Student Workbook

California Education and the Environment Initiative

B

Biology Standard B.6.b.

Ecosystem Change in California

California Education and the Environment Initiative

Approved by the California State Board of Education, 2010

The Education and the Environment Curriculum is a cooperative endeavor of the following entities:

California Environmental Protection Agency

California Natural Resources Agency

Office of the Secretary of Education

California State Board of Education

California Department of Education

California Integrated Waste Management Board

Key Leadership for the Education and Environment Initiative:

Linda Adams, Secretary, California Environmental Protection Agency

Patty Zwarts, Deputy Secretary for Policy and Legislation, California Environmental Protection Agency

Andrea Lewis, Assistant Secretary for Education and Quality Programs, California Environmental Protection Agency

Mark Leary, Executive Director, California Integrated Waste Management Board

Mindy Fox, Director, Office of Education and the Environment, California Integrated Waste Management Board

Key Partners:

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Office of Education and the Environment

1001 I Street • Sacramento, California 95812 • (916) 341-6769

http://www.calepa.ca.gov/Education/EEI/

Contents

Allelopathy: The inhibition of the growth of a plant caused by the release of toxins produced by another plant.

Baseline: A measurement that provides a starting point for analyzing change, such as the initial temperature of something.

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

Climate: The prevailing, average weather conditions influenced by temperature, precipitation, humidity, and other meteorological factors in a given region over a long period of time.

Conservation easement: A legal agreement between a landowner and government or land trust, that places development restrictions on a tract of land for conservation purposes.

Cumulative: The successive addition of effects or amounts of something, such as money or environmental effects.

Duration: The length of time an activity, process, or object continues or exists.

Ecological succession: Change in the composition in species in an ecosystem over time.

Ecosystem: A specific area, such as a kelp forest, that contains a characteristic set of interdependent species that interact with each other and the abiotic components found there.

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

Ecosystem management: Actions and decisions of individuals, organizations, and government entities related to maintaining ecosystems and providing ecosystem goods and ecosystem services to current and future generations.

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.

Endemic: (noun) Species or taxa found only in a specified geographic region. (adjective) Prevalent in a particular region.

Invasive species: A species that is introduced to an area beyond its normal range, where it spreads rapidly and crowds out native species.

Nonnative species: A species not originally found in an area, that was transported to the area through human activity.

Pollen core: A cylinder-shaped sample of soil or sediment that is used to analyze the types of pollen in a location at a given time.

Serpentine: A soil type in California derived from weathered serpentinite rock and known for its unique chemical composition.

Stakeholders: Individuals, groups, or organizations that have an interest in, or concern about, a particular action or decision.

Survey: (verb) To measure and make an accurate, detailed map of an area.

Synergistic: A process whereby two or more factors acting together cause greater effects than the sum of the effects of the individual factors.

Tree ring: An annual growth band that appears on a cross section of a trunk or branch that can be used to determine the age and history of a tree.

Name: _____

Instructions: Based on reading ***California Connections: The Transformation of Our Native Grasslands*** (Student Edition, pages 2–5), list variables that have altered the California grasslands in the first column in the chart below. Next, describe how these changes have altered the grassland ecosystems, both its biotic and abiotic components, in the column on the right.

Variable (2 points each)	**How did it change the grassland ecosystem?** (2 points each)
_____ _____	
_____ _____	

Name: _____

Variable (2 points each)	**How did it change the grassland ecosystem?** (2 points each)
_____ _____	
_____ _____	
_____ _____	

Name: _____

Part 1: Data Collection

Instructions: Using the **Sample Grassland Plot** (Student Edition, pages 7-11) your group was assigned, conduct a survey of the vegetation (kinds of plants) that is currently in your plot.

Record the frequency (number of colored squares) of quadrats in which each of the various plants is dominant. Record your data in the chart below. Describe where your plot is located at the **Rancho Grassland Study Site** (Student Edition, page 6). Fill in the rest of the table as the other groups share information about their **Sample Grassland Plots**.

