PUBLICATION 8323

Forest Stewardship Series

The Forest Stewardship Series has been developed to provide owners of California forestland with a comprehensive source of information pertinent to the management and enjoyment of their lands. The information provided will help you formulate and implement strategies for achieving your personal goals as a landowner. The series provides an introduction to the lifelong study of forest stewardship that is part of owning forest property.

UNIVERSITY OF CALIFORNIA
Division of Agriculture and Natural Resources
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PUBLICATION 8231

FOREST STEWARDSHIP SERIES 1

Introduction and Glossary

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The Forest Stewardship Series has been developed to provide owners of California forestland with a comprehensive source of information pertinent to the management and enjoyment of their lands. The authors hope that the information provided will help you formulate and implement strategies for achieving your personal goals as a landowner.

Your property is unique, and your vision or expectations for it are equally unique and personal. This series covers many topics. You may already be knowledgeable about some of them; you are encouraged to consult whatever leaflets you find useful. The series is not organized like a textbook. Some of the topics naturally relate to each other and should be read together, whereas others are virtually independent. Together, the series provides an introduction to the lifelong study of forest stewardship that is part of owning forest property.

The publications in the series do not tell you what to do but instead help you learn more about your forest and your many management options, and give you some of the tools necessary to define and achieve your goals. Reading the publications may lead you to conclude that you need to know more about a particular topic. The University of California Cooperative Extension (UCCE) offers workshops and courses that can further your education and planning for your property. You can find out about these courses by consulting the UC Berkeley Forestry Center Web site at http://forestry.berkeley.edu.

This first publication in the series introduces the series and also contains a glossary of terms used in forest stewardship.

WHAT IS FOREST STEWARDSHIP?

Forest stewardship is a general approach to management. Definitions abound, ranging from simple to complex, but the thrust of all definitions is that forest stewardship entails an approach to management that meets the needs of the current owners but does not detract or degrade the use by future generations. Furthermore, forest stewardship is based on conservation principles that ensure protection of all forest resources including wildlife, timber, soil, water, recreational opportunities, and natural beauty. Forest stewards actively manage their land on a long-term basis by following management objectives that are multiple-resource based, economically viable, conservative of natural resources and socially, environmentally and ecologically responsible.

The Forest Stewardship Series provides many of the intellectual and scientific premises underlying the forest stewardship management approach. The other equally important element is personal commitment to carry out management activities that are based on stewardship objectives and principles.

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PUBLICATIONS IN THE SERIES

Stewardship management requires broad knowledge that crosses a variety of disciplines. The Forest Stewardship Series currently includes the publications listed below. In the future, more publications may be added or existing publications may be revised.

- A Forest Stewardship Framework (Publication 8232)
- Forest Ecology (Publication 8233)
- Forest History (Publication 8234)
- Tree Growth and Competition (Publication 8235)
- Forest Vegetation Management (Publication 8236)
- Forest Regeneration (Publication 8237)
- Forest Wildlife (Publication 8238)
- Forest Streams (Publication 8239)
- Riparian Vegetation (Publication 8240)
- Forest Water Quality (Publication 8241)
- Fish and Fish Habitat (Publication 8242)
- Threatened and Endangered Plants (Publication 8243)
- Exotic Pest Plants (Publication 8244)
- Wildfire and Fuel Management (Publication 8245)
- Forest Pests and Diseases (Publication 8246)
- Forest Roads (Publication 8247)
- Stewardship Objectives and Planning (Publication 8248)
- Laws and Regulations Affecting Forests, Part I: Timber Harvesting (Publication 8249)
- Laws and Regulations Affecting Forests, Part II: Activities Other Than Timber Harvesting (Publication 8250)
- Economic Considerations in Forest Stewardship (Publication 8251)
- Forest Taxation, Estate Planning, and Conservation Easements (Publication 8252)
- Technical and Financial Assistance (Publication 8253)
- Professional Assistance (Publication 8254)

Each publication provides a general introduction to the topic and suggests ways in which you may learn more about your property. The underlying premise is that as a forest landowner you should be informed enough to know the implications of your management actions. For example, you should know enough about forest ecology and wildlife to be able to weigh the benefits and impacts of practices such as timber harvesting. In many cases, you may be the one carrying out the management actions on your property. But in situations where others are doing work on your behalf, you should be able to communicate your objectives and avoid unpleasant surprises.

The best outcome of all would be that if reading these publications stimulates you to develop a forest stewardship plan for your property. The tools for developing a plan are provided here. With a plan, you are not only able to communicate with others but also have a benchmark to assess your progress.

We welcome you to the Forest Stewardship Series and hope you enjoy using it.

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GLOSSARY

Abney level. An instrument used to determine slopes, elevations, and heights. Replaced by **clinometers**.

anadromous. Fish such as salmon, steelhead, and shad that spend part of their life cycle in fresh water and part of it in the ocean. As adults they migrate from salt water to fresh water to spawn. The young are partly raised in fresh water and then migrate to the ocean until they reach sexual maturity.

aspect. The direction a landscape slope faces, expressed as a cardinal direction or compass direction.

bankful discharge. The maximum volume of water that a stream channel can carry before it overtops its banks. It is further defined as the flow that occurs on average once every 1.2 years.

beneficial uses. Legally defined as the priority uses of water for humans and nonhumans, including drinking water, irrigation water, hydropower generation, recreation, fisheries, and aquatic habitat.

best management practice (BMP). In water-related usage, a practice or combination of practices that is determined by a state government agency to be the most effective, practicable means of preventing or reducing the amount of pollution generated by point and nonpoint sources (such as forests and farms) to a level compatible with water quality goals.

biodiversity. The variety of organisms in a community, their ecological roles, and their genetic variation.

biological control. The application of a natural control agent to regulate pest species, such as using *Bacillus thuringensis* (Bt) to control foliage-eating caterpillars.

biomass. The living or dead weight of organic matter in a tree, stand, or forest; also, the wood product from in-woods chipping of whole unmerchantable trees, limbs, tops, and slash for energy production in a wood-burning electric power plant.

BLM. See **Bureau of Land Management.**

BMP. See **best management practice.**

BOF. California State Board of Forestry and Fire Protection, which develops rules and regulations for management on private forest lands.

bole. The main stem or trunk of a tree. Seedlings and saplings have stems, not boles.

browse. Woody vegetation, buds, stems, and leaves consumed by livestock or wildlife, mainly ungulates.

buffer strip. Zones adjacent to a watercourse that are managed to preserve water quality and protect aquatic habitat.

Bureau of Land Management (BLM). An agency of the U.S. Department of the Interior that manages 15 million acres in California for multiple uses, today primarily recreation and watershed or environmental protection but formerly for cattle grazing; also manages some forested land in Northern California. Formerly known as the Grazing Service and the General Land Office, which was responsible for disbursing public lands under the Homestead Act.

CAL FIRE. See **California Department of Forestry and Fire Protection.**

California Department of Fish and Game (CDFG). Agency that reviews timber harvest plans and provides recommendations for the protection of wildlife and threatened and endangered species.

California Department of Forestry and Fire Protection (CAL FIRE). The primary agency responsible for review and approval of timber harvest plans; formerly known as the CDF.

California Environmental Quality Act (CEQA). The California equivalent of the federal National Environmental Policy Act.

California Geological Survey (CGS). Formerly the Division of Mines and Geology (Department of Conservation). Agency that participates in review of timber harvest plans in regard to landslides, debris flows, and other geological hazards.

cambium. Layer of stem cell tissue between the inner bark (phloem) and the wood (xylem) that generates new cells annually for the inner bark and wood.

canopy cover. The outer limits of a tree or shrub's crown projected on the ground (or water) surface. Usually expressed as a percentage, such as 50 percent cover.

carrying capacity. The maximum number or biomass of a species that can be sustained or survive on a long-term basis within an ecosystem.

cat. A Caterpillar tractor, which runs on steel treads and is used to move soil for road construction and maintenance, logs to a landing, vegetation for site preparation and planting, or fuels and vegetation for fire suppression.

cat ex. See **categorical exclusion**.

categorical exclusion (cat ex). An exemption for federal agencies from requirements to prepare an environmental impact statement or an environmental assessment for categories of action that have been determined not to involve significant environmental impacts. A conformance determination record exempts federal agencies from having to prepare an EIS or EA for actions that have already been covered in existing EISs or EAs. See **National Environmental Policy Act of 1969.**

CDFG. See **California Department of Fish and Game.**

CEQA. See **California Environmental Quality Act.**

CESA. California Endangered Species Act.

CFPR. California Forest Practice Rules.

CGS. See **California Geological Survey.**

channel classification. Categorization of stream channels or parts of a stream into discrete types based on physical or biological criteria including channel slope, geometry, confinement, flow, aquatic habitat, or location within a watershed.

channel complexity. Characteristics of a stream channel determined by the relative proportions of different habitat units (pools, riffles) and structural elements (large woody debris, boulders) and their arrangement in the stream.

channel substrate. Rock and soil materials that comprise a streambed.

chaparral. A plant community characterized by fire-adapted shrubs and other plants.

chipper. A machine for chipping logs, tree tops, and slash into chips, consisting of a conveyor belt, debarker (to produce clean chips for paper or other products), and chipping blades, with the chips being blown into a chip truck for transport, onto a pile, or onto the ground as a mulch.

choker. A short length of wire cable or chain that forms a noose around the end of a log to be moved to a landing for processing and loading.

choker setter. A person whose job is to wrap a choker around the end of the log so that the yarder or skidder can drag the log to the landing.

CHRIS. California Historical Resources Information System.

Class 1 stream. Year-round stream in which fish are always or seasonally present. It may also be a stream that provides a source of domestic water supply.

Class 2 stream. Stream within 1,000 feet upstream from a Class 1 stream; contains aquatic habitat for nonfish species such as amphibians. May be a seasonal stream.

