RESILIENT COMMUNITIES LESSONS

FROM THE OAK WOODLAND

OVERVIEW

Students examine the oak woodland to learn about the characteristics that make an ecosystem resilient and the changing conditions and disturbances that can increase its vulnerability.

GRADE LEVEL: 9–12

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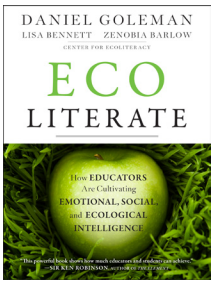

These lessons relate to "Embracing Sustainability as a Community Practice," one of five practices of emotionally and socially engaged ecoliteracy described in the Center for Ecoliteracy's book *Ecoliterate: How Educators Are Cultivating Emotional, Social, and Ecological Intelligence* (Jossey-Bass, 2012).

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Learning in the Real World®

Learning in the Real World is a publishing imprint of the Center for Ecoliteracy, a not-for-profit, tax-exempt organization. Created in 1997, Learning in the Real World offers resources to support schooling for sustainability, stories of school communities, and the ecological framework that informs the work of the Center.

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PURPOSE

In order to understand how to design resilient communities, we can learn from nature's resilient features as well as from the conditions that increase vulnerability.

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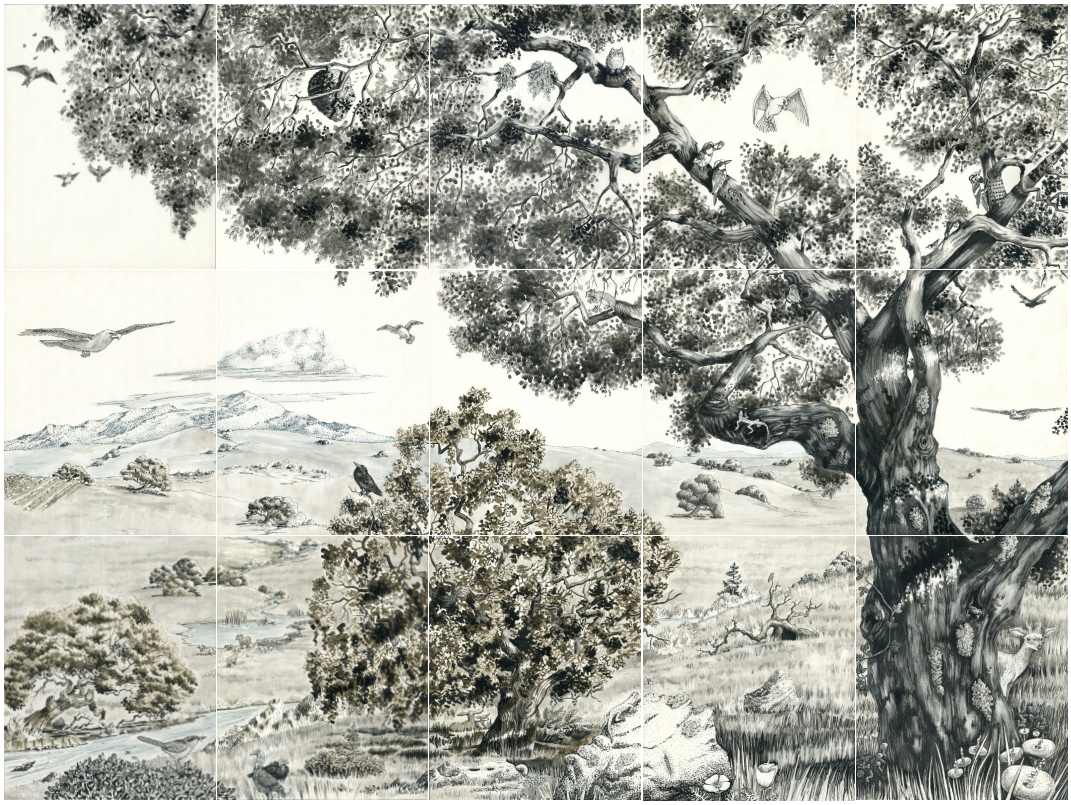

The assembled oak woodland mural

BACKGROUND

A resilient community is one that can cope and recover in the face of adversity. Brian Walker and David Salt describe resilience as "…the ability of a system to absorb disturbance and still retain its basic function and structure." [1]

Over the long term, a healthy ecosystem by definition supports the survival of its species, even when conditions are less than ideal. Of course, two fundamental features of a resilient ecosystem are the presence of conditions that meet the *basic needs* and the *reproductive capabilities* of its inhabitants. Inevitably, there will be disruptions that negatively affect the availability of food, water, and so on, as well as the conditions necessary for reproduction, but a resilient community can weather these disruptions through self-regulation. For example, in a year when food is particularly scarce, some inhabitants might produce fewer offspring or expand their ranges to gain access to additional food sources.

A third feature of a resilient community is its *biodiversity*. Resilience is enhanced not only by the number of different species within a natural ecosystem, but also by variation and redundancy in the functions, or niches, of ecosystem members. This diversity can allow the ecosystem to continue to function if a particular species is reduced. For example, both brown creepers and nuthatches move along oak tree trunks and branches, eating insects and larvae (some of which can be harmful to the oak tree). However, a nuthatch has the unusual ability to travel downward, so it can find food that the upward-bound brown creeper has missed. As a result, the same ecosystem can support both species, and will not lose the functions they provide, such as eating insects, if something happens to one of them.

A fourth resilience feature is the collective ability of the ecosystem's members to *adapt* and *coevolve* over time. Ecosystems that have a high adaptive capacity are able to innovate and reorganize themselves in such a way that their basic structure and function are retained. For example, the coevolution of the oak tree and a type of fungus has created a symbiotic relationship that increases the nutrient intake of both organisms. Without this relationship, both organisms may be compromised when an abrupt change or disruption reduces the availability of nutrients.

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[1] Walker, Brian, and David Salt. *Resilience Thinking: Sustaining Ecosystems and People in a Changing World* (2006, Island Press).