	Plot #1	Plot #2	Plot #3	Plot #4	Plot #5
Location of Plot					
Native plants found in grassland habitats					
Plantago erecta California plantain					
Thysanocarpus curvipes Fringe pod					
Lupinus bicolor Lupine					
Trifolium gracilentum Pinpoint clover					
Plagiobothrys canescens Popcorn flower					
Nassella pulchra Purple needlegrass					
Clarkia purpurea Purple clarkia					
Chlorogalum pomeridianum Soaproot					
Layia platyglossa Tidy tips					
Dichelostemma multiflorum Wild hyacinth					
Native plants found in woodland habitats					
Baccharis pilularis Coyote brush					
Quercus lobata Valley oak					

Name: _____

	Plot #1	Plot #2	Plot #3	Plot #4	Plot #5
Location of Plot					
Native plants that are adapted to spending part of the year in water					
Triphysaria eriantha Johnny-tuck					
Lasthenia californica California goldfields					
Downingia ornatissima Folded calicoflower					
Eleocharis macrostachya Spike rush					
Nonnative plants, farmed for their fruits					
Olea europaea Olive					
Opuntia ficus-indica Mission cactus					
Nonnative invasive plants					
Poa annua Annual bluegrass					
Brassica nigra Black mustard					
Erodium cicutarium Redstem filaree					
Bromus diandrus Ripgut brome					
Rumex acetosella Sheep sorrel					
Hypochaeris glabra Smooth cat's ear					
Avena fatua Wild oat					
Other					
Buildings and roads					

Name: _____

Part 2: Predicting Change

Instructions: Use the information in Part 1 to answer the following questions. (5 points each)

1. Based on the data for all five plots, which **Sample Grassland Plots**, have the most nonnative plants? How can you tell?

2. Why do you think that this **Sample Grassland Plot(s)** has the most nonnative plants? Where else are there a large number of nonnative plants?

3. Which parts of **Sample Grassland Plot #5** are showing indicators of ecological succession?

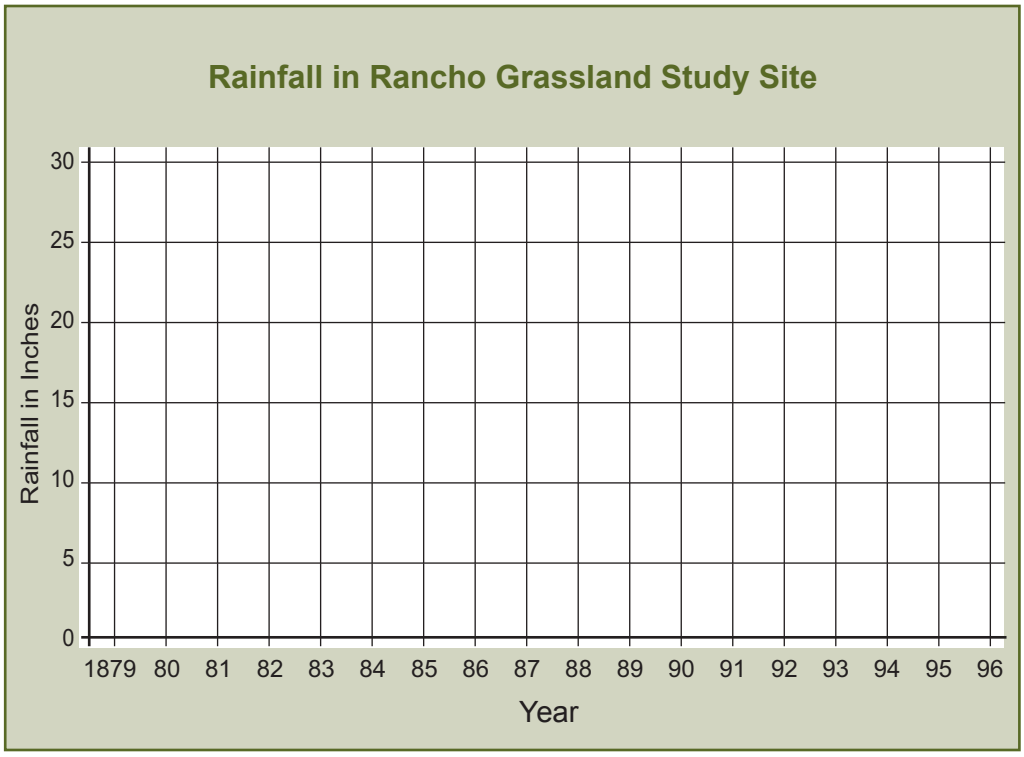
Name: _____

Part 1: Reading Tree Cores

Instructions: Use the data on the chart below to plot a graph of the rainfall in the sample area.