Class 3 stream. No aquatic life present. Capable of sediment transport to a Class 1 or 2 under normal water flow conditions. Usually flows only in response to storms.

Class 4 stream. Man-made watercourse, ditch, or diversion.

clear. Wood or lumber that does not have (is clear of) knots. Clear wood is produced in the tree stem where branches have been shed or pruned. All the wood grown radially after the branch has been lost will be clear.

clear cut. Harvest in which all or most of the merchantable-size trees have been removed in one operation.

clinometer. An instrument that measures vertical angles of elevation or depression from level, used to determine landscape slopes, elevations, and tree heights.

CNDDB. California Natural Diversity Database.

codominant. Trees with crowns at the level of the highest forest canopy. Codominant trees receive full light from above but little light from the sides.

commercial forestland. Land deemed suitable for and capable of producing timber crops, capable of growing 20 cubic feet wood per acre per year.

community. In ecology, all of the populations of organisms living in an ecosystem.

compaction. An increase in soil density and decrease in porosity resulting from applied loads, vibrations, or pressure, usually due to equipment traffic, operations, or log skidding.

conk. The visible fruiting body, or mushroom, of a wood-decaying fungi on a tree trunk, branch or stump; shelf fungus.

conservation. Gifford Pinchot, a forester at the turn of the twentieth century closely associated with President Teddy Roosevelt, applied the word to describe a natural resource philosophy. It meant "wise use." Through the years it has taken on an extended meaning of "wise use over a period of time."

consumers. In ecology, the animals that depend on plants or other animals as their source of food.

coppice. Forest stand produced by sprouts from stumps or roots of trees previously cut. Many hardwood species sprout and readily coppice when young. Few conifers will sprout from the stump, with coast redwood being a notable exception.

cost-share. Usually, a government grant program to share the cost with forest landowners of maintaining or producing some public benefit such as improving water quality, wildlife habitat, forest productivity, or reforestation following wildfire or insect mortality.

cover. The area occupied by vegetation or foliage; vegetation that protects the soil and provides shade to the ground or stream. Usually expressed as a percentage.

crown. The live branches and foliage of a tree or shrub.

crown class. A category of tree based on its crown position relative to those of adjacent and competing trees. See **dominant**, **codominant**, **intermediate**, and **suppressed.**

crown fire. A fire that spreads through the crowns of trees or shrubs independently of a surface fire. Crown fires cannot be effectively or safely fought until the fire drops to the ground.

cull. Any log or portion of log rejected by a mill because it does not meet specifications or standards. Often refers to logs that are rejected because of defects such as rot or breakage. Generally used in forestry for seedlings, trees, foresters, or equipment not up to standard.

culvert. A metal or plastic pipe set beneath the road surface to drain water from the inside ditch to the outside of the road. Culverts drain ditches, springs, and streams across the road alignment.

cut bank. The rock–soil face or slope created along the inside of a road constructed on steep mountainsides.

cut to length. Harvest method in which trees are delimbed and cut to log lengths at the stump before they are yarded to the landing; an alternative to whole-tree yarding.

DBH. See **diameter at breast height.**

debris jams. Collections of logs and other debris in streams and watercourses. Once thought to block fish passage, most debris jams are important in creating stream structure and hiding cover for fish and do not block fish passage.

deck. A stack of logs at the mill or on a landing; usually sorted by species and size.

decomposers. In ecology, organisms that break down organic material into chemical elements and compounds.

defensible fuel profile zone (DFPZ). Shaded fuelbreak from a few hundred feet to a ¼ mile wide, where the canopy and cover of the larger trees has been retained but the ladder and ground fuels have been removed or treated; defensible in the sense that firefighters can safely take a stand in the DFPZ to fight an oncoming fire.

DFPZ. See **defensible fuel profile zone.**

diameter at breast height (DBH). Diameter of a tree measured 4½ feet above the ground; the standard measure of tree diameter.

dib. Diameter inside bark, the diameter of the woody portion of a tree stem.

diurnal. Daily, or functional or active during the day.

diversion. The withdrawal of water from a natural stream or spring, often into a canal or pipe.

diversion potential. A stream crossing on a road has diversion potential if, when the culvert plugs, the stream would back up and flow down the road rather than directly over the road and back into the natural drainage channel.

dominant trees. Trees with crowns that extend above the general level of the forest canopy. Dominant trees receive full light from above and partial light from the sides.

drainage structure. A device installed to control or divert water from a road, including but not limited to culverts, bridges, ditch drains, fords, water bars, and rolling dips.

drought tolerance. Ability of a tree or plant to survive under conditions of limited soil moisture.

duff. The partially decomposed organic matter on the forest floor beneath the litter of freshly fallen twigs, needles, and leaves.

EA. See **environmental assessment.**

easement. An agreement that defines the conditions under which one party may traverse a property owned by someone else. It may also refer to an agreement that restricts the use of property in specific ways.

ecological dominance. In ecology, the relative abundance or sizes of plants or animals in a community.

ecology. The study of the interactions among living organisms and their environment.
ecosystem. A place or system with defined boundaries that includes a biological community and its physical environment.
ecotone. The interface between two distinctly different ecosystems.
EEZ. Equipment exclusion zone.
EIR. See **environmental impact report.**
EIS. See **environmental impact statement.**
ELZ. Equipment limitation zone.
endangered species. Any species of plant or animal defined through the federal or a state Endangered Species Act as being in danger of extinction throughout all or a significant portion of its range.
endemic. Native to a particular region or area; restricted to and constantly present in a particular region.
environmental assessment (EA). A concise public document containing a federal agency's analysis of the significance of potential environmental consequences of an action; used to determine whether the more-comprehensive EIS is required or a "finding of no significant impact" is warranted. See **National Environmental Policy Act of 1969**.
environmental impact report. A full-disclosure documentation of the environmental impacts of a project. An EIR is prepared pursuant to the requirements of the California Environmental Quality Act.
environmental impact statement (EIS). A detailed statement of a federal project's environmental consequences, including adverse environmental effects that cannot be avoided, alternatives to the proposed action, the relationship between local short-term uses and long-term productivity, and any irreversible or irretrievable commitment of resources. See **National Environmental Policy Act of 1969**.
EPA. See **U.S. Environmental Protection Agency.**
ephemeral. A stream or portion of a stream that flows only in direct response to precipitation or snowmelt runoff.
erosion. The wearing away of the land surface by rain, running water, wind, ice, gravity, or other natural or management actions.
ESA. U.S. Endangered Species Act.
eutrophication. Creating lakes or ponds rich in plant nutrients and organisms, which often develop oxygen-deficient conditions.
even-aged. A stand of trees composed of a single age class; a tree age range of plus or minus 20 percent of rotation age. For example, a 100-year-rotation even-aged stand would have tree ages within 20 years of each other.
federally listed species. A species that has been designated as endangered or threatened pursuant to the federal Endangered Species Act as listed in the Federal Register.
feller-buncher. A harvesting machine that cuts a tree with a hydraulic shear or saw, gathering one or more cut trees in hydraulic arms before placing them on the ground. Usually limited to 24-inch DBH or smaller trees.
felling crew. One or more tree fallers and the falling boss. They do the felling, limbing, and bucking (cutting logs to specific length). Fellers are also referred to as "cutters" or "choppers."
fiberboard. A wood product manufactured from wood fibers and synthetic resins or other binders compressed into panels in a hot press.
fill. Rock or soil material placed in low areas, compacted, and built up to form a road bed.
fire frequency. The period of time between fires; also known as fire return interval.
fire intensity. The rate of heat release from a flaming front.
fire regime. The characteristic frequency, extent, intensity, severity, and seasonality of fires in an ecosystem.
fire return interval. The period of time between fires; also known as fire frequency.

fire severity. The degree to which site conditions (vegetation, soils) have been altered or affected by a fire; a product of fire intensity, duration, and fuel consumption.

fire tolerance. The ability of a tree or plant to survive a fire.

Fish and Wildlife Service (FWS). An agency of the U.S. Department of the Interior that develops rules for the protection of federally listed threatened and endangered species such as northern spotted owl and bald eagle. Also manages the federal wildlife refuge system and performs many other missions related to fish and wildlife.

flagging. Colored plastic ribbon attached to trees, brush, or stakes to mark boundaries or to make these objects visible; also brown, dead branches in an otherwise green crown, standing out because of their color contrast, which is often the result of diseases such as blister rust or Elytroderma needle blight.

floodplain. The area adjacent to a stream constructed by the stream in the present climate and inundated during periods of high flow.

food web. The network of organisms that supply and consume food (nutrients and energy) in an ecosystem. Also known as food chains.

forbs. Any broadleaf nonwoody herbaceous plant other than grasses; wildflowers.

ford (dry). A rock, concrete, or other hardened surface built on the bed of a swale, gully, or usually dry stream that allows vehicle passage during periods of low or no flow.

ford (wet). A rock, concrete, or other hardened surface built on the bed of a live stream that allows vehicle passage during periods of low flow.

forest. An ecosystem characterized by a more or less dense and extensive tree cover, often consisting of stands varying in characteristics such as species composition, structure, density, age class, and associated processes, and commonly including meadows, streams, fish, and wildlife. Forests include special kinds such as industrial forests, nonindustrial private forests, public forests, urban forests, and parks and wilderness.

Forest Practice Act (FPA). The law that regulates private forest management in California. Division 4, Section 8, of the Public Resources Code that declares the policy of the state "to encourage prudent and responsible forest management." Authorized by the Z'Berg-Nejedly Forest Practice Act of 1973.

forest practice rules. Rules and regulations developed and promulgated by the State Board of Forestry pursuant to the Forest Practice Act. Most rules address the protection of water quality, wildlife habitat, and archaeological sites and artifacts.

Forest Service. An agency of the U.S. Department of Agriculture that manages 20 million acres in 18 national forests in California for watershed and wildlife habitat protection, recreation, and timber and grazing.

forest type. A forest category defined by forest vegetation, particularly the dominant vegetation as based on percentage cover of trees.

