Student Edition

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

The Transformation of Our Native Grasslands

Rolling, green-gold hills are an icon of California. Therefore, it may come as a surprise to learn that those "waves of grain" are actually barnyard weeds from Spain and other Mediterranean areas. Ninety-nine percent of California's grasslands today are made up of plant species from Europe and other continents. In fact, grasslands have been altered more than any other ecosystem in the state, and are among the most endangered in the nation.

Clues to the Past

The transformation of California's native grasslands was rapid and widespread. Because of this, no one knows what these grasslands really looked like at the time of first European contact. We can only glimpse the past by looking at remnant patches of native grasses that exist today. Scientists search for clues in fossilized pollen, archeological sites, and historical accounts. They use these clues to answer questions about how our native grasslands came to be, how these ecosystems once functioned, and how they declined so rapidly.

From the fossil record, we know large changes in California's grasslands took place over the past 10,000 years. Grasslands at times were much larger and covered more area than today, and at other times, they covered less area. The fossil record indicates that 6,000 years ago, California received more rain than present day. Two thousand years later, the climate became drier, similar to what our climate is today—a cool, wet winter followed by a long, warm, dry season that lasts through late fall. During the rainy season, the grasses

Tule elk (*Cervus elaphus nannodes*)

grew. The long, dry seasons invited fire. Our native grasses benefit from some fire, which opens up space for more of them to grow. Fires also remove thatch and recycle nutrients.

Native Grazers and Fire

California's native grasses evolved alongside seasonal native grazers, such as tule elk and pronghorn antelope. In addition to eating the grass, grazers pruned trees and shrubs at the grassland edge. Large grazers compacted the soil with their hooves, making the terrain more favorable for grasses than woody plants. The shift to a drier climate thousands of years ago occurred at about the same time American Indian communities expanded in California. Their use of controlled burns (fires) to improve hunting and crop cultivation prevented shrubs and trees from growing in specific areas, changing the species mix in California's grasslands over time.

A California Native

When you see an area of native California grass, it appears bumpy. That is because the grass grows in "bunches." Many "bunches" can live to be very old—200 years or longer—due to adaptations the species have to their environment. Depending on the species, some are short-lived, 10 years or less. The state grass of California, purple needlegrass, is a perennial species that is native to the state's valleys and coasts. Like other perennials, purple needlegrass lives for many growing seasons. Its roots may average depths of 6 to 8 feet, with root hairs extending as much as 18 feet or more down into the soil. This allows this species to have access to water and nutrients even during the dry summer and fall months. Like other California bunch grasses, purple needlegrass has a growth point near the base of the plant that enables this grass to resprout after a fire. This growth point also allows the grass to survive occasional mowing and seasonal grazing. Unlike the European annual grasses that turn brown early in the summer, purple needlegrass stays fairly green through August, but can die back and lose a lot of its "green" over the driest months. However, unlike annual grasses, purple needlegrass does not die out completely in the hot weather.

Grassland Ecosystems

Grasslands are an important natural system. Perennial grass root systems build topsoil by "injecting" organic material deep in the soil profile. Most productive agricultural land was former grassland because of this well-developed topsoil. In addition, grasslands are being explored for their potential to sequester (collect) carbon from the atmosphere. Large amounts of carbon are sequestered in grassland root systems, so much so that they may rival forests in their ability to

Purple needlegrass (*Nassella pulchra*)

pull carbon out of the atmosphere. Research into this feature of grasslands is ongoing.

As the roots decompose, they open up channels for rainwater to infiltrate deeply as well. This allows the soil to store the water later in the dry season, allowing it to flow underground into creeks, instead of sheeting off the surface quickly into streams. These abandoned root systems help control potential flooding during the wet season. Grasslands made up of native bunch grasses support a high level of biodiversity. In between the "bunches" there is room for native wildflowers to grow. These spaces can also become resting places for acorns—the seeds of an oak tree. For this reason, oaks have historically studded California grasslands. The decrease in native bunch grasses is thought to be a problem for two of California's native oak species, the blue oak and the valley oak. When these trees drop their acorns in areas without bunch grass, the acorns do not germinate. There are many factors contributing to the decline in native oaks, but this one—the connection between bunch grass and acorn germination—is particularly disconcerting.

Pronghorn antelope (*Antilocapra americana*)

Compared with 2,000 years ago, only 1% of the native California grasslands remain. Scientists believe this transformation was due to a combination of factors. One was the introduction of nonnative annual grasses from Europe. Spanish sailors, first reaching California in 1542, may have brought European grasses as food for themselves or livestock. To make space for California cargo bound for the return trip to Spain, ballast was dumped off ships. This ballast also may have contained tiny grass seeds from Europe, where the ballast was loaded. The winds easily spread these seeds and helped pollinate the new plants. In less than 200 years, California's native perennial grasslands were converted into annual grasslands made up of nonnative grasses from Europe. Evidence of this takeover is found in the adobe bricks used in the construction of Spanish missions. Adobe bricks are made of mud, and contain a "seed record" for the area at the time of construction of local missions. Bricks from the first

Nonnative grass

missions contained few nonnative grass seeds, while the bricks from later missions contained progressively more and more seeds of European grasses.

