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FOREST STEWARDSHIP SERIES 8

Forest Wildlife

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WHAT IS WILDLIFE?

The term "wildlife" means different things to different people. A common definition of wildlife is "living things that are neither human nor domesticated," a definition that can include plants as well as animals. In the past, "wildlife" was generally limited to game species (e.g., deer, bear, quail), but more recently it has come to include all undomesticated animals, including insects. This discussion of wildlife will include the major animal groups found in the forest.

Wildlife is an integral part of any forest. In addition to intrinsic value, wildlife perform numerous functions that are necessary to sustain the forest ecosystem. These include energy and nutrient cycling, pollination, seed dispersal, decomposition, control of pest populations, and much more. In addition, most people enjoy observing wildlife, and many participate in recreational activities such as bird watching, insect collecting, photography, hunting, and fishing, to name a few.

It is important to recognize that there is a wide diversity of wildlife in the forest. Each species has its own niche, or ecological role, in the forest ecosystem. Some of these are well understood, others less so. Not only does each species have its own unique roles and needs, but there are equally important relationships between and among the various species, the plant community, and the physical environment. All of these together form the complex forest ecosystem.

Mammals

Mammals are the group most people think of as wildlife. They are a highly diverse group of animals, with some living below ground and others flying overhead. Forest mammals include carnivores such as bears, mountain lions, skunks, and otters; herbivores such as deer, rodents, and rabbits; and insectivores such as bats, moles, and shrews. Rodents such as voles turn over the soil and cycle nutrients, while others such as mice provide a prey base for many other species (fig. 1).

Birds

Birds add color, movement, and sound to the forest. They play crucial roles in the forest ecosystem by dispersing seeds, pollinating plants, and by eating insects and rodents. They are as diverse in their feeding behaviors as the mammals, with nectar feeders (hummingbirds), seed eaters (sparrows and finches), and carnivorous predators (hawks and owls). Some nest in fragile straw and grass cup nests (warblers), while others build huge platforms made of sticks weighing hundreds of pounds (ospreys and eagles). Some nest on the ground, others in trees and shrubs.

Objectives

Understand forest wildlife relationships and functions, habitat structures, and elements and how to maintain or enhance them.

Competencies

- *Know the basic needs of wildlife for cover, food, water, and living space.*
- *Ability to identify common forest wildlife and their habitat requirements.*
- *Ability to predict the effects of human and natural disturbances on wildlife.*
- *Understand the effects of human residential living in the forest with wildlife.*
- *Ability to promote wildlife use and presence in the forest.*
- *Understand the legal status and special needs of endangered wildlife species.*

Related Forest Stewardship Publications

- *Forest Ecology, ANR Publication 8233*
- *Forest Vegetation Management, ANR Publication 8236*
- *Laws and Regulations Affecting Forests, Part I: Timber Harvesting, ANR Publication 8249*

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Figure 1. The red-backed vole is known to disperse the mycorrhizal fungal spores important for the productivity of Douglas fir. *Source:* Illustration by Ellen Blonder, from J. Verner and A. Boss, eds., California wildlife and their Habitats: Western Sierra Nevada (Berkeley: Southwest Forest and Range Experiment Station General Technical Report PSW-37, 1980).

Figure 2. Mollusks, like this banana slug, are important because they recycle many nutrients found in various plant materials. *Photo:* Gerald and Buff Corsi, © 1999 California Academy of Sciences.

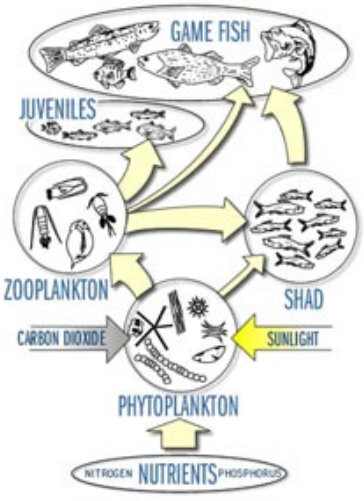

Figure 3. Diversity can be expressed by analyzing the number of animals that partition various resources found in a forest freshwater aquatic setting. *Source:* Courtesy Water on the Web, http://WaterOntheWeb.org, University of Minnesota-Duluth.

Reptiles

These cold-blooded animals (ectotherms) regulate their body temperature by behavioral means. That is, when too cold, they move to warm places, and when too warm, they move to cooler places. Though not as appealing to people as birds and mammals, these animals play important roles in the ecosystem. Reptiles are both predators and prey, keeping populations of rodents and insects in check and serving as food for many other animals. Recently it was learned that western fence lizards cleanse ticks' blood of Lyme disease, reducing the level of the potential inoculum in the environment.

Amphibians

Frogs and salamanders are another largely overlooked group in the forest. These are an important food source for a number of other animals, and they also help control insect populations. Their migrations across the forest floor may play a role in fungal dispersal and movement.

Fish

Fish are a major component of many food chains. In addition, it is now recognized that anadromous fish, those that move from freshwater to the ocean and back (e.g., salmon or steelhead), play a major role in bringing nutrients from the ocean to the terrestrial ecosystem when they return to spawn and be eaten or die on the riverbank.

Invertebrates

This is likely the least appreciated wildlife group in the forest. Invertebrates are animals that lack backbones, including worms, slugs, spiders, and insects. Besides providing food for many other species, invertebrates perform a great number of functions in the forest. Many are decomposers, having the essential job of recycling nutrients through the ecosystem (fig. 2). Others are predators that keep populations of pests under control. Soil-dwelling invertebrates help aerate and build the soil. Some invertebrates are also pollinators, without which many plants could not reproduce. Invertebrates are probably the most interesting and important group of animals in the forest, containing the greatest total animal biomass and performing some of the most important services.

BIOLOGICAL DIVERSITY

Biological diversity is the variety of life over a spatial unit. It can be measured at several different levels, from ecosystem diversity (the variety of habitats and communities within an ecosystem), to species diversity (the number and mix of species within an ecosystem), to genetic diversity within a species (fig. 3).

Groups of individuals of a species make up populations, and these populations in aggregate with other species populations make up communities. Communities across large geographic regions make up a landscape.

Figure 4. The differences among forest relationships can be subtle and can be affected by easily overlooked resources like the mosses growing on the bark of California black oak. *Photo:* Gary Nakamura.

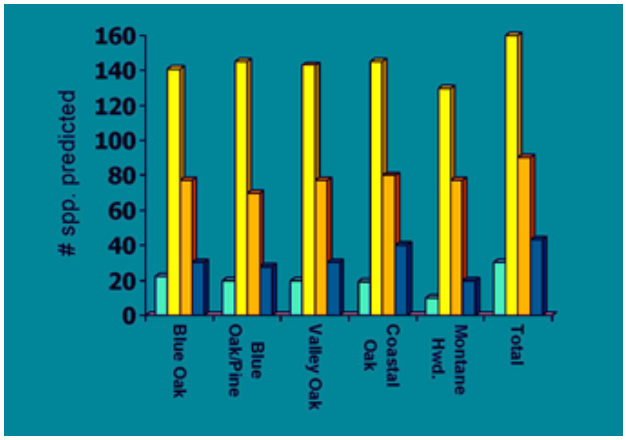

Figure 5. The diversity and overlap of wildlife species found in different oak woodlands across the state.

A forest contains a great variety of plant and animal species. Groups of individuals of a species make up populations, and these populations in aggregate with other species populations make up communities. Communities across large geographic regions make up a landscape. Across this landscape, there are genetic differences between individuals and populations of the same species, which is collectively called genetic variation. The variety of species in a community (species diversity) and the genetic variation within them (genetic diversity) is called biological diversity, or biodiversity. The biological diversity and variation within a forest system includes plants, mammals, birds, amphibians, reptiles, fish, soil and aerial invertebrates, fungi, and bacteria.