FPA. See **Forest Practice Act.**

fry. Young fish when they first emerge from the embryo stage.

fuelbreak. A generally wide (60 to 1,000 feet) strip of land on which native vegetation has been reduced or modified so that a fire burning into it can be reduced in intensity and rate of spread and more readily controlled. See **defensible fuel profile zone**.

fungus. A non-photosynthesizing (green) plant composed of hyphae (thin, threadlike filaments) that can be found in the forest floor and duff and in decomposing wood. Some fungi produce fruiting body mushrooms that contain spores for reproduction.

FWS. See **Fish and Wildlife Service.**

generalist. In ecology, an organism that can tolerate a wide range of habitat conditions.

genotype. An individual organism's genetic makeup.

germination. The beginning of growth of a mature seed, spore, or pollen grain; the development of a seedling from a seed.

girdle. To make continuous incisions around a living stem, through the bark and cambium, disrupting the flow of water and sap, generally with the object of killing the tree to thin the forest or create snags for wildlife habitat.

GIS. Geographic information system.

GPS. Global positioning system.

grading. In road construction, grading refers to the act of excavating and moving soil along the road alignment to a defined slope and surface. In road maintenance, it refers to scraping the road surface smooth.

group selection unit. A small clear cut, usually less than 5 acres, used to regenerate shade-intolerant species in an uneven-aged forest comprised of many small even-aged units. Though the group selection stand is even-aged, at the forest landscape scale the groups would create a mosaic of age classes and thus an all-aged forest. See **selection**.

gully. A channel generally larger than 1 square foot in cross-section formed by concentrated surface water runoff.

habitat. The combination of shelter, food, and water that is required for the life support of a given species.

habitat conservation plan (HCP). An agreement between the U.S. Secretary of the Interior and either a private party or state, specifying the conservation measures that will be implemented in exchange for a permit that would allow taking (harassing or killing) of a threatened or endangered species.

habitat quality. The informed value judgment about the ability of a habitat to support a particular species' needs for reproduction, feeding, water supply, and shelter.

harvest. The removal of commercial, merchantable products or materials from the forest.

HCP. See **habitat conservation plan.**

heartwood. The wood that forms in the center or heart of the tree main stem from inactive sapwood as it is overgrown and replaced by new sapwood.

helicopter logging. Using a helicopter to yard, or move, logs from the harvest area to a landing. Used where landscape sensitivity, steepness, or landslide threat precludes the use of ground-based yarding equipment or where access roads are not available or desired.

herbicide. A pesticide used to kill or control the growth of plants.

high thinning. Removal of some dominant and codominant trees in order to favor the best trees of those classes in the reserved stand. Also known as thinning from above or crown thinning.

home range. Area covered by the normal annual movement of a wildlife species in carrying out its life cycle.

industrial forests. Forestland owned by a company or individual managed primarily for wood products. Owner may or may not operate sawmills or other wood-using plants.

in-sloped road. A road design in which the road surface is sloped in towards the cut bank, usually draining water to an inside ditch.

integrated pest management (IPM). The management of pest organisms at an acceptable level, rather than trying to eliminate the pest, using a variety of preventive, suppressive, or regulatory tactics that are ecologically and economically efficient and socially acceptable. An alternative to pesticides, which are more direct and usually quicker methods of control.

intermediate trees. Trees that are shorter than dominant or codominant trees but have some branches extending into the general crown cover. They receive little light from above and none from the sides. See **crown class.**

intermittent. A stream that does not sustain year-round flow in all or most years.

IPM. See **Integrated pest management.**

IWM. Integrated weed management.

keystone species. A species whose presence increases or whose absence decreases the diversity of a system; usually a competitively superior species; a species upon which important ecological processes depend.

ladder fuels. Combustible material that provides vertical fuel continuity between vegetation strata and allows fire to climb from the ground into the crowns of trees or shrubs. Ladder fuels help initiate and sustain crown fires.

landing. A cleared area in the forest where logs are skidded or yarded for processing and loading on to trucks for transport.

landing crew. A loader operator, log processor, and possibly a landing person or knot bumper who trims limbs and knots from the logs before loading.

large woody debris (LWD). Logs, stumps, and branches generally larger than several inches in diameter and several feet long that are found in a stream or on the forest floor.

legacy trees. Usually, large trees left as examples of the size and characteristics of trees in the original stand. They can also become wildlife trees and snags.

licensed timber operator (LTO). A person or firm licensed by the state of California to conduct commercial timber harvests on private forests.

limiting factor. An environmental or habitat-related condition (e.g., growing season, climate, food source, soil nutrients, water, etc.) that limits plant growth or population size, animal population size, or ecological productivity.

litter. Leaves, twigs, and branches on the forest floor that are still discernible as plant parts.

log. The stem of a felled tree, trimmed of limbs, cut to specified lengths for final products, for example, 16.5 feet or 33 feet for lumber that will eventually be sold in 8-foot lengths.

log decks at the mill. Logs accumulated during the logging season for winter, when logging is curtailed because of weather.

low thinning. The removal of trees from the lower crown classes or understory to favor trees in the upper crown classes; thinning from below.

LTO. See **licensed timber operator.**

lumber. The sawn wood product from a tree; solid wood, sawn dimension lumber, and boards as opposed to wood peeled for plywood or chipped for reconstituted wood products such as oriented-strand board or fiberboard.

LWD. See **large woody debris.**

macroinvertebrates. Animals without backbones, such as insects, worms, and mollusks.

macronutrients. Elements required in relatively large amounts by plants and other organisms for healthy metabolism and growth, such as nitrogen, phosphorus, calcium, and potassium.

mast. The fruit or nuts of trees considered as food for wildlife and livestock. Hard mast is the fruit or nut of trees such as oak, walnut, and chinquapin. Soft mass includes the fruits and berries from plants such as dogwood, elderberry, huckleberry, grape, and blackberry.

mastication. Mechanically chewing up trees, wood, brush, and slash to reduce fire hazard, which creates chips that are scattered on the forest floor or soil surface.

mature tree. A tree that has reached its maximum growth or height or has reached merchantable product size.

memorandum of understanding (MOU). A formal written agreement between two or more organizations or agencies that presents the relationship between the entities for the purposes of planning and management.

merchantable height. The marketable length of a tree to a minimum diameter top. **See merchantable top diameter**.

merchantable top diameter. The inside bark diameter above which a stem is considered nonmerchantable for a particular product; usually a diameter inside bark of 6 to 10 inches. Also known as merch top.

microclimate. The climatic conditions in a geographically limited area that may be different than the general climate for the landscape, such as the climate beneath a forest canopy, next to a log or topographic feature, on an open hillside, or along a stream.

micronutrients. Elements required by plants and other organisms in small or trace amounts for healthy metabolism and growth, such as boron, iron, and magnesium.

MOU. See **memorandum of understanding.**

multiple land use. The management of land and forests for timber, wildlife, water, recreation, and grazing in an integrated and comprehensive program.

mycorrhizae. Fungi that live in symbiotic associations with the roots of many plant species. The fungi receive nutrients from the plant and facilitate movement of water and inorganic nutrients from the soil to the plant.

National Environmental Policy Act of 1969 (NEPA). The federal law that ensures that U.S. government agencies consider the National Environmental Policy when making decisions by requiring one (or possibly more) of four classes of documentation: an environmental assessment; an environmental impact statement; a categorical exclusion; or a programmatic environmental impact statement.

national forest. A forest, range, or wildland reserve managed by the Forest Service for multiple uses, including timber, water, wildlife, recreation, and grazing. National forests differ from national parks in having multiple-use goals of which recreation is only one. Nationwide, the national forest system administers 154 forests and 19 grasslands.

National Marine Fisheries Service (NMFS). An agency of the National Oceanic and Atmospheric Administration. Pronounced "nymphs." Responsible for the protection of endangered fish such as the coho salmon.

National Park Service (NPS). Established by Congress to promote and regulate the use of national parks, monuments, and reservations, and to conserve the scenery and the national and historical objects and wildlife therein for the public in perpetuity. The Park Service administers 295 units, primarily for historical or recreational uses.

Natural Resources Conservation Service (NRCS). Formerly the Soil Conservation Service (SCS).

NEPA. See **National Environmental Policy Act of 1969.**

niche. The ecological role and habitat occupied by a species in an ecosystem.

NIPF. See **nonindustrial private forest**.

nitrogen fixation. The process by which inert atmospheric nitrogen gas is converted by bacteria into ammonium, which is usable by plants.

NMFS. See **National Marine Fisheries Service**.

NOAA. National Oceanic and Atmospheric Administration.

nocturnal. Nightly, or active and functioning at night.

nodule. In reference to nitrogen fixation, the swollen tissue on the roots of some plants (e.g., genus *Ceanothus*) where nitrogen-fixing bacteria reside.

nonindustrial private forest (NIPF). Forestland that is privately owned by individuals or companies other than the forest industry and where management usually includes objectives other than timber production.

nonindustrial timber management plan (NTMP). A long-term (100-year) timber harvest plan limited to ownerships of 2,500 acres or less.

nonpoint source pollution. Water that is polluted by sources that cannot be identified as discrete points or sources, such as areas of timber harvesting, roads, surface mining, agriculture, and urban land use.

NPS. See **National Park Service.**

NRCS. See **Natural Resources Conservation Service**.

NTMP. See **nonindustrial timber management plan**.

nursery log. A fallen tree that provides habitat for the regeneration of other plants, including some trees.

nutrient stress. Lack of nutrients indicated by symptoms that appear in a plant when the plant is not supplied with adequate nutrients to sustain normal growth and function. Often characterized by a yellowing of leaves (chlorosis), distortion of buds and leaves, or premature dropping of leaves.