A tree core was collected from a valley oak growing in the **Rancho Grassland Study Site** (Student Edition, page 6). The chart below shows the width of the rings that grew between the years 1879 to 1896. Each millimeter of tree growth represents one inch of rainfall that year. Plot the data on the graph below.

Year	Width of tree ring (mm)
1879	10
1880	8
1881	11
1882	9
1883	6
1884	7
1885	9
1886	10
1887	11
1888	15
1889	14
1890	17
1891	17
1892	20
1893	25
1894	18
1895	22
1896	19



(*Note: Rings are counted back from the year when the tree is cut down.*)

Instructions: Answer the questions in the spaces provided. (3 points each)

1. Which year had the highest rainfall? _____ Number of inches: _____

2. Which year had the lowest rainfall? _____ Number of inches: _____

3. How do you think the grasslands might have changed in 1883?

Name: _____

4. Were these effects short-term or long-term?

5. Do you think the changes shown on this graph represent short-term variation in the climate or a long-term trend?

Part 2: Identifying Pollen in Soil Samples

Instructions: Look at the three soil samples. Use the **Pollen Identification Guide** (Student Edition, pages 13–14) to identify the pollen in the samples. Count each grain of each type in each sample and record your data below. Calculate the percentage of each kind of pollen for each sample.

	Sample 1: 24,000 years ago		**Sample 2: 7,000 years ago**		**Sample 3: 4,000 years ago**	
	Number of grains	**Percent of total**	**Number of grains**	**Percent of total**	**Number of grains**	**Percent of total**
Amaranth						
Goldfields						
Greasewood						
Juniper						
Oak						
Pine						
Sagebrush						
Total pollen count:		**100%**		**100%**		**100%**

Name: _____

Instructions: Answer the questions in the spaces provided. (3 points each)

1. What plants were most common in the oldest soil sample?

2. What plant was most common in the most recent soil sample?

3. What kind of change in grassland plants occurred between 24,000 years ago and 7,000 years ago?

4. How do you think this is related to climate change in the past?

5. Do you think that climate change in this area had long-term or short-term effects on the grassland? Why?

Name: _____

Instructions: Use evidence from **Spanish Journal Entries from the 1700s** (Student Edition, pages 16–17) and **California Ranchos** (Student Edition, pages 18–19) to complete the chart below. (2 points each cell)

	Human Activities at the Time	Natural Features of the Ecosystem at That Time	How do you think the human activities at this time changed the grasslands?
California in the 1700s			
California in the 1840s and 1850s			

Name: _____

	Human Activities at the Time	Natural Features of the Ecosystem at That Time	How do you think the human activities at this time changed the grasslands?
California in the 1950s			
California in 21st Century			

Name: _____

Part 1

Instructions: Read the following background information to learn about some of the characteristics of nonnative plants and animals that have been brought to the grasslands. Discuss with your partner which of these characteristics make it more likely that the plant or animal will become invasive.

Of California's approximately 6,000 plant species growing in the wild, 15–30% are nonnative species. Humans introduced these plants in a variety of ways. Some were planted intentionally for food, livestock forage, erosion control, or ornamental purposes. Others traveled as stowaway seeds in grain shipments or ship ballast. Of these nonnatives, about 200 are considered invasive, crowding out native plants and altering ecosystems dramatically.

Invasive animal species have altered many California ecosystems and interrupted food webs. Nonnative red foxes that were originally introduced for hunting now compete with the endangered San Joaquin kit fox and prey on birds, including the endangered California clapper rail. Their presence increases the risk of extinction for these animals.

Marine and aquatic invasive species, such as the tiny but prolific New Zealand mudsnail, as well as northern pike and zebra mussel, outcompete native species for resources, clog waterways, and, in the case of the adult northern pike, voraciously prey on native fish, frogs, and even ducklings.

Invasive plant species also reduce biodiversity and cause a wide variety of changes to an ecosystem. For example, tamarisk plants in the desert have long taproots that allow them to exploit water resources and outcompete native plants. Eucalyptus leaf litter is allelopathic, poisoning the soil around the tree and suppressing the growth of other plants.

Human-caused disturbances to environments amplify the effects of nonnative species in cumulative and synergistic ways. Invasive species tend to have certain characteristics that aid their establishment: they reproduce rapidly and in large numbers; they tolerate a wide range of environmental conditions; plant species may be able to reproduce asexually; animal species have a varied diet. All these characteristics are even more helpful for species establishing themselves in disturbed environments. When activities, such as construction, ranching, or farming disrupt an ecosystem, invasive species may be best suited to re-establish themselves post-disruption. Their characteristics act synergistically with human-caused disturbances to promote their invasive establishment. This can cause ecosystems to experience long-term consequences as they lose biodiversity that may never be restored.

