity. While extinction is a natural process over the long run—the life of any one species can run from 0.5 to 10 million years—in recent history, extinction rates have increased rapidly. As of January 2003, a total of 539 U.S. species are recorded in the Natural Heritage Central Databases as extinct or missing. This list

Grade 7 Activities

These activities encompass species diversity; biodiversity; rare, threatened and endangered species; ecosystem services; biome; and evolutionary adaptations.

Activity Goals

7.1. Here Today, Gone Tomorrow
Students will:
1. Define native and non-native species.
2. Identify and describe causes of extinction within animal and plant species.
3. Define "threatened," "rare," and "endangered."
4. Identify local threatened or endangered species.
5. Identify the factors affecting potential elimination of wildlife species.

7.2. Adapted for Survival?
Students will:
1. Describe adaptations of birds to their environment.
2. Explain how the adaptive characteristics of a bird enable it to survive in its environment.
3. Describe why extinction of a species could occur when the environment changes and the adaptive characteristics of the species are insufficient for its survival.

7. 3. Survivor: California
Students will:
1. Understand the processes and limiting factors that drive evolution.
2. Find solutions to present day problems facing species survival.

includes only species, but if subspecies and varieties were included, the list would be much larger. California ranks third in the nation in numbers of extinctions (35), behind Hawaii (249) and Alabama (96). Many of California's native plant and animal species are in peril of extinction today because their environment can no longer support them: there are 373 species or subspecies listed as either threatened or endangered by the State of California or the federal government. One of the reasons so many are listed is that 1,500, or 26 percent of the native species found in California, are endemic—they are found no place else on Earth.
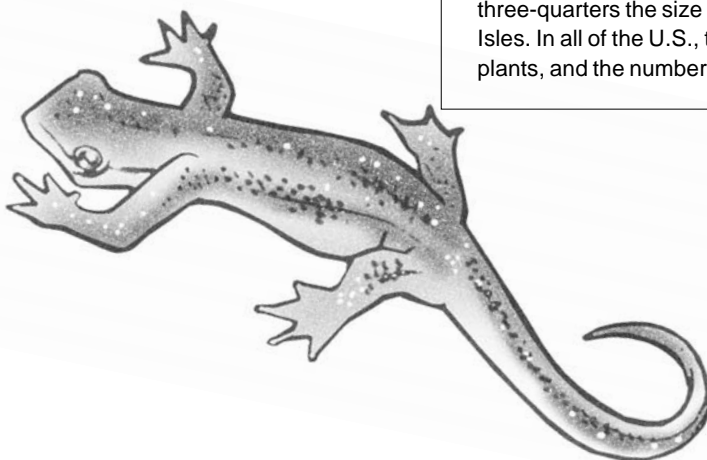
In prehistoric time, extinctions were caused by natural disasters and competition with other species. Today the main causes of species extinctions include habitat destruction, pollution, and other side effects of our increasing population. In addition, in our global economy, people, planes, and ships can travel quickly and often between countries, oceans, and ecosystems. Native species are being forced out by foreign invasive species that are able to out-compete native species for habitat. Often, introduced species do not serve the same functions in the habitat, such as food and shelter for other species. This spells disaster for the plants and animals that depend upon a displaced native species for survival.

Scientists make discoveries every day that help us understand the natural processes that govern life on Earth. In fact, much of the environmental degradation we see today is a result of yesterday's mistakes, misunderstandings, lack of knowledge, and shortsighted actions. But things can change—learning more about how natural systems work helps us understand how we can take care of our planet Earth.

One of California flora's outstanding features is that more than one-third (36 percent) of its native species, subspecies, and varieties are endemic. If looking at species alone, it is still an astounding 26 percent. Compare this with the entire northeastern U.S. where only 13 percent of the flora is endemic. Consider this: only one percent of the plants of the British Isles, an area three-quarters the size of California, are endemic to the British Isles. In all of the U.S., there are 19,473 identified species of plants, and the number of endemic species is 4,036.

California newt
Taricha torosa

Brown pelican
Pelecanus occidentalis

Science skills
- Researching
- Investigating
- Deducting
- Communicating

Concepts
- *Rare*, *threatened*, and *endangered* are words used to describe plant and animal species in varying degrees of danger of becoming extinct.
- Our actions can decide whether a species is tipped over the edge to extinction, or brought back to increase in numbers for future generations.

California Science Content Standards
3. Biological evolution accounts for the diversity of species developed through gradual processes over many genera-tions. As a basis for understanding this concept, students know:
3.a. Both genetic variation and environ-mental factors are causes of evolution and diversity of organisms.
3.e. Extinction of a species occurs when the environment changes and adaptive characteristics of a species are insuffi-cient for its survival.

Activity 7.1
What's So Special About Native Species?

If extinction means gone forever, what about the threatened, rare, or endangered species? Discover the distinctions, and then learn about some special plants and animals in your own neighborhood.

Background *(may be photocopied for student reading)*

California has a diverse and extraordinary wildlife. More than 1,275 species of mammals, birds, reptiles, amphibians and fish live within our borders, and many are found nowhere else in the world. About 6,300 flowering plants, gymnosperms, ferns, and fern allies are native to California, more than we find in the entire northeastern United States and adjacent Canada, an area ten times larger than California. California has the largest number of native plant species in the nation, and another thousand plants that are non-native, weedy introductions, or escapees from gardens and agricultural fields.

The term "native species" is used to describe a plant or animal that is a native of California, that is, for as long as it can be traced back, its origins have not been found to be from out of the state. Native species have been here for so long they are specifically adapted to our climate, soils, and habitats. The California sagebrush is a native species, as is the California sea lion. Many of California's native plants are also "endemic species"— this term means a species is found naturally nowhere else on Earth.

Non-native species, also known as introduced or exotic species, are species whose arrival in California have been documented—they came from somewhere else, such as European dune grass (*Ammophila arenaria)* which was intentionally introduced to stabilize dunes along the coast. Unfortunately, we now know it is an aggressive invader that has natural-ized along the dunes and coastal wetlands, overtaking areas previously covered by native species with greater wildlife value. A number of programs are involved in erradicating European dune grass and replacing it with non-invasive native species that include grasses and perennials historically found in the area.

Because native species are special, they have special status. Native species that are in peril of extinction are considered rare, threatened, or endan-gered (see definitions below). California's flora and fauna, especially its rare plants, are increasingly threatened by the spread of urbanization, conversion of land to agriculture, alteration of natural hydrological cycles, recreational activities, invasion of habitat by non-native plants and animals, and pollution. Many of the unique habitats that harbor rare plants are being destroyed. About forty California native plants probably became extinct in the last century, and hundreds more are endangered and could perish if present trends continue.

It is difficult to pinpoint an exact number of species that become extinct each year around the world, as many plants and animals are still

unnamed and unknown. Human beings have become a hundred times more numerous than any other land animal of comparable size in the history of life. Our species appropriates 40 percent of the solar energy captured in organic material by plants. There is no way that we can draw upon the resources of the planet to such a degree without drastically affecting the condition of most other species. There is some controversy regarding the estimates of extinction rates for plants and animals. Some scientists estimate that human activity is responsible for the extinction of 100 plants and animals each day; that's almost four species extinctions per hour. Other scientists offer lower figures, but few experts disagree with the belief that the rate of species extinction is being accelerated by human actions.

Extinction is a problem across the United States. As of December 2002, the U.S. Fish and Wildlife Service (USFWS) list of the total number of species that are endangered or threatened is 1,258 (515 animals, 743 plants). California's rare and threatened species make up a large part of this list, and many other species from our state are under review for classification as threatened or endangered.