OHP. California Office of Historic Preservation.

old growth forest. The late successional stage of forest development, usually characterized by large, old trees; standing dead trees, or snags; closed or dense canopy conditions; and down logs and coarse, woody debris. Old growth forest is commonly perceived as uncut, virgin forest with very little human-caused disturbance.

out-sloped road. A road in which the road surface is sloped out away from the cut bank so that the road surface drains water directly onto adjacent slopes, dispersing water off the road surface quickly so it will not accumulate and run down the road and erode it.

overstory. In a forest that has more than one layer of trees, the overstory is the highest canopy layer.

Pacific Southwest Research Station (PSW). The research branch of the Forest Service for California, Hawaii, and the Pacific Islands.

partial cut. Removal of only part of a stand for purposes other than regenerating a new age class of trees.

PCT. See **precommercial thinning**.

perennial stream. A stream that flows throughout the year in a well-defined channel.

permanent road. A road that is designed, built, and maintained for all-season, wet weather use. Often surfaced with rock or pavement.

pesticide. A chemical compound used to control animals, insects, diseases, or plants.

phenotype. An individual organism's outward, visible expression of a genetic character or trait.

pheromone. A chemical released into the environment by an individual to influence the behavior of other individuals of the same species, for example, to attract bark beetles to a tree for mating.

PHI. See **preharvest inspection.**

phloem. The conductive tissue found between the wood and the outer bark of a tree that carries carbohydrates (sap) from the leaves to the branches and roots.

photosynthesis. The process by which energy in sunlight, carbon dioxide, and water is converted by green plants into organic compounds, principally carbohydrates.

plane surface. Lumber that has a smooth surface from being run through a planer or surfacing machine. Surfaced lumber is lumber that has been planed. It can be either green (undried) or dried. Dried lumber is often air-dried for a while then placed in a kiln to bring lumber moisture down to a specified amount to stabilize its shrinkage and twisting.

point source pollution. Water and air pollution that can be identified with a specific source such as a pipe, sewage outfall, spill, etc.

pole timber. A small tree that is 3 to 12 inches in DBH, larger than a sapling but smaller than sawtimber.

pool. A low point in a stream where water velocity is reduced and water depth is greatest.

population. A group of organisms usually of the same species or otherwise capable of interbreeding.

precommercial thinning (PCT). Thinning to reduce competition and improve individual tree growth and vigor; cutting small trees that will not make a commercial product or are too costly to process and transport.

preharvest inspection (PHI). Part of the timber harvest plan process.

prescribed burning. To deliberately burn wildland fuels under specified environmental conditions (a burn prescription), which ensures that the fire will be controllable and confined to a predetermined area and intensity.

prescriptive easement. An obtained right to enter a property by someone other than the landowner when access is open, continuous, and uninhibited for 5 years in California. Posting "No Trespass" signs and other evidence of active resistance to the use prevent this easement.

preservation. Protecting an area from treatment or management. The meaning stems from nineteenth-century land reserves in which areas and resources were set aside for limited or restricted use and development. Preservation often restricts land uses to recreation or scientific study.

processor head. A saw and delimbing machine mounted on a tractor or boom that cuts the tree stem and delimbs and cuts it into logs, leaving slash at the stump.

producers. In ecology, the plants that photosynthesize; also known as primary producers.

programmatic EIS. A document that discloses the environmental consequences of a program or plan of actions rather than disclosing the environmental consequences of every site-specific project of that program or plan. See **National Environmental Policy Act of 1969.**

PSW. See **Pacific Southwest Research Station.**

public trust resources. Natural resources that the federal and state government regulate in the interests of the general public, including air, water, and wildlife. Protection of public trust resources is often a control or limitation on private property rights and activities, and it is the basis of our environmental protection laws and regulations.

Quincy Library Group (QLG). A broad-based community forestry group (loggers, environmentalists, businesses, educators, and concerned citizens) in Quincy, Lassen, Plumas, and Sierra Counties that developed and proposed a shaded fuel break program to protect communities from wildfire, improve the condition of the forest, produce economic return to the community, and minimize the extent and intensity of wildfire. See **defensible fuel profile zone**.

QLG. See **Quincy Library Group.**

RCD. Resource Conservation District.

recovery. In conservation biology and legal terms, the process by which a species legally defined as threatened or endangered achieves a status of population size or stability such that it is no longer in danger of extinction.

redd. A depression excavated in stream bottom gravel by salmonid fish where they deposit their eggs.

regeneration method. A method of harvesting to regenerate trees, a new stand or forest.

registered professional forester (RPF). A person licensed by the State of California to practice forestry; requires 7 years of education and professional experience to take the qualifying examination.

reproduction. Tree seedlings or sprouts 0 to 1 inch DBH.

residual stand. The portion of trees remaining after any partial cut or thinning.

respiration. The process of converting food molecules such as sugar into energy, carbon dioxide, and water; the energy released powers the activities of the cells and ultimately the organism.

response reach. In hydrology and geomorphology, stream segments where sediment, large wood, and other materials tend to collect. They tend to be the most "responsive" to land use impacts.

riffle. A high point in a stream over which stream flow is accelerated, creating waves, broken water surface, and white water.

rill. A channel varying in size from a rivulet up to about 1 square foot in cross-section that typically forms where rainfall and runoff is concentrated on a slope.

riparian. Relating to the land area parallel and immediately adjacent to a river or stream.

riparian buffer. A zone adjacent to a stream or other water body where land use is restricted to minimize impacts.

riparian vegetation. Vegetation found adjacent to a stream and which depends on it for water or other life support.

riprap. A generic term for rock or other material placed on stream banks or other exposed surfaces to prevent or reduce erosion.

road runoff. Precipitation or snowmelt that is intercepted by a road and flows off it.

rock armor. Coarse rock placed to protect a soil surface from erosion caused by flowing or falling water. It is commonly placed at culvert outlets, on exposed slopes, or on stream banks.

rolling dip. A shallow, gradual dip in a road where the road grade reverses for a short distance and surface water runoff is directed in the dip or trough to the outside of the road.

roots. Belowground plant parts that anchor a tree or plant and absorb water and nutrients for plant growth.

rough surfaced. Lumber surface resulting from the saw cut alone, without planing or sanding.

RPF. See **registered professional forester**.

RWQCB. Regional Water Quality Control Board.

salmonid. Fish of the family *Salmonidae,* including salmon, trout, chars, whitefish, ciscoes, and graylings.

sanitation cutting. The removal of dead, damaged, or insect- or disease-susceptible trees to prevent the spread of pests or pathogens and to promote forest health.

sapling. A young tree less than 3 inches DBH. The minimum size is usually placed at 1 inch DBH.

sapwood. The part of a tree that carries water and nutrients from the roots to the leaves or needles; also called the xylem. The outermost rings of wood in a tree stem.

seasonal road. A road designed and intended for use only during part of the year, typically the summer or dry season. See also **permanent road** and **temporary road**.

seedling. A tree grown from seed that is less than 3 feet tall or 1 inch DBH.

seed tree. A tree left after a timber harvest to produce seed for natural regeneration.

seed zone. A designated geographic area containing trees with relatively uniform genetic composition. Seed gathered from a seed zone is adapted to growing there.

seep. A surfacing of groundwater such as a spring.

selection. A silvicultural system in which individual trees of all size (age) classes are removed more or less uniformly throughout the stand to promote the growth of the remaining trees and to create space for regeneration. Shade-tolerant species like true firs do well under this method, but shade-intolerant species like pine may require larger openings. See **group selection**.

self-pruning. The process by which a tree sheds its lower branches.

SFI. See **Sustainable Forestry Initiative.**

shade tolerance. The ability of a tree or plant to grow in partial or full shade.

shelterwood. A silvicultural system in which residual trees are left to produce seed for regeneration and some "shelter" or shade for the seedlings.

silviculture. The art and science of controlling the establishment, growth, composition, health, and quality of forests and woodlands to meet the needs and values of landowners and society on a sustainable basis.

single tree selection. See **selection**.

site. The area in which a plant or stand grows, considered in terms of its environment, particularly as this determines the type and amount of the vegetation the area can support.

site class. A classification of site quality and productivity for timber production usually expressed as dominant tree heights at a standard reference age (50 or 100 years).

site index. A classification of site productivity for timber production, expressed as dominant tree height at a reference age (50 or 100 years). For example, Site Index 80 (50) is a site that can grow trees 80 feet in height in 50 years.

site preparation. Preparing a forest area for regeneration, which usually entails removing competing grass and brush and debris that would hamper planting, or disturbing the forest floor to create a suitable seedbed for seed germination during natural regeneration.

skidder. Usually, a rubber-tired machine that moves logs from the felling site to the landing or deck. A track machine (cat) may sometimes be referred to as a skidder in that both are used to skid logs to the landing.

slash. The branches, bark, tree tops, wood chunks, cull logs, uprooted stumps, and broken or uprooted trees left on the ground after logging; also, large accumulations of debris after wind-throw or fire.

slope position. A particular location on a slope as upper, middle, or lower slope; also ridge top or bottom land.

SMZ. See **streamside management zone**.

snag. Standing dead tree that provides wildlife habitat and may also provide large organic debris or large woody debris input to nearby streams.

snow load tolerance. The ability of a tree to shed snow from its crown and have sufficient flexibility to not break under a snow load.

