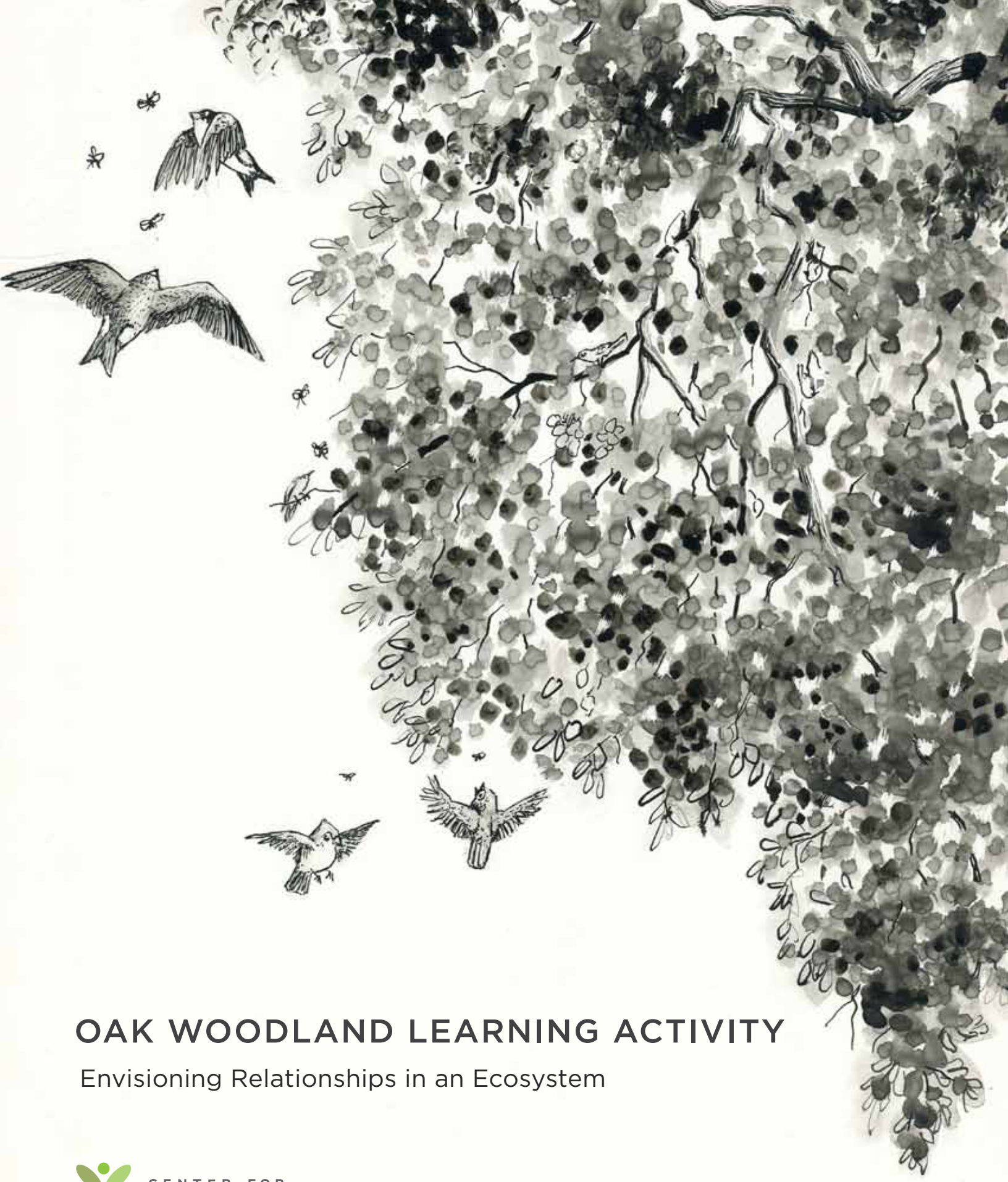

OAK WOODLAND LEARNING ACTIVITY

Envisioning Relationships in an Ecosystem

CENTER FOR ECOLITERACY

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SMART BY NATURE™ downloadable resource

Learning in the Real World

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OAK WOODLAND LEARNING ACTIVITY

PURPOSE

Students learn to look at an ecosystem—the oak woodland—as a system and, by doing so, become aware of relationships among living things, the processes and patterns that drive survival and evolution, and the importance of abiotic characteristics in sustaining life.

The assembled oak woodland mural

GRADE LEVEL

Sixth grade and up

(Note: The oak woodland mural can be used with an even wider grade range. For younger or more advanced students, you may need to modify the information cards for reading level and content appropriateness.) There are blank cards included for the teacher's use.

MATERIALS

- Oak woodland mural (15 panels)
- Oak woodland information cards (30 cards)
- Scratch paper and pencil for each pair of students
- Materials for assembling the mural (see **Preparation.**)

PREPARATION

Print out the 15 panels of the oak woodland mural. Trim away the outside edges so that just the image remains. If you plan to use the panels multiple times, mount them on lightweight, biodegradable foam board or cardboard.

Number the panels in order (1–15) on the back so you can quickly assemble the mural during the lesson. Determine how and where you will assemble the mural so that everyone will be able to see it as one scene. You can lay the mural flat on a table, or you may want to apply Velcro to the backs of the panels and hang them on cardboard or a piece of fabric. Alternatively, you might use removable tape to join the panels.

Use the information cards provided, or create cards more appropriate for your students' reading level and area of study. If you are creating a new set of cards, make 15-30 copies of the blank cards provided on page 37, and add suitable information to each one. It is ideal to have two information cards for every panel of the mural (resulting in a total of 30 cards).

BACKGROUND INFORMATION

The oak woodland is a common ecosystem in the western United States, and is also found in many other areas of the world. There are between 300 and 500 species of oaks worldwide. In California alone, there are 20 species of oaks and more than 5,000 species of insects, nearly 60 species of amphibians and reptiles, 100 species of mammals, and more than 150 species of birds that rely on oaks for some aspect of their survival. The primary reasons that oak woodlands support such a variety of species are that they produce an abundant supply of food in the form of acorns and they provide ample shelter, nesting sites, and shade.

The oak woodland is an ideal ecosystem for illustrating the complex interactions that go largely unnoticed by humans, but that drive the survival of hundreds of species. By looking at the oak woodland as a whole system, many of its invisible attributes are revealed, giving us a richer sense of how nature sustains life over time.

LESSON INTRODUCTION

Ask students if they are familiar with oak trees. Ask how many have ever seen an acorn. Encourage them to make connections with previous experiences with oaks, such as studying Native Americans who relied on acorns for food.

Explain the importance of the oak woodland ecosystem and how examining it as a whole system allows us to see the complex relationships and processes that are usually invisible to the human eye. (See **Background Information**.)

Remind students that when scientists begin to study a particular ecosystem, they often divide it up into sections or quadrants, then observe and record what they find in each quadrant. Then, they consolidate the information and draw some generalizations about the makeup and general characteristics of the ecosystem.