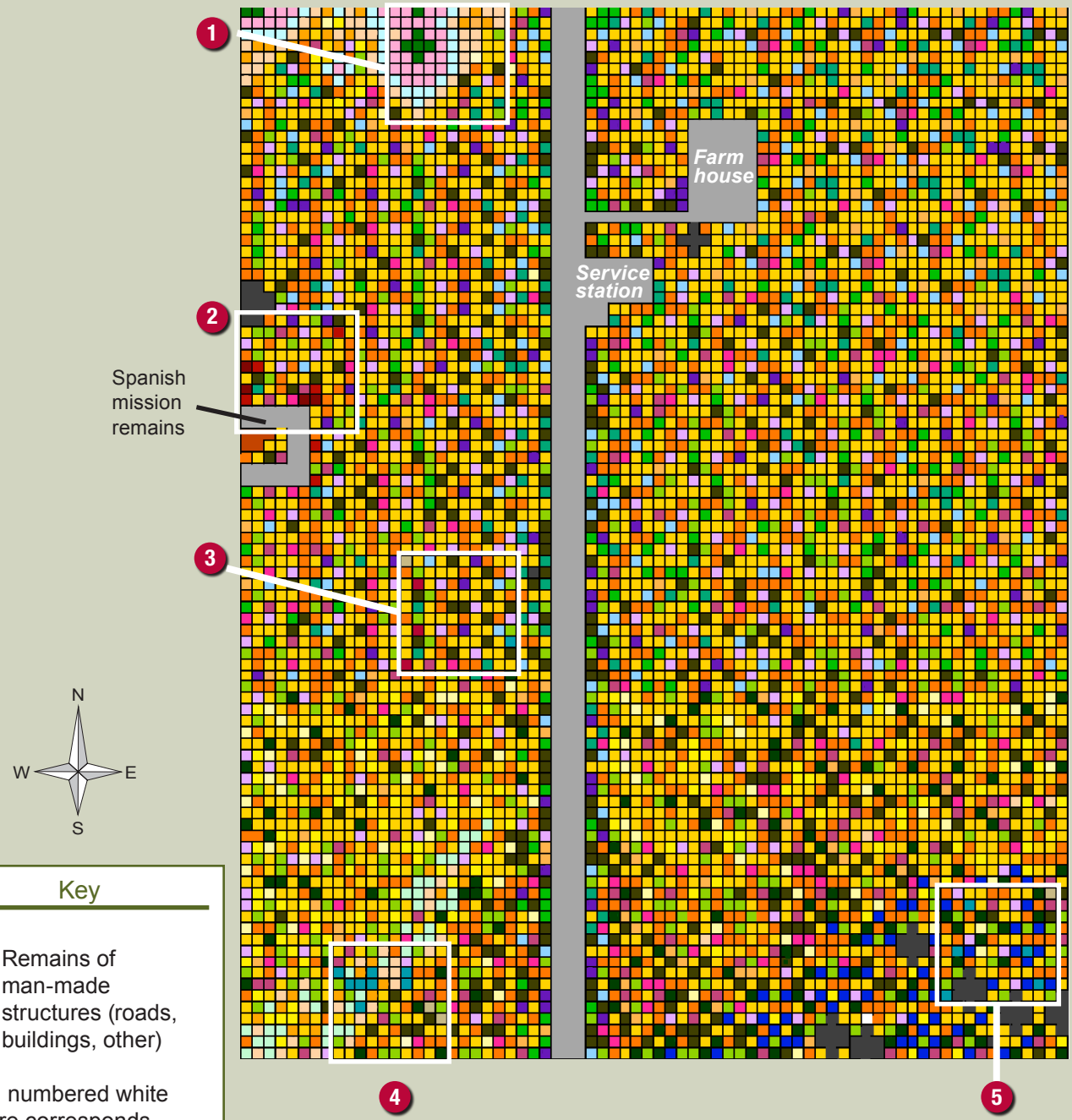
European grasses are very competitive. They produce thousands of seeds per square foot, germinate quickly, grow rapidly, and tolerate drought. Annual grasses tend to grow taller, and the thatch smothers natives. However, studies have shown that they cannot outcompete established native bunch grasses by rapid reproduction alone. There had to be some other factor at work, giving the nonnative grasses from Europe an "edge" over the native bunchgrasses.

One theory is grass species from Europe were better adapted to the disruptive activities of large human populations. Although American Indians settled in and around California grasslands, Europeans colonizers brought about a significant increase in the level of human-caused disturbances. Spanish livestock grazed all year, rather than seasonally, as did the native tule elk and pronghorn antelope species they displaced. The Spanish also prevented American Indians from controlled burning of the grasslands. This source of renewal for the native perennial grasses may have led to their replacement by scrubland and woodlands. Grasslands around the Spanish missions were plowed under, wiping out native seed banks. On top of this, Europeans accidentally introduced the yellow dwarf virus to North America by planting contaminated barley. Aphids spread the virus quickly through the grasslands, causing massive amounts of native grasses to die off.

Managing and Protecting What Remains

Many threatened and endangered species live in the relict patches of grassland that exist today, bringing public attention to the grassland's decline. Despite the attention, grasslands remain one of the most under-protected ecosystems in the state. As California's population continues to grow, pressures on these grassland ecosystems intensify. Climate continues to change, now at an exceptionally rapid rate due to human activities, pushing native species to their limits and beyond. Our understanding of the value of our native grasslands has increased. Several private conservation organizations and state and local agencies are acting to help protect what native grasslands remain.