SOD. Sudden oak death.

solarization. A method using solar heating to kill insects and disease organisms.

source reach. In stream systems, areas or segments where most sediment and large woody debris recruitment is occurring.

specialist. In ecology, an organism that requires specific habitat conditions that may be unusual or uncommon, such as plant species confined to serpentine soils.

spoil. Excess soil, rock, and organic debris generated during road construction, reconstruction, and maintenance.

spoil disposal site. A place where excess material generated during road work can be safely placed or stored without creating an erosion or slope stability hazard.

sprout. A tree originating from a root or stump.

stand. A contiguous group of trees sufficiently uniform in composition, structure, and site productivity to be distinguished as a unit.

stocking. A measure of the proportion of an area occupied by trees.

stomata. Small pores in leaves or needles that when open allow gas exchange, carbon dioxide to enter for photosynthesis, and water to transpire.

streambed alteration agreement. A legally binding agreement between the California Department of Fish and Game and a project proponent or landowner regarding a land use activity affecting a natural stream.

stream classes. Four California state classifications for regulatory purposes. See **Class 1 stream**, **Class 2 stream**, **Class 3 stream**, and **Class 4 stream.**

stream crossing. The place where a road, trail, pipeline, or other structure crosses a stream, such as a bridge, ford, culvert, etc.

streamside management zone (SMZ). A strip of land adjacent to a water body or stream channel where soils, organic matter and vegetation are managed to protect the physical, chemical, and biological integrity of surface water adjacent to and downstream from forestry operations; also called a "filter strip" or "buffer zone."

succession. In ecology, the process by which a plant community changes in species composition and structure over time, generally from simple to more complex communities.

suppressed trees. Trees found below the general prevailing height of a forest canopy. They receive little or no direct sunlight, and as a result, their growth is inhibited.

surface fuels. The loose surface litter on the soil surface such as fallen leaves or needles, twigs, bark, cones, branches, grasses, shrub and tree reproduction, downed logs, stumps, seedlings, and forbs interspersed with or partially replacing the litter.

sustainable forestry. Forest management that meets the forest resource needs and values of the present without compromising the similar capability of future generations; the stewardship and use of forests and forestlands in a way and at a rate that maintains their biodiversity, productivity, regeneration capacity, and vitality now and in the future.

Sustainable Forestry Initiative (SFI). A comprehensive set of forestry and conservation practices sponsored by the American Forest and Paper Association that are designed to ensure that future generations of Americans will have the same abundant forests and wildlife that we enjoy today.

sustainability. The capacity of forests to maintain their health, productivity, diversity, and overall integrity in the long run.

sustained yield. Management of a forest stand to provide a continuing supply of timber and revenue while protecting public trust resources of water, watersheds, wildlife, air quality, and soil productivity.

SWRCB. California State Water Resources Control Board.

symbiosis. In ecology, a relationship between two organisms that is beneficial and necessary to both.

take. In conservation biology and law, to conduct activities that will harass, harm (including significant habitat modification or degradation), pursue, hunt, shoot, wound, kill, trap, or capture an endangered species.

temporary road. A road that is used only for the duration of a management activity such as timber harvest, thinning, site preparation, or controlled burn. It is neither designed nor intended for all-season use. See also **permanent road** and **seasonal road**.

thinning. In forestry, removing trees or other vegetation to decrease competition among remaining trees for light, nutrients, and water.

THP. See **timber harvest plan.**

threatened species. A plant or animal species likely to become endangered throughout all or a significant portion of its range within the foreseeable future.

timber. Forests and stands containing timber; wood, other than fuelwood, potentially usable for lumber.

timber harvest plan (THP). An environmental review document required by the California Forest Practice Act laying out the conditions of a logging operation. The functional equivalent of a CEQA environmental impact report.

timber production zone (TPZ). Zoning that assesses property tax rates based upon value as forestland, not "highest and best use" or development values.

timber stand improvement (TSI). An intermediate treatment made to improve the composition, structure, condition, health, and growth of a stand; usually a thinning of competing trees or release from competing shrubs and plants.

TMDL. See **total maximum daily load**.

total maximum daily load (TMDL). An estimate of the total quantity of pollutants from all sources in a watershed, including point, nonpoint, and natural, that may be allowed into waters without exceeding water quality criteria.

TPZ. See **timber production zone.**

transpiration. In biology, the process by which water vapor is lost to the atmosphere when the stomata on the leaves or needles of plants are open.

transport reach. In hydrology and geomorphology, stream segments that predominantly function to move sediment, water, and wood rather than supply (source) or accumulate (response) them.

tree. A woody perennial plant that typically is large with a well-defined stem or stems carrying a definite crown of branches and leaves.

trophic level. A position in a food or energy chain. In ecology, trophic levels correspond to producers (plants), consumers (herbivores), and top consumers (carnivores and omnivores) in food chains.

TSI. See **timber stand improvement.**

turbidity. The optical condition of water as determined by suspended solids, dissolved solids, algae, and human or natural chemicals; commonly observed as cloudiness.

understory. The vegetation layer formed by grasses, shrubs, and small trees under the canopy of larger trees and plants.

uneven-aged. A stand with trees of three or more distinct age classes, either mixed together or in small groups.

USDA. See **U.S. Department of Agriculture**.

USDI. See **U.S. Department of the Interior.**

USEPA. See **U.S. Environmental Protection Agency.**

USFS. See **Forest Service**.

U.S. Department of Agriculture (USDA). Agency that administers the Forest Service and the Natural Resources Conservation Service.

U.S. Department of the Interior. Administers the National Park Service, Bureau of Land Management, Bureau of Indian Affairs and the Fish and Wildlife Service.

U.S. Environmental Protection Agency (EPA or USEPA). The federal agency charged with developing and enforcing regulations on uses of pesticides, controlled disposal of other toxic materials, and other aspects of environmental protection.

vernal pools. Shallow, ephemeral pools that form during the rainy season in winter and spring.

water bar (waterbreak). A shallow ditch and speed bump placed at an angle across a road or trail to capture and drain surface runoff, preventing it from eroding the surface.

water course and lake protection zone (WLPZ). Stream or lakeside area specified for protection measures by the California Forest Practice Rules.

watercourse class. See **stream classes**.

water quality. The quality of water for different uses based on its chemical, thermal, bacterial, and physical properties.

Water Quality Control Board (WQCB). California regulatory agencies whose staff review timber harvest plans for compliance with the Clean Water Act and Porter-Cologne Water Act.

WHRS. See **Wildlife Habitat Relationship System**.

wildfire. Fires burning out of control regardless of how or why they were started.

wilderness. In the strictest sense, an area that has never been developed by man. The 1964 Wilderness Act defined it as "A Wilderness, in contrast with those areas where man and his own works dominated landscape, is hereby recognized as an area where the earth and its community of life are untrammeled by man, where man himself is a visitor and does not remain." In common usage, the word is associated with these undeveloped areas and other areas set aside with little development. In some cases man-made items are dismantled to reduce the area to a primitive state. Under these broader definitions, some roadless areas are considered to be wilderness when the access is limited to hiking, canoeing, or horseback riding and the use is set aside for recreation.

Wildlife Habitat Relationship System (WHRS). Lists species likely to be found in specific vegetation types and habitat conditions. Can be used to predict the effects of timber harvest and other actions on wildlife habitat.

wind-throw. Tree or trees downed or broken off by wind; also known as blowdown.

winterize. Perform erosion prevention and control work on a road in preparation for winter rains and flood flows. Winterizing activities may include installing water bars, ditch cleaning, culvert cleaning, resurfacing, etc.

winter operating period. In forest practice regulation, the period generally between October 1 and April 1 when regulated forestry operations are restricted and subject to special rules.

WLPZ. See **water course and lake protection zone.**
WMA. Weed management area.
wolf tree. A dominant tree with a broad, spreading crown that occupies more growing space than its neighbors.
WQCB. See **Water Quality Control Board.**
xylem. The outermost wood rings; conducting tissue in a tree that carries water and nutrients from the roots to the needles, also known as sapwood.
yard. To drag logs or move them about.
yarder. Machine equipped with a tower and cable wound on winches that is used to yard logs from the felling site to the landing.
yarding crew. Two or more choker setters, yarder operator, or skidder operators; depending on the crew size, there may be a separate side rod or crew foreman.

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FOREST STEWARDSHIP SERIES 2

A Forest Stewardship Framework

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B. E. Fernow, chief of the USDA's Division of Forestry in 1894, wrote in that year's *Book of Agriculture*, "in order to harmonize the requirements of the wood lot from a sylvicultural point of view, and the needs of the farmer for wood supplies, the cutting must follow some systematic plan." This astute statement, written over 100 years ago, still rings true today. In those simpler days, a landowner's primary worries dealt only with the immediate needs of planting, cultivating, and producing a "crop" of trees over time. It is interesting that even with these modest goals, the author spoke eloquently of the need to have a management plan for guidance.

In today's world, landowners need to know many things to be successful forest stewards. It is of the utmost importance to understand the ecological and environmental effects of various management practices. For those seeking economic returns, it is essential to be informed about markets, costs, and regulatory requirements. Landowners today must consider their place in the community and how their activities can influence their neighbors, other species, and other forest users.

Simply stated, there is a great deal more to forest stewardship today than just growing, cutting, and marketing trees. Forest stewards must plan activities well in advance, accurately assess resources, manage potential wildland fuel sources, address erosion and water quality issues, and know how to use sound information to make management decisions. For many California forest landowners, economic returns are incidental or unimportant; they may be more interested in forest restoration or enhancement. Nevertheless, these landowners too must consider the effects of their management (or nonmanagement) actions.

Forestland management decisions are implemented over a long time span, often exceeding an individual's lifetime. The impacts of those decisions affect you and your family as well as your neighbors. These decisions also influence the management of nearby lands and may impact streams and water sources hundreds of miles away. Your decisions have repercussions on wildlife, fire protection, water quality, and scenic values. Even if your decision is to do nothing and let the forest take care of itself, that decision impacts a multitude of resources.

A FOREST IN SPACE AND TIME

The condition of the forest you own or manage today is largely a consequence of historical land use practices. In all but a small percentage of public lands, forestlands throughout the state have been significantly altered by harvest activities in the relatively recent past.

The society of the indigenous peoples of California before the appearance of Europeans was essentially a subsistence-based culture very different from the modern market-based culture that dominates today. Understanding these societal differences is important if we are to understand how human intervention has impacted forest conditions. Prior to the California Gold Rush, indigenous Californians manipulated

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the forest for food production, shelter, and protection to meet their needs. Though they relied heavily on harvestable products from the forest, in most cases they left the forest structure relatively intact. Hence the extensive presence of "old growth" forests prior to European settlement.