Note: In the lesson, students are given individual panels to observe. We suggest that you avoid pointing out to students that the set of panels make up one mural. While there is no reason to hide that information, students are often pleasantly surprised and re-engaged when they realize they have been looking at one portion of a much larger picture.

OAK WOODLAND MURAL EXPLORATION

1. Ask students to work in pairs and decide who will take notes. Give each pair one panel from the oak woodland mural and invite them to take a few minutes to discuss what they notice on their particular panel. Encourage them to jot down notes, using any previous knowledge they may have in addition to what they observe.

2. After the pairs seem to have exhausted all they know and have observed about the oak woodland, provide each pair with two information cards that pertain to their panel. Ask them to read the cards and talk about them with their partner.

3. Instruct the pairs to join with another pair of classmates and each share what they know about their panel, drawing from previous knowledge, what they observed on their panel, and what they learned from their information cards. When both pairs have shared, instruct them to join another pair and share again. Have them repeat once more by sharing with a third pair of classmates.

4. After students have shared with three other pairs, ask them to bring you their panels to assemble for the whole group to observe.

5. Explain to them that the panels can be put together to form one picture, and invite them to do that.

DISPLAY MURAL AND DISCUSS

1. Ask students: "Now that you see the oak ecosystem in its entirety, do you have any thoughts or questions for each other about what is going on in this ecosystem?"

2. There are a lot of ***objects*** in the oak woodland. Scientists usually begin by naming what they see. Can you name some of what you noticed? What ***functions*** do some of them play in the oak woodland?

3. What ***relationships*** did you discover within the oak woodland?

4. One way scientists learn about an ecosystem is to count the organisms and species in it. Another way is to "map" the ecosystem, as we did in this lesson, showing the parts and their relationships. What strengths or weaknesses does each of these two approaches have? What different information can be gleaned from the two methods?

5. Mapping requires choosing what to include and what to emphasize. Can you imagine different ways to map this ecosystem?

6. Can you give any examples of surprising and important ***processes*** that help maintain the oak ecosystem? Processes are usually invisible but are crucial to the survival of an ecosystem. For example, in what ways do nutrients flow through the ecosystem? How do abiotic factors, such as water, light, temperature, and soil help support the ecosystem?

7. Shifting from what we see to ***patterns***, which are also largely invisible, reveals crucial information. Within any ecosystem, certain patterns recur. Were there any patterns that were revealed through our study of the oak woodland?

WRAP-UP

Keep the mural visible and use it for a variety of writing prompts that reinforce the discussion topics above, such as:

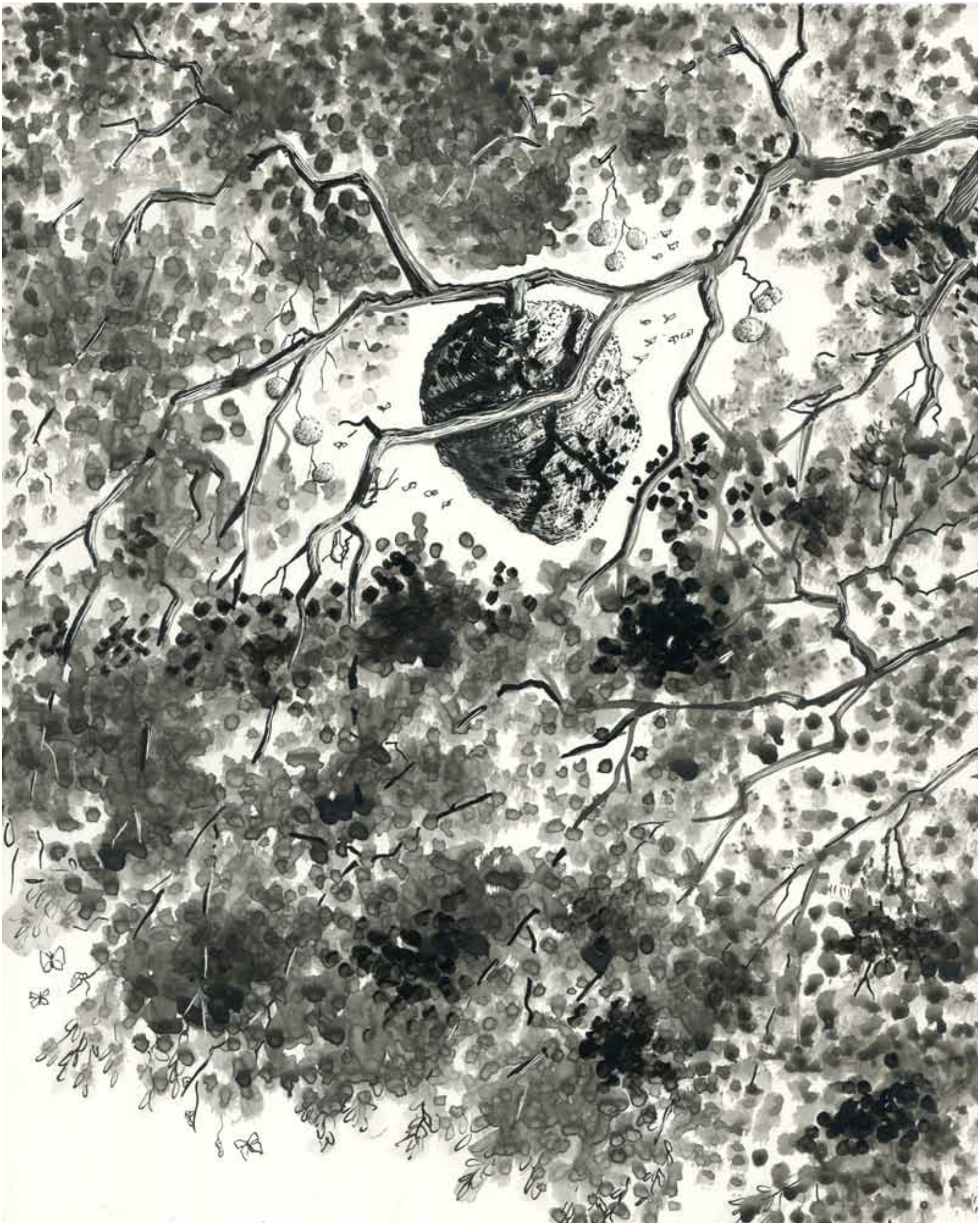
- How would you describe an oak woodland to someone who is unfamiliar with that particular ecosystem?

- Write a letter explaining why human communities should think twice before destroying an oak woodland for ranching or development.

- Compare the oak woodland to another ecosystem. Compare and contrast the relationships among inhabitants and processes that drive each ecosystem. What patterns do you notice?