Evolution can also sometimes result in reduced resilience for a species that develops a high level of specialization in response to some change in its circumstances, but is not able to adapt to further changes. In this case, the resilience of the whole ecosystem will depend in part on its supporting enough diversity that other species can fulfill the role of the one that does not survive.

A fifth feature that affects resilience in an ecosystem is the complex *network of relationships* within and among species. Living organisms have found ways to coexist in the locations they share through cooperation and competition. Cooperative relationships usually result in more opportunities to acquire nutrients and avoid predators. Competition is usually driven by resources such as food, shelter, and reproduction.

All ecosystems experience periods of vulnerability that may threaten their survival. They are often susceptible to disruptions, such as a fire or the disappearance of a keystone species, which interrupt normal functioning. Vulnerability can also increase during periods of "normal" changes over time, such as the period of succession from a pond to a bog and then to a meadow.

In order to understand how to design resilient communities, we can learn from nature's resilient features as well as from the conditions that increase vulnerability.

MATERIALS

- Oak woodland mural (15 panels that can be combined into a mural)
- Oak woodland information cards (30 cards)
- Materials for assembling the mural (see Preparation)
- Mural panels and information cards from the Oak Woodland Learning Activity
- Chart paper
- Tape
- Felt markers

PREPARATION

1 Print out the 15 panels of the oak woodland mural, provided on page 22–36. Trim away the outside edges so that just the images remain. If you plan to use the panels multiple times, mount them on lightweight, biodegradable foam board or cardboard.

2 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.

3 Use the information cards provided, or create cards more appropriate for your students' reading levels and your area of study. If you are creating a new set of cards, make 15–30 copies of the blank cards provided on page 52 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).

4 Prepare and hang six sheets of chart paper with the following headings:

- Access to elements that meet basic needs: air, water, food, shelter
- Availability of conditions that support reproduction
- A rich diversity of inhabitants
- The ability to adapt and coevolve
- A network of relationships within and among species
- Evidence of vulnerability resulting from disturbances or changing conditions

LESSON INTRODUCTION

Explain that members of resilient natural communities have collective characteristics, including a rich diversity of inhabitants; the ability to adapt and coevolve; access to basic provisions such as air, water, food, and shelter; and a

network of relationships within and among species. Refer to the Background section of this lesson to explain each of these characteristics.

Point out to students that natural communities are also vulnerable to changing conditions and disturbances. Ask students to quickly brainstorm the kinds of changing conditions and outside disturbances that might threaten the survival of an ecosystem.

Remind students that there are valuable lessons to be learned from nature and that by examining one common ecosystem—the oak woodland—they will learn about features of resilience and vulnerability and determine if there are things we can learn about resilience in nature that could be applied to human communities.

CONDUCTING THE LESSON

Refer to the poster sheets you have displayed in the classroom. Explain that you will give students a picture of part of an oak woodland, along with two information cards that address an object or process represented in their picture. While working in pairs, they will use the picture, the two cards, and their previous knowledge to find examples of resilience and vulnerability.

Pair students and give each pair one oak woodland mural panel and the two related information cards. Ask them to look carefully at their panel, and read the cards, and then jot down "evidence" or examples of resilience or vulnerability. Once they have identified at least three ways the oak woodland is resilient or is vulnerable to changes and disturbances, ask them to enter their examples on the six charts.

DISCUSSION AND WRAP-UP

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

Now that the class can see the oak woodland in its entirety, lead a discussion to identify ways that the oak woodland ecosystem is designed not only to survive over time but also to be able to withstand disturbances. Review the lists and allow time to clarify the features listed.

Then ask the pairs of students to use the lists and other ideas they have gleaned as a starting point for identifying lessons learned from nature that may apply to designing resilient human communities. For example, developing local systems to meet basic needs—such as locally grown food—could make a community more resilient if a disaster disrupted its access to food shipped over a long distance. Communities that support diversity (such as by developing affordable housing so that people who provide essential services can live near where they work) can make communities more resilient. Or, just as natural ecosystems are made more resilient by networks of relationships, creating social networks such as neighborhood emergency response teams can make a community more resilient in the face of an earthquake or flood.

RESOURCES

INSTRUCTORS' ANSWER KEYS

The mural panels and information cards reveal many features that contribute to resilience as well as examples of ways an ecosystem can be vulnerable.

The answers listed here are included as references for instructors. They are abbreviated versions of the Oak Woodland Learning Activity information cards, illustrating one or more examples of resilience or vulnerability. Students need not write full explanations of each feature; encourage them to post summarizing phrases to the charts.

Students may come up with additional answers that are also correct. For example, there are many examples of the rich diversity of inhabitants in the mural and on the information cards, and students may also bring previous knowledge to the lesson.

ANSWER KEY #1: EXAMPLES OF CHARACTERISTICS CONTRIBUTING TO RESILIENCE OR VULNERABILITY, BY MURAL PANEL NUMBER

PANEL 1: COOPERATION IN AN OAK WOODLAND

A network of relationships

The oak tree, the oak titmouse, and the bushtit share relationships. The oak provides food and shelter for these birds and they feed on oak moth larvae that can harm the oak tree.

PANEL 1: OAKS AND CLIMATE CHANGE

Access to basic needs

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.

PANEL 2: OAKS AND GALLS: A COMPLEX INTERACTION

Conditions that support reproduction

Gall wasps deposit eggs inside the oak's plant tissue, which chemically stimulates the plant tissue to mutate in that spot and form a gall.

PANEL 2: PAPER WASPS IN THE OAK WOODLAND

Access to basic needs

The paper wasp rids the oak tree of destructive caterpillars, which it uses as nourishment for its larvae.

PANEL 3: MISTLETOE: FRIEND OR FOE?

A network of relationships

Animals that consume mistletoe distribute its pollen and seeds. The mistletoe also depends on its host tree for water and nutrients.

PANEL 3: THE DIVERSE RELATIONSHIPS OF A SCREECH OWL

A rich diversity of inhabitants

The western screech owl will use the nest of other birds. It eats insects, birds, small mammals, snakes, and lizards, and it is preyed upon by jays, crows, raccoons, and bigger owls.