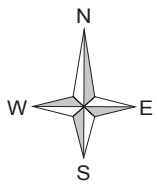
Rancho Grassland Study Site



Plot #1

D. o.	*D. o.*	*E. m.*	*D. o.*	*D. o.*	*T. e.*	*T. g.*	*L. p.*	*T. g.*	*T. g.*
D. o.	*D. o.*	*D. o.*	*D. o.*	*T. e.*	*T. g.*	*L. p.*	*L. c.*	*L. p.*	*T. g.*
T. g.	*D. o.*	*E. m.*	*D. o.*	*D. o.*	*T. e.*	*T. g.*	*T. g.*	*A. f. NN*	*E. c. NN*
D. o.	*E. m.*	*E. m.*	*E. m.*	*D. o.*	*T. e.*	*T. g.*	*T. g.*	*A. f. NN*	*A. f. NN*
D. o.	*D. o.*	*E. m.*	*D. o.*	*D. o.*	*T. e.*	*T. g.*	*P. a. NN*	*A. f. NN*	*A. f. NN*
D. o.	*D. o.*	*D. o.*	*D. o.*	*D. o.*	*T. e.*	*T. g.*	*B. d. NN*	*A. f. NN*	*B. n. NN*
T. e.	*D. o.*	*D. o.*	*D. o.*	*T. e.*	*T. g.*	*B. n. NN*	*A. f. NN*	*C. p.*	*B. d. NN*
T. g.	*T. e.*	*T. e.*	*T. e.*	*T. g.*	*A. f. NN*	*B. d. NN*	*T. c.*	*A. f. NN*	*A. f. NN*
A. f. NN	*T. g.*	*T. e.*	*T. g.*	*A. f. NN*	*A. f. NN*	*D. m.*	*A. f. NN*	*A. f. NN*	*T. c.*
B. n. NN	*A. f. NN*	*T. g.*	*A. f. NN*	*A. f. NN*	*D. m.*	*A. f. NN*	*T. c.*	*A. f. NN*	*E. c. NN*

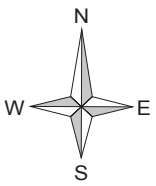
Quadrats are 1 square meter.
Note: All species abbreviations that include “NN” are nonnative species.



Plot #2

		B. d. NN	A. f. NN	L. b.	A. f. NN	E. c. NN	L. b.	B. n. NN	A. f. NN
A. f. NN	E. c. NN	E. c. NN	D. m.	B. d. NN	C. p.	A. f. NN	B. d. NN	R. a. NN	A. f. NN
C. p.	A. f. NN	B. d. NN	O. e. NN	E. c. NN	O. e. NN	B. d. NN	E. c. NN	A. f. NN	B. d. NN
B. d. NN	E. c. NN	O. e. NN	O. e. NN	O. e. NN	O. e. NN	C. p.	A. f. NN	A. f. NN	B. d. NN
O. f. NN	R. a. NN	A. f. NN	C. p.	B. d. NN	P. c.	A. f. NN	A. f. NN	B. n. NN	H. g. NN
A. f. NN	B. n. NN	E. c. NN	B. d. NN	A. f. NN	A. f. NN	B. n. NN	A. f. NN	A. f. NN	B. d. NN
O. f. NN	T. c.	A. f. NN	B. d. NN	B. n. NN	D. m.	R. a. NN	A. f. NN	B. d. NN	L. b.
R. a. NN	A. f. NN	D. m.	A. f. NN	H. g. NN	O. f. NN	O. f. NN	B. d. NN	A. f. NN	B. d. NN
Man-made structure						A. f. NN	B. d. NN	A. f. NN	E. c. NN
						A. f. NN	L. b.	E. c. NN	A. f. NN

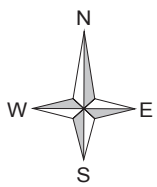
Quadrats are 1 square meter.
Note: All species abbreviations that include “NN” are nonnative species.



Plot #3

L. c.	*A. f. NN*	*P. c.*	*A. f. NN*	*B. n. NN*	*A. f. NN*	*L. b.*	*B. d. NN*	*A. f. NN*	*A. f. NN*
B. d. NN	*E. c. NN*	*A. f. NN*	*A. f. NN*	*A. f. NN*	*B. d. NN*	*A. f. NN*	*B. n. NN*	*B. d. NN*	*C. p.*
A. f. NN	*R. a. NN*	*A. f. NN*	*C. p.*	*B. d. NN*	*L. b.*	*A. f. NN*	*A. f. NN*	*P. c.*	*E. c. NN*
A. f. NN	*B. n. NN*	*E. c. NN*	*B. d. NN*	*A. f. NN*	*A. f. NN*	*A. f. NN*	*B. n. NN*	*A. f. NN*	*B. d. NN*
A. f. NN	*T. c.*	*A. f. NN*	*B. d. NN*	*Ch. p.*	*Ch. p.*	*C. p.*	*A. f. NN*	*A. f. NN*	*B. n. NN*
B. d. NN	*E. c. NN*	*A. f. NN*	*A. f. NN*	*A. f. NN*	*B. d. NN*	*A. f. NN*	*B. n. NN*	*B. d. NN*	*C. p.*
A. f. NN	*R. a. NN*	*A. f. NN*	*C. p.*	*B. d. NN*	*L. b.*	*A. f. NN*	*A. f. NN*	*P. c.*	*E. c. NN*
A. f. NN	*B. n. NN*	*E. c. NN*	*B. d. NN*	*A. f. NN*	*A. f. NN*	*A. f. NN*	*B. n. NN*	*A. f. NN*	*N. p.*
A. f. NN	*T. c.*	*A. f. NN*	*B. d. NN*	*B. n. NN*	*A. f. NN*	*C. p.*	*A. f. NN*	*A. f. NN*	*B. n. NN*
R. a. NN	*A. f. NN*	*D. m.*	*A. f. NN*	*H. g. NN*	*B. d. NN*	*B. d. NN*	*T. c.*	*A. f. NN*	*A. f. NN*