Since the mid-1850s, trees have been harvested and exported to the far reaches of the world to meet the needs of a larger, more mobile and more consumer-driven society. These modern activities, along with the absence of periodic fires, have shaped the structure and composition of the forests we see today. The modern land use practice of cutting and growing trees on a rotational time frame is a relatively new practice in California's forests, and we still have much to learn about its long-term ecological effects.

FORESTRY: A MULTIDISCIPLINARY SCIENCE

Forestry is commonly defined as the science of developing, caring for, or cultivating forests. In all but a few cases, people in California own and manage native forests; that is, the forests being managed were not artificially planted to produce wood fiber (as are plantations, woodlots, etc.). These forests, however, are often the result of timber harvesting followed by natural regeneration from remaining and surrounding forests.

California's forests are a product of climatic and soil conditions that have evolved over millions of years. The first redwood trees are found in the fossil record 66.4 million years ago. This precursor to modern redwoods was growing in Wyoming! Fossilized pollen deposits show that today's oak woodlands, so widespread across California's landscape, were established just after the last ice age 10,000 years ago.

Caring for and cultivating a forest should be premised on the fundamental principle that not all forests are created equal. In other words, a pine forest has different needs and requirements than a redwood forest or a fir forest or an oak forest. However, in every case, each forest type deserves equal consideration when cultivating its properties so that the intricacies of each forest type can be conserved.

Modern forest management recognizes the importance of applying a multidisciplinary assemblage of technical skills, practical experience, and educated judgment. Whether your goal is to manage your forest for recreational purposes, economic gain, or both, over time you will need to use information from a broad range of sources and disciplines. These include:

- Silviculture: The art of growing and harvesting trees to ensure sustainable production of timber and nontimber resources over time.
- Forest protection: The need to manage pests, pathogens, weeds, and wildland fuels to maintain the overall health and economic and personal values associated with your land.
- Ecology: The science of understanding the relationships between organisms and their environment and how management decisions can influence those relationships.
- Engineering: The physical science important for properly planning and building roads, sizing and placing culverts, and restoring streams.
- Soil science: The understanding of soil protection and conservation measures to avoid compaction and erosion.
- Business administration: Knowledge of how to select a forester and other contractors, as well as how to sell logs, minimize taxes, and conduct other business endeavors.
- Marketing: Ability to identify what you have to market and sell, such as logs, other forest products, or recreational opportunities.

There is no question that modern management activities can dramatically alter forest conditions, affecting ecological integrity and potentially resulting in long-lasting environmental consequences. In order to get full personal enjoyment and financial returns while still protecting the forest's integrity you will need to continually seek out new information so that your decisions are based on current science and select a registered professional forester (RPF). Selecting a forester is similar to selecting any other professional service provider, whether a physician, attorney, tax consultant, or auto mechanic. You will want to choose someone with whom you are comfortable sharing complex and personal information.

DEFINING FINANCIAL OBJECTIVES

Do not ask the forest to do something that is beyond its capacity. Forests grow at predictable rates depending on species, soil conditions, weather patterns, and geographic location. Think of your forestland as a bank account with the trees serving as principal and their annual growth as interest. In the simplest terms, if withdrawals (harvests) exceed deposits (growth), over time the account will be liquidated. Developing a financial strategy based on periodic conservative harvests will ensure that the principal will grow over time. For example, if you develop a harvest strategy that is premised on extracting from 25 to 30 percent of growth over any 10-year period, then you can realize a compounding benefit of growing more wood fiber than you are extracting. Over time, this will result in higher volumes of timber per acre being grown in larger trees of higher quality. This strategy will provide far greater financial returns over time than more aggressive harvest schedules that often result in long periods of no harvest activities.

DEFINING ENVIRONMENTAL OBJECTIVES

The financial objectives established for your forestland will have environmental consequences. A financial strategy based on a conservative, sustainable level of harvest will, over time, heal many of the environmental impacts of past short-term extraction schemes. Aggressive, high-intensity forestry may subject a forest to environmental conditions that are not conducive to maintaining ecological functions, potentially impacting wildlife and fish populations, water quality, and regeneration efforts. A management plan should recognize the inherent conditions and disturbance regimes of your particular forest type so your management actions will be appropriate to your forestland.

WHERE TO START?

As you can imagine, managing a piece of forest property is a complex and often intimidating task. One starting point all landowners should pursue is a written management plan. This can be as simple as collecting documents such as deeds and receipts along with maps and written notes, or it can be as complex as a detailed prescriptive plan using forest inventory and growth analysis to explore alternative management scenarios. Setting obtainable goals and specific management objectives down on paper helps you create the forest that you desire. A written plan

- documents the information you use to reach your decisions
- allows you to clearly communicate your desires for your property to others, such as your family and land management professionals
- helps demonstrate your commitment to forest management for tax purposes
- helps you prioritize management decisions and turn your objectives into actions
- can help guide your heirs in continuing management of the property

A key benefit of developing a written forest management plan is that it helps you learn more about your property and its management. Consider developing the plan to be an educational experience. You will learn more about your land—probably quite a lot—and also gain new insights and information you need in order to make informed decisions.

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FOREST STEWARDSHIP SERIES 3

Forest Ecology

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A forest is more than trees. It is also the shrubs, wildflowers, and grasses; the animals that depend on and live among these plants; the soil in which the plants grow; the dead trees and plants; the stream that flows through it; the insects, fungi, bacteria, and organisms you cannot readily see; and the climate. In short, a forest is an ecosystem. An ecosystem is simply a specific area of the earth that includes all the living organisms and nonliving components of the environment that interact within its boundaries. An ecosystem can be any size, such as a log, pond, field, forest, or the whole earth's biosphere.

It is useful to understand and manage your forest as an ecosystem because all the components influence one another: for example, if you want certain tree species in your forest, you may have to manage the competing vegetation. You cannot control certain aspects of the ecosystem such as climate; you must learn to live within its constraints of temperature and precipitation. In many cases the dates of last and first frost control the growing season, the types of plants you can grow, and the productivity of your forest. High temperatures and low precipitation limit the growing season at low elevations, as do cold temperatures and snow at higher elevations.

Much of what we do in forestry is based on an understanding of ecology. Ecological concepts provide a basis for predicting the effects of our actions on ecosystems. Timber harvesting, grazing, wildlife habitat improvement, even fire control intentionally or unintentionally change vegetation to favor or discourage certain ecological functions. For example, when we harvest a forest, we change the wildlife habitat in ways that are positive for some species and negative for others. Techniques such as thinning may be used to develop forest conditions suitable to grow bigger trees faster by reducing competition. When we use controlled burns to reduce dense fuel loads in shrub communities we are mimicking some natural disturbance processes.

Viewing our management activities in an ecological context provides a basis for understanding the effects of those activities on ecosystem processes. Altering vegetation can change many things beyond the obvious, immediate changes in plant cover. Taking an ecosystem approach would mean considering the effects of vegetation management on all comprehensible ecological functions and processes.

Most of our activities in the forest are aimed at improving the production of goods and services for human benefit. Evaluating those activities in an ecological context can provide insight into a larger picture, predict and avoid potential negative effects, and perhaps lead to a thoughtful weighing of human benefits versus ecological effects. An ecosystem orientation requires a broader vision and understanding, which includes not just the human community and its needs but the entire ecosystem and its processes.

Objective

Understand the structure and functions of forested ecosystems in California.

Competencies

- *Identify the forest ecosystem(s) on your property.*
- *Appreciate the relationships between climatic and environmental conditions and vegetation.*
- *Understand the essential role of soil and soil conservation in preserving the productivity of the forest.*
- *Identify the trees, shrubs, and other plants that comprise the forest.*
- *Observe the many interactions between plants, animals, and other microorganisms in the forest.*
- *Understand energy, water, and nutrient cycling in forest ecosystems.*
- *Understand ecological succession and its relationship to natural disturbances and forest management.*
- *Manage the forest in an ecologically sustainable manner.*

Related Forest Stewardship Series Publications

- *Vegetation Management (ANR Publication 8236)*
- *Forest Regeneration (ANR Publication 8237)*
- *Forest Wildlife (ANR Publication 8238)*

UC PEER REVIEWED

FOREST TYPES OF CALIFORNIA

California is a large state, 300 miles east to west and 800 miles north to south. It is very diverse geologically, topographically (mountains and valleys), and climatically (coastal, desert, and continental). This diversity of conditions conspire to create the many different California forest types.

California forest types vary in relation to climate and soils. In any of the mountain ranges, as one rises in elevation the temperature drops and annual precipitation increases. This same gradient occurs as one travels north in latitude. At lower elevations, oaks and pine tolerate the higher temperatures and low precipitation, while at higher elevations Douglas-fir, true fir, and hemlock respond to the cooler temperatures and increases in precipitation. These forest types are associations of trees, shrubs, and herbs. The species occur together in communities because they share some of the same environmental requirements and tolerances for light, water, nutrients, and other necessities of life. In some cases there is interdependence, for example, the trees create the shade necessary for understory plants to grow.

Careful observation of your forest will reveal some of the environmental conditions conducive to the occurrence of certain species. Which plants grow in full sunlight? Which prefer shade? Many plants are able to grow in conditions somewhere in between. For example, ponderosa pine grows best in full sunlight, and, though it can tolerate shade for years, it generally will not respond with more rapid growth to a thinning of competing trees. White fir, on the other hand, can grow slowly for many years in deep shade but will respond with increased growth if an opening in the forest canopy allows more sunlight to reach it. Plants differ in their tolerance to a number of other factors including moisture stress (drought), disease, air pollution, soil nutrients, frost and heat.