PANEL 4: THE SOCIAL SYSTEM OF THE ACORN WOODPECKER

Conditions that support reproduction

Young woodpeckers stay with their parents to help raise younger siblings. Individuals may also breed within the family and members can be highly competitive in the mating process.

PANEL 4: FOOD STORAGE OF THE ACORN WOODPECKER

Access to basic needs

Acorn woodpeckers store acorns in the trunks and branches of a single tree, called a granary. They will also use human-made structures such as fence posts, utility poles, and buildings in their habitats.

PANEL 5: THE BROWN CREEPER: BIRDS AMONG THE BARK

A rich diversity of inhabitants

Brown creepers are found all over the United States, southern Canada, and parts of Mexico. They live in a variety of tree species, but prefer old growth trees and a relatively closed canopy. They have the special ability to use their stiff tails for balance as they spiral up a tree while foraging for insects and larvae.

PANEL 5: THE NUTHATCH: THE UPSIDE-DOWN BIRD

The ability to adapt and coevolve

Nuthatches have an 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.

PANEL 6: CAN FARMS AND OAKS COEXIST?

Evidence of vulnerability

Oak trees and their inhabitants are disappearing as woodlands are converted to farmland, rangeland, and housing tracts. Agricultural conversion usually alters water distribution, making land less suitable for oaks. Entire oak woodlands have been wiped out or fragmented by the expansion of vineyards.

PANEL 6: RANCHING IN THE OAK WOODLAND

Evidence of vulnerability

The behavior of grazing animals threatens oak survival. They tend to cluster under shade trees, which compacts the soil around the tree's root zone. This also causes erosion that can damage the tree's roots. Cows and other grazers eat and

trample oak seedlings. Horses and goats chew off bark, exposing the trees to harmful organisms.

PANEL 7: LARGE-SCALE CHANGE IN AN OAK COMMUNITY

A rich diversity of inhabitants

In the natural cycle of plant succession, an oak woodland is preceded by a grassland. Perennial grasses prevent erosion, suppress invasive species, and serve as food for wildlife. Grasslands have been largely replaced by European annuals, due to an increased demand for agriculture and grazing. Approximately 90 percent of the species listed in California's *Inventory of Rare and Endangered Species* are residents of the grassland.

PANEL 7: RAVENS: INTELLIGENT LEARNERS

A network of relationships

Several cultures have documented a mutualistic relationship between ravens and wolves. Ravens not only shadow wolves as they hunt, in order to take advantage of the wolves' kills, but they have been known to lead wolves to herds of prey.

PANEL 8: ADAPTATIONS TO MAXIMIZE PHOTOSYNTHESIS

The ability to adapt and coevolve

Oaks are adapted to maximize photosynthesis in the hot, dry summers of the Mediterranean climate. The structure of the outer leaves of coast live oaks allows them to maximize solar absorption while reradiating heat, and also allows sunlight to reach the inner leaves. The structure of the inner leaves allows them to photosynthesize by capturing light that penetrates through the canopy.

PANEL 8: THE IMPACT OF INTRODUCED SPECIES

Evidence of vulnerability

The western gray squirrel is considered threatened in Pacific states, due to habitat loss and the introduction of invasive species that can outcompete the native squirrels.

PANEL 9: "TICKED OFF" ALLIGATOR LIZARDS

A rich diversity of inhabitants

A region with alligator lizards will likely have fewer cases of Lyme disease because ticks, which carry Lyme disease, feed on the blood of alligator lizards when in their nymph stage. 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.

PANEL 9: ECOSYSTEMS AND HUMAN LIFE

A network of relationships

Trees, including the oak, support human life in myriad ways. They provide shade and protection from ultraviolet rays. They store carbon, helping counteract climate change. Their leaves provide oxygen necessary for living organisms, including humans. Their roots mitigate floods and erosion and participate in nitrogen cycling.

PANEL 10: HYGIENE OF THE TURKEY VULTURE

The ability to adapt and coevolve

Turkey vultures are scavengers, playing a crucial role in nature as the cleanup crew. The vulture's bald head, while looking grotesque to humans, plays an effective role in hygiene, as the bird needs to stick its head inside carrion to reach the meat and entrails. A feathered head would collect unwanted bacteria, threatening the health of the adult bird and its young.

PANEL 10: THE WHOLE IS MORE THAN THE SUM OF ITS PARTS

The ability to adapt and coevolve

Lichens are composed of fungi and one or two other organisms: algae and cyanobacteria (a type of bacteria that can photosynthesize). Together, these organisms form a partnership that is mutually beneficial and enables them to function more successfully than they would on their own.

PANEL 11: PARTNERS IN SURVIVAL

The ability to adapt and coevolve

Western scrub jays play a role in the success of the oak woodland, and vice versa. They bury acorns, the main staple of their diet, up to a mile away from the tree for retrieval in the winter. However, they recover less than one in four of the acorns, increasing the potential for the acorns to sprout into new seedlings.

PANEL 11: ENERGY FLOWS THROUGH AN OAK WOODLAND

Access to basic needs

The oak receives energy from the sun and converts it to carbohydrates through photosynthesis. Animals like caterpillars and oak moths eat the oak leaves, absorbing some of their energy. Then, in turn, turtles and scrub jays eat the caterpillars and oak moths, among other organisms. The great horned owl will eat a scrub jay. This continuous flow of energy sustains life.

PANEL 12: OAKS CREATE HEALTHY SOIL

Access to basic needs

The oak leaf and twig litterfall promotes the development of thicker topsoil, which attracts earthworms and other organisms that mix organic matter with the soil.

PANEL 12: COOPERATIVE COURTSHIP

Conditions that support reproduction

During their mating season, groups of male wild turkeys will exhibit full mating display. Only the dominant male will eventually copulate with a female; the other males help corral the females and chase away other males but will not mate. This cooperative behavior is a successful reproductive strategy.