The U.S. Endangered Species Act of 1973 gives authority to protect endangered species to the U.S. Departments of Interior and Commerce, with responsibilities further delegated to the U.S. Fish and Wildlife Service and the National Marine Fisheries Service. It is not easy to get a new species added to the federal list of endangered or threatened species. In order to list, reclassify, or delist a species, the USFWS must follow a strict legal process for proposing a new rule. The rule is first proposed in the *Federal Register*, a U.S. government publication. After a public comment period, the USFWS decides if the rule should be approved, revised, or withdrawn.

There can be differences in state and federal lists of endangered, threatened, or rare species. These differences occur because habitats, and the species that live in them, cross state lines. An animal or plant may have been lost within one state's boundaries, but may be abundant in another and therefore not considered threatened by USFWS. Individual states have their own lists of rare, threatened, or endangered species. In California, the California Department of Fish and Game enforces the California Endangered Species Act (CESA) which identifies procedures so individuals, organizations, or the Department can submit petitions to the Fish and Game Commission requesting that a species, subspecies, or variety of plant or animal can be added to, deleted from, or changed in status on the state lists. Once a species is on this list, it has special protection and any project that threatens one of these species (such as development, hunting season, or catch limits) must undergo a more intensive review to ensure that the listed species is protected.

Although extinction is a natural process, excessive and intensive human activities in the environment cause a dramatic increase in its rate. Loss of habitat as a result of human activity is considered to be the most common cause of species extermination. Other major causes of species extermination and endangerment include unregulated or illegal com-

Materials

1. Internet access (preferred) or query letter writing to obtain information from state and federal agencies about listed plants and animals
2. Poster board and poster supplies
3. Writing materials
4. "Species in Peril" worksheet and "California Endangered Species Resource List"
5. Overhead projector

Outline

Before class
1. Review definitions.
2. Photocopy "Species in Peril" worksheet and resource list for each student.
3. Reserve a day in the computer lab.
4. Photocopy onto overhead transparency or copy onto blackboard the "Species Listing Status" table.
5. Plan the extensions your class will complete and gather materials as required.

During class
1. Review and discuss term definitions.
2. Hand out "Species in Peril" worksheet and species resource list.
3. Describe report preparation requirements and deadlines.

mercial and personal use, disruption of migration routes and breeding behaviors, pollution, human disturbance, predator control, competition or predation from introduced species, and natural causes.

Generally accepted definitions of the terms used in this activity are:
Endangered Species: in immediate danger of extinction.
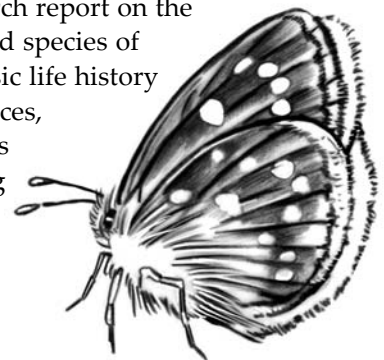**Critically Endangered Species:** will not survive without direct human intervention.
Threatened Species: present in its range, but threatened because of a decline in numbers.
Rare Species: not currently in danger, but of concern because of low numbers. (Some species were always rare because of their position in the food chain or due to habitat preference.)
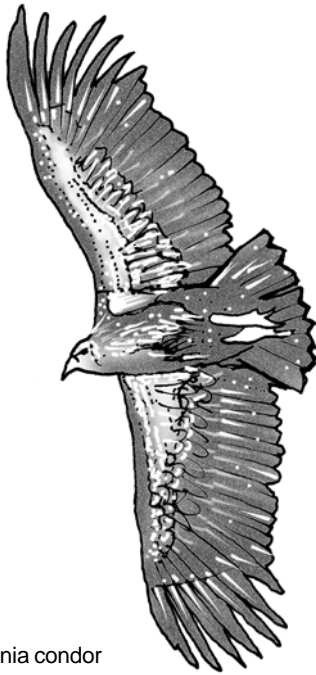**Extinct species:** complete disappearance of a species.

Activity

1. Ask students what they know about native species, and rare and endangered species. What do they think about protecting endangered species in California? Why do it? Write their responses on the board. Review and discuss with the students the definitions of threatened, endangered, rare, and extinct, as used in wildlife conservation as well as in a dictionary. Note that words defined in a standard dictionary may have additional legal connotations outside the dictionary.

2. Hand out "Species in Peril" worksheets. Using the Internet, by e-mail, or U.S. mail, have students contact the California Department of Fish and Game and research the lists of plants and animals that are classified as endangered, critically endangered, threatened, rare, or extinct in California. Students may contact local chapters of conservation organizations (see list on worksheet) for additional information on species of concern. Post the list.

3. Each student or pair of students will select from the list a rare, threatened, or endangered mammal, reptile, bird, plant, fish, invertebrate, or amphibian (preferably a coastal species) to research and write a report. See worksheet for research questions.
Caution: Be sure that each student or team is working on a species that is not already being researched by someone else in the class.

4. Students or pairs will produce a research report on the California rare, threatened, or endangered species of their choice. Information will include basic life history description, habitat and feeding preferences, migration patterns (if applicable), reasons for listing, current status, and steps being taken to preserve the species.

Xerces blue butterfly
Glaucopsyche xerces

California condor
Gymnogyps californianus

Hearst's ceanothus
Ceanothus hearstiorum

Results and reflection

1. Upon completion of research reports, each student or group will briefly present his or her findings to the entire class.

2. Make a table on the blackboard or overhead projector that looks similar to this:

Species Listing Status Table

Plant or Animal	California Status	Federal Status	Factors Affecting Status

As students present their data, fill in the blanks on the table. Upon completion, list the most prevalent factors affecting the species (habitat loss, pollution, impact from introduced species, etc.). Why would some species be on the California list but not on the federal list? Discuss what can be done to reduce impacts on listed species.
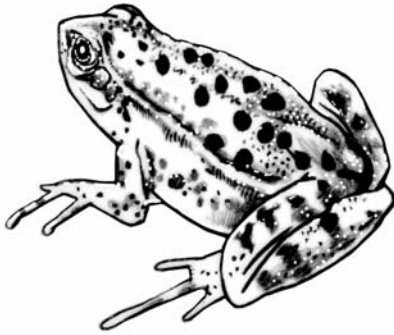
Conclusions

Species extinction is a factor of evolution, but the rate at which species are becoming extinct is rapidly increasing due to human actions. Federal or state listing of plants and animals as rare, endangered, or threatened is a first step towards protection of these species.

Extensions and applications

1. Students or pairs may create a poster on their species, and have a class-wide Rare and Endangered Species Poster Session where they present their results and what they have learned about their species.

2. Look at web sites with data on rare/endangered wetland species and exotic species introductions. Are there species in peril in your area? Students may research a local problem, its history and present state, suggestions for future, and recommendations for action. Are any actions being taken now to protect these species in your area? Find out what organization is responsible for protecting these species and ask a representative to visit your classroom. After your research, as a class write a letter to support their actions and send it to the editor of your local newspaper (see Appendix D for tips on how to write an effective letter).

3. Have groups of students choose a state government agency or a conservation group to research how they are protecting endangered plants and animals in California. What can each of us do to help protect native plants and animals?

4. Do some research on native species in your area. Take a field trip and try to find your native species in nature. Have students bring blank paper and a clipboard to record their observations, or record their experience in a nature journal. What was the habitat like—was it sufficient to support a large population of the species? Was the species thriving? Have students draw a map of the field trip area, and mark where the species occur. Is the species near water, the shade of trees, a hillside, or in an open meadow? Are there other species that the chosen species is dependent upon for survival? Map them, too. What are the limitations posed by the habitat that would keep species from thriving?