Maintaining biodiversity is essential for supporting a number of processes in the forest. It is important because biological diversity within a forest ensures that energy and nutrient cycles will function properly. These cycles ensure that the biological integrity of a forest will be maintained. Aspects of biological integrity include natural regeneration, insect and disease resilience, and resistance or resilience in response to natural disturbances such as fire.

WILDLIFE HABITAT RELATIONSHIPS

The animals and plants that coexist in a forest depend on the physical environment (climate, soils, topography). These conditions largely determine what plant species can exist in an area. This in turn defines the plant community (the association of plants that live together). California includes a great range of physical conditions—different elevations, soil types, precipitation levels, proximity to the ocean, and other parameters. Because of this, the state has a wide diversity of forest types and wildlife habitats (fig. 4).

Animal species are often found in association with specific plant communities. However, while forests of pine, redwood, fir, and oak are generally sharply defined geographically, wildlife patterns tend to be less clearly defined (fig. 5). Many species are mobile and can readily exploit many forest types. For example, sharp-shinned hawks can be found in redwood forests, pine forests, and in mixed forests of conifers and hardwoods throughout the state.

Often, the composition of the forest (the actual species of plants found there) is not as important as the structure of the forest (the size, condition, and distribution of plants) in determining the occurrence of animal species. For example, the sharp-shinned hawk needs suitable nesting sites combined with adequate prey and necessary resting places and could conceivably be found in

Figure 6. Snags (standing dead trees) provide important nesting, roosting, and foraging sites for many species of vertebrates and invertebrates. *Photo:* Gary Nakamura.

many forest types within its range. Many wildlife species depend on particular structural components such as snags, rock piles, fallen trees, and perching branches. A forest setting with a representative assemblage of trees of various sizes and ages, as well as snags, fallen logs, some ground cover plants, and stumps, will meet the basic ecological needs of most of the species found in that forest type (fig. 6).

A few species have more specific needs. For example, a species that requires acorns for a portion of its diet must live in a forest with oaks (although it is generally not important which species of oak), and certain insects are completely dependent on one type (or group) of plant. These specialist species will more easily be at risk if that limited habitat element or plant species is lost. Many of the animals that are threatened or endangered belong to this specialist group. Species with very specific needs may require special management consideration.

COMPONENTS OF HABITAT

Generally, wildlife management does not involve managing the animals themselves, but rather managing the habitat in which they live. The idea is that if appropriate habitat is available, animals will utilize it. Wildlife requires four basic elements to successfully complete their life cycles: food, water, cover, and space. These elements are collectively known as habitat, and each animal species has its own unique habitat requirements. Suitable habitat provides these basic elements to sustain both individuals and populations of individuals over time.

Food

Food is an obvious requirement for life. Some wildlife species eat only plants (herbivores), others only animals (carnivores), while still others eat both (omnivores). Animals may have very specific food requirements

THREATENED AND ENDANGERED WILDLIFE SPECIES

California is home to nearly 800 species of vertebrates, thousands of plants, and an uncounted number of invertebrates. This vast biological diversity is directly related to the great variety of habitat types found throughout the state. The combination of different forest types plus deserts, valleys, mountains, coastal, and marine environs have resulted in a proliferation of species and communities over evolutionary time. Because of this, many species evolved to exploit extremely limited ecological niches. These species, some of which are naturally rare, are more susceptible to extinction through habitat alterations. Other historically common species, such as salmon, have suffered from extreme alterations to their natural habitats over time.

The rapid increases in human population and concurrent habitat destruction of the twentieth century put many species in harm's way throughout California, and more generally, throughout the United States. The federal Endangered Species Act (ESA) of 1973 was passed by Congress and signed into law by President Richard Nixon. It was designed to slow or stop the human-caused extinction of plants and animals in the United States. The ESA is administered by the U.S. Fish and Wildlife Service (FWS) and, in the case of anadromous fishes, the National Marine Fisheries Service (NMFS). A comparable state law, the California Endangered Species Act (CESA), is administered by the California Department of Fish and Game (DFG) and may have jurisdiction over some species not identified in the federal law.

The ESA can have direct impacts over forest management on private property if a federally listed species (such as northern spotted owl, Coho salmon, red-legged frog, or marbled murrelet) occurs or is thought to occur there. It comes into play only when an activity is proposed that requires a permit. In California, a timber harvest plan (THP) is required to commercially harvest timber, thereby necessitating an ESA consultation if a listed species is thought to occur within the impact area of the activity.

As of January 2006, 69 animal species were listed under the ESA, 31 species were listed under CESA, and 54 species appeared on both lists. Current information about the species on these lists is found under Threatened and Endangered Species on the DFG Web site at *http://www.dfg.ca.gov*.

or may eat a variety of foods depending on availability. Common plant foods are categorized as soft mast (berries and other fruit), hard mast (nuts and acorns), forbs (grasses and herbs), and browse (shrubs). Many of these items such as hard and soft mast are seasonally available and must be supplemented with other food sources throughout the year.

The movement of energy through the forest ecosystem can be characterized as a food chain, or food web. Plants convert light from the sun into biomass (their stems, leaves, and fruit) which can be eaten by herbivores. Herbivores, in turn, are eaten by carnivores. By tracing these connections it is easier to see relationships and interdependence among living things in the forest (fig. 7).

Water

Water is essential for all animals. While a few can get the water they need from their food, most require a surface water source. This means that water in all forms is an extremely important forest element. Besides access to a water source (creek, spring, pond, or droplets of morning dew on grasses), animals need the ability to reach the water safely, which often involves corridors of vegetation or other cover leading to the water. If water is a limiting factor for a desired species, artificial sources of water such as ponds or troughs can be provided.

Cover

The cover elements of a habitat are not as obvious as food and water. Shrubs, brush piles, tree cavities, fallen logs, and stumps and burrows in the ground can all serve as cover. Cover requirements depend on the species and are essential for addressing various needs throughout the year. At any time, cover is necessary for protection from predators and adverse weather conditions. Cover for travel, escape, and feeding is also needed in varying degrees. During the spring, suitable cover is needed for nesting sites and protection for the young. During summer months, cover such as large trees, rock piles, and fallen logs may provide shade from the sun or daytime roost sites for nocturnal species. During winter, elements that provide cover may include evergreen

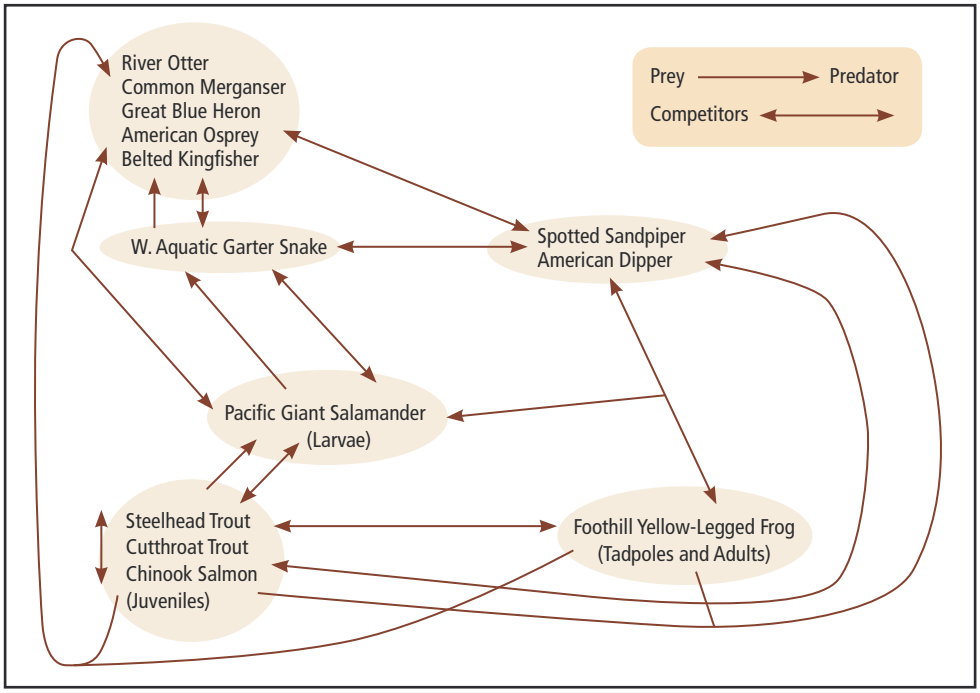

Figure 7. Relationships among groups of species in a forest can be quite complex, as illustrated by this food web developed for a perennial creek in the coast redwood region in Del Norte County.