PANEL 1

ILLUSTRATOR: ANE CARLA ROVETTA | © CENTER FOR ECOLITERACY



PANEL 2

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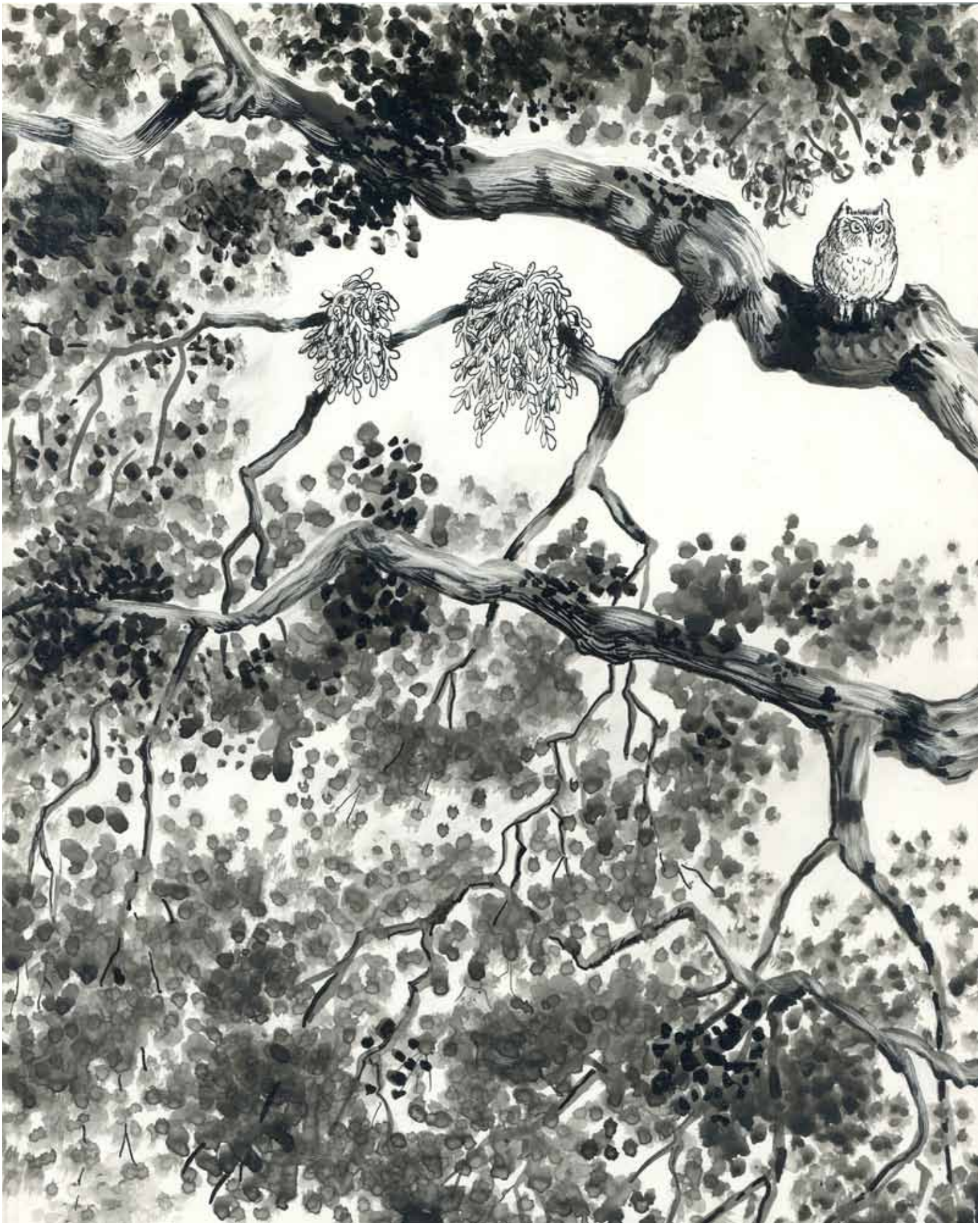

PANEL 3

ILLUSTRATOR: ANE CARLA ROVETTA | © CENTER FOR ECOLITERACY

PANEL 4

ILLUSTRATOR: ANE CARLA ROVETTA | © CENTER FOR ECOLITERACY

PANEL 5

ILLUSTRATOR: ANE CARLA ROVETTA | © CENTER FOR ECOLITERACY

PANEL 6

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PANEL 7

ILLUSTRATOR: ANE CARLA ROVETTA | © CENTER FOR ECOLITERACY

PANEL 8

ILLUSTRATOR: ANE CARLA ROVETTA | © CENTER FOR ECOLITERACY

PANEL 9

ILLUSTRATOR: ANE CARLA ROVETTA | © CENTER FOR ECOLITERACY

PANEL 10

ILLUSTRATOR: ANE CARLA ROVETTA | © CENTER FOR ECOLITERACY

PANEL 11

ILLUSTRATOR: ANE CARLA ROVETTA | © CENTER FOR ECOLITERACY

PANEL 12

ILLUSTRATOR: ANE CARLA ROVETTA | © CENTER FOR ECOLITERACY

PANEL 13

ILLUSTRATOR: ANE CARLA ROVETTA | © CENTER FOR ECOLITERACY

PANEL 14

ILLUSTRATOR: ANE CARLA ROVETTA | © CENTER FOR ECOLITERACY

PANEL 15

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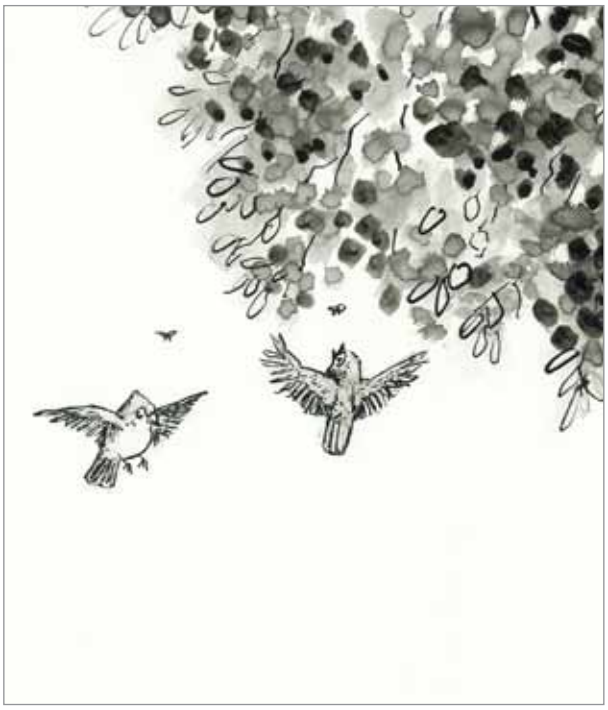
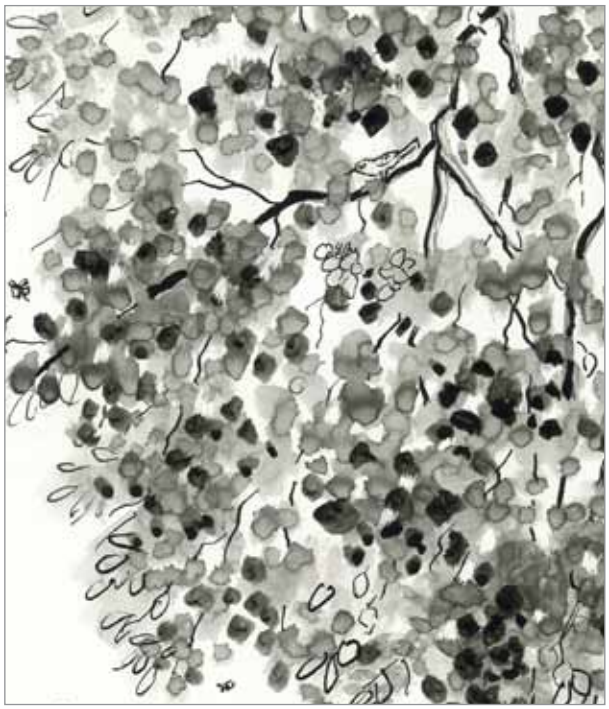
COOPERATION IN OAK WOODLAND