Draw them on the map. How would students modify the area to provide room for their species to increase? How would it affect other plants and animals living in the area?

5. Research an invasive species, explain how it is impacting native California species, and describe possible solutions to the problem.

California red-legged frog
Rana aurora draytonii

Caution! Invasion of the Exotic Algae

Caulerpa taxifolia, an alga native to tropical waters, is popular in home saltwater aquaria. This fast grower has invaded intertidal and subtidal areas throughout the world. *Caulerpa* blankets an area, pushing out invertebrates, fish, and native plants. It is thought to have entered coastal waters worldwide by people dumping their aquaria into household drains, storm drains or directly into the sea. *Caulerpa* outcompetes native plants, is toxic to many fish, and adversely affects invertebrates.

In 2000, *Caulerpa* was discovered in a half-acre area in a lagoon north of San Diego. It was eradicated by covering the infested site with plastic tarps and injecting chlorine, thereby killing everything underneath. This technique has been successful in eradicating this infestation and one other within California.

To prevent future invasions, *Caulerpa* has been banned from sale in the U.S. If you have *Caulerpa* in your aquarium, dispose of it immediately by freezing it for 24 hours and placing it in the trash; never flush it down a drain or dump it in the street or local water body. Aquarium water should not be dumped outside, but may be disposed of down a toilet or sink. Additional information is available in the Southern California Caulerpa Action Team website, www.sccat.net.

Xerces blue butterfly
Glaucopsyche xerces

Species in Peril Worksheet

California newt
Taricha torosa

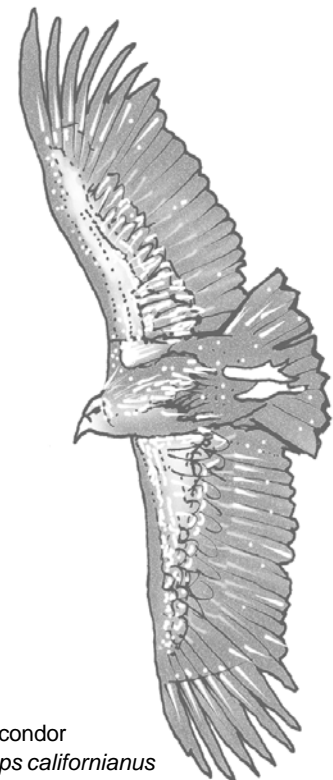| Term	Definition	Example
Species	Groups of populations whose members are capable of interbreeding in nature to produce fertile offspring and do not interbreed with members of other species	**Humans**
Native species	A species' origins cannot be traced from out of the state	**California newt**
Endemic species	Occurs naturally in one area; not found in nature elsewhere	**Island grey fox**
Rare species	Not presently in danger, but of concern because of low numbers (Some species were always rare because of their position in the food chain or due to habitat preference)	**Hearst's ceanothus**
Threatened species	Present in its range, but threatened because of decline in numbers	**Southern sea otter**
Endangered species	In immediate danger of extinction	**Beach layia**
Critically endangered	Will not survive without direct human intervention	**California condor**
Extinct species	Complete disappearance of a species	**Santa Barbara song sparrow**

Research Report

Write a two page report. Include the following information in your report:

1. Basic life history description, including illustration or photograph of species

2. Habitat and feeding preferences

3. Past and current range

4. Migration patterns (if applicable)

5. Reason for listing

6. Current status

7. Steps being taken to preserve the species

California condor
Gymnogyps californianus

Southern sea otter
Enhydra lutris nereis

California's Endangered Plants and Wildlife (2004)

The following are listed by the State of California or the federal government as rare, threatened, or endangered.

Mammals: 31 species and subspecies
www.dfg.ca.gov/hcpb/species/t_e_spp/temammal/temammala.shtml

Plants: 218 species and subspecies
www.dfg.ca.gov/hcpb/species/t_e_spp/teplant/teplanta.shtml

Reptiles: 13 species and subspecies
www.dfg.ca.gov/hcpb/species/t_e_spp/tereptil/tereptla.shtml

Amphibians: 12 species and subspecies
www.dfg.ca.gov/hcpb/species/t_e_spp/teamphib/teamphiba.shtml

Birds: 33 species and subspecies
www.dfg.ca.gov/hcpb/species/t_e_spp/tebird/tebirda.shtml

Fishes: 34 species and subspecies
www.dfg.ca.gov/hcpb/species/t_e_spp/tefish/tefisha.shtml

Invertebrates: 32 species and subspecies
www.dfg.ca.gov/hcpb/species/t_e_spp/teinvert/teinverta.shtml

California Endangered Species Resource List

California Department of Fish and Game
Habitat Conservation Planning Branch
1416 Ninth St., Sacramento, CA 95814
(916) 653-4875 *www.dfg.ca.gov/hcpb/index.shtml*

U.S. Fish and Wildlife Service
Pacific Region

Conservation Projects
California Coordinated Resource Management
   and Planning
California Environmental Resources
   Evaluation System (CERES)
California Legacy Project (CCRISP)
California Oak Mortality Task Force
Integrated Hardwood Range Management Program
Natural Resource Projects Inventory

Conservation Organizations
California Biodiversity Council
California Native Plant Society
Ecological Society of America
National Audubon Society,
   California chapter
The Natural Areas Association
The Nature Conservancy
California Partners in Flight
Riparian Habitat Joint Venture
Society for Conservation Biology
The Wildlife Society
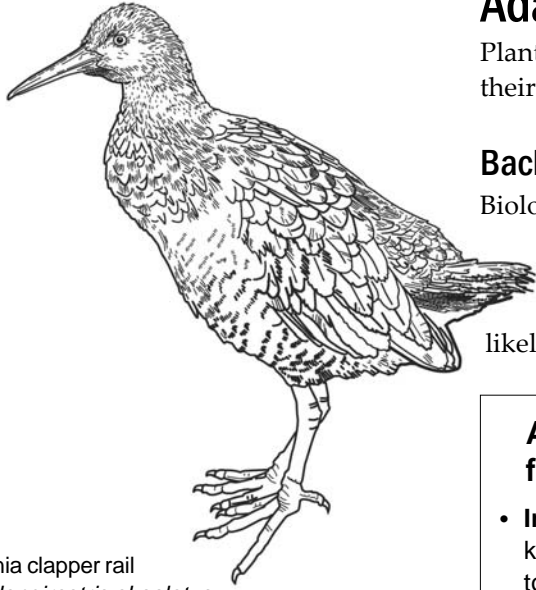
Research and Universities
California Academy of Sciences
Information Center for the Environment,
   University of California, Davis
Los Angeles Museum of Natural History
San Diego Natural History Museum
Santa Barbara County Museum of Natural History
University of California Cooperative Extension
Forestry Natural Resources News Calendar

Hearst's ceanothus
Ceanothus hearstiorum

Activity 7.2
Adapted for Survival?

Plants and animals have adaptations that allow them to survive within their habitat. Design a habitat and a bird to thrive in it.

Background

Biological evolution accounts for the diversity of species that has developed through gradual processes over many generations. Mutations occur randomly, but the ones that better allow an individual to survive and reproduce within its habitat are more likely to spread throughout the population.

California clapper rail
Rallus longirostris obsoletus

Science skills

- Observing
- Describing
- Hypothesizing
- Analyzing
- Comparing

Concept

Plants and animals have specific adaptations that contribute to the survival of the individual, and ultimately the species.

California Science Content Standards

Life Sciences

3. Biological evolution accounts for the diversity of species developed through gradual processes over many genera-tions. As a basis for understanding this concept, students know:

3.a. Both genetic variation and environ-mental factors are causes of evolution and diversity of organisms.