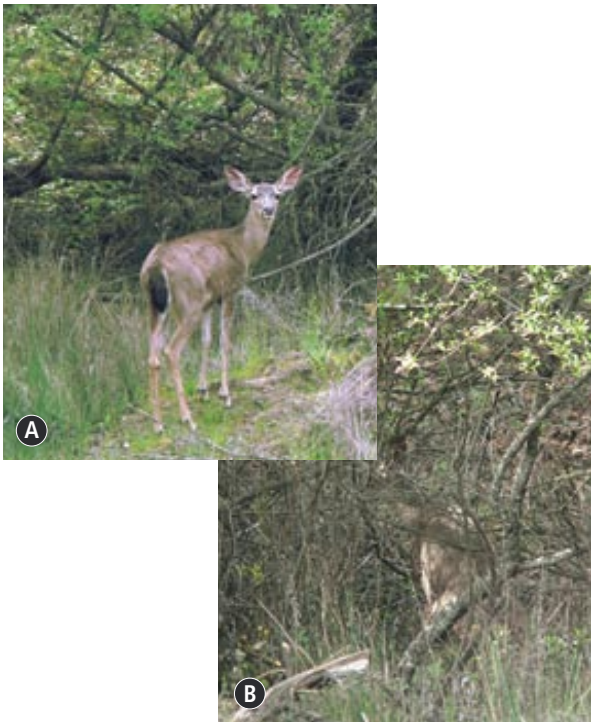

Figure 8. A deer browsing in the open (A) is quite visible and vulnerable to predators. Stepping into the forest just a few feet (B), the deer's coloration and form give it hiding cover and make it difficult to see. *Photos:* Gary Nakamura.

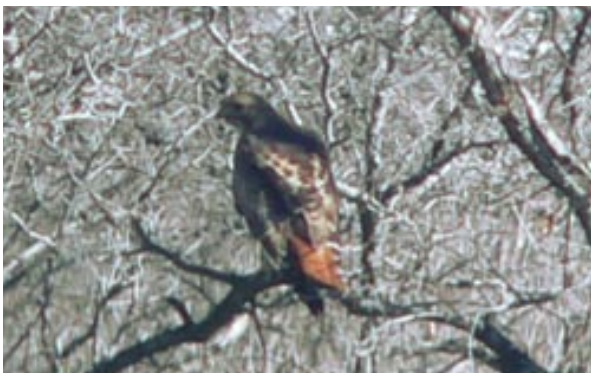

Figure 9. Snags can come in many shapes, sizes, and species. They offer nesting and roosting sites to a variety of species such as this red-tailed hawk in a blue oak. *Photo:* Gary Nakamura.

Figure 10. Over time, downed logs acquire many unique habitat attributes. They supply food for termites and ants, which in turn become food for lizards and birds. *Photo:* Gary Nakamura.

trees that offer escape from a storm or a communal roost during cold nights. When animals are displaced from their homes (cover), they become particularly vulnerable until an appropriate unoccupied place is found (fig. 8).

Cover is essential for wildlife. Natural elements suitable for providing cover include:

- **Snags.** Dead standing trees provide potential nesting, roosting, and perching sites for reptiles (mostly lizards), mammals (bats, flying squirrels, raccoons), birds (swallows, bluebirds, chickadees), and invertebrates. Snag characteristics change over the years as the snag decays. A forest should have numerous snags at various stages of decay since each stage is used by different species in different ways (fig. 9).
- **Fallen logs.** Along with other large downed wood, fallen logs provide cover for salamanders, chipmunks, and nesting or courtship sites for birds (grouse, juncos). These are also important sites for invertebrates (fig. 10).
- **Rock piles and brush piles.** The spaces among the rocks provide cover for reptiles, ground squirrels, and species such as pika and marmots in high-elevation forests. Brush piles are used by a number of bird species as well as reptiles and invertebrates.
- **Grasses and forbs.** Many birds nest in grasses and forbs, and snakes, lizards, and small rodents may use them for cover.
- **Leaf litter and small wood.** Species such as shrews and salamanders use leaf litter and small wood for protective cover and foraging cover (fig. 11).
- **Evergreen plants.** Evergreen trees and shrubs provide sheltered areas during winter storms. Even mistletoe clumps can provide cover and food during the winter for many birds, such as cedar waxwings.
- **Vernal pools.** Seasonal ponds are important for amphibian and invertebrate reproduction and support a number of unique species of plants and associated pollinators.
- **Shrubs.** Low-growing plants such as poison oak and huckleberry can provide cover for wildlife. It is important to recognize that it is the structural properties of the plant rather than the particular species that provide the protection. This becomes important when plants are slated for removal, as in the removal of exotic species for a restoration project. Simply removing the exotic plant may remove a key habitat element for a particular species. Such removal must be followed up by replanting a more desirable species to replace the lost habitat.

Space

Space requirements are more difficult to define and visualize than the more tangible requirements for food, water, and cover, but they are just as important. Space refers to the area an animal needs to secure the food, water, and

Figure 11. Salamanders and newts take advantage of the cover provided by leaf litter and small wood. *Photo:* Jo-Ann Ordano, © 2004 California Academy of Sciences.

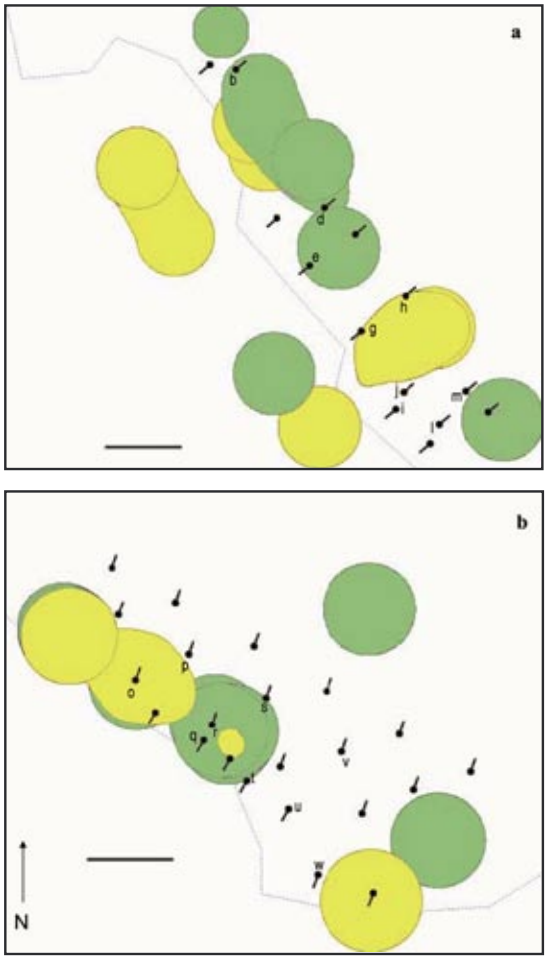

Figure 12. The "space" used regularly by animals is referred to as their home range. Home ranges for different individuals can readily overlap across many habitat elements. This is an example of individual deer mice (*Peromyscus* spp.) home ranges. A creek is denoted by a dashed line. Microphones and the direction they were facing are indicated by directional microphone symbols. *Peromyscus boylii* ranges are shown in green; *P. californicus* ranges are shown in yellow. Horizontal line is 10 meters. Source: Courtesy M.C. Kalcounis-Rueppell, J. Metheney, and M. Vonhoff, "Production of ultrasonic vocalizations by *Peromyscus* mice in the wild," Frontiers in Zoology 3:3 (February 2006), http://www.frontiersinzoology.com/content/3/1/3.

cover needed over its entire life cycle. This area is called an animal's home range. If an animal actively defends its space, that space is called a territory. The home range of any particular species is determined by the animal's mobility and its habitat needs. Commonly, unrelated species have overlapping home ranges and share space and resources, or use different elements of the habitat at different times and in different ways (fig. 12).