PANEL 13: ACORNS AS GIFTS FROM THE EARTH

Access to basic needs

Acorns were a highly valued resource in early Native American communities. Each adult consumed one ton of acorns each year, so they collected acorns from many different oak species.

PANEL 13: NATIVE AMERICANS' RELATIONSHIP WITH NATURE

A network of relationships

Native Americans viewed themselves as both stewards and consumers of nature. For example, they used soaproot for food, for stunning fish, and for medicine. They would burn areas where it grew to stimulate its seeds to sprout and they would limit the amount they harvested so that the soaproot could thrive until the next year and beyond.

PANEL 14: PLANT SUCCESSION IN OAK WOODLAND

The ability to adapt and coevolve

Prior to becoming an oak woodland, a grassland evolves into an oak savannah. As oaks become increasingly abundant, they create a canopy with 25 to 80 percent tree cover, which provides shade for their seedlings and shrubs such as elderberry, coyote bush, and poison oak. Forbs, such as California poppies, blue-eyed grass, and brodiaea, also thrive. When Douglas firs appear in the understory, they signal the beginning of a transition from oak woodland to Douglas fir forest.

PANEL 14: THE CYCLE OF LIFE AND DEATH

Access to basic needs

A fallen oak tree provides shelter for more than 80 vertebrates, including small mammals, amphibians, and reptiles. It also provides food for various insects, beetles, fungi, and other decomposers that help recycle nutrients back into the soil.

PANEL 15: OAK-FUNGI PARTNERSHIPS

A network of relationships

Gilled bolete is a fungus with a symbiotic relationship with oak trees. Its underground filaments become entangled around the oak's roots, helping them absorb water and nutrients from the soil. In turn, the oaks give up small amounts of nutrients and amino acids to the fungus.

PANEL 15: OBSERVING MULE DEER NEAR YOU

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The mule deer and the scrub jay have a symbiotic relationship. The jay will stand on the back of a deer, eating ticks and other parasites in its fur. The deer will often stay very

still and hold up its ears, making the job easier for the jay. This association is an example of cooperation between species.

ANSWER KEY #2: EXAMPLES OF CHARACTERISTICS OF RESILIENCE AND VULNERABILITY BY TYPE

A Rich Diversity of Inhabitants

PANEL 3: THE DIVERSE RELATIONSHIPS OF A SCREECH OWL

The western screech owl will use the nest of other birds; it eats insects, birds, small mammals, snakes, and lizards, and it is preyed upon by jays, crows, raccoons, and bigger owls.

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In the natural cycle of plant succession, an oak woodland is preceded by an herbaceous grassland, which is vital to the regeneration of oaks. Perennial grasses prevent erosion, suppress invasive species, and serve as food for wildlife. As grasslands have been largely replaced by European annuals, due to an increased demand for agriculture and grazing, there has also been a decline in grassland birds across the United States. Approximately 90 percent of the species listed in California's *Inventory of Rare and Endangered Species* are residents of the grassland.

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A region with alligator lizards will likely have fewer cases of Lyme disease because ticks, which carry Lyme disease, feed on the blood of alligator lizards when in

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Access to Basic Needs: Air, Water, Food, Shelter

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Evidence of Vulnerability from Changing Conditions or Disturbances

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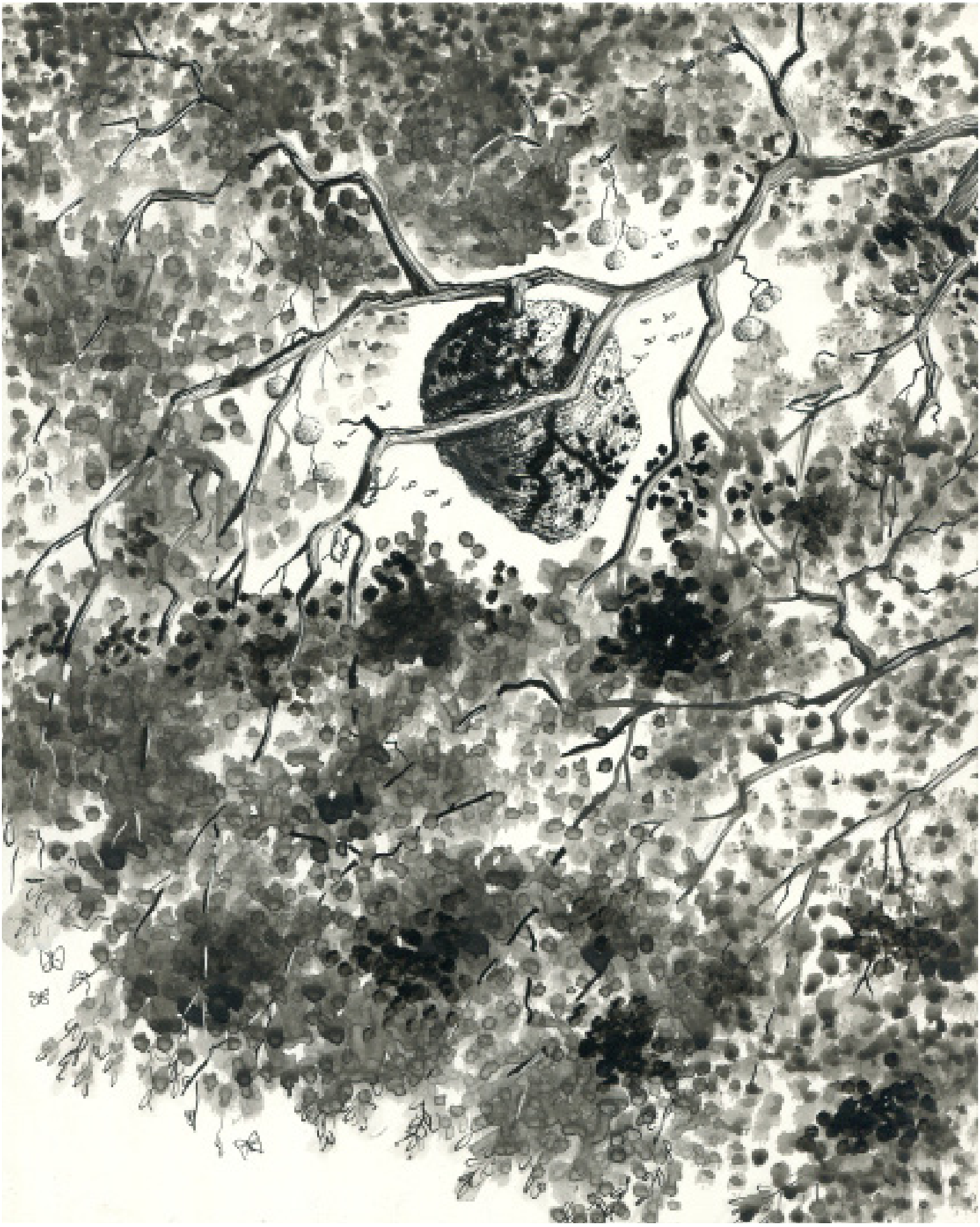