3.e. That extinction of a species occurs when the environment changes and adaptive characteristics of a species are insufficient for its survival.

Animals are more vulnerable to extinction from human impacts if they:

- **Interfere in some way with people's activities.** Some animals may kill livestock, eat or ruin crops, or feed on animals that people also like to eat. Because they interfere with peoples' activities, these animals may be shot, poisoned, or harmed in some other way (*e.g., eagles, wolves, jaguars, tigers, and geese, ducks, and birds that eat crops*).

- **Migrate**. Animals that migrate depend on several different habitats and are very vulnerable to habitat destruction. For example, songbirds, butterflies, turtles, and whales migrate great distances; if the habitat they are migrating to no longer provides the food or shelter they seek, they may not make it back.

- **Have very specific food or nesting requirements.** Some animals are picky about what they eat or where they live. They are adapted to eating only one type of food or live in only one habitat, and become endangered if their food sources or nesting site disappears. Native species who have adapted along with a specific environment also have to compete with introduced species. One example is bluebirds, a species native to North America, that have a hard time competing for nesting sites with starlings introduced from Europe in the early 1900s.

- **Are sensitive to changes in their environment.** For example, birds of prey are very sensitive to chemical changes in their environment, such as the introduction of pesticides.

- **Have small broods and long gestation periods.** If animals give birth to only one or two young every year or every two or three years (such as elephants, bats condors, and others), when their populations decline it takes much more time to recover because of the low birth rate. Sometimes they become extinct before they have time to make a comeback. For example, sharks have a very low reproduction rate—some species bear only one young per year—but cockroaches have 80 young every six months!

- **Are naturally rare.** Some animals and plants are naturally rare throughout their range, and others have a limited range. These animals are more vulnerable to habitat destruction. For example, many of the native plants and animals that live on the islands of Hawaii are naturally rare, and as more people move into the area, many of these already rare species face habitat loss, competition from introduced species, new diseases, and other problems.

From: Endangered Species: Wild and Rare, National Wildlife Federation, Learning Triangle Press, 1997. Reproduced with permission of The McGraw-Hill Companies.

Objectives

- Students will describe adaptations of birds to their environment.
- Students will explain how the adaptive characteristics of a bird enable it to survive in its environment.
- Describe why extinction of a species could occur when the environment changes, and the adaptive characteristics of the species are insufficient for its survival.
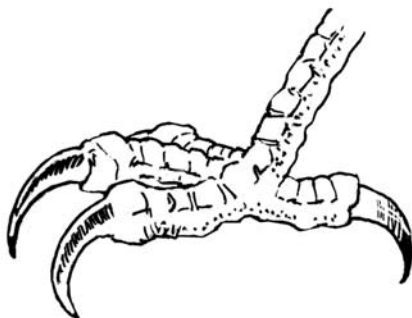
Time to complete

One hour and fifteen minutes

Mode of instruction

Pairs of students choose a habitat, draw it, and design a bird to live in it. Pairs share what they have designed and their rationale in small groups, then share with larger class. The activity includes a worksheet on the California clapper rail.
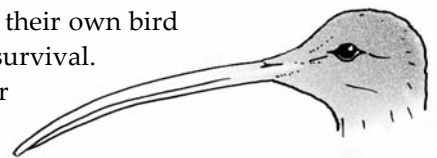
Materials

1. One large poster-size piece of paper and one small piece of paper (8 ½" x 11") for each student pair
2. Markers, colored pencils, scissors, and tape
3. Copies of "Adapted for Survival?" and "Create a Bird" worksheets, one per student pair
4. One copy of "Habitat Descriptions," photocopied and cut into cards
5. Copies of "California Clapper Rail" worksheet, one per student

When a habitat changes, either slowly or catastrophically, the species with characteristics better adapted to the new conditions are the ones most likely to survive. Some species have adapted to such a narrow range of habitat conditions that they are extremely vulnerable to change and may be more susceptible to death or extinction than other species.

Activity

1. Begin the activity with a discussion of what students know about habitats and adaptations. What are some common habitats in California? What are some adaptations plants and animals have that help them survive in these habitats?

2. Introduce the story of the California clapper rail as an example of how a species can be extremely dependent on a specific habitat. Either read aloud, or students read to themselves "California Clapper Rail." After reading, hold a classroom discussion about the story. On which habitats are the clapper rail dependent? What is happening to these habitats? If time, you may have students answer the questions at the bottom of the worksheet or send home as homework.

3. Explain that students will create their own bird that is dependent on a habitat for survival. Divide students into groups of four and hand out one set of materials to each group (one poster-size piece of paper, one 8 ½" x 11" unlined piece of paper, "Adapted for Survival" worksheet, and drawing pens or pencils).

4. Two members of each group will choose a habitat card out of the "hat" (salt marsh, redwood forest, freshwater pond, grasslands, mountain, desert riparian or river habitat, and beach). <u>Make sure that each group of four students has two different habitats to work with.</u>

5. Have students in each group choose a partner. Each pair of students will work with one habitat. The pairs draw the habitat on the poster paper following the written descriptions on the cards.

6. After drawing the habitat, each pair must choose from the "Create a Bird" worksheet adaptations for beak shape, foot type, and nesting strategy. Students design and draw their bird to fit their habitat based on their chosen adaptations. They will draw, color, and cut out their bird separately from the habitat so they can exchange habitats later.

7. When student pairs are finished, they complete the "Adapted for Survival" worksheet, and then share their bird with the class, explaining its adaptations and why the bird is well suited to its particular habitat.

8. After sharing, pairs trade habitats with the other pair in their group. Each pair must then discuss among themselves and answer worksheet questions pertaining to the fate of their bird in its new habitat. Could it survive, and why? Each pair will discuss their birds' ability to survive in the new habitat with the other pair in their group.

Preparation

Gather poster materials. Photocopy "Habitat Descriptions" (two copies only, then cut into squares), "Create a Bird," and "Adapted for Survival," and "California Clapper Rail" (one each per student).

Outline

Before class

Photocopy materials and gather poster materials.

During class

1. As a class, read "California Clapper Rail" story and discuss.
2. Divide students into groups of four.
3. Students pair up within groups.
4. Pass out poster and smaller paper, one to each pair.
5. Student pairs choose a habitat description from the hat, then draw it on the poster paper.
6. Student pairs choose from the "Create a Bird" worksheet to design and draw a freestanding bird to live in their habitat.
7. Each pair explains their results with the other pair in the group.
8. Pairs exchange habitats with each other, place their bird in its new habitat, and discuss its fate. ◇

Results and reflection

Assessment is embedded in the activity. If the students have previously read excerpts from Darwin's *Theory of Natural Selection*, there may be time for a whole class discussion on the bonus question: What role do adaptations play in Darwin's theory?

Conclusions

Many characteristics of plants and animals have adapted over time to ensure survival in their habitat. If their habitats change quickly, these plants and animals may not survive.

Extensions and applications

1. Species that do not survive habitat change or other obstacles are more prone to become rare, endangered, or extinct. Students may choose one of the habitats and identify plants and animals that are rare or endangered in the habitat. What is the reason for their endangered status? What has happened in particular to their habitat that has made it difficult for them to survive? Are there species in neighboring habitats that may be affected by the loss of this species or this habitat? Students may write a short research report based on these questions.

2. Some fish populations are declining because of overfishing. What characteristics make certain species more vulnerable to overfishing? (*Long lives, late reproduction, etc.*). See Appendix C for some interesting facts about overfishing.