The size of a given wildlife species alone cannot be used to determine their space requirements. Consider the movement patterns of the California newt, a common forest amphibian. This diminutive creature spends most of its life, and most of the year, in upland areas, often in the protective niche of a pocket gopher burrow system or under a fallen log. In the winter when the rains begin, newts move from their summer residence to a water source (pond, lake, or other still body of water). There they mate and deposit their eggs, then return to their summer cover, leaving the eggs and larvae to hatch and develop on their own. For this species to successfully reproduce, it must have enough space to secure suitable cover to persist through the summer months, and it must also have free access to reproduction sites. Any disturbance that prevents this movement can have serious consequences to a local newt population.

Some species, such as deer mice and salamanders, have a small home range; they travel very little and their populations are easily influenced by the actions of a single landowner. Others, such as mountain lions, salmon, and migratory bird species, have very large home ranges that can extend far beyond individual property boundaries. When large, forested areas are subjected to habitat changes by timber harvesting, subdivision, or other uses, species with large home ranges may be adversely affected. That is why it is important for adjoining landowners to consider landscape-scale conservation goals as a way to maintain contiguous acres of suitable habitat by establishing and maintaining corridors and functionally larger habitats that go beyond a single property.

CARRYING CAPACITY

Some species have complex or multiple habitat requirements. Quail, for example, feed on grasses, forbs, seeds, and insects in forest clearings in the spring and summer; in the fall they feed on hard mast such as acorns. Other species live on the boundaries (ecotones) of two or more habitat types; for example, Wilson warblers often nest in the riparian zone between the stream and upland sites. A species may require a dense forest for reproduction or nesting but a more open forest or brush field for foraging and food. Northern spotted owls behave in this way, roosting and nesting in dense forests and foraging for rodents in adjacent young forests, brush fields, or meadows.

When an essential habitat element is scarce, it becomes a *limiting factor* for a species. To increase the abundance of a desired species, it is often necessary to determine the limiting factor and find a way to increase it. Keep in mind that manipulating the environment in favor of one species may adversely affect another.

The overall quality of the habitat determines its *carrying capacity*, a measure of the number of individuals of a particular species that the habitat can support. Thus, if an area has ample amounts of food, water, and cover it can conceivably sustain a larger population of a species than if one of the habitat elements is in short supply. No matter how suitable the habitat, however, there is a limit to how many individuals can be supported. If the population exceeds this level, there will usually be a crash in numbers due to disease, starvation, or an increase in predator populations in response to the increased supply of prey. Some populations of animals exhibit periodic cycles of increased population followed by a sharp decline when the carrying capacity is exceeded and one or more habitat elements becomes overtaxed. For example, when deer browse is limiting, many deer are underfed and weak. Mountain lions usually prey on the large number of young or weak deer, returning deer populations to the habitat carrying capacity. The carrying capacity of any given area can also be affected by the behavioral traits being exhibited by individuals defending a territory. As an example, during the nesting season, there may be a number of suitable nesting sites for a bird species, but a resident dominant male may exclude all rivals, limiting the number of individuals within his sphere of influence. The same can be said for many large carnivores such as bears, coyotes, and mountain lions.

Resource Partitioning

As many as 311 different vertebrate species use mixed-conifer forests throughout the year. To avoid intense competition, species have evolved ways to partition the environmental resources in space and time.

Some species utilize different resources throughout the year. For example, when California ground squirrels emerge from hibernation in early spring, they feed extensively on grass and forb leaves. As the season progresses and grasses begin to set seed, the squirrels slowly switch their diet to include seeds. By the time they are ready to reenter their winter sleep, their diet consists almost entirely of seeds. This change in feeding behavior allows the animals to take advantage of the most readily available and most nutritious food source by season.

Similar species often evolve traits that decrease interspecies competition and allow them to coexist. For example, throughout the forests of the Sierra Nevada, three different species of tree squirrel can be found in the same general habitat: the chickaree, the western gray squirrel, and the northern flying squirrel. These animals could conceivably be fierce competitors if not for having evolved behaviors that allow them to share the area. The most obvious partitioning is the separation of activity times between the diurnal chickaree and gray squirrel and the nocturnal flying squirrel. Simply being active at different times of day allows for less direct interaction. Additionally, the larger gray squirrel can access food from larger seed cones (sugar pines), while the smaller chickaree feeds on seeds from smaller Douglas-fir or white pine cones. A primary food source for the flying squirrel is fungi (mushrooms and truffles), not seed. Thus, because their activity patterns and food resources are partitioned, these animals can exploit different components of their shared habitats. Resource partitioning can also be seen in other similar species: chipmunks and ground squirrels, rabbits and hares, and species of birds.

FOREST TYPES AS HABITATS

There is no one-size-fits-all management prescription or condition that will serve all wildlife all the time for all forest types. Forest habitat conditions change over time as the plants and trees grow, die, and are affected by drought, insects, disease, wind, and flood. Each forest type has its own unique characteristics and can support a broad assemblage of wildlife species. Because of this, it is important to understand your forest and tailor your wildlife management plans to it. For example, in a pine forest one would expect to find animals that rely heavily on pine nuts as a food source (Clark's nutcracker, chickarees, chipmunks). Given the presence of these animals, one would expect predator species that prey on rodents and small birds (Cooper's hawk, pine marten).

To a large extent, the character of a forest and the wildlife it supports is determined by climate. In California, the forests of the Klamath Range and the Sierra-Cascades region receive most of their moisture in the form of snow during winter months. Because of the dry summers and extremely cold winters, there are relatively few amphibians in those forests.

Coastal redwood forests have winter and spring rains and summer fog that greatly influence the forest vegetation and moisture regimes. The summer fog, coupled with the presence of large logs and thick leaf litter on the forest floor, provides suitable year-round moist conditions to sustain high numbers and diversity of amphibians.

Understanding the differences between forest types can assist in the development of management regimes aimed at protecting or encouraging wildlife species. For example, the redwood forest is a long-lived, relatively stable environment that is not subject to catastrophic fires or pest and disease outbreaks; the natural disturbance regime of low-intensity, frequent fires coupled with long-lived trees does not lead to the rapid recruitment of habitat elements such as tree hollows or dead tops. Being scarce, these habitat elements deserve a higher level of consideration when managing coastal redwood forests.

The mixed-conifer forests of the Klamath Range and Sierra Nevada, with their component of white fir, are subject to pests, diseases, and drought that, in the absence of fire or timber harvest, result in the rapid and continual recruitment of snags. Therefore, compared to the assemblage of wildlife species of the coastal redwood forest, the mixed-conifer forest has a higher diversity of snag-dependent organisms such as woodpeckers, songbirds, and small mammals.