Panel 1

When visiting the oak woodland, you may see the diminutive oak titmouse flitting around a tree branch, seizing insects in midair. You can easily identify it by its small head tuft. The oak titmouse has a range that is identical with the oak woodland's range, and it prefers living in and around oaks. This suggests mutual adaptation over time. It does not excavate its own nest cavities, but may use an old woodpecker nest or a natural hollow in an oak trunk or branch. Titmice and bushtits are both voracious predators of oak moth larvae, which feed on oak leaves. When present in high numbers, oak moths may defoliate the oak tree.

OAKS AND CLIMATE CHANGE



Panel 1

Carbon storage (sequestration) occurs in forests, woodlands, and soils primarily through the process of photosynthesis. Carbon dioxide (CO_2) in the atmosphere is absorbed by leaves and is stored in the woody biomass of trees and other vegetation. The Earth has lost nearly 45 percent of its original forest cover to date, and current levels of deforestation account for nearly 20 percent of carbon currently released into the atmosphere. These releases of carbon and other gases are significant contributors to climate change. Furthermore, as temperatures rise, oaks and other types of vegetation are at risk. Survival of any species is dependent upon its adaptation to its external environment, and there is concern about the potential effects of rising temperatures on oak woodlands.

OAKS AND GALLS: A COMPLEX INTERACTION

Panel 2

There are over 200 species of oak gall wasps. When the time is right, based on many factors, the gall wasp pierces a part of the oak tree (leaves, branches, twigs, buds, or roots) and deposits an egg inside the plant tissue. The fluid surrounding the egg stimulates that part of the plant to multiply cells and create a shelter—or gall—for the developing eggs. The gall's lining provides food for the eggs as they grow into larvae. Mature larvae chew their way out of the gall. Although gall wasps are not considered to be parasites, many other parasitic organisms take advantage of the gall for food and shelter. A single gall can be home to a variety of organisms, including the "host" oak gall wasp larvae. Predators such as acorn woodpeckers and other insects feast on gall larvae. Galls are harmless to a healthy tree.

PAPER WASPS IN THE OAK WOODLAND

Panel 2

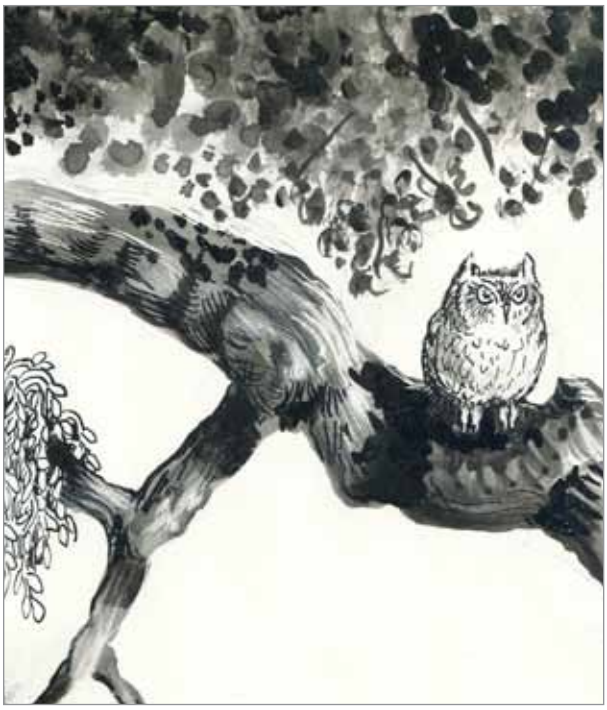
Paper wasps get their name from the intricate nests they build out of chewed wood fiber. They often build these nests in oak trees, where they play an important role in the oak woodland ecosystem. To feed its young, a paper wasp will remove caterpillars from oak trees and take them to its nest, thereby helping rid the oak of destructive pests. In the nest, the paper wasp will paralyze the caterpillar, stuff it in a cell of the nest, and lay an egg in the cell with it. When the larva, or "grub," hatches, it will have plenty of food as it transforms into a pupa and then emerges from the nest as an adult wasp. People fear wasps because they can be aggressive—and some species are more aggressive than others—but they are considered a beneficial insect.

MISTLETOE: FRIEND OR FOE?

Panel 3

Mistletoe has long been considered a pest that kills trees and diminishes the health of natural habitats. Recently scientists have recognized that it may also have ecological benefits because a broad array of animals depends on it for food. When the animals consume the leaves and young shoots, they distribute pollen and disperse the sticky seeds. As a semiparasitic plant, mistletoe can photosynthesize, but it depends upon its host tree for water and nutrients. Its roots penetrate the tree's bark and branch out through the trunk, ambushing the tree's transpiration system for its own use. Native Americans used mistletoe as a cure for headaches and as a method for ending pregnancies.

THE DIVERSE RELATIONSHIPS OF A SCREECH OWL



Panel 3

The western screech owl is common in fourteen Western states. It nests in tree cavities and will readily use the nests of other birds, like the woodpecker, as well as man-made nesting boxes. Once established, it will forcefully defend its nesting site. The screech owl's diet includes insects, birds, small mammals, snakes, and lizards. Like most owls, it is nocturnal and begins to hunt for food at about sundown, returning to roost within 30 minutes of sunrise. The western screech owl is what is known as a "sit-and-wait" predator, leaving the perch to sweep down and capture prey. Its predators include jays, crows, raccoons, and bigger owls. There is evidence that the western screech owl has a symbiotic relationship with the tree ant, which sometimes occupies the screech owl's nest and will sting and bite any would-be predators that happen by.