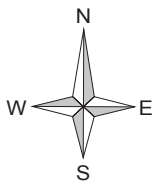
Quadrats are 1 square meter.
Note: All species abbreviations that include “NN” are nonnative species.



Plot #4

A. f. NN	D. m.	A. f. NN	E. c. NN	T. g.	B. d. NN	P. e.	E. c. NN	T. g.	A. f. NN
D. m.	A. f. NN	T. g.	L. p.	P. e.	T. g.	C. p.	A. f. NN	A. f. NN	B. d. NN
N. p.	P. e.	L. p.	N. p.	T. g.	T. g.	N. p.	B. d. NN	B. d. NN	Ch. p.
E. c. NN	N. p.	N. p.	N. p.	L. p.	T. g.	N. p.	A. f. NN	A. f. NN	B. d. NN
L. p.	E. c. NN	P. e.	L. p.	A. f. NN	B. n. NN	A. f. NN	B. d. NN	D. m.	B. d. NN
T. g.	P. e.	N. p.	T. g.	E. c. NN	A. f. NN	B. d. NN	Ch. p.	L. c.	E. c. NN
A. f. NN	A. f. NN	T. g.	A. f. NN	D. m.	E. c. NN	A. f. NN	A. f. NN	B. n. NN	L. c.
P. e.	P. e.	A. f. NN	B. n. NN	A. f. NN	B. d. NN	Ch. p.	B. n. NN	A. f. NN	A. f. NN
E. c. NN	T. g.	B. d. NN	A. f. NN	B. d. NN	A. f. NN	P. a. NN	H. g. NN	B. d. NN	B. d. NN
A. f. NN	A. f. NN	Ch. p.	B. d. NN	E. c. NN	E. c. NN	A. f. NN	B. d. NN	A. f. NN	Ch. p.

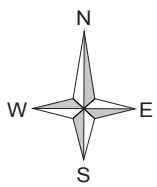
Quadrats are 1 square meter.
Note: All species abbreviations that include “NN” are nonnative species.



Plot #5

B. d. NN	C. p.	A. f. NN	A. f. NN	B. d. NN	B. d. NN	A. f. NN	A. f. NN	Ch. p.	L. c.
B. p.	B. d. NN	N. p.	A. f. NN	D. m.	A. f. NN	C. p.	B. p.	B. d. NN	D. m.
Ch. p.	E. c. NN	B. d. NN	Ch. p.	B. n. NN	A. f. NN	A. f. NN	B. d. NN	Ch. p.	B. n. NN
B. d. NN	Ch. p.	A. f. NN	P. a. NN	E. c. NN	Ch. p.	B. p.	E. c. NN	B. p.	E. c. NN
A. f. NN	B. d. NN	C. p.	Ch. p.	B. d. NN	A. f. NN	A. f. NN	B. d. NN	B. d. NN	B. d. NN
B. d. NN	N. p.	B. p.	P. a. NN	A. f. NN	C. p.	B. p.	N. p.	B. p.	A. f. NN
B. p.	Ch. p.	B. d. NN	A. f. NN	E. c. NN	Ch. p.	B. d. NN	B. p.	A. f. NN	E. c. NN
B. d. NN	E. c. NN		A. f. NN	A. f. NN	B. d. NN	A. f. NN	A. f. NN	B. d. NN	B. d. NN
E. c. NN	Man-made structure			B. p.	A. f. NN	C. p.	B. p.	N. p.	B. p.
N. p.				A. f. NN	E. c. NN	Q. l.	A. f. NN	A. f. NN	E. c. NN

Quadrats are 1 square meter.
Note: All species abbreviations that include “NN” are nonnative species.