PANEL 2

ILLUSTRATOR: ANE CARLA ROVETTA | © CENTER FOR ECOLITERACY

PANEL 3

ILLUSTRATOR: ANE CARLA ROVETTA | © CENTER FOR ECOLITERACY

PANEL 4

ILLUSTRATOR: ANE CARLA ROVETTA | © CENTER FOR ECOLITERACY

PANEL 5

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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

PANEL 10

PANEL 11

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PANEL 12

PANEL 13

ILLUSTRATOR: ANE CARLA ROVETTA | © CENTER FOR ECOLITERACY

PANEL 14

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PANEL 15

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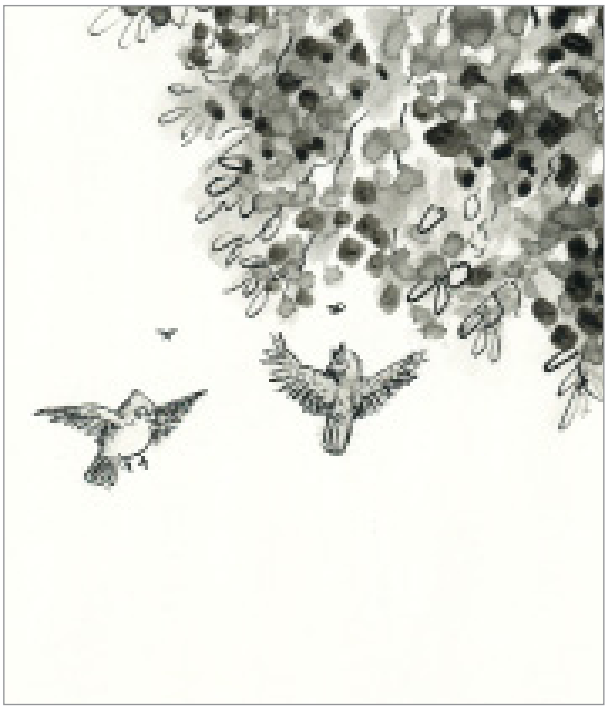
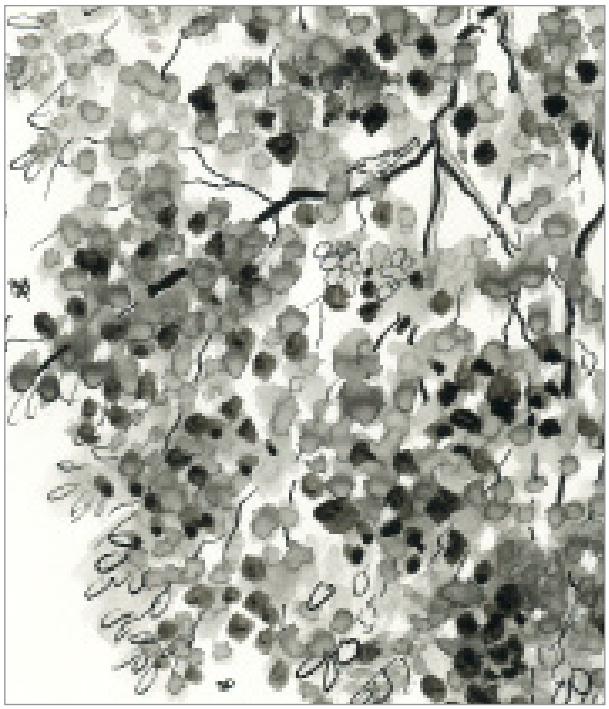
COOPERATION IN AN OAK WOODLAND



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

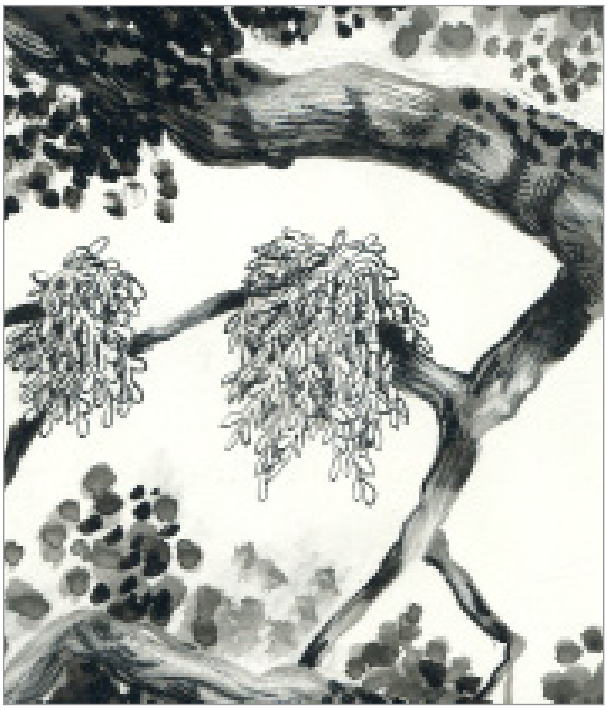
There are over 200 species of oak gall wasps. When the time is right, based on many factors, the gall wasp pierces a part of the oak tree (leaves, branches, twigs, buds, or roots) and deposits an egg inside the plant tissue. The fluid surrounding the egg stimulates that part of the plant to multiply 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.