Adapted from

Adapted for Survival. Save The Bay's San Francisco Bay Watershed Curriculum (Based on *Fashion-A-Fish*, found in Aquatic Project Wild and published by the Western Regional Environmental Education Council.)

Adapted for Survival?

Introduction

Does the coloration of an animal affect its chances for survival? Do feeding mechanisms influence an organism's chance of living? How would an organism's reproductive strategy affect the individual? How would it affect the species? Throughout time, people have marveled at the great amount of diversity found in nature. It is these adaptations that have led to Earth's vast array of spectacular life forms and enormous variety among species. Adaptations are any feature that increases an organism's reproductive success (or fitness) in its environment. In this activity, you will study the effects that adaptations have on a bird's success in different California habitats.

Create a Bird Instructions

1. **Read** the description of the habitat your pair has chosen and draw the habitat on the large piece of paper, showing details such as plants, animals, water, soil, etc.

2. **Design** a bird to live in this habitat.
    a. Choose one of each type of adaptation for beak, feet, and nest, using the "Create a Bird" page.
    b. On another sheet of paper, list and describe your bird's specific adaptations.
        1) What does it eat and how does it get its food?
        2) How does it build its nest, reproduce, and raise its young?
        3) How does it protect itself from predators?
        4) Explain why your bird is adapted to survive in its specific habitat.

3. Using the smaller piece of paper and pencils provided, **design, color, and cut out** one bird showing all of the adaptations you have chosen and described. Use your imagination to add details!

4. **Assign** your bird a scientific name (genus first letter capitalized, species in all lower case) and a common name. Write both on the other sheet of paper, and on the back of your bird.
For example: Scientific name: Genus, species (e.g., *Studentus restlifolius)*
                 Common name (e.g., restless student):

5. **Place** your bird in its habitat.

6. When all groups have finished designing their birds, your pair will **explain** to the group how your bird is adapted for this particular environment. Describe the habitat your bird lives in and the adaptations that are most important to your bird's survival in this habitat.

7. **Trade** habitats with another group, keeping the bird you designed.

8. **Place** your bird in the new habitat and reevaluate the probability of success for your bird. After placing your bird in its new habitat, answer the questions below.

ANALYSIS QUESTIONS
Answer these questions on the other sheet of paper:
1. List and justify any adaptations that will limit the success of your bird in its new habitat.

2. List and justify any adaptations that will enhance the success of your bird in its new habitat.

3. Which adaptation is most important for the survival of the individual bird? Explain your reasoning.

4. Which adaptation is most important for the survival of your bird's species? Explain your reasoning.

5. BONUS: What role do adaptations play in Darwin's *Theory of Natural Selection*?

Adapted for Survival?
Habitat Descriptions

1. Salt Marsh
Salt marshes are wetlands found at the edges of bays and estuaries. The tide carries salty water in and out of the marsh. Low-growing plants, such as pickleweed and cordgrass, grow here. Plankton and fish live in the water, crabs and clams burrow in the mud, and mice and insects live in the plants.

2. Redwood Forest
Redwood forests exist where fog creates a moist environment. Tall red-woods form a dense canopy that shades the forest floor. Ferns, moss, and fungus grow in the understory and redwood needles form a soft blanket of duff on the ground. Squirrels, slugs, and deer live in the forest.

3. Grasslands In California's Central Valley, low-lying flat areas are covered with grasses. Lizards and snakes bake on exposed rocks. Kit foxes and kangaroo rats roam during the night. Summers are hot and winters are cold.

4. Mountains/Alpine
In the high elevations of the Sierra Nevada mountain range, granite peaks are inhabited by pine trees and aspens. Snow falls through the winter and melts in the spring, running down creeks to rivers. The air is crisp and cold.

5. Desert. Much of south-ern California consists of arid regions that are typically hot during the day and cool at night. Very little rain falls, and all of the plants and animals have to find ways to conserve water and tolerate the heat.

6. Riparian. Located along-side rivers and streams in California, riparian habitat includes willow, alder, buckeye, cottonwood, and oak trees. A wide variety of animals seek shelter, food, and water in these shady areas. The river water flows over rocks and sandy areas inhabited by invertebrates and fish.

7. Beach/Shoreline. Sandy shore is where ocean meets land. Invertebrates live in the sand. Dead bits of kelp and animals are washed up with the tides each day. Decomposers work at drift kelp lying on sand. Sand dunes form at highest points on beach, and beach grasses and flowering plants grow.
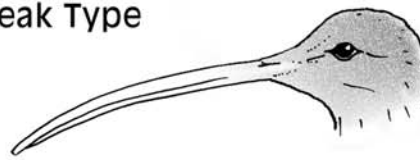
Teacher Instructions

1. Make 2-3 copies of this sheet, depending upon class size (you will need one habitat for each pair of students; if you have 28 students, make 2 copies, which yields 14 habitats).
2. Cut along dotted lines, and place in a "hat" for student pairs to select a habitat.
3. Discuss in class each habitat to add to the descriptions so students can make accurate drawings.
4. Student pairs design a bird to live in their habitat.

Beak Type

Long, slender beak
Long-billed curlew

Sharp, hooked beak
Hawk

Create a Bird

1. Choose a habitat.
2. Choose a beak.
3. Choose a foot type.
4. Choose a nesting strategy.
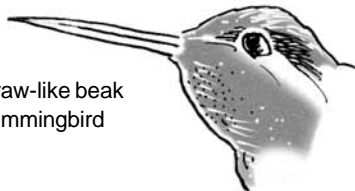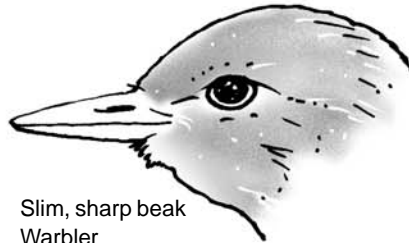5. Draw your bird.
6. Place it in its habitat.
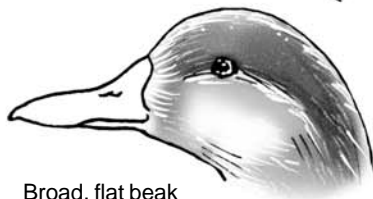
Straw-like beak
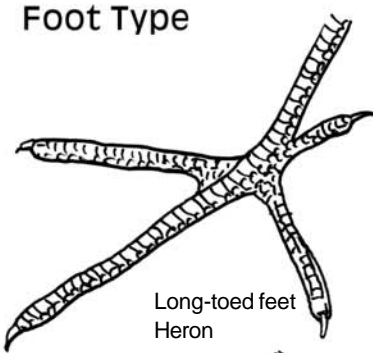Hummingbird

Slim, sharp beak
Warbler

Broad, flat beak
Mallard

Long, broad beak
Heron

Long, hooked beak
Cormorant

Foot Type
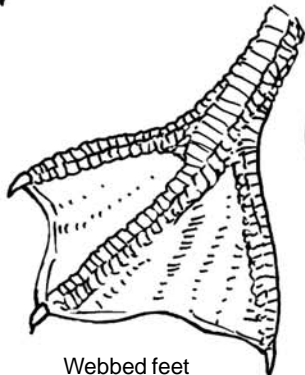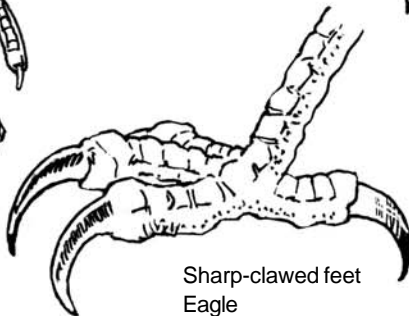
2 front/2 back
Woodpecker