Historically, forests of pine, fir, and oak were subjected to more intensive fire regimes than coastal redwoods, resulting in a patchy forested landscape of various ages and species composition. This mosaic of stand ages and sizes over a landscape provides a broad spectrum of habitat elements that can support a relatively large number of wildlife species.

DISTURBANCE AND SUCCESSION

Disturbance is a natural and necessary part of any ecosystem. Fire, wind storms, insect and disease outbreaks, drought, landslides, and even earthquakes or floods make their mark on the forest, transforming habitat in various ways depending on severity of the disturbance.

Wildlife conservation requires that forest management actions mimic conditions that sustain wildlife species that have evolved within a particular forest type. Therefore, you should understand the natural disturbance regime of your forest.

Wildlife habitat is constantly changing, although the changes may not always be dramatic. Components of habitat grow, die, and decay and disturbances occur, changing the habitat conditions over time. Habitat changes may have a positive, negative, or

neutral effects on wildlife, depending upon the species. Remember, no one-size-fits-all management prescription or condition will serve all wildlife all the time for all forest types.

Succession is the somewhat predictable sequence or pattern of vegetation change that occurs in a forest after disturbance. A clearing in the forest is first colonized by plants that are able to germinate quickly and live under direct sunlight (generally grasses and forbs). As time passes, slower-growing species of shrubs become dominant and shade out the herbs. Eventually, trees grow up above the shrubs, shading them out in turn. These stages in succession occur throughout the forest at various scales, sometimes in a very small area (as when a tree falls), other times over a much larger area (such as after a forest fire or timber harvest). Smaller disturbances throughout a forest over time can create a mosaic of habitats at different stages of succession.

Immediately after a severe fire kills most of the trees in a stand, the forest enters the early successional stage. Surface vegetation is gone, as is the forest canopy. Animals that need these habitat elements can no longer live on the site. However, fire-killed trees become food for millions of insects, which in turn provide food for a number of insect-eating species. The standing dead trees (snags) provide perches for raptors. Decayed trees provide nest sites for cavity nesters (birds and mammals) and, as these fall, other fire-killed trees decay and provide habitat. In time early-successional stages of vegetation come to dominate the site: grasses and forbs, then shrubs and tree saplings. These provide forage and dense cover for small mammals, nesting sites for birds, and a high-quality food source for ungulates such as deer and elk. In 30 to 50 years, trees replace the early-successional plants and the forest can again provide the habitat needed by animals that use the forest interior. The number of nesting sites for cavity-nesting birds and mammals decreases as the remaining fire-killed snags decay and fall, but these become dead wood on the forest floor. The fallen wood serves as cover for small mammals, amphibians, ground-nesting birds, and a host of invertebrates. Fungi and invertebrates living in the dead wood provide food for birds and small mammals. Valuable habitat is also produced when dead trees and wood fall into streams, creating structure and cover for fish and other aquatic wildlife.

Animals have evolved to coexist with disturbance and exhibit similar patterns of response. Some animals require habitat found at a specific successional stage. For example, after a stand-replacing fire, certain species are favored while others are excluded. As the plant community (and thus the habitat) changes over time, so does the animal community, the species favored, and the carrying capacity.

OLD-GROWTH FOREST

While some species of animals, such as deer, quail, and many small songbirds, thrive in early-successional vegetation stages, others require the more complex habitats found only in older forests. Characteristics of old forests often include multiple canopy layers, many cavities, and trunk hollows and broken tops that can serve a large variety of species.

An example of a forest species that requires old forest characteristics is the marbled murrelet (fig. 13). The murrelet is a robin-sized ocean-going bird that nests on large, moss-covered trees in the coastal redwood forest while spending the bulk of the year off-shore feeding on small fish. Its suitable nesting habitat requires tree branches that are 8 inches or greater in diameter. This habitat element is usually found only on very old, large trees.

Figure 13. Marbled murrelets spend most of their time at sea, coming to land only to nest and raise young. *Photo:* Rich MacIntosh, courtesy USGS.

HUMAN DISTURBANCE

While disturbance is a natural process, humans have greatly accelerated the speed and extent of disturbance, making it harder for many natural systems to recover.

Fire

For more than 100 years, fire has been successfully suppressed in many California forests. The historical fire regime in most forests was one of frequent fires every 25 years or less, low-intensity surface fires that did not kill all the trees. Lack of fire has changed forest characteristics and habitat. Sierra Nevada forests, once dominated by widely spaced, large ponderosa pine trees, now have increasingly dense undergrowth and shade-tolerant white fir that frequent surface fires used to remove. These changes in plant composition and structure have resulted in associated changes in the animal community that uses this habitat.

Exotic Species and Invasive Species

The introduction of exotic (nonnative) species, both intentionally and accidentally, is responsible for widespread disruption of natural ecosystems. Often, the quality of the habitat changes when exotic plants become established. While this can be beneficial for some animal species, it is disastrous for others. Exotic animals can also wreak havoc, in many cases outcompeting natives. Nonnative species, both plant and animal, have evolved in a different community with its own checks and balances (e.g., competitors, disease, predators, etc.). When nonnative species successfully establish in a new environment, the animals and plants living there may have no defenses against them. Most problematic are exotic species that become invasive. They are aggressive in becoming established, spread quickly, and are highly competitive with native species. Only a handful of exotic species are invasive, and these are the most important to control.

Fragmentation

Land uses have tended to break up large tracts of forest into smaller acerage ownerships that are often managed differently, creating different forest habitats. This can be a problem, especially for wildlife species that require continuous, undisturbed home ranges of relatively uniform habitat. Large highways or other impassable areas can disrupt vital migration or mating paths. Depending on the species, some fragmentation effects can be mitigated. Travel corridors from one intact tract of forestland to another allow some mobile animals to use larger areas.

Conversion

Generally, when habitats are transformed, the wildlife living there will not persist. This can be seen in many places in California where forests are increasingly converted to uses such as vineyards and urban areas. These practices also contribute to habitat fragmentation, the potential introduction of exotic pests, and increased challenges related to fire and fuels management.

Pesticide Use

A number of pesticides are used in forest management, including herbicides (for plants), insecticides (insects), fungicides (fungal diseases), and rodenticides (rodents). All of these chemicals are toxic to wildlife to some extent. Some are very specific, affecting only the target species, while others are more general poisons. All pesticides should be used judiciously and only when necessary. Questions regarding the application of pesticides should be addressed to either the local county agricultural commissioner's office or the county office of the University of California Cooperative Extension.

Figure 14. Development can dramatically alter the habitat elements found in a forest. Roads break up wildlife corridors, and vehicles are a threat to crossing wildlife. Houses and people bring pets that may prey upon wildlife or be preyed upon; deer eat flowers and garden vegetables; ground squirrels and gophers tunnel in lawns. The red trees shown here are dead ponderosa pines due to drought-induced bark beetle infestation. *Source:* CAL FIRE.

Timber Harvest

Logging is another human disturbance in the forest. Depending on the logging practice, it can be a small or large disturbance. Single-tree selection creates small openings in the forest and minimizes the change to existing vegetation structure and composition. Clear-cutting creates relatively large openings and greatly alters the structure and species composition of the forest. This dramatic change in forest structure and composition can cause a change in wildlife species from those that inhabit a mature forest to those adapted to an earlier successional stage. Timber harvest can be planned to minimize disturbance to wildlife by retaining important habitat elements, protecting wetlands and associated riparian vegetation, leaving corridors of habitat to allow animals to move from one forested tract to another, timing harvest to avoid sensitive wildlife periods, replanting harvested areas, and other measures. Many of these considerations are incorporated into the approval of timber harvest plans by the state.

LIVING IN THE FOREST

People who live in the forest have a unique opportunity to interact with the animals and plants living there. This carries with it some special challenges and the responsibility to minimize their impact on the forest ecosystem.