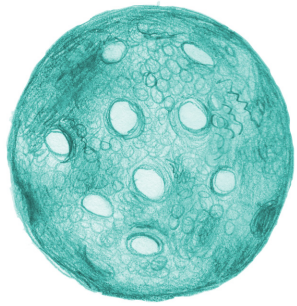
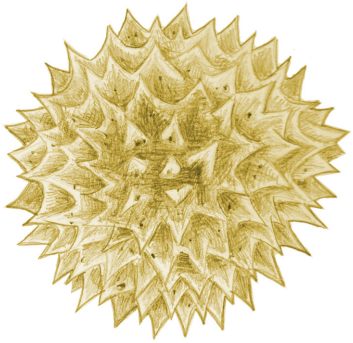
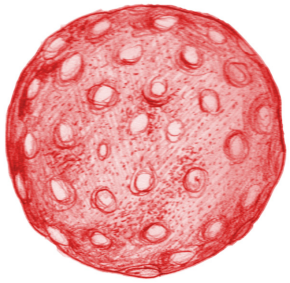
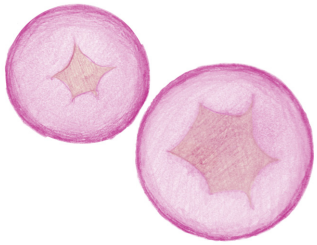
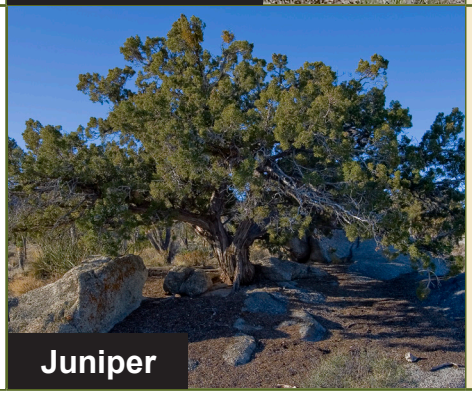
Plant Species in the Sample Grassland Plots				
A. f.	*Avena fatua*	Wild oat	Nonnative	Grass
B. p.	*Baccharis pilularis*	Coyote brush	Native	Bush
B. n.	*Brassica nigra*	Black mustard	Nonnative	Forb
B. d.	*Bromus diandrus*	Ripgut brome	Nonnative	Grass
Ch. p.	*Chlorogalum pomeridianum*	Soaproot	Native	Forb
C. p.	*Clarkia purpurea*	Purple clarkia	Native	Forb
D. m.	*Dichelostemma multiflorum*	Wild hyacinth	Native	Forb
D. o.	*Downingia ornatissima*	Folded calicoflower	Native	Forb
E. m.	*Eleocharis macrostachya*	Spike rush	Native	Forb
E. c.	*Erodium cicutarium*	Redstem filaree	Nonnative	Forb
H. g.	*Hypochaeris glabra*	Smooth cat's ear	Nonnative	Forb
L. c.	*Lasthenia californica*	California goldfields	Native	Forb
L. p.	*Layia platyglossa*	Tidy tips	Native	Forb
L. b.	*Lupinus bicolor*	Lupine	Native	Forb
N. p.	*Nassella pulchra*	Purple needlegrass	Native	Grass
O. e.	*Olea europaea*	Olive	Nonnative	Tree
O. f.	*Opuntia ficus-indica*	Mission cactus	Nonnative	Bush
P. c.	*Plagiobothrys canescens*	Popcorn flower	Native	Forb
P. e.	*Plantago erecta*	California plantain	Native	Forb
P. a.	*Poa annua*	Annual bluegrass	Nonnative	Grass
Q. l.	*Quercus lobata*	Valley oak	Native	Tree
R. a.	*Rumex acetosella*	Sheep sorrel	Nonnative	Forb
T. c.	*Thysanocarpus curvipes*	Fringe pod	Native	Forb
T. e.	*Triphysaria eriantha*	Johnny-tuck	Native	Forb
T. g.	*Trifolium gracilentum*	Pinpoint clover	Native	Forb

Forb An herb, other than a grass, that has leaves and stems.

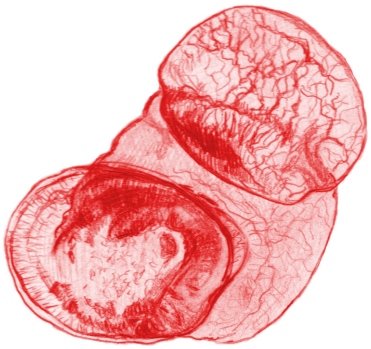
Grass A plant with jointed stems, narrow leaves, and tiny clusters of flowers that form on a "bract."

Tree A woody plant that typically has a single trunk or stem and a crown of branches and/or foliage. It lives for more than two years.

Bush A woody plant, with many branches, that is smaller than a tree.

Pollen grain	Plant Species	Preferred Climate
	 Amaranth	Mediterranean climate: cool, wet winters and warm, dry summers
	 Goldfields	Mediterranean climate: cool, wet winters and warm, dry summers
	 Greasewood	Desert climate: cold, dry winters and hot, dry summers
	 Juniper	Desert climate: cold, dry winters and hot, dry summers

Note: Pollen colors reflect stains used to increase visibility under a microscope; they are not true colors. In general, pollen grain sizes vary from about 5 to 200 micrometers.