Long-toed feet
Heron

Sharp-clawed feet
Eagle

Webbed feet
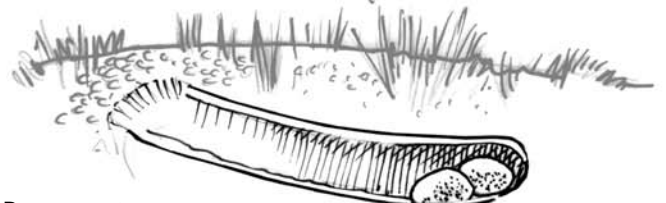Duck

3 front/2 back
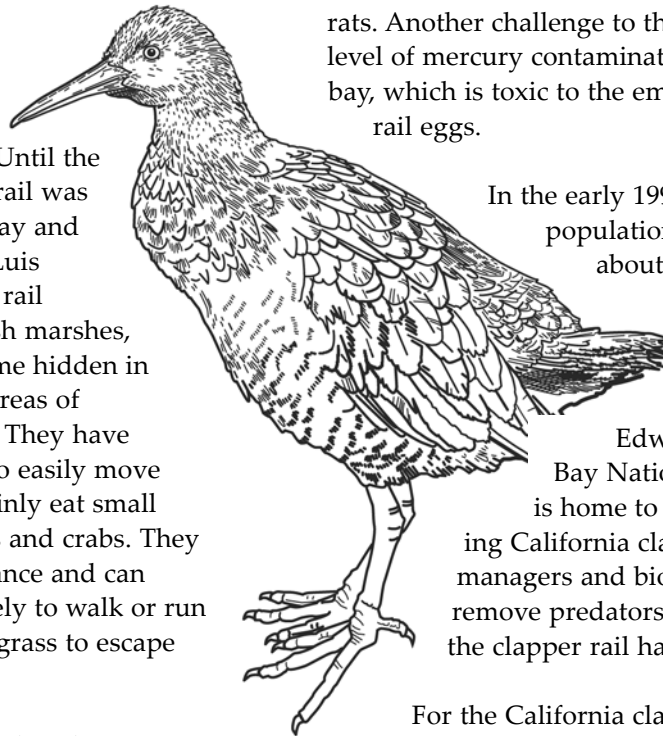Perching birds

Nest Type

Ground nest

Tree or bush nest

Burrow nest

California Clapper Rail: Story of an Endangered Species

The California clapper rail, *Rallus longirostris obsoletus*, is a native California species listed as endangered under both federal and state law. Until the late 1800s, this species of clapper rail was found as far north as Humboldt Bay and as far south as Morro Bay in San Luis Obispo County. The habitat of the rail consists of coastal salt and brackish marshes, where they spend most of their time hidden in dense vegetation, particularly in areas of pickleweed and Pacific cordgrass. They have flattened bodies that allow them to easily move among the tall grass. The rails mainly eat small invertebrates such as snails, clams and crabs. They seldom fly more than a short distance and can swim fairly well, but are more likely to walk or run to the nearest dense stand of cordgrass to escape danger.

California clapper rails were once abundant in marshes along the coast. From 1850 to the early 1900s, over-hunting greatly reduced the population. During this time, rails were served in San Francisco restaurants and shipped off to feed gold miners. Clapper rail hunting was made illegal in 1918 with the Migratory Bird Treaty Act, but the birds were then faced with loss of their wetland habitat. About 85 percent of the original marshland in the San Francisco Bay has been lost. Most of the marsh was filled so that cities could be built on the once-wet mud. Some of the marsh was converted to ponds to produce salt. Laws enacted since the 1960s have limited the destruction of wetlands, requiring extensive permits and studies in order for any filling to occur.

Though their previous habitat covered much of the coast, California clapper rails are now only found in the remaining marshes of San Francisco Bay. In their reduced habitat, they face new, introduced predators such as red foxes, feral cats and Norway rats. Another challenge to the birds is the high level of mercury contamination in parts of the bay, which is toxic to the embryos inside clapper rail eggs.

In the early 1990s, the clapper rail population reached a low of about 500. The population now may be as large as 1,500 due to conservation efforts. The Don Edwards San Francisco Bay National Wildlife Reserve is home to many of the remaining California clapper rails. Refuge managers and biologists work to remove predators and keep them out of the clapper rail habitat.

For the California clapper rail population to continue improving, more marshland habitat must be made available. There are many wetland restoration efforts currently in progress. In 2002, Cargill, Inc. agreed to sell 16,500 acres of former salt ponds to the State of California and the federal government for wetland restoration, which will increase the San Francisco Bay's existing tidal wetlands by 50 percent. This project will take many years to complete, but its existence provides a brighter outlook for the future of the California clapper rail.
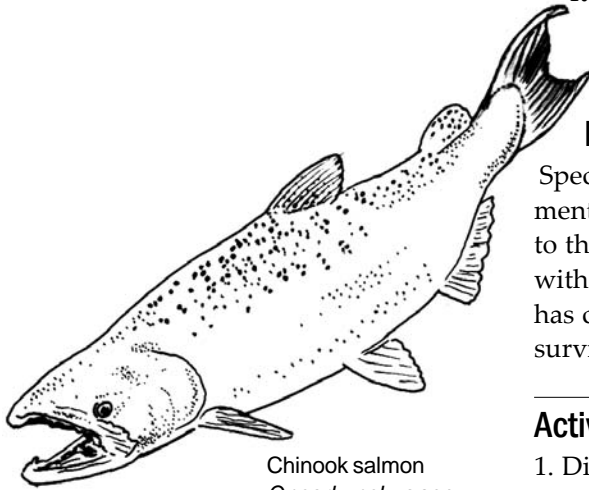
Questions:

1. How is the California clapper rail adapted to the salt marsh?
2. What issues have affected the California clapper rail in the past and what issues are affecting it now?
3. Is it important to protect the remaining salt marshes? Why?

Activity 7.3
Survivor: California

It can be hard for a species to adapt in light of present day environmental challenges. See if you are one of the lucky few to beat the odds and survive in this game of life.

Background

Species spend hundreds of thousands of years adapting to the environmental conditions of Earth, and thousands of years adapting specifically to the local conditions in California. Over the past 150 years, beginning with the Gold Rush, there has been a human population explosion that has changed the natural environment forever. How will these species survive the changes? Is survival or extinction next for them?

Activity

1. Divide the students into six groups. Student groups sit in a semi-circle facing the "Survivor: California" game board. Explain that all groups will start out at the beginning of the phylogenic tree, and can choose their own paths as they evolve. All paths have the same number of steps; the cards they draw will determine how quickly they move on the board. Two groups cannot evolve into the same species, so there are limits to the routes each group can take on the phylogenic tree.

2. The scenario cards describe historical events that have changed Earth's environments. Natural selection determines the differential survival of groups of organisms. Organisms that were adapted to a particular change survived, while others died or failed to reproduce. **Make sure the students realize that these scenario cards are not in correct historical order, as they are drawing them from the bag randomly. The scenario cards demonstrate many of the factors that have occurred over the history of life on Earth that have affected the evolution of species BUT the scenario cards may not have truly affected the particular species the students are evolving into in this game. Emphasize that this is a simulation!**

3. Now is your chance to evolve! Each group rolls the dice. The highest roll gets first pick from the scenario bag, play proceeds around the room counterclockwise. Each group takes a turn drawing scenario cards from the bag. After drawing a card, each group needs to choose together which forks to take on the phylogenic tree and decide where to move on the board. As they make their choice and evolve, mark their spaces on the overhead with six differently colored dry-erase markers. Used cards go back in the bag.