THE SOCIAL SYSTEM OF THE ACORN WOODPECKER

Panel 4

The acorn woodpecker has a complex social system. Family groups create and defend territories, and young woodpeckers stay with their parents for several years, helping the parents raise younger siblings. Many different individuals of each sex may breed within a family; there can be up to seven breeding males and three breeding females in one family at any given time. In family groups that contain more than one female breeder, the females lay their eggs in the same nest. Even within a family, there is often zealous reproductive competition between breeding females, who repeatedly destroy eggs laid by other females. Reproductive males exhibit competition by attempting to disrupt copulation between another pair.

FOOD STORAGE OF THE ACORN WOODPECKER

Panel 4

Acorn woodpecker groups spend most of their time gathering, storing, and defending acorns. Typically, they drill holes into a single tree, called a granary. One granary tree may have up to 50,000 holes in it, each holding a single acorn. Acorn woodpeckers will also use human-made structures to store acorns by drilling holes in fence posts, utility poles, and buildings. Studies have shown that granaries are so important to acorn woodpeckers that they are one of the main reasons these birds live in extended families. Only a sizeable colony can collect a large number of acorns and also defend them against other groups.

THE BROWN CREEPER: BIRDS AMONG THE BARK

Panel 5

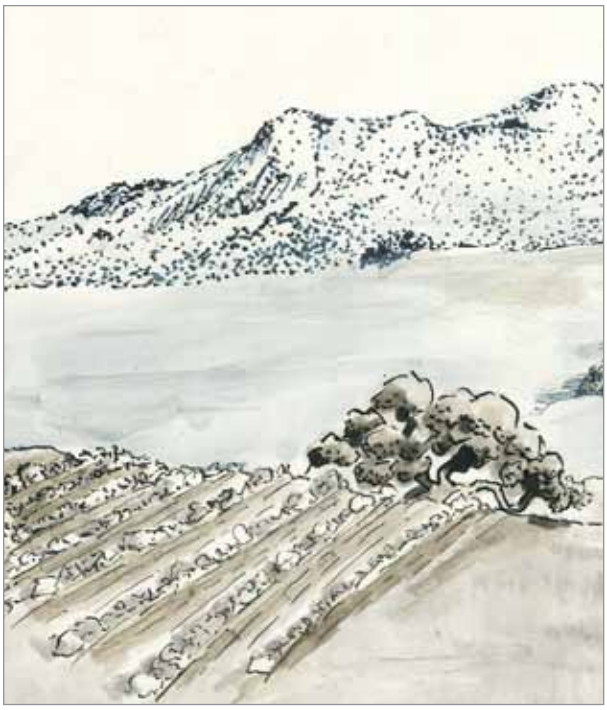
Brown creepers are found all over the United States, in southern Canada, and in parts of Mexico. They are primarily insectivorous and are called “creepers” because they use their stiff tail for balance as they spiral up a tree trunk, foraging for insects and larvae. When they reach the tree’s top, they usually fly down to the base of the trunk and start back up since they are unable to move headfirst down the trunk. They have no strong preference for a particular species of tree, but seem to prefer old-growth trees and a relatively closed canopy. It can be difficult to spot a brown creeper because their coloration blends in with the tree’s trunk and, when threatened, they flatten their bodies against the tree and remain motionless until they decide they are safe. During nonbreeding months, they tend to flock with chickadees and some species of woodpeckers.

THE NUTHATCH: THE UPSIDE-DOWN BIRD

Panel 5

Nuthatches are found from southern Canada to southern Mexico. Like brown creepers, nuthatches prefer old-growth trees and can be found in a variety of tree species. They have the unusual ability to move down a tree headfirst, using their strong feet for traction as they forage for insects. This skill allows them to find insects unnoticed by upward-bound insect-eaters, such as brown creepers and woodpeckers. Nuthatches also eat nuts, including acorns, and will store them in tree crevices for later use, sometimes covering them with bits of lichen or bark chips. Nuthatches have been observed carrying out a housekeeping task referred to as “bill sweeping.” They will seek out an insect with a strong odor and, holding it in its bill, sweep the nest with it to deter predators like raccoons and squirrels.

CAN FARMS AND OAKS COEXIST?



Panel 6

Oak woodlands are disappearing as humans convert them to farmland, rangeland, and housing tracts. Not only are oaks cut down to make room for human activities, those that remain are vulnerable to a host of changes to their habitat. Agricultural conversion usually alters the habitat's water distribution, making it less suitable for oaks and more desirable to many invasive species. While California's oak woodlands are naturally dry in the summer due to its Mediterranean climate, agricultural irrigation is frequently heaviest during that time of year, putting stress on the oak's root zone. Areas of California that were once covered with oak woodlands have proved particularly favorable for growing wine grapes and many acres have been rapidly converted to vineyards. Entire oak woodland ecosystems have been wiped out or fragmented with this recent expansion of "vineyardization."

RANCHING IN THE OAK WOODLAND

Panel 6

Approximately 80 percent of California's oak woodland is privately owned and most of that is used for livestock production. The behaviors of grazing animals severely threaten oak survival. When numerous animals share a relatively small area of open land, they tend to cluster under shade trees, and compact the soil around the root zone. This also causes erosion, which can expose the tree's roots. Cows and other grazers will often eat and trample oak seedlings; horses and goats will chew off the bark, exposing the trees to harmful organisms. However, providing oak seedlings with protective tree shelters greatly increases their chance of survival. Also, rotating grazing animals away from oak woodlands during the summer—when there are few green plants to eat and large animals seek shade—can help protect the oaks.

LARGE-SCALE CHANGE IN AN OAK COMMUNITY

Panel 7

Plant succession is the natural process of an ecosystem changing over time until it forms a stable community. Like most plant communities, the oak woodland is preceded by an herbaceous community. Until the 1800s, California's grasslands were composed of native perennial grasses, which are vital to the regeneration of oaks. Perennial grasses are able to prevent erosion, suppress invasive species, and serve as a food source for wildlife. Yet, European annual species have largely replaced perennials across North America, largely due to an increased demand for agriculture and grazing. The concomitant decline in grassland birds across the United States has been faster and more continual than that of any other bird species sharing a community. This dramatic decline has affected other grassland species as well. Approximately 90 percent of the species listed in California's Inventory of Rare and Endangered Species are residents of the grassland.

RAVENS: INTELLIGENT LEARNERS

Panel 7

Ravens have long been considered to be one of the most intelligent animals on Earth and have been present in North America since the Pleistocene (1.8 million to 10,000 years ago). Raven intelligence is well-documented. They can solve novel problems without trial and error, have been known to play dead to falsely signal a poisonous carcass to other ravens, and may trick each other by creating stashes of nonexistent food as a decoy to lure others away from the real supply. Several cultures have documented a mutualistic relationship between ravens and wolves. Ravens not only shadow wolves as they hunt to take advantage of their kill, they even have been known to lead wolves to herds of prey. Researchers have demonstrated that many raven behaviors are not hard-wired; rather, they learn from observing others in socially complex interactions.