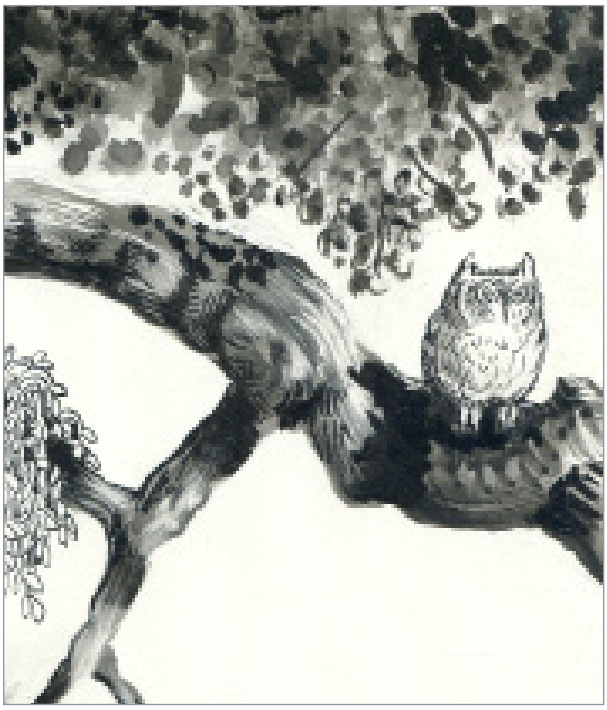
MISTLETOE: FRIEND OR FOE?



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

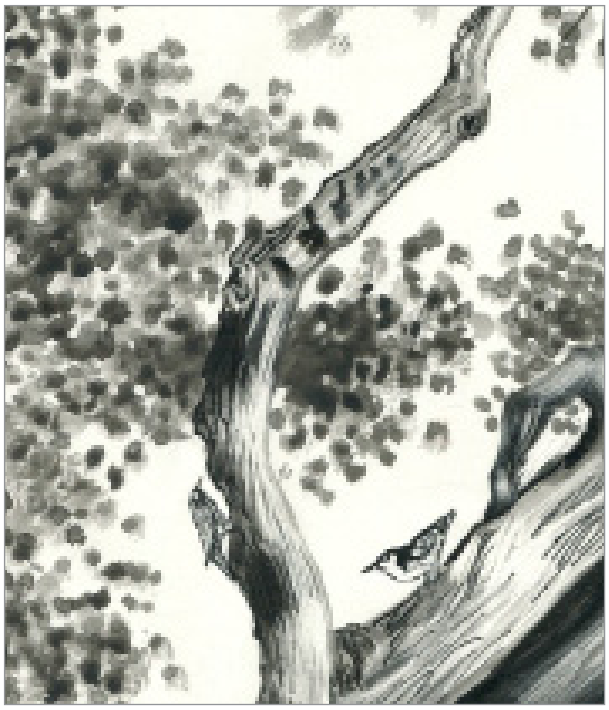
The acorn woodpecker has a complex social system. Family groups create and defend territories, and young woodpeckers stay with their parents for several years, helping the parents raise younger siblings. Many different individuals of each sex may breed within a family; there can be up to seven breeding 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.

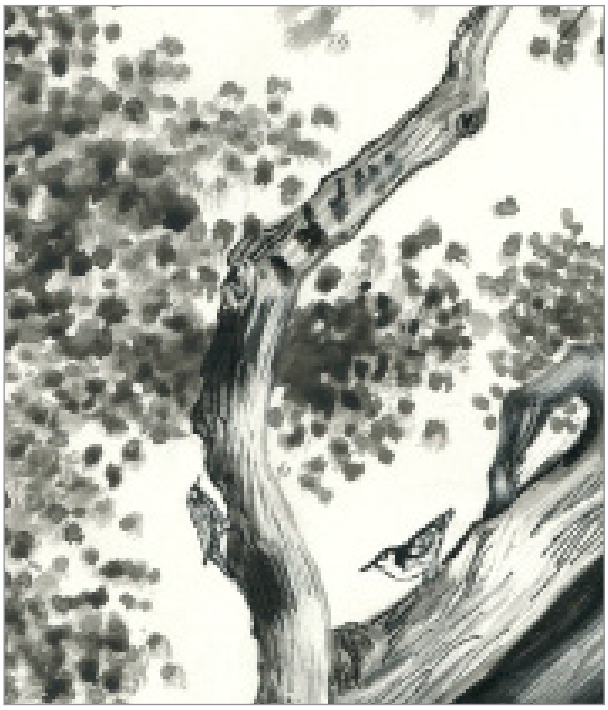
THE BROWN CREEPER: BIRDS AMONG THE BARK



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.

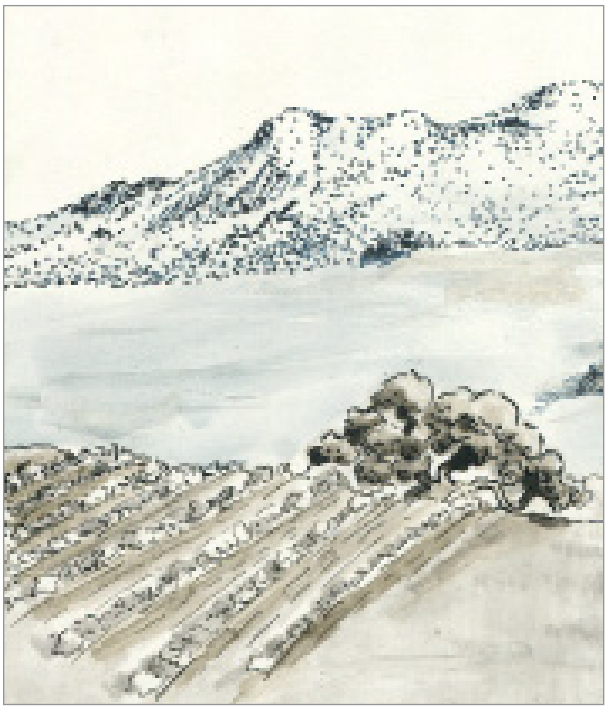
THE NUTHATCH: THE UPSIDE-DOWN BIRD



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 hardwired; 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