Coastal Redwood

Coastal redwoods (fig. 1) are the world's tallest tree. They grow along the north coast of the state in a fog belt strongly influenced by proximity to the Pacific Ocean. This maritime climate has heavy winter rains, frequent storms, and cool summers. Fog provides moisture year-round. Redwoods are able to grow rapidly and are adapted to survive periodic fires and flooding. It is a highly unusual conifer species because it can sprout following a disturbance and does not need to germinate from seed. Trees associated with the redwood include Douglas-fir, tanoak, grand fir, Pacific madrone, and California bay. The understory can consist of shrubs (hazelnut, salal, poison oak, huckleberry, and rhododendrons) along with numerous ferns and herbs such as sword fern, redwood sorrel, and Solomon's seal.

Figure 1. Coast redwood forest, Jedidiah Smith State Park. *Photo:* Gary Nakamura.

Riparian Forest

"Riparian forest" is a generic term for the communities that occur as narrow, often dense groves of broadleaf winter-deciduous trees along watercourses, rivers, streams, springs, seeps, and lakes. Black cottonwood, white alder, big leaf maple, dogwood, and willow are characteristic trees. Riparian forest has a very high value for many wildlife species, providing water, thermal cover for terrestrial animals as well as fish, migration corridors, and nesting and feeding opportunities. Riparian forests are given special protection by the Forest Practice Rules' Watercourse and Lake Protection regulations and by the California Department of Fish and Game (DFG) and Water Quality Control Board (WQCB) regulations.

Oak Woodland

The California foothills have hot, dry summers and mild, wet winters. Oaks and gray pines are the dominant trees in these woodlands, along with a number of associated chaparral shrub species such as manzanita, ceanothus, and mountain mahogany (fig. 2). Plants growing here have to be able to conserve water and tolerate drought during the long dry season. Some grasses avoid the drought by completing their life cycle and going to seed before the dry season. Manzanita has hairy or waxy leaves that minimize water loss during the dry season. Plants native to oak woodland are adapted to frequent low-intensity fires and may resprout or germinate from seed following fire. Non-native annual grasses have almost completely replaced the native perennials in these woodlands, resulting in poorer wildlife habitat and changes in the fire regime. Acorns, nuts, and berries support a rich wildlife fauna of over 300 species.

Montane Chaparral

The term "chaparral" is derived from *chaparro*, Spanish for "scrub oak." Chaparral is the most extensive vegetation type in California, comprising 10 million acres, and the dominant species varying with annual precipitation, elevation, and climate (coastal, mountain, or desert). Though not technically a forest type, chaparral vegetation is often part of the oak woodland and lower-elevation mixed conifer forest. Manzanita and ceanothus species are usually principal components of montane chaparral. Wildfire plays an important role in montane chaparral ecology; dominant plants are adapted to fire and usually resprout or germinate quickly following a wildfire. Though drought resistant, chaparral plants are not conservative of water. They consume available soil moisture in the early spring, set seed, and go dormant during the summer drought. Rapid regeneration of chaparral shrubs may serve to stabilize soils following fire, but it also creates intense competition for moisture with germinating or planted tree seedlings.

Montane chaparral provides habitat for a wide variety of wildlife, such as rodents, which serve as food for birds nesting in adjacent conifer forest. Deer and other herbivores make extensive use of chaparral for summer browse, escape cover, and fawning habitat. Chaparral shrubs provide seeds, fruits, insects, and protection from predators for birds, as well as roosting and nesting sites.

Figure 2. Oak woodland. Blue oak, Shasta County. *Photo:* Gary Nakamura.

Mixed Conifer

Mixed conifer forests are found in the middle elevations of the Sierra Nevada and the Cascade and Klamath mountain ranges from about 3,000 to 6,000 feet (fig. 3). Summers are warm and dry; winters are cool, and most of the precipitation, with some snow, occurs during this time. Soil moisture is a critical factor in determining where and how well species grow. Conifers grow here in various combinations. In fact, these forests claim the greatest diversity of coniferous trees in the world, including ponderosa (yellow) pine, Jeffrey pine, sugar pine, incense cedar, white fir, and Douglas-fir, as well as black oaks and many other trees. Shrubs such as manzanita, ceanothus, bitter cherry, and mountain misery are prominent in the understory. Periodic fires are an essential part of the mixed conifer forest ecosystem. Fire suppression over the last century has changed the density and species composition of mixed conifer and other California forests.

Douglas-fir–Mixed Evergreen Forests

Douglas-fir is a dominant tree in much of the Pacific Northwest and in several forest types in California from the Oregon border down through the Coast Ranges and inland to the northern Sierra Nevada (fig. 4). It is often associated with mixed evergreen hardwood species, including California bay, coast and canyon live oaks, tanoak, and Pacific madrone. A wide variety of plants and animals are found in Douglas-fir forests.

Red Fir Forests

The red fir forests are found along a belt in the Sierra Nevada at elevations of approximately 6,000 to 8,000 feet, between the mixed conifer and subalpine forests (fig. 5). This area receives heavy snowfall each year. Red fir forests do well on deep, rocky soils with good soil aeration such as glacial moraines. Other trees associated with red fir in much of their range include white fir, Jeffrey pine, lodgepole pine, and juniper.

Subalpine Forests

The subalpine forests are found at roughly 8,000 to 11,000 feet elevation, just below the timberline of the central and southern Sierra Nevada as well as the Cascades and

Figure 3. Sierra Nevada mixed conifer forest. Overstory of ponderosa and sugar pine, Douglas-fir, incense cedar, and black oak and an understory of incense cedar and white fir. UC Blodgett Forest Research Station, Georgetown, CA. *Photo:* Gary Nakamura.

Figure 4. Douglas-fir forest, Trinity County. *Photo:* Gary Nakamura.

Figure 5. True fir forest. White fir, Klamath Mountains. *Photo:* Gary Nakamura.

Figure 6. Subalpine forest. Mountain hemlock and red fir; Lassen Volcanic National Park. *Photo:* Gary Nakamura.

Warner and Klamath Mountains (fig. 6). Southern California has a drier subalpine habitat. This is a challenging environment: winter conditions of snow and frost may prevail much of the year, the wind is harsh, and solar radiation intense. The soil is generally shallow and has minimal water-holding capacity, creating droughty growing conditions for plants. Whitebark pine, mountain hemlock, lodgepole pine, and junipers are the characteristic tree species.

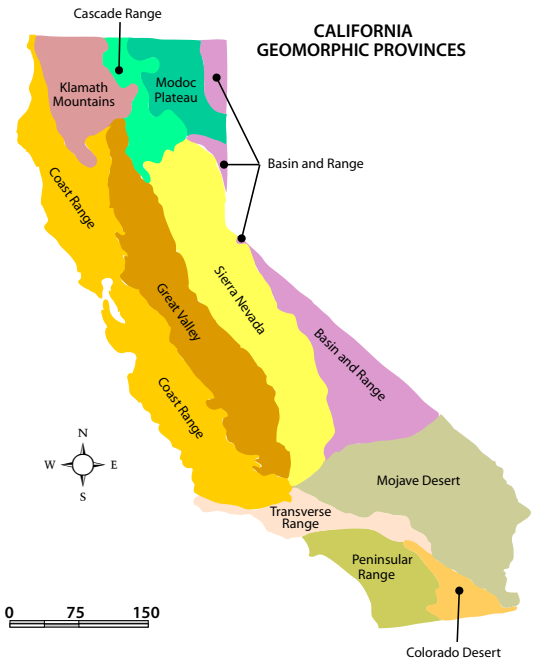

Figure 7. Map of the geomorphic units of California. *Source:* California Department of Conservation, California Geological Survey, 2002.

PHYSICAL FACTORS THAT INFLUENCE YOUR FOREST

The physical environment determines the conditions for the living components of the ecosystem. Physical factors include topography, climate (temperature, precipitation amount and pattern, humidity), the physiochemical nature of the soil and water (nutrients and acidity), underlying geological material, and human influences such as air pollution.

The topography of the land—mountains, valleys, rivers, and so on—affects the climate, soils, and water. California has an incredibly diverse topography. Elevation ranges from 282 feet below sea level in Death Valley to 14,496 feet at Mt. Whitney. Interestingly, these two locations are only about 50 miles apart. Mountain ranges include the Coast Ranges, which extend the length of the state along the Pacific Ocean; the Sierra Nevada; the Klamath Mountains in the northwest corner of the state; and the Transverse Range, which extends east to west, separating southern California from the Central Valley and Sierra Nevada (fig. 7).

The weather patterns in California result primarily from influences of the Pacific Ocean, the Central Valley, and the various mountain ranges. Moist air from the ocean moves up the mountains, cooling and condensing as it rises. This causes rain to fall on the west slopes of the Coast Range and Sierra Nevada, and on the south side of the Transverse Range. As a result, these

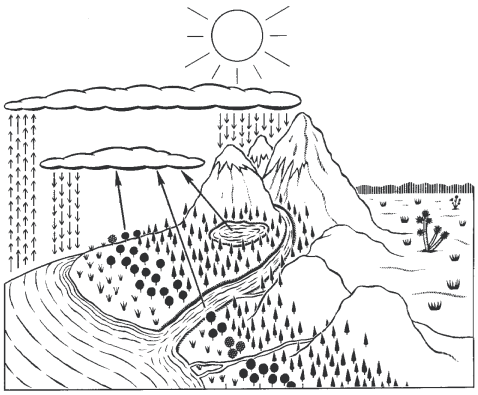

Figure 8. Mountains produce "rain shadows." A portion of the West Coast in California showing the water cycle west of the mountains and the desert east of the mountains. *Source:* Redrawn from Buchsbaum and Buchsbaum 1972.