ADAPTATIONS TO MAXIMIZE PHOTOSYNTHESIS

Panel 8

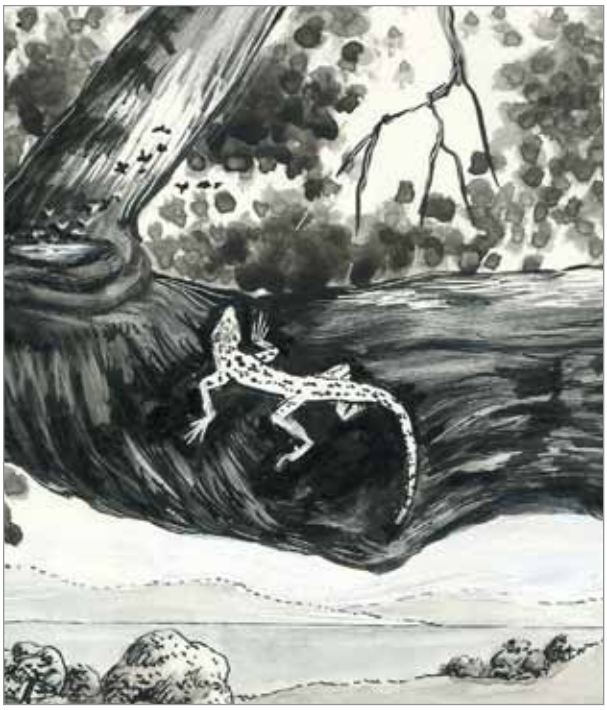
Oaks are adapted to maximize photosynthesis in the hot, dry summers of the Mediterranean climate. The coast live oak is a good example of this. Variation in leaf size and shape is common among coast live oaks, with two main types of leaves serving different functions. The outermost leaves are thick, curved, and small, with three layers of photosynthetic cells. This structure allows them to maximize solar absorption while reradiating heat, and also allows more sunlight to reach the inner leaves. The leaves found toward the middle of the tree are usually thinner, flatter, and broader, with only one layer of photosynthetic cells. With this arrangement, the outermost leaves shade the tree from intense heat, while the inner leaves can still photosynthesize by capturing light that penetrates through the canopy.

THE IMPACT OF INTRODUCED SPECIES

Panel 8

The western gray squirrel was once a common sight in oak woodlands of the Pacific states. However, it is now considered threatened in parts of the West, primarily because of habitat loss and the introduction of invasive species. The western gray squirrel competes with three introduced species—the ground squirrel, the eastern gray squirrel, and the fox squirrel—for the same types of food, including acorns, Douglas fir nuts, and fungi. A study conducted during a food shortage in California concluded that while the western gray squirrel population decreased, the ground squirrel population increased due to its ability to outcompete the gray squirrel. The introduced eastern gray squirrel and fox squirrel are found in similar natural habitats, but are also common in human-dominated environments. They are more flexible in their adaptive behaviors and can produce two litters per year, while the western gray squirrel has only one.

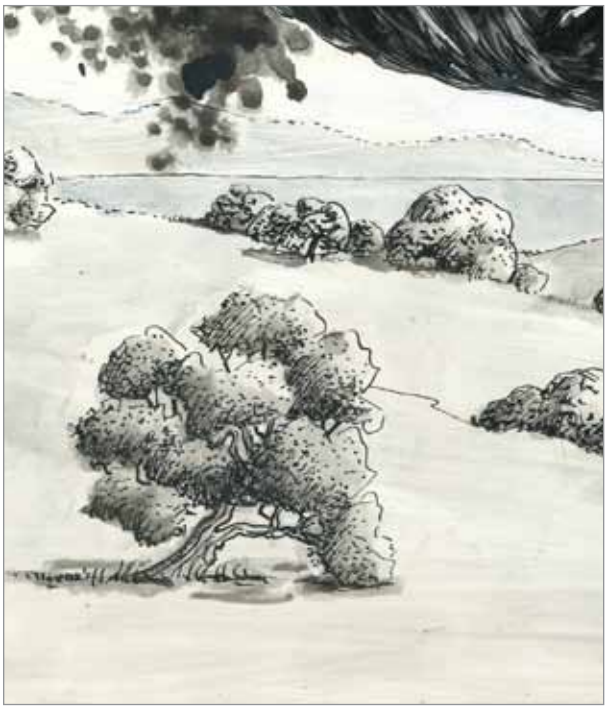
“TICKED OFF” ALLIGATOR LIZARDS



Panel 9

Lizards play a vital role in the dynamic balance of the oak woodland. They feed on a variety of small invertebrates, such as ticks, spiders (including black widows), insects, snails, millipedes, and caterpillars. In turn, they are eaten by hawks, owls, crows, and coyotes. Native Americans also regularly ate lizards as part of their diet. Recent studies have shown that there are fewer cases of Lyme disease in regions where alligator lizards are plentiful. Ticks, which carry Lyme disease, feed on the blood of alligator lizards while in their nymph stage. It turns out that the alligator lizard carries a bacterium that kills the causative agent of Lyme disease residing in the nymph’s gut. Hence, fewer ticks that reach adulthood are able to transmit the disease.

ECOSYSTEMS AND HUMAN LIFE



Panel 9

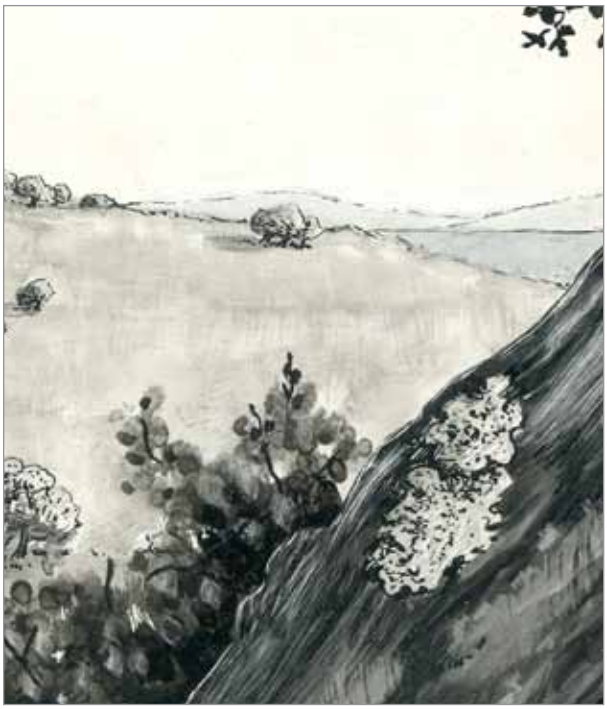
Ecosystems sustain human life through their processes and resources. The oak woodland was a vital part of Native American life and it has much to offer us today. The trees offer shade and protection from ultraviolet rays. They also store or sequester carbon, helping counteract climate change. The leaves of trees and shrubs provide oxygen necessary for the existence of all life, including humans. Plant roots mitigate floods and erosion and participate in nitrogen cycling. Birds serve as seed dispersers and also keep many pests in check. Even the alligator lizard diminishes the number of ticks in this habitat. All living things contribute to the regeneration of soil, if left to decompose. And, finally, the oak woodland provides an aesthetic beauty appreciated by people worldwide.