Name: _____

Part 2

Instructions: Write one or two sentences about how each of the characteristics listed below may or may not contribute to a plant becoming invasive.

1. Can disperse seeds widely by wind:

2. Makes only a few seeds at a time:

3. Grows quickly:

4. Can reproduce asexually (does not need another plant to reproduce), causing new plants to grow from its roots or cuttings:

5. Can grow deep taproots to access water resources unavailable to others:

Name: _____

6. Has very specific soil requirements for growth:

7. Seeds can remain dormant (not growing) for a very long time, growing again when conditions are optimal:

8. Releases chemicals into the ground that prevent other plants from growing, called allelopathy:

9. Creates lots of shade:

Part 3

Instructions: Write one or two sentences about how each of the characteristics listed below may or may not contribute to an animal becoming invasive.

10. Can eat a wide range of foods:

Name: _____

11. Produces only one offspring at a time, with a long time between generations:

12. Tolerates humans:

13. Can survive in a variety of habitats:

14. Uses a particular plant species on which to lay its eggs:

Name: _____

Instructions: Turn to **Rancho Grassland Study Site** (Student Edition, page 6) and **Grassland Vegetation Key** (Student Edition, page 12) and review these items to prepare to investigate the spread of nonnative plants on the landscape.

Part 1: Data Collection

Instructions: Turn to page 2 of **Survey of a Grassland** (page 6 in this book) and look at the sections of the chart named "Nonative plants, farmed for their fruits" and "Nonnative invasive plants." Use the information in these two sections and the chart below to answer the following questions. (2 points each)

Species	Common Name	Native To:
Avena fatua	Wild oat	Mediterranean Europe
Brassica nigra	Black mustard	Mediterranean Europe
Bromus diandrus	Ripgut brome	Mediterranean Europe
Erodium cicutarium	Redstem filaree	Mediterranean Europe
Hypochaeris glabra	Smooth cat's ear	Mediterranean Europe
Olea europaea	Olive	Mediterranean Europe
Opuntia ficus-indica	Mission cactus	Mexico
Poa annua	Annual bluegrass	Mediterranean Europe
Rumex acetosella	Sheep sorrel	Mediterranean Europe

1. Which two species are nonnative, but not invasive (they are located only near places where humans have lived or worked, and they have not spread beyond where they were planted by people)?

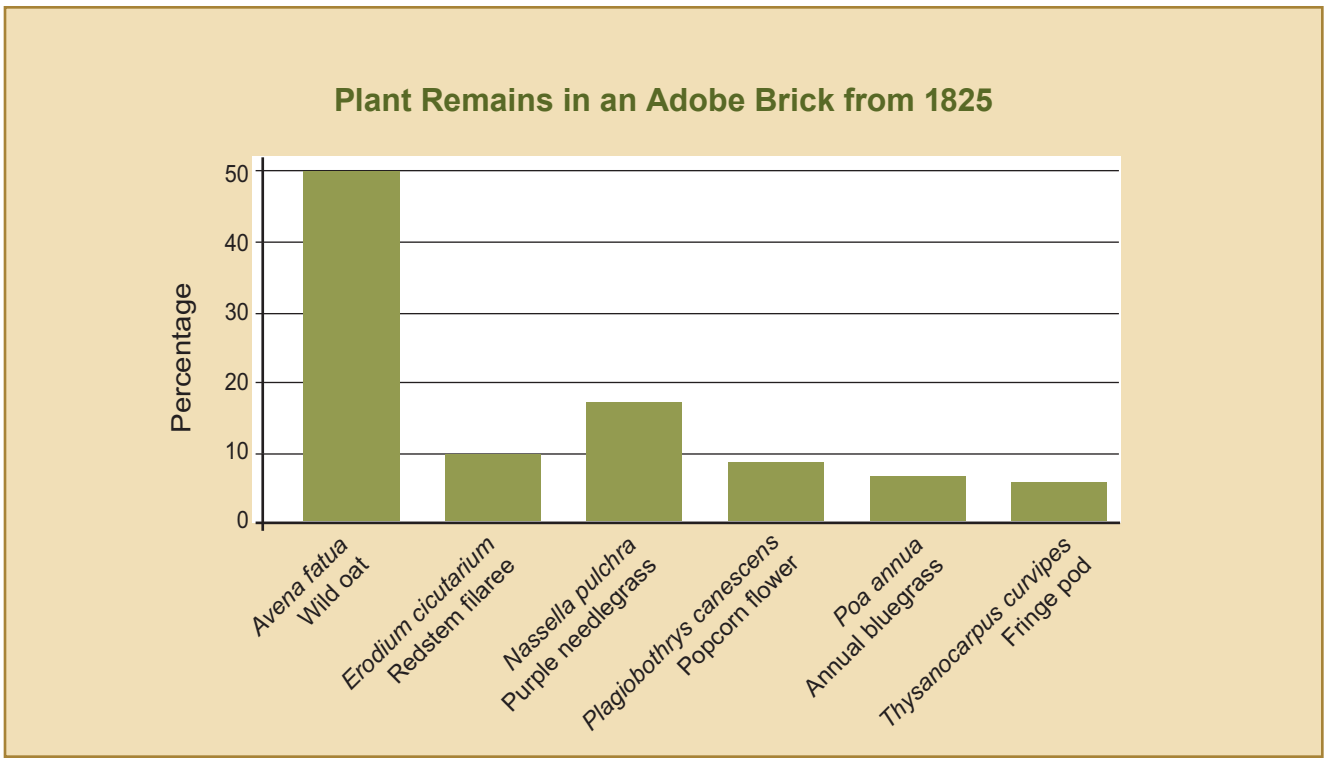
2. Which plants are highly invasive (plants that appear in all the sample grassland plots, often as a dominant species)?