Homes

Some of the attributes of civilization can be detrimental to the forest environment (fig. 14). People living in the forest increase the potential for forest fire; roads can impact tree roots, streams, and water quality, and can fragment habitats; landscaping can increase the risk of exotic plants becoming released and established; and pets can kill forest wildlife. It is essential to understand our roles in and impacts on a forest.

Roads

Poorly designed and maintained roads impair the quality of streams and waterways, which can have severe impacts on wildlife. Road problems must be evaluated, and roads must be well maintained. Some road rights-of-way provide light to the forest floor, allowing grass and shrubs to grow, which attract deer that pose a danger to traffic. Roads also create canopy openings, providing light and bare soil for exotic or invasive plants to become established. In addition, roads can be impassable barriers to small animals and dangerous places for all animals. To the extent possible, identify sensitive areas (migration routes, foraging areas, travel corridors) on your property. Wildlife crossing signs can help alert drivers to these areas. Drive cautiously, especially at night. Limiting access should be considered as part of your wildlife management approach.

Unwanted Animals

Even people who value wildlife may look upon some species as undesirable neighbors, especially if they feed on gardens or your pets, carry diseases, or bite. Identify what is attracting the unwanted animal and determine if the problem can be alleviated. Remove any food sources or other attractants (compost piles, chicken coops, pet food left outdoors). Many repellents are available for protecting plants, but they require frequent applications to be effective. Fencing is an good way to exclude animals from small areas. Trapping and relocating persistent pests may sometimes solve the problem, but mobile animals may return. In many cases, it is illegal to trap animals and relocate them

to another location, since you are simply relocating your problem to someone else. Some animals bite. Insect repellent containing DEET (20 percent) is effective for mosquitoes and small biting flies. Avoid bees and wasps and their nests, which are often in the ground, among rocks, or in snags and downed logs. At certain times of the year, snakes or ticks may be a problem. Be aware of the habitats and seasons in which these animals are found, wear appropriate clothing, and be familiar with first-aid recommendations in case of a problem.

Gardens

Wild animals do not respect ownership and property boundaries, nor do they recognize the difference between cultivated gardens or tree seedlings and natural forest habitat. The best way to protect your private garden is to fence it in. Seedlings can be protected with special plastic netting or tubes. Animal repellents are available, but these have limitations and may not provide the protection desired.

Pets and Feral Animals

Domesticated animals are not a natural part of the forest community and can cause a great deal of damage or be damaged themselves in the forest. Cats and dogs are hunters that will kill and injure small mammals and birds. Young wildlife is especially at risk. By the same token, your pets are at risk of injury by mountain lions, coyotes, raccoons, skunks, and porcupines. Domesticated animals may also carry diseases that can be transferred to the wild population. Pets should be vaccinated for diseases they can catch from or pass on to wildlife, such as rabies and distemper. Pets should never be allowed to roam free. Never abandon unwanted animals in the forest (fig. 15).

Feeding Animals

It is essential to the health and well-being of wild animals that they not be fed by humans. Reasons for this include the following.

- Human food does not contain the nutrients or moisture that wild animals need.
- Animals may die after consuming food packaging.
- Animals become habituated to human-provided food and alter their foraging behavior.
- Birds that are fed cluster unnaturally and are vulnerable to density-dependent diseases.
- As populations of raccoons, skunks, and other animals grow unnaturally large and dense from being fed, the potential for rabies, distemper, and other diseases increases.
- Populations of some species can become unnaturally large, putting undue predation pressure on other species (e.g., raccoons, skunks, and jays can reduce or eliminate local songbird and amphibian populations).
- Large predators who become habituated to human food may become a threat to humans, such as black bears accustomed to eating from trash cans.

Figure 15. Abandoned animals, particularly house cats, can become fierce predators in a forest setting. *Photo:* Gary Nakamura.

WILDLIFE MANAGEMENT PLANNING

Since habitat alterations can attract one species and exclude another, you should recognize that your management decisions will impact forest wildlife. Your management goals should aim to maintain as many of the naturally occurring species for your forest type as feasible. To achieve this, it will be important to retain and enhance as many of the forest habitat elements as possible. For example, if your property

Figure 16. Trunk hollows, commonly called goose pens, are the result of a succession of fires that scar the trunk. They provide important roosting and resting sites for many species of wildlife. *Photo:* Gary Nakamura.

lacks large snags, you should identify dead and dying trees (of different species) that can be left indefinitely to fulfill their ecological roles for roosting, nesting, and foraging. Similar decisions can be made for selecting and maintaining good acorn-producing trees, trees with obvious nesting cavities, fallen logs, and trees with broken tops.

Obviously, the location of your property, its size, shape, and the animals native to the area will determine what you can do. Be realistic. If your goal is species richness you will need a diversity of habitat types and elements. Some desirable attributes are a function of parcel size. If you have a small property, it may be best to focus on adding appropriate elements to attract and hold species; examples of these elements include brush piles and leaving mistletoe growth in trees away from structures to provide winter berries. You may choose to work with neighbors to develop a multiple-owner approach to wildlife habitat enhancement at the community and landscape level.

Rare and Essential Elements

Every forest type in California includes a rich mix of wildlife species that require specific habitat elements in order to survive. If a particular forest type does not lend itself to ready recruitment of certain habitat elements, care must be taken to inventory and retain those already present. For example, "goose pens" (burned-out hollows) in old-growth coastal redwood forests are an important habitat for bat roosting (fig. 16). However, forestry practices that include even-aged, short-term rotations are not conducive to recruiting this relatively scarce habitat element, and it may be extremely difficult to mimic the recurring, low-intensity fires that created them originally. In this case, if snags or partial snags (goose pens) are present, attention should be given to keeping them. The prudent management strategy would be to retain all goose pen trees.

In the Sierra Nevada, where white fir is very common and offers ready snag recruitment, you might want to survey your property to identify other "hard" snags that may be rare or absent. White fir snags are readily available but they don't last as long as "hard" snags created by ponderosa pine. Identifying and leaving a representative sample of this missing habitat element could enhance the diversity of wildlife on your property.

Water sources are essential to most animals and should always be protected. Not only is the water body itself important, but the associated riparian vegetation and corridors are critical for a number of forest animals.

Figure 17. Management decisions can have long- and short-term impacts, both positive and negative. A: Salvage harvesting and planting after the Fountain Fire, 1992. B: The Fountain Fire ten years after replanting, 2002. C: The Show Plantation at 85 years of age, 2005. *Photos:* Gary Nakamura.

A Balancing Act

Proper forest management is always a balancing act. In some cases it requires weighing short-term financial gain against long-term ecological values, or short-term ecological impact against long-term ecological benefit. All management decisions affect habitat and, thus, the wildlife of the forest (fig. 17).

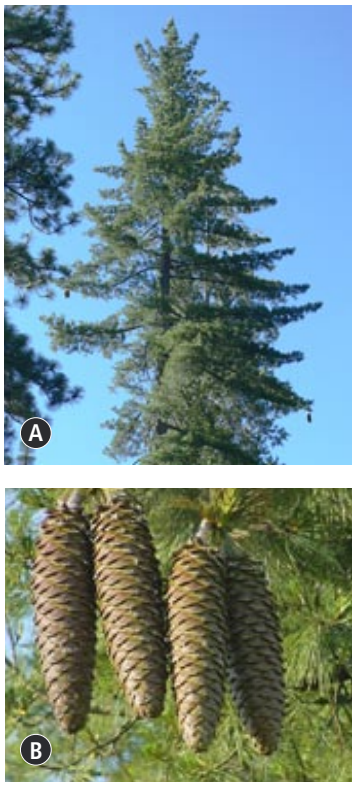

Figure 18. A: Sugar pines (center tree) are a prominent component of a Sierra mixed conifer forest and provide an important food source for many seed-eating species *Photo:* Gary Nakamura. B: Cones, which can grow to 18 inches long as shown here, hang from the tips of the branches. *Photo:* Richard Sniezko, courtesy US Forest Service.