HYGIENE OF THE TURKEY VULTURE

Panel 10

Turkey vultures are common in and around the oak woodland. They can be seen soaring high above the treetops, their signature V-shaped wing position distinguishing them from other birds of prey. Turkey vultures are scavengers, playing a crucial role in nature as the cleanup crew. Due to their acute sense of smell and excellent eyesight, they can locate dead animals from far up in the sky. They prefer fresh kill, but will supplement their carrion diet with other items such as rotting pumpkins, juniper berries, or coyote feces. The turkey vulture's bald head, while grotesque looking, plays an effective hygiene role, as the bird needs to stick its head inside carrion to reach the meat. A feathered head would collect unwanted bacteria, threatening the health of the adult bird and its young.

THE WHOLE IS MORE THAN THE SUM OF ITS PARTS



Panel 10

There are more than 3,600 species of lichens in North America. Often spotted on the bark of trees or rock surfaces, lichens come in various textures, shapes, and colors. They are composed of fungi and one or two other organisms: algae and cyanobacteria (a type of bacteria that can photosynthesize). The fungal cells form the main body of the lichen and protect its partners from desiccation. The algae and cyanobacteria produce carbohydrates through photosynthesis. Together, these organisms form a partnership that is mutually beneficial and functions more successfully than they would on their own. Lichens provide valuable information about the health of an ecosystem. Lichens can establish themselves in adverse conditions with little soil and extremes in climate. Yet, they are highly vulnerable to habitat alterations. Scientists consider them to be indicator species that provide valuable information about the health of an ecosystem: when lichens disappear, it is a warning that ecosystem health is declining.

PARTNERS IN SURVIVAL

Panel 11

Western scrub jays, found throughout North America, play a significant role in the success of the oak woodland. The acorn is the main staple of their diet, so when acorns are ripe in fall, they gather and carry them up to a mile from the tree, where they bury them for retrieval in winter and early spring. Scrub jays are highly intelligent and rely on their superb spatial memory to find and retrieve the acorns. But, while a jay can bury up to 4,500 acorns in one year, it retrieves less than one in four of them. The missed acorns are perfectly situated to sprout into new seedlings, enabling the oak woodlands to reproduce and spread. Scrub jays often steal the caches of other jays, and if watched while hiding their cache, will dig it up and move it to avoid theft.

ENERGY FLOWS THROUGH AN OAK WOODLAND

Panel 11

All organisms need a constant flow of energy to survive. In the oak woodland, the oaks receive energy from the sun and convert it to carbohydrates through photosynthesis. Caterpillars and oak moths eat oak leaves, absorbing some of their energy. Woodrats also eat oak leaves, as well as acorns, poison oak, and grasses. Turtles eat insects like caterpillars and oak moths, as well as small fish and aquatic plants. Scrub jays eat acorns and pine nuts, fruits, insects, and nestling birds. The great horned owl preys upon woodrats, mice, rabbits, and squirrels, and other owls. Cows eat grasses, and oak and willow seedlings. And many humans eat cows. This continuous flow of energy—in the form of food—sustains all life.

OAKS CREATE HEALTHY SOILS

Panel 12

In oak woodlands, scattered trees, shrubs, and open grasslands create a mosaic-like landscape. The oak's canopy creates islands of enhanced soil fertility, which contribute to the health of the ecosystem as a whole. The oak leaf and twig litterfall promotes the development of thicker topsoil, which in turn attracts earthworms and other soil fauna that mix the organic matter into the soil. The enhanced topsoil has a rich mineral profile and also reduces erosion and leaching. As humans increasingly remove oaks for livestock grazing, agriculture, and urban development, one unintended consequence is a rapid and large decrease in soil quality. By minimizing oak tree removal, we can sustain ecosystem health while protecting soil quality, water quality, species diversity, and wildlife habitat.

COOPERATIVE COURTSHIP

Panel 12

Wild turkeys are native to the United States, but were not introduced in California until the 1870s. Flocks of turkeys adapted to living in oak woodlands are often seen adjacent to housing developments. Watch them during mating season and you may observe something unusual. While in full mating display—fanning their tails, dropping their wings, and blushing red and blue—two or more related males will follow a group of females. Yet, only the dominant male will eventually copulate with a female. His brothers will help corral the females and chase away other males, but will not mate. This cooperative behavior—referred to as kin selection—is a successful reproductive strategy that results in the fittest passing along DNA while the others sacrifice their opportunity to breed. Studies show that dominant wild turkey males father seven times more offspring than do subordinate males.

ACORNS AS GIFTS FROM THE EARTH

Panel 13

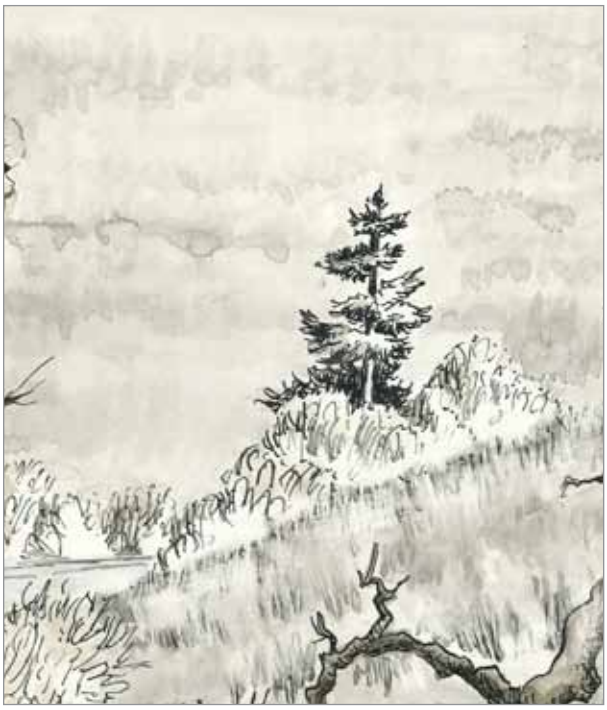
Native Americans hold a worldview that considers their relationship with nature to be vital and reciprocal. It requires a deep understanding of place and the local resources—or "gifts"—that nature offers. In the past, acorns were a highly valued resource, a staple of many Native Americans' diet for more than 4,000 years. Since each adult consumed one ton of acorns each year, they collected acorns from many different oak species. Acorns were collected in the fall, dried in the sun, and stored in granary baskets. The women would prepare them for cooking by cracking and removing the shells, then using a mortar and pestle to grind the nuts into flour. After leaching tannins from the flour, they mixed the flour with water and made it into mush or bread. Grinding rocks can still be found in some oak woodlands, and many Native Americans still celebrate the acorn harvest.