3. Which species is invasive and appears to be found only in disturbed areas like Plots #2 and #3?

4. Are there any trends that you can distinguish about where invasive plants live?

Name: _____

An adobe brick was taken from the ruins of the Spanish mission on the western edge of the the Rancho Grassland Study Site. It is estimated that the brick was made in approximately 1825. It contains the remains of plant material in the following proportions:



Instructions: Use the information provided in the graph above and **Survey of a Grassland** for Plot #2 to answer the following questions. (2 points each)

5. Which nonnative species must have been introduced to the sample area before 1825?

6. Which additional nonnative species have been introduced to the sample area since 1825?

Name: _____

Part 2: Analysis

Instructions: Answer the questions below in the spaces provided. (2 points each)

7. Give an example of how nonnative species affected the grassland between 1825 and today (after humans settled in the area).

8. Nonnative species have affected grasslands in many ways. Are these effects short-term or long-term?

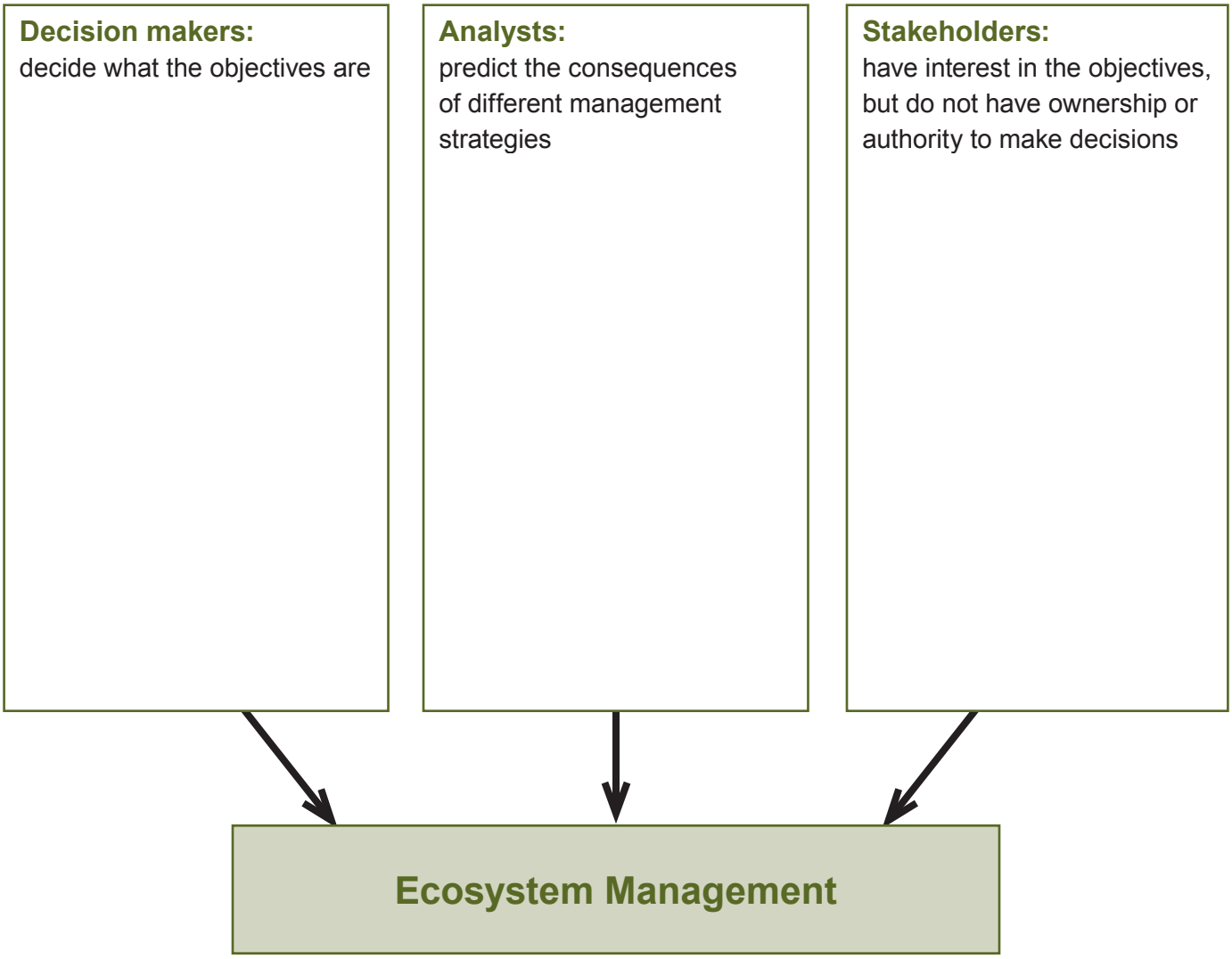
9. What other variables have contributed to the success of nonnative plants? How?

Name: _____

Ecosystem management: Actions and decisions of individuals, organizations, and government entities related to maintaining ecosystems, and providing ecosystem goods and ecosystem services for current and future generations.

Part 1

Instructions: Several different roles are involved in making decisions about ecosystem management. Identify at least three types of people or agencies, within each category, who make decisions about ecosystem management. (3 points each)



Name: _____

Part 2

Instructions: List at least five objectives that might be important in making decisions related to ecosystem management. (1 point each, 5 points total)

Name: _____

Part 3: The Management of California's Grasslands

Instructions: Read the following paragraphs and then answer the questions below. (3 points each)