What is important is that forest landowners and managers take the needs of wildlife into consideration when making management decisions. By understanding the habitat requirements of various species, it is possible to find creative ways to achieve your goals while doing the best for the wildlife.

Get to Know Your Forest

Before undertaking a wildlife project, spend some time considering your goals and your property's potential. You may want to consult a qualified wildlife biologist who can help answer some of these questions.

- Decide on your goals: Do you want to encourage particular species or increase all species (the overall diversity of wildlife in your forest)?
- Consult a species list to determine which species may be found on your property.
- What species are commonly found in your area or were found there historically?
- What are the habitat requirements of the species you're interested in?
- What habitat elements are easily recognizable on your property? What is their relative abundance and distribution on your property?
- What habitat elements are obviously missing, scarce, or rare? These may include snags, logs, stumps and mast-producing trees and shrubs.
- What management techniques can you employ to enhance or restore the habitat?
- Are there any sensitive species? If so, you may want to provide habitat to help recover or even prevent the species from being lost on your site.
- What are the limiting factors in your forest? What techniques are available to address those limitations? What times of year are best to do the work?

California Forest Habitat Types

A mandatory first step in wildlife management planning is to identify the forest type you are working with. The most common forest types in California are described below in terms of their predominant trees. Also important and associated with most of these forest types are shrub species of *Ceanothus*, manzanita *(Arctostaphylos)*, cherry *(Prunus)*, and tanoak *(Lithocarpus)*.

Sierra mixed conifer

Five conifers and one hardwood typify the Sierra mixed conifer forest: white fir, Douglas-fir, ponderosa pine, sugar pine, incense cedar, and California black oak (fig. 18). This mixed conifer forest types supports some 355 species of wildlife species.

Figure 19. Mature white fir stand composed almost exclusively of white fir. *Photo:* Gary Nakamura.

White fir

Mature white fir stands tend to be monotypic, more than 80 percent pure white fir (fig. 19). They are found at the higher elevations of the mixed conifer forest throughout California from the Klamath Mountains to the south Coast Range and Transverse Range. White fir habitats represent the coolest, moistest nonriparian habitat with a high percentage of defective trees. It is preferred habitat for many insect-gleaning birds, including warblers and tanagers.

Figure 20. A: The mix of plants found in Klamath mixed conifer forests. *Photo:* Gary Nakamura. B: Snowshoe hare. *Photo:* Robert Potts, © 2002, California Academy of Sciences. C: Siskiyou Mountain salamander. *Photo:* © Stuart Farber, Timber Products Company.

Klamath mixed conifer

Found in interior northwestern California and very similar to the Sierra mixed conifer forest, the overstory layer of Klamath mixed conifer is characterized by a mixture of white fir, Douglas-fir, ponderosa pine, sugar pine, and incense cedar. Other species include Shasta red fir, lodgepole pine, mountain hemlock, western white pine, knobcone pine, Jeffrey pine, and Brewer spruce. The mix of plants in combination with the complex geology of the region has created a rich habitat that includes many rare, threatened, and endangered plant and animal species (fig. 20).

Douglas-fir

Found in northwestern California east of the Coast redwood forests, the Douglas-fir forest's overstory composition depends on the soil parent materials (fig. 21). Associates can include ponderosa pine, canyon live oak, tanoak, and Pacific yew. This forest type supports a high abundance of wildlife species. It has been reported to support more bird species that any other type of conifer forest habitat in North America.

Ponderosa pine

In Northern California, ponderosa pine stands occur in a narrow elevational band above oak woodland habitats and below mixed conifer habitats (fig. 22). Montane hardwood stands may be interspersed with ponderosa pines. In Southern California, ponderosa pines can occur in mixed chaparral, oak woodlands, and bigcone Douglas fir and mixed hardwood-conifer sites. Ponderosa pine forests can often be migratory pathways for deer and are generally considered extremely important for deer feeding and holding areas.

Eastside pine

Found in northeastern California, in the rain shadow and east of the crest of the Cascades and northern Sierra Nevada, eastside pine habitats exist on coarse, well-drained volcanic soils in dry, cold settings. The dominant species are Jeffrey pine and ponderosa pine with associates including lodgepole pine, white fir, incense cedar, and Douglas-fir. Pine types typically have good structural diversity supporting a large number of species (fig. 23).

Figure 21. Douglas-fir forest type. *Photo:* Gary Nakamura.

Lodgepole pine

Found at the higher elevations of the Cascade Range and Sierra Nevada, above the mixed conifer habitat, lodgepole pine forms open stands of even-aged, similarly sized trees in association with few other species with a sparse understory (fig. 24). Lodgepole pine stands tend to have low structural diversity and support relatively few animal species.

Figure 22. Ponderosa pine stand in Northern California. *Photo:* Gary Nakamura.

Figure 23. A: Eastside pine forests are dominated by Jeffrey pine and ponderosa pine. *Photo:* Gary Nakamura. B: The diversity of plants and soils support a broad array of wildlife species such as this anglewing butterfly. *Photo:* Charles Webber, © 2002 California Academy of Sciences.

Figure 24. Lodgepole pine is commonly found at the higher elevations of the Cascade and Sierra Nevada mountains. It tolerates cold temperatures and high water tables better than other conifers. This stand at the edge of a meadow will probably encroach on the meadow over time. *Photo:* Gary Nakamura.

Coast redwood

Coastal redwood forests are found along the north and central coast, within the fog belt, and inland along major river drainages. Most privately owned coast redwood is second- or third-growth forest habitat characterized by even-aged structure with dense crown closure. Associates include Douglas-fir, western hemlock, grand fir, Sitka spruce, tanoak, and red alder. Redwood habitats provide food, cover, or special elements for 193 wildlife species (fig. 25).

Blue oak–foothill pine

Found in a ring around the Central Valley, above the valley grassland and agriculture and below the ponderosa pine belt, this forest type is typically diverse in structure both vertically and horizontally, with a mix of hardwoods, conifers, and understory shrubs. It may be dominated entirely by blue oak, especially on soils of marginal quality. Blue oak–foothill pine forests provide breeding habitats for a large variety of wildlife species. Many migratory fish spawn in areas dominated by oaks (fig. 26).

Montane hardwood conifer

Found on the harsher, drier, rockier sites within the coast range, Klamath, Cascade, and Sierra Nevada mountain forests, this forest type contains variable proportions of broadleaved trees and conifers. Common associates include California black oak, Oregon white oak, white fir, Douglas-fir, and ponderosa pine. This widely distributed forest type with its hard and soft mast food sources provides habitat for many wildlife species (fig. 27).

What Is the Age of Your Forest?

You can directly estimate the age of your forest by counting the rings on stumps or by boring live trees. Note that tree diameter does not always correlate well with tree age (fig. 28). You may also infer the age by asking the following questions.

- When did the last major disturbance occur? Disturbance may be natural, such as fire or human-caused, such as logging. Disturbances at different times create stands of different ages.
- Do some parts of your forest have different structural or compositional characteristics? If so, what are they? Different structures, especially the presence of multiple canopies, are a good indication of age and time since the last disturbance.

The age class distribution of forest stands on your property is a good surrogate for wildlife habitat values. Younger stands of shrubs, grasses, forbs and small trees support some species, while older ones dominated by the trees with little understory vegetation support others. Having a diversity of age classes generally means that a property has relatively high habitat values for many species.

Figure 25. A: The coast redwood forest supports a number of insectivorous species. *Photo:* Gary Nakamura B: The broad-footed mole commonly inhabits coastal redwood forests. *Photo:* Jerry P. Clark.