4. The game ends once each group reaches the end of the game board and becomes a present-day species. At this point, place the "Species Cards" in a "hat" and have groups appoint a representative to draw a card. Groups will draw according to the species "number" they arrived at on the game board. Tell students to pretend that the evolutionary path they followed in the game led them to become the species on their card.

Chinook salmon
Oncorhynchus spp.

Science skills
- Analyzing
- Hypothesizing
- Deducting
- Predicting

Concept

Exploding population growth in California creates new limits to survival and species evolution.

California Science Content Standards

Life Sciences

3. Biological evolution accounts for the diversity of species developed through gradual processes over many generations. As a basis for understanding this concept, students know:

3.a. Both genetic variation and environmental factors are causes of evolution and diversity of organisms.

3.b. The reasoning used by Darwin in making his conclusion that natural selection is the mechanism of evolution.

3.d. How to construct a simple branching diagram to classify living groups of organisms by shared derived characteristics, and expand the diagram to include fossil organisms.

3.e. Extinction of a species occurs when the environment changes and adaptive characteristics of a species are insufficient for its survival.

Objectives

Students will:
- Understand the processes and factors that drive evolution.
- Find solutions to present day problems facing species survival.

Time to complete

One class period

Mode of instruction

Students play a board game followed by a whole class discussion.

Materials

1. Overhead projector
2. Overhead transparency copy of "Survivor: California" game board
3. Dry erase markers (6 different colors)
4. "Scenario Cards" photocopied onto card stock
5. "Species Cards" photocopied onto card stock and cut out

Preparation

Conduct Activity 7.1 previous to this activity, so students understand definitions and importance of rare and endangered species and the factors that may create challenges to survival.

Outline

Before class
1. Photocopy onto a transparency "Survivor: California" game board.
2. Photocopy Scenario Cards and Species Cards onto card stock, and cut up.
3. Place Scenario Cards into bag labeled "Round 1."

During class
1. Divide students into six groups.
2. Explain game instructions.
3. Play game.
4. Each group presents their solutions to the rest of the class as the class votes, Survival or Extinction.
5. Whole class discussion wrap-up.

5. All groups have evolved to become a present-day species that depends upon California's unique environment to survive. Is survival or extinction next for these species? It's in the cards. In order for a group's species to survive, they must come up with some reasonable solutions to their threats to survival. Allow groups time to discuss solutions to the problems on their "Species Cards." Each group will then present their solutions to the rest of the class, and the class will vote: Survival or Extinction.

Results and reflection

1. After the solutions are discussed, hold a class discussion about evolution and threats to survival. Questions for possible discussion include: Is evolution happening today? Are the rapid extinctions of large numbers of species that occur now "natural?" Why would we want to save species from extinction?

Conclusions

Environmental changes induced by an expanding human population add new factors that affect the ability of highly evolved species to survive.

Extensions and applications

1. Research a locally rare or endangered species in your area. Define the predominant factor affecting its ability to survive or become extinct. Find three ways that protection of this species can be assured. Would there be any negative impacts on human communities if the species is protected?
2. Research a species that has become extinct in California. What caused its decline? If we knew then what we know now about extinction and biodiversity, would it have made a difference—would the people have made different choices? Write a short story on how things could have turned out differently.
3. Visit a natural area that is known to harbor a rare or endangered species. If you can locate your species in the wild, leave it where it is and draw a scientific illustration that includes the habitat in which you found it. Are there any plants or animals that have a special relationship with your species? If so, draw them in the picture also. Record the date, location, and weather on your drawing.

Adapted from

Survival or Extinction. Save the Bay's San Francisco Bay Watershed Curriculum. Survival or Extinction activity adapted from the *Limiting Factors/Evolution Game* by Amy Quillen and Gail Correy, as part of the Woodrow Wilson Leadership Program in Biology.

Additional References
California Department of Fish and Game: *www.dfg.ca.gov/hcpb/*
California Native Plant Society: *www.cnps.org*
California Environmental Resources Evaluation System (CERES) (*www.ceres.ca.gov*), a program of the California Resources Agency (*www.resources.ca.gov*)
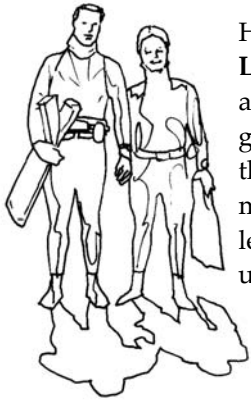Save The Bay: *www.savesfbay.org*

Survivor: California

Scenario Cards

Congratulations! You have evolved to the point where you have lungs! Evolve 2 spaces.

Your species is contributing to biodiversity of the land mammal population. Evolve 2 spaces.

A volcanic eruption has distributed ash on all land vegetation. Regress 2 spaces.

An abundance of food in the ocean has increased the biotic potential of your species. Evolve 1 space.

An increase in atmospheric CO2 causes an increase in phytoplankton in the ocean, increasing the fish population (your food supply). Evolve 1 space.

Volcanoes are erupting all over Earth's surface, but you are relatively unaffected due to the buffering effect of your ocean. Evolve 2 spaces.

A meteor has created a nuclear winter. The added insulation provided by your fur has increased your chance for survival. Evolve 2 spaces.

Your food supply is successful and provides you with a stable food supply for a long period of time. Evolve 3 spaces.

As a result of tectonic movement, desert habitat has become a redwood forest. Other species fail to adapt and you thrive. Evolve 2 spaces.

Your ability to filter feed on krill using your baleen allows you to eat lower on the food chain (a helpful adaptation). Evolve 3 spaces.

Increased CO2 in the atmosphere has melted the polar ice caps, decreasing the ocean's salinity and upsetting the osmotic balance of plankton, your food supply. Regress 2 spaces.

An increase in the population of krill has brought different species into your area of the ocean. Your ability to compete allows you to evolve to the next level. Evolve 1 space.

An increase in carbon dioxide has contributed to an increase in land vegetation. Evolve 1 space.

Your forelimbs have broadened, making you a much better swimmer. Evolve 2 spaces.

You have the ability to give birth to live young. Since you need not worry about egg snatchers, evolve 1 space.

A small population becomes geographically separated from the rest of the species, due to a newly formed mountain range. Evolve 2 spaces.

Your water environment filters out much of the solar radiation before it gets to you. Evolve 3 spaces.

The Ice Age ends and bays are formed as water levels rise. This provides you with habitat. Evolve 2 spaces.

A decrease in temperature causes freezing of the polar ice caps. Land mass increases. Evolve 3 spaces.

Sedimentation from rivers flows into your bay, increasing your wetland habitat. Evolve 2 spaces.

The salinity in your ocean increased due to a long period of increased climate temperature. These stresses reduce your ability to reproduce. Regress 1 space.

The loss of your legs over many generations has made you more streamlined. This increases your swimming speed and your success as a species. Evolve 2 spaces.

You win in the Darwin gene pool. Evolve 3 spaces.

You win in the Darwin gene pool. Evolve 3 spaces.

Survivor: California
Species Cards

HUMAN
Limits to Survival: Emissions from cars and industry are causing greenhouse gasses to build up. Global warming will threaten your ability to grow food, and melt the polar caps which will raise sea level. Low lying coastal areas will be underwater.

Humans
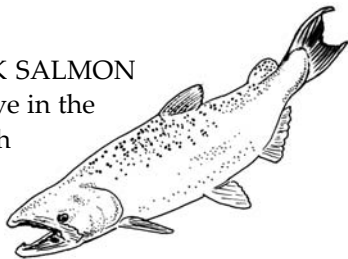*Homo sapiens sapiens*

BROWN PELICAN
Limits to Survival: DDT, a now banned pesticide once used in agriculture and still found in soil, makes its way to the oceans. DDT weakens your eggshells, causing them to crack. You are unable to successfully reproduce.