A "conservation easement" is a voluntary agreement that landowners make about the use of their land. Owners agree to certain restrictions on how their land will be used now and in the future. For example, they may agree never to develop their property for housing or business use. They make this promise to a government entity, such as the California Natural Resources Agency, or to a conservation organization that will make sure these restrictions are enforced. These restrictions become part of the deed to the land. If the owner ever sells the land, future owners buy it knowing that they, too, must follow these restrictions.

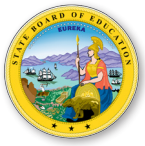
Some landowners agree to a conservation easement voluntarily. Many would like to help preserve their land, but they still want to own it, live on it, or use it for their livelihood. Others allow conservation easements in order to lower their taxes. When owners agree to a conservation easement, the value of their property can go down, because now future owners cannot do whatever they want to on the land. In exchange, the government lowers owners' property taxes based on how much the value of their land may have dropped. In addition, the government offers grants to landowners that agree to conservation easements, to help pay for them. This is just one way the government manages ecosystems and human use of them.

Current global climate change, believed to be caused by human activity, is going to further complicate the decision-making process related to ecosystem conservation. For example, as species (particularly native species) are pushed to other regions, or those living in extreme ecosystems (for example, high altitude) are pushed toward extinction, ecosystem conservation may prove less effective as the process of preserving ecosystems becomes more complicated. Ecosystem conservation efforts become significantly more complex when the climate in areas intended to protect certain species can no longer support those species.

1. What factors make ecosystem management of California's grasslands so challenging?

Name: _____

2. Do you think conservation easements are a good way to manage California grassland ecosystems? What is another alternative that you think California could use?



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