Figure 26. A: Blue oak–foothill pine forests provide breeding habitats for a large variety of wildlife species, including migratory fish such as the steelhead trout. *Photo:* Gary Nakamura. B: Adult steelhead trout in Parson's Creek. *Photo:* © Robert J. Keiffer.

Figure 27. A: The widely distributed montane hardwood forest type provides both hard and soft mast food sources as well as habitat for many wildlife species. *Photo:* Gary Nakamura. B: The black-headed grosbeak, common in montane hardwoods. *Photo:* Glenn and Martha Vargas, © California Academy of Sciences.

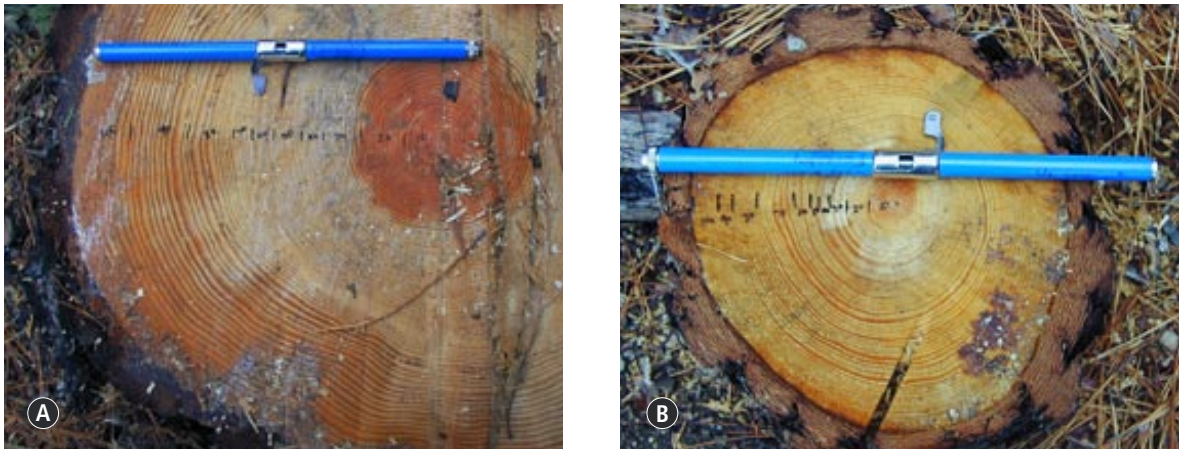

Figure 28. The size of a tree is not a good indicator of tree age because the growing conditions (light, water, nutrients) control growth. A: Ponderosa pine, 100 years old. The blue increment borer is 12 inches long (shown for scale). *Photo:* Gary Nakamura. B: This ponderosa pine, also 100 years old, was growing within 30 feet of the tree in figure A. The same blue increment borer is shown for scale. Though the same age, the tree in A is four times the diameter of the tree in B. *Photo:* Gary Nakamura.

What Important Habitat Elements Are Present or Absent?

Identify and locate unique habitat elements that are present or absent on the property:

- snags (dead or partially dead standing trees)
- fallen logs
- rock piles
- stream corridors
- cliffs
- caves
- acorn-producing trees
- berry-producing trees or shrubs
- slash piles
- ponds
- wetlands
- nesting platforms

What Management Actions Will Improve Habitat Values?

Identify specific management actions that can promote habitat element retention or recruitment, such as

- snag and downed log retention or recruitment through conservative salvage harvesting or removal of dead and dying trees
- buffer zones to protect sensitive habitats (stream corridors, wetlands, water sources, rock piles)
- retention of trees with peculiar shapes or attributes (goose pens, nesting platforms, broken tops)
- silvicultural techniques that mimic natural disturbance patterns

Write It Down

It is a good idea to incorporate your wildlife management objectives in your written forest plan to help guide your activities over time. This also allows you to more easily share your ideas with wildlife professionals or funding agencies. Professional advice can save you time, energy, and money.

Adaptive Management

Before you begin your wildlife management activities, create a system to monitor the results. That way you can determine whether your plans are working as expected and obtain information you may need to change or adapt your techniques. Monitoring gives you valuable data about your forest and helps you become more familiar with the wildlife there.

EASY WAYS TO ENHANCE WILDLIFE HABITAT

It is a good idea to consult with a qualified biologist before implementing wildlife habitat enhancements. Many forestry consulting firms regularly employ qualified biologists to aid in making these determinations

- Plant native oaks or other mast-producing trees or shrubs. These benefit numerous animals—over 300 wildlife species use oaks either directly or indirectly.
- Leave snags in place or create new ones. Snags in various stages of decay are necessary habitat for a great number of species in the forest.
- Thin or control-burn patches of the forest to create browse plants for deer or other herbivores.
- Leave downed wood, such as logs, to decay in place on the forest floor.
- Leave or augment large woody debris in streams.
- Plant native grasses and forbs.
- Remove exotic and particularly invasive pest plants. (http://www.cal-ipc.org, California Invasive Plant Council)
- Add artificial shelters, such as nesting boxes for birds or bat boxes, especially when snags or other appropriate cover are limiting. Artificial shelters should be considered a supplement rather than a substitute for habitat restoration.
- Plant native wildflowers to attract butterflies and other insects. (See the *Sunset Western Garden Book* for lists of plants.)
- Use pesticides and herbicides only when absolutely necessary; they may harm nontarget species. Use the least toxic, most specific method of control.
- Create brush or rock piles when this type of cover is limiting.
- Provide water through guzzlers or other structures.
- Leave riparian vegetation and corridors to ensure adequate cover for animals using water sources.
- Increase the variety of vegetation types. This not only increases the diversity of food and cover available, it also introduces redundancy into the forest ecosystem. Thus, if one species of plant does poorly, wildlife may be able to use another.

RESOURCES

Fortunately, there is widespread recognition of the value of wildlife in the forest. Cost-share programs are available to help private landowners fund activities to restore and enhance wildlife habitat. In many cases this funding is available for larger areas—streams, watersheds, or communities—which encourages working together with your neighbors.

The California Forest Stewardship Helpline at 1-800-738-TREE (see http://www.ceres.ca.gov/foreststeward/) can help you identify programs, agencies, and private consultants that can help you meet your wildlife management goals.

Other sources of information include

- California Department of Forestry and Fire Protection (CAL FIRE), http://www.fire.ca.gov/
- California Department of Fish and Game (DFG), http://www.dfg.ca.gov/
- Resource conservation districts (RCDs), http://www.nacdnet.org/resources/CA.htm
- California Native Plant Society, http://www.cnps.org/
- National Audubon Society, http://www.audubon.org/
- Land trusts (see, for example, http://www.lta.org/findlandtrust/CA.htm) and other conservation organizations (see, for example, http://forest.org/)

Always contact local offices or chapters of these agencies and organizations, as they will be the most informed about your area.

The *Cost Share and Assistance Programs for Individual California Landowners and Indian Tribes* contains information on numerous cost-share programs. The complete booklet can be found online at http://ceres.ca.gov/foreststeward/pdf/costshare00.pdf, or contact the California Forest Stewardship Helpline at 1-800-738-TREE.

Potential Funding Sources

- California Forest Improvement Program (CFIP), administered by CDF, http://www.ceres.ca.gov/foreststeward/html/CFIP.html
- Environmental Quality Incentives Program (EQIP), administered by the NRCS, http://www.nrcs.usda.gov/PROGRAMS/EQIP/
- CalFED Bay-Delta Program (administered by the California Bay-Delta Authority), http://calwater.ca.gov/
- California Department of Fish and Game programs, http://www.dfg.ca.gov/
- U.S. Fish and Wildlife Service programs, http://www.fws.gov/

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