Brown pelican
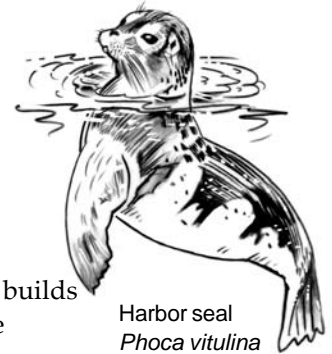*Pelecanus occidentalis*

WINTER RUN CHINOOK SALMON
Limits to Survival: You live in the ocean, but lay eggs in fresh water rivers and streams. Dams have been built on nearly every California river, and you are unable to return to your breeding grounds in order to reproduce.

Winter run Chinook salmon
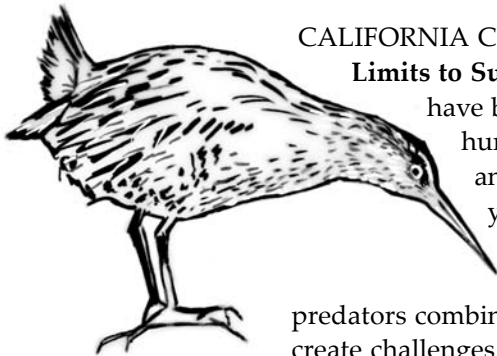*Oncorhynchus* spp.

HARBOR SEAL
Limits to Survival: Pollution from streets, yards, agricultural fields, farms, and industries flows into California's ocean and bays each day. Polluted plankton are eaten by fish and you eat the fish. Ultimately, pollution builds up in you, and you are unable to reproduce.

Harbor seal
Phoca vitulina

CALIFORNIA CLAPPER RAIL
Limits to Survival: Red foxes have been introduced by humans to California and are eating you and your young. About 1500 California clapper rails remain: predators combined with habitat loss create challenges to survival.

California clapper rail
Rallus longirostris obsoletus

SALT MARSH HARVEST MOUSE
Limits to Survival: Your salt marsh habitat is disappearing. Only 10% of all California's salt marshes are left and they are threatened by development.

Salt-marsh harvest mouse
Reithrodontomys raviventris
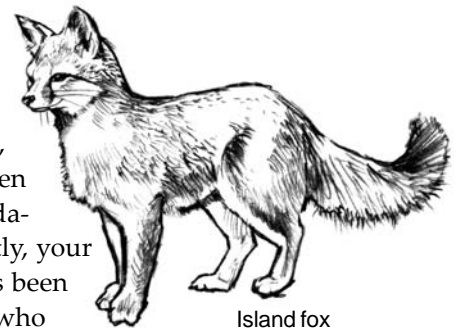
CALIFORNIA RED-LEGGED FROG
Limits to Survival: Your populations were decimated by humans for food by the begining of the 1900s. Predators such as non-native bullfrogs, crayfish, and fishes have taken care of what's left. You have disappeared over 99% of your former range, and your riparian habitat is constantly threatened.

California red-legged frog
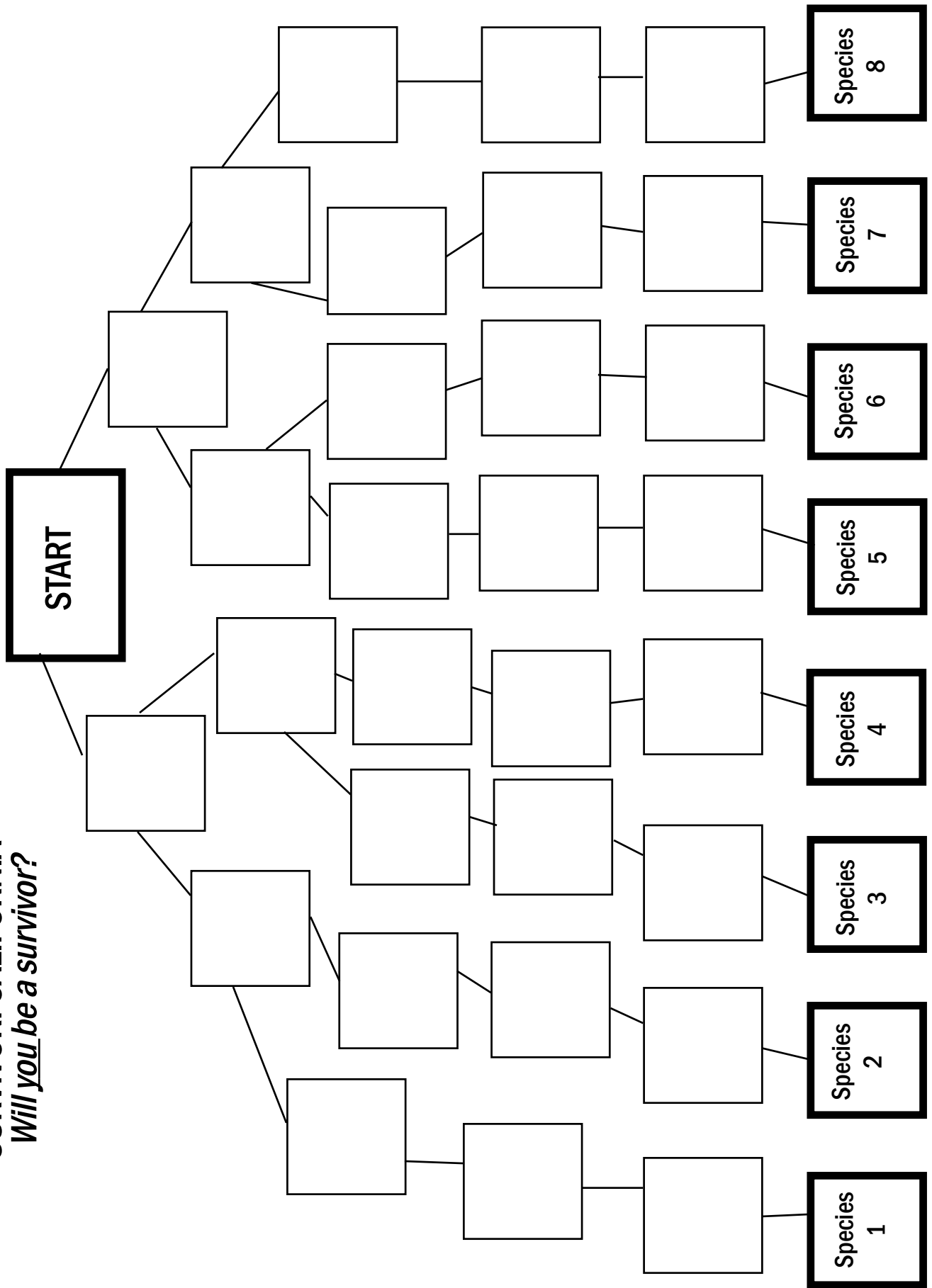*Rana aurora draytonii*

ISLAND FOX
Limits to Survival: Your life on the Channel Islands is threatened by disease, predation by the golden eagle, loss and degradation of habitat. Recently, your dramatic decrease has been due to golden eagles who have begun to nest on the islands. However, golden eagles are also endangered.

Island fox
Urocyon littoralis

SURVIVOR: CALIFORNIA
Will you be a survivor?

START

Species 8

Species 7

Species 6

Species 5

Species 4

Species 3

Species 2

Species 1

Notes

Waves, Wetlands, and Watersheds: California Coastal Commission Science Activity Guide