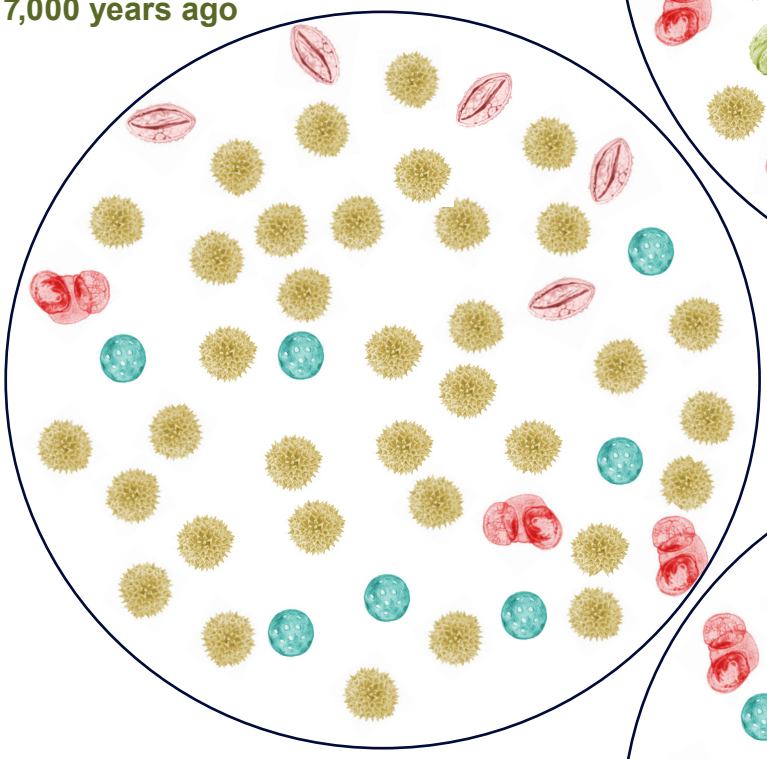
Pollen grain	Plant Species	Preferred Climate
	 **Oak**	Mediterranean climate: cool, wet winters and warm, dry summers
	 **Pine**	Mediterranean climate: cool, wet winters and warm, dry summers
	 **Sagebrush**	Desert climate: cold, dry winters and hot, dry summers

Note: Pollen colors reflect stains used to increase visibility under a microscope; they are not true colors. In general, pollen grain sizes vary from about 5 to 200 micrometers.

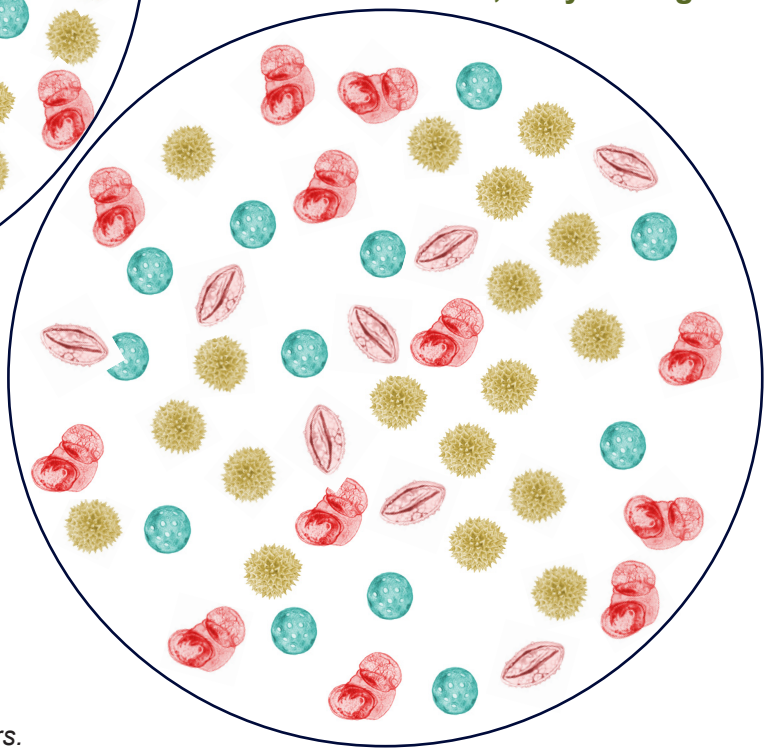
Sample 1
24,000 years ago

Note: Each sample contains 50 grains of pollen

Sample 2
7,000 years ago



Sample 3
4,000 years ago



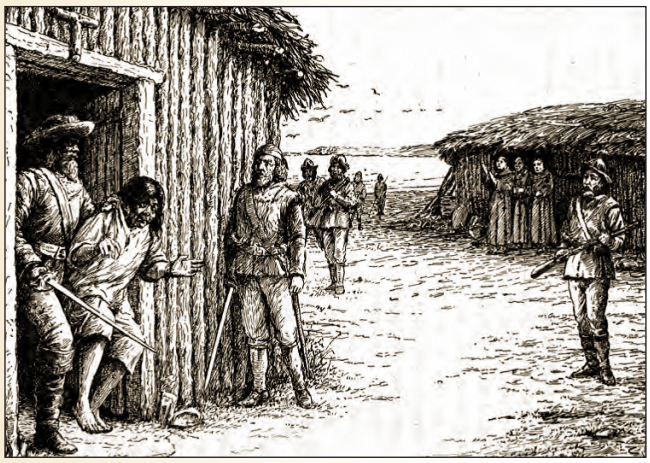
Note: Pollen colors reflect stains used to increase visibility under a microscope; they are not true colors.

Spanish Journal Entries from the 1700s

The following excerpts are taken from the journals of Spanish missionaries and leaders from California in the 1700s. At that time, Spain claimed ownership of California, but the region's population was predominantly California Indians.