NATIVE AMERICANS' RELATIONSHIP WITH NATURE

Panel 13

The worldview of Native Americans includes using nature's resources judiciously. They have developed a deep understanding of each species, its life cycle, and its growth patterns. While modern-day resource management often consists of remediation from over-exploitation, traditional Native Americans lived as members of the natural world and viewed their role toward plants and animals as both stewards and consumers, but never abusers. One concrete example of this view is their relationship with soaproot, which they used many ways. The bulbs would be roasted and eaten, mashed up to poison fish, or used as soap or medicine. Many tribes burned areas where soaproot grew in order to stimulate its seeds to sprout. They also separated the bulblets and replanted them. Like other plants and animal resources, soaproot was harvested only to the degree that there was enough remaining for it to thrive until the next year and beyond.

PLANT SUCCESSION IN OAK WOODLAND



Panel 14

An oak habitat begins as an oak savannah, where trees and shrubs are scattered over a dense ground covering of herbs and grasses. As the oaks become increasingly abundant, they create an open to partially closed canopy with 25 percent to 80 percent tree cover, which provides shade for their seedlings and for shrubs such as elderberry, coyote bush, and poison oak. Conditions are also conducive for a variety of forbs to move in, such as California poppies, blue-eyed grass, and brodiaea. Eventually, as the oak population matures, Douglas fir seedlings appear in the understory and grow faster and taller than oaks. This signals the beginning of the transition from oak woodland to Douglas fir forest. Fire suppression and management have thwarted blazes that would periodically destroy Douglas fir saplings, allowing them to take over the oaks more quickly.

THE CYCLE OF LIFE AND DEATH

Panel 14

A fallen oak tree is a valuable component of California's oak ecology. It provides shelter for more than 80 vertebrates, including small mammals, amphibians, and reptiles, and perching platforms for many birds. It also provides food for various insects, beetles, fungi, and other decomposers that help recycle nutrients back into the soil. There are about 200 species of saprophytes that specialize in breaking down dead oak stumps, branches, and trunks. A dead oak is an important member of the oak ecosystem and should not be removed. Due to its slow decaying process, it can provide food, shelter, and soil enhancement for hundreds of years.

OAK-FUNGI PARTNERSHIPS

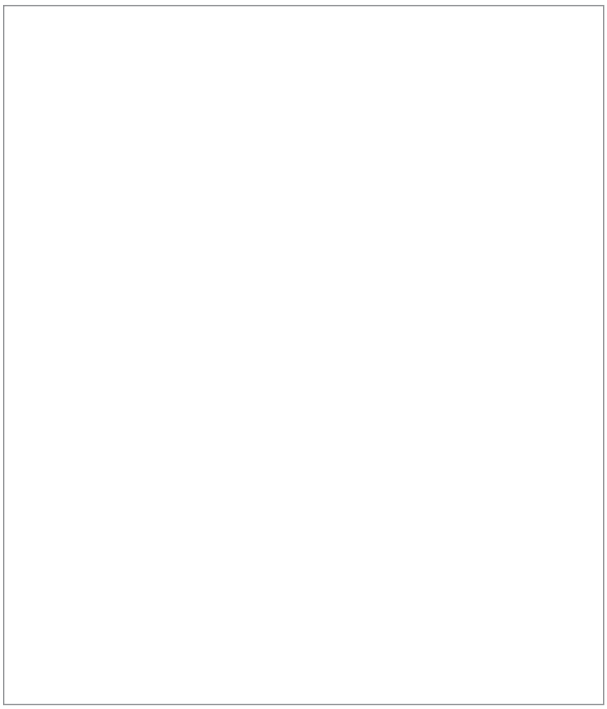
Panel 15

Gilled bolete is a type of fungus often found under oak trees. The fruit of the fungus can be seen above ground as a reddish-brown cap on a reddish (or sometime yellowish) stem. However, most of the fungus is underground. Its delicate web of underground filaments—called hyphae—entangles the rootlets of the oak, helping them absorb water and nutrients from the soil. In turn, the oak gives up small amounts of nutrients and amino acids to the fungus. Their relationship is called a "mycorrhizal" association, which is a symbiotic relationship between a plant and fungi that is beneficial for both of them. This partnership promotes the health and growth of the oak tree and the fungus, giving them a stronger chance for survival.

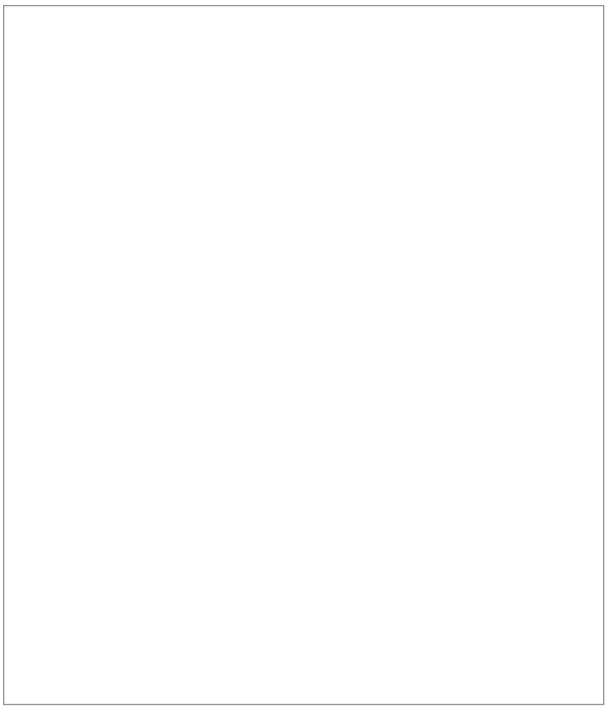
OBSERVING MULE DEER NEAR YOU

Panel 15

As cities and towns expand into surrounding oak woodlands, people and mule deer often share open spaces. Mule deer eat young seedlings and shrubs; hence, they take a toll on landscaped yards. As opportunistic browsers, mule deer will decapitate your roses, decimate your tomato seedlings, and leave no trace of your tulips. Yet, they are fascinating to watch and since many have little fear of humans, they are a wildlife species that is safe and easy to observe. If you are lucky, you might notice an unusual association between a mule deer and a scrub jay. The jay will stand on the back of a deer, eating ticks and other parasites in its fur. The deer will often stand very still and even hold its ears up, making the job easier for the jay. This association is another example of cooperation among species.



Panel



Panel

ABOUT THE CENTER FOR ECOLITERACY

The Center for Ecoliteracy is dedicated to education for sustainable living. Through its initiative Smart by Nature™, the Center offers expertise, inspiration, and resources to the sustainability movement in K–12 education, including its Rethinking School Lunch projects and the book *Smart by Nature: Schooling for Sustainability*, which showcases inspiring stories about school communities across the nation. The Center's services include a publishing imprint, seminars, academic program audits, coaching for teaching and learning, in-depth curriculum development, keynote presentations, technical assistance, and a leadership training academy. For further information, visit **www.ecoliteracy.org.**

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