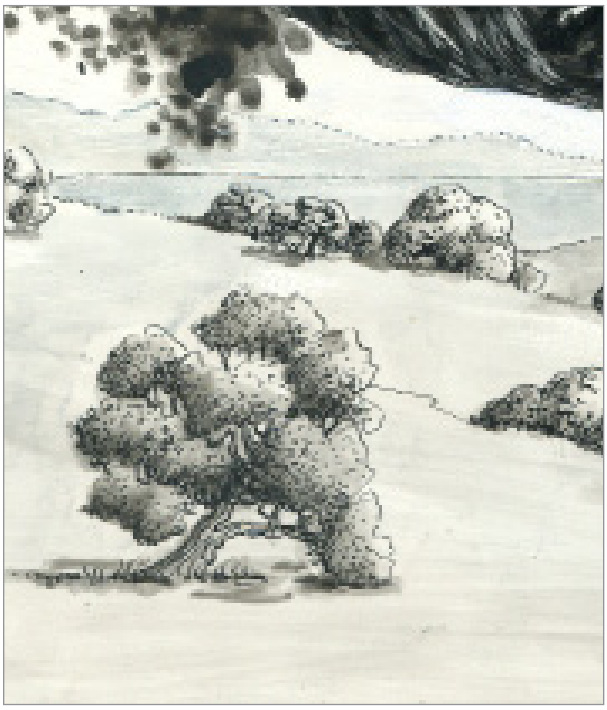
The western gray squirrel was once a common sight in oak woodlands of the Pacific states. However, it is now considered threatened in parts of the West, primarily because of habitat loss and the introduction of invasive species. The western gray squirrel competes with three introduced species—the ground 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.

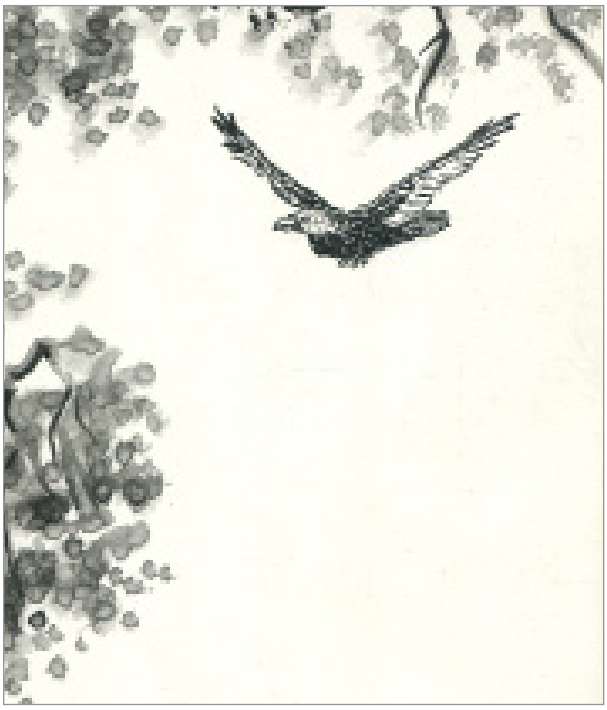
ECOSYSTEMS AND HUMAN LIFE



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.

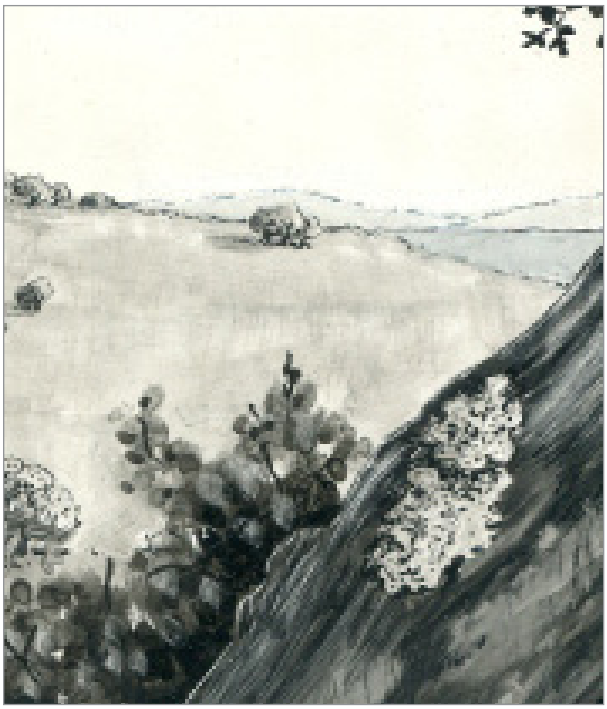
HYGIENE OF THE TURKEY VULTURE



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, 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 SOIL

Panel 12

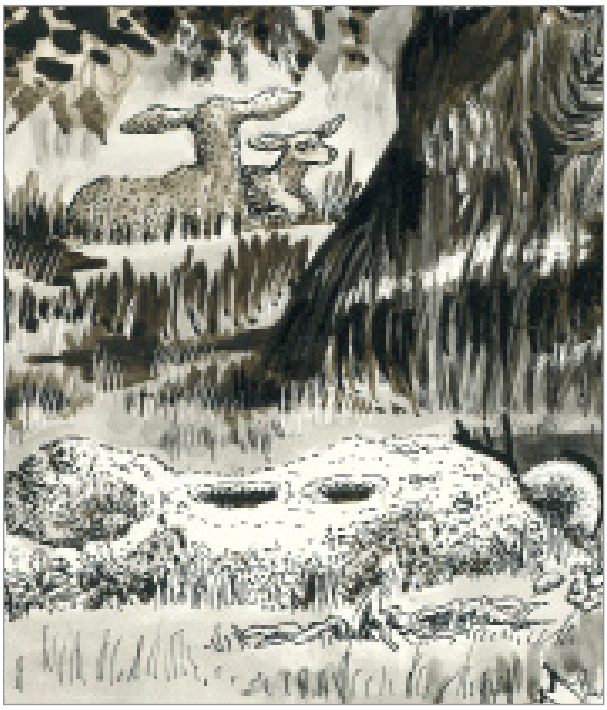
In oak woodlands, scattered trees, shrubs, and open grasslands create a mosaic-like landscape. The oak's canopy creates islands of enhanced soil fertility, which contribute to the health of the ecosystem as a whole. The oak leaf and twig litterfall promotes the development of thicker topsoil, which in 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.