Governor Fernando Rivera y Moncada

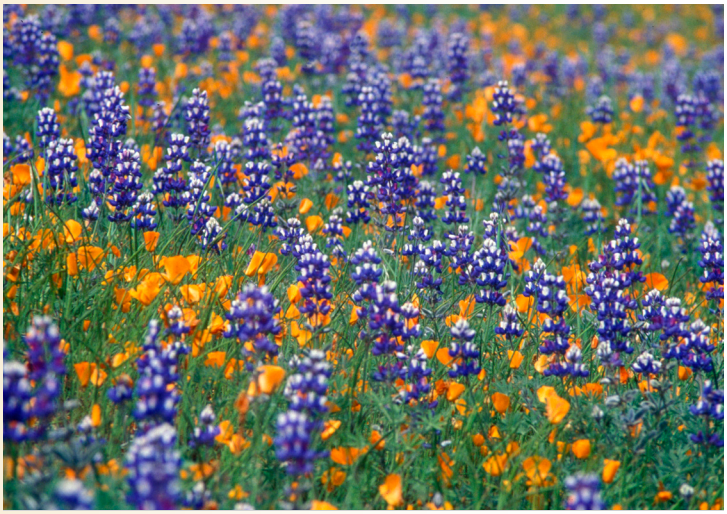
Fernando Rivera y Moncada served as Spain's regional governor of California in the mid-1700s. The following entry comes from his journal.



1776:

'In the countryside there is extreme need of pasture for the animals, all occasioned by the great fires of the Indians who, not having to care for more than their own bellies, burn the fields as soon as they gather up the seeds.'

Father Juan Crespi



Father Juan Crespi was a Spanish missionary and explorer. He recorded these entries in his journal while traveling through what is now California.

August 1769:

We went over land that was well covered with fine grasses and very large clumps of very tall, broad grass, burnt in some spots and not in others.

We went almost all the way over salt-grass, all very much burnt off by the [Indians], with some descents to dry creeks. On going about a league and a half, we reached a stream with a good amount of fresh water emptying into the sea, but no village nor soil of any worth upon it. The soldiers had scouted up to this point, and it was not a full day's march, nor was there grass for the animals, as it had all been burned off.

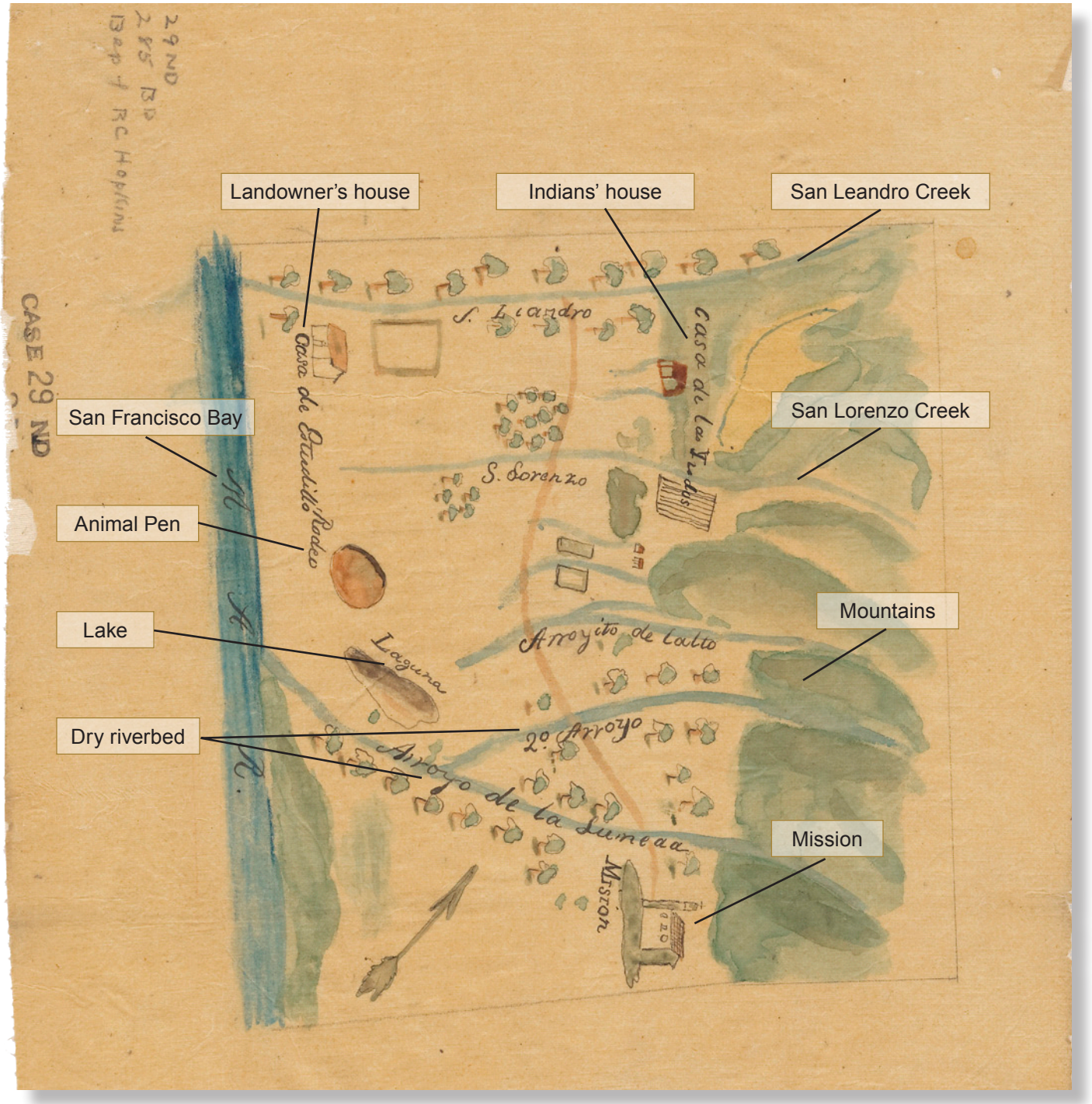
May 1770:

At once after setting out, we commenced to find the fields all abloom. As many as were the flowers we had been meeting on the way and on the channel, it was not such plenty as here, for it is all one mass of blossom, great quantities of white, yellow, red, purple and blue ones; many yellow violets or gilly-flowers of the sort that are planted in gardens, a great deal of larkspur, poppy and sage in blooms, and what graced the fields most of all was the sight of all the different sorts of colors together. On this whole march we have seen not a bush.

Rancho San Leandro in the 1840s

Location: Alameda County

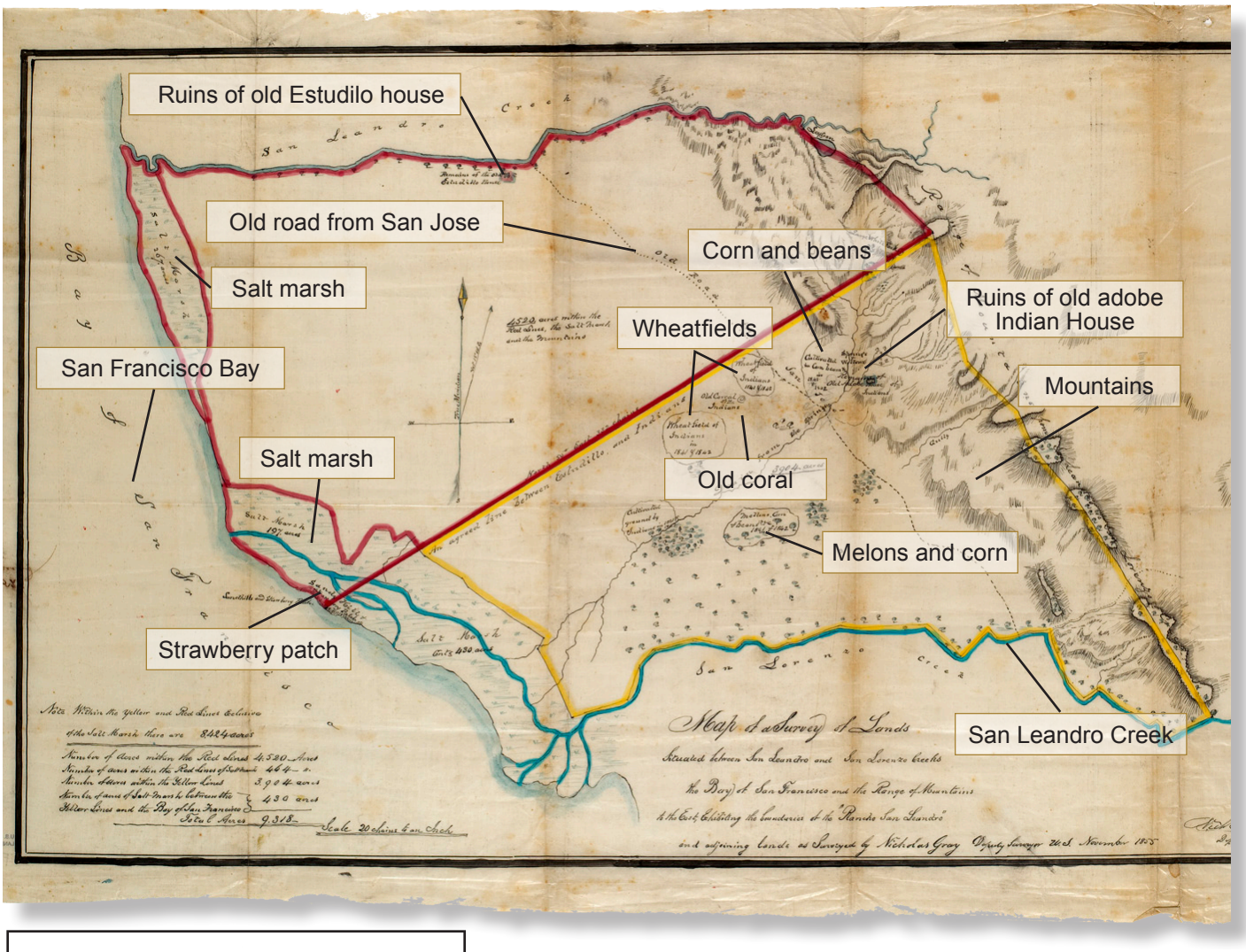
Mapmaker: Mexican Landowner



Rancho San Leandro in 1855

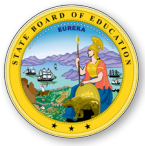
Location: Alameda County

Mapmaker: U.S. Surveyor



Key

- Boundary of Rancho San Leandro
- An agreed line between Estudillo and the Indians
- San Leandro Creek
- Mountain ranges



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