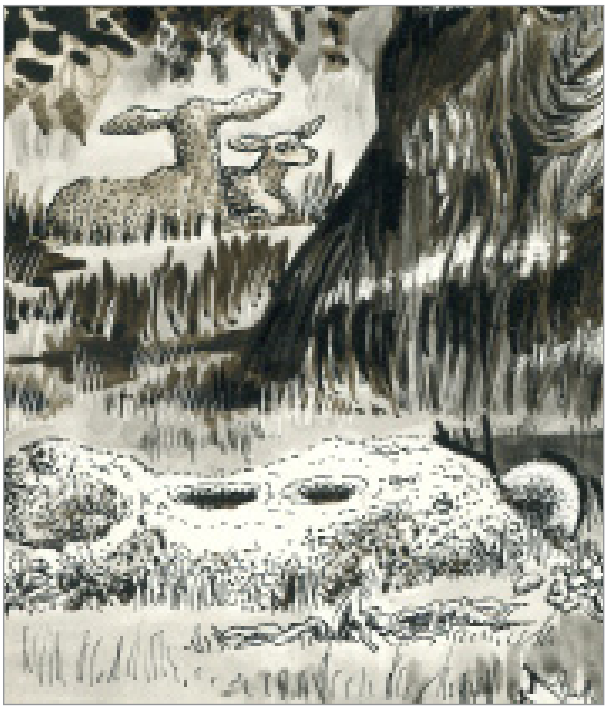
ACORNS AS GIFTS FROM THE EARTH



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 overexploitation, 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 in 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 plant 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

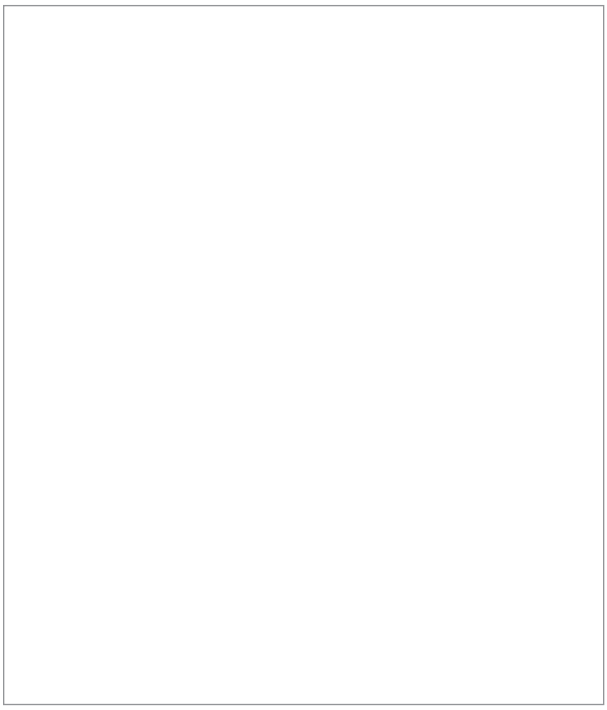
Panel 15

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.

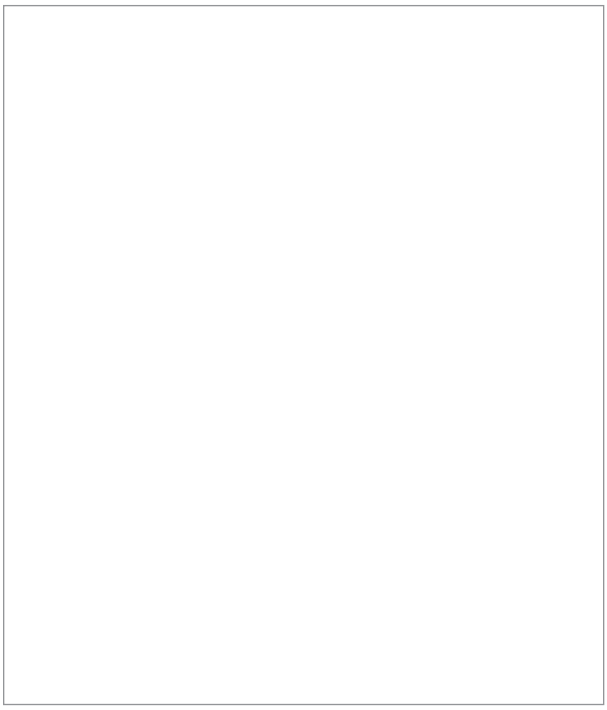
OBSERVING MULE DEER NEAR YOU

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 an internationally recognized leader in systems change innovations in education for sustainable living. Since 1995, the Center has engaged with thousands of educators from across the United States and six continents. The Center offers publications, seminars, academic program audits, coaching for teaching and learning, in-depth curriculum development, keynote presentations, and technical assistance. Books authored or coauthored by the Center for Ecoliteracy include *Ecoliterate: How Educators Are Cultivating Emotional, Social, and Ecological Intelligence* (Jossey-Bass, 2012); *Smart by Nature: Schooling for Sustainability* (Watershed Media, 2009); and *Ecological Literacy: Educating Our Children for a Sustainable World* (Sierra Club Books, 2005).

The Center for Ecoliteracy is grateful to the Roy A. Hunt Foundation for its support for this publication.

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Cover Oak leaf: istockphoto 14804133, marilyna; paper wasp: istockphoto 4155871, macroworld