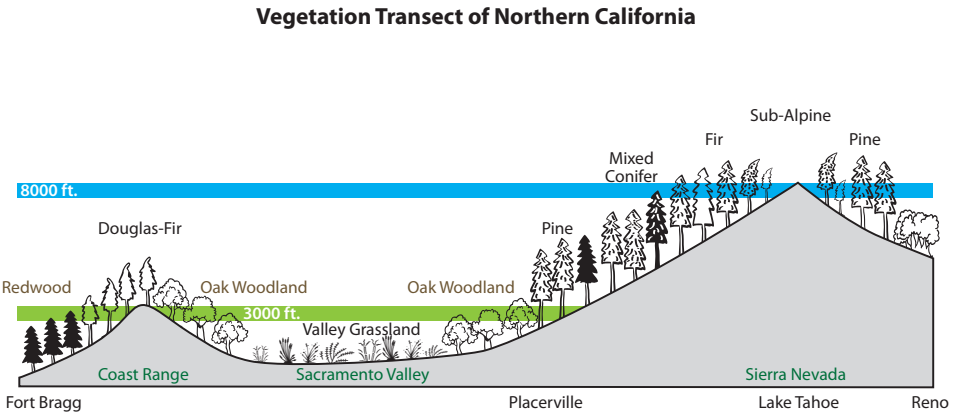

Figure 9. Vegetation transect from the ocean across the Coast Range mountains, Central Valley, and the Sierra Nevada mountains. Moisture-laden storms from the west drop most of their precipitation on the western slopes of the Coast Range and Sierra Nevada. The eastern slope of these mountains are in a droughty rain shadow.

areas have the most extensive forests in California. By the time the air gets to the lee side of the mountains it is depleted of moisture, resulting in a rain shadow—the dry San Joaquin Valley, Great Basin, and the Mojave Desert (fig. 8). Many plants tolerate only limited, specific ranges in temperature and moisture. The extremes of temperature (usually first frost in the fall) and moisture (the length of dry season) are two of the major factors that determine which plant and animal communities can survive. In California's Mediterranean climate most of the state receives little or no precipitation from April to October. However, because of its diverse topography and wide span in latitude there is a great variety of local climates and microclimates. California temperatures can reach 130°F in the desert or go below –50°F in the mountains (fig. 9).

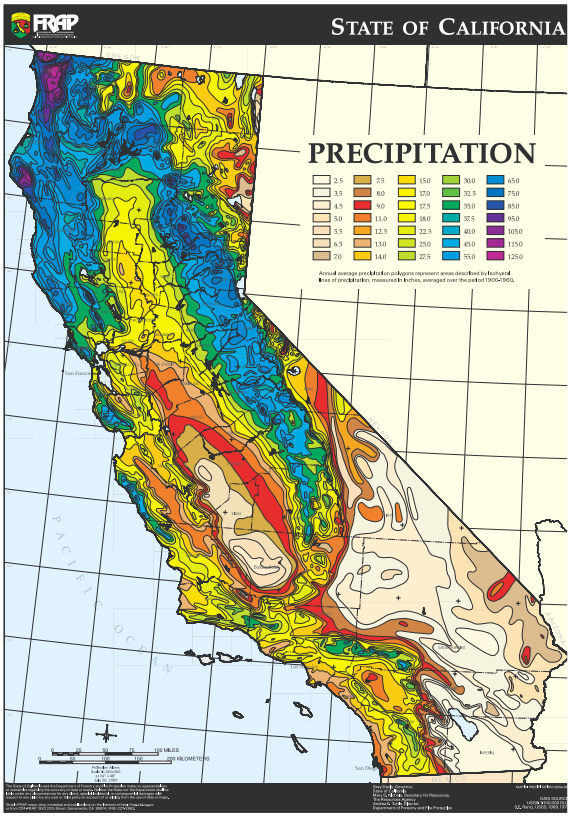

Figure 10. Precipitation map of California; mean zones, 1900–1960. *Source:* California Department of Forestry and Fire Protection.

The amount, timing, and form of precipitation (rain, snow, or fog) are the major determinants of what vegetation will grow in an area. California forests receive a wide range of precipitation—from as much as 200 inches per year on the North Coast to less than 10 inches in the desert (fig. 10). Snowfall occurs at higher elevations, and the snowpack represents an important source of water for the summer growing season. The unique North Coast redwood forests exist because of the fog belt and year-round temperate growing season along the coast.

Within the dominant climate of an area there are local climates (e.g., the cooler and moister environment of a riparian area along a stream or the difference in temperature between south- and north-facing slopes). At an even smaller scale, plants and animals may find microclimates that meet their special needs. Examples include burrowing animals that live underground where climate and temperature conditions remain very constant, or mosses that find adequate moisture around a spring or seep. On your land you may recognize different microclimates and notice they support different species.

FOREST SOILS

Soil is the substrate upon which plants grow and from which they get their nutrients and water. Your forest's soil determines what plants can and cannot grow there, and how fast and how much biomass those plants can produce. Keeping the soil healthy and in place protects your land.

Soil is derived from decomposed and weathered parent rock. In the Sierra Nevada and Transverse Range soils develop mainly from granitic rocks. Volcanic materials form most soils in the Cascades. Sedimentary rocks that have been broken down, moved, and deposited by water form the typical North Coast soils. Soils include varying amounts of organic matter, depending on their age and location. The soil's chemical and physical properties, which include texture, structure, organic matter content, nutrients and soil acidity (pH), determine its capacity to grow plants, its susceptibility to erosion and water transmission, and its suitability for construction of roads, septic tank leach fields, and building foundations.

Soil texture is the size and proportions of the mineral particles that make up the soil. It determines how well the soil will retain water and nutrients. The three major soil texture categories are sand, silt, and clay. The relative proportions of these determine the soil texture and physical properties. Sandy soils are coarse textured, clay soils fine textured, and silty soils are intermediate in texture. Loam is a soil texture consisting of nearly equal amounts of sand, silt, and clay. Textures between these classifications can also be used to describe soil types, e.g., sandy loam or clay loam.

Clays are the smallest particles. When wet, they are sticky and plastic, easily deformed, and unable to bear great weight (they make a poor road base). They become hard and strong when dry. Clay soils have tiny spaces between soil particles that hold water for a long time. Clay particles also have large surface areas that hold important plant nutrients. Silt is smooth and slippery when wet. The individual particles are much smaller than those of sand, though larger than clay. Sand is gritty to the touch. It is the largest of the three size classes of soil particles, and the individual grains or particles can be seen with the naked eye. Sand has large spaces between the grains and gives up water to plants easily but also loses water quickly as water drains through the porous grain structure.

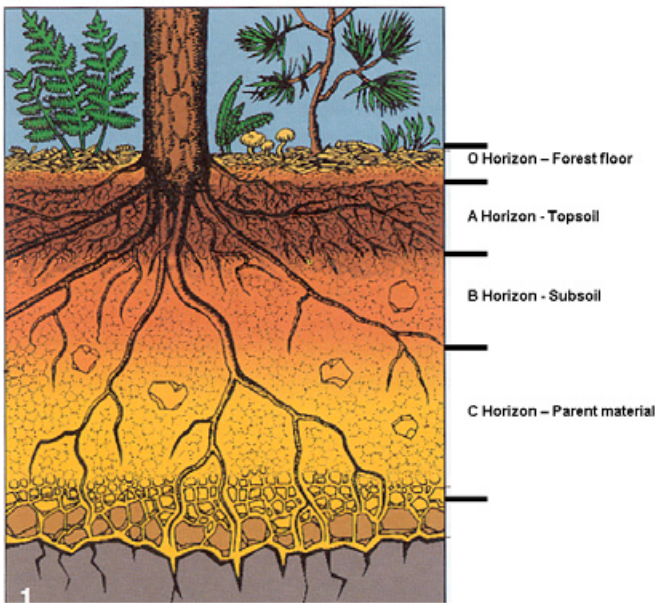

Figure 11. Soil profile. Soil horizons develop like cake layers in response to geology, climate, plants and animals, and time, creating organic matter and nutrient-rich topsoil (A horizon) and clay-accumulating, moisture-holding subsoil (B horizon). Forest soils have a litter (leaves, branches) layer and an organic matter horizon (O horizon) that distinguish them from valley agricultural soils with very little surface organic matter. *Source:* Powers 1990, p. 14.

Soil structure refers to the horizontal layers, or horizons, of soil, starting with the humus on top, then topsoil, subsoil, and on down to the parent material on the bottom (fig. 11). Organic matter (the decomposed remains of plants and animals) holds soil particles together and provides the phosphorus, sulfur, and nitrogen that are essential for plant growth. Darker-colored soil usually means a relatively high level of organic matter is present. In the inland forests of California where all of the precipitation occurs in the winter, moisture is the most limiting plant growth factor. The soil must hold all the water a plant will require during the rainless growing season. Soils that have a medium or loam texture and are 2 to 4 feet deep to bedrock hold sufficient moisture to sustain and grow conifer forest trees.

Soils supply all the nutrients necessary for plant growth except carbon, which is supplied by

the atmosphere as carbon dioxide. Soil nutrients include six macronutrients required in relatively large amounts (pounds per acre per year) and eleven micronutrients required in small amounts (ounces or grams per acre per year). The three most important macronutrients are nitrogen (N), phosphorus (P), and potassium (K). Forest soils are typically low in nitrogen content compared with agricultural soils, with less than 1 percent available nitrogen. However, this naturally low level does not result in poor tree growth or health because trees have many years to accumulate the nitrogen necessary for healthy growth (unlike corn or annual crops that must complete their growth in a few months), and trees internally recycle nitrogen and other elements and are not dependent upon decomposition of leaves on the forest floor for nutrients every year. While conifers will respond to nitrogen and other fertilizers, they are unnecessary for normal, healthy tree growth and development. As noted above, growing season moisture is usually the growth limiting factor in California forests.

Mineral deficiencies and imbalances can be seen in plants. A few unique soils, such as those derived from serpentine (California's state rock), have compositions that are toxic to many plants. Specially adapted plant communities have evolved in these areas, including plants that can tolerate the high nickel, copper, and magnesium concentrations.

The concern is often raised that tree harvest will deplete the forest of essential nutrients. In California's temperate forest ecosystems 90 percent or more of a forest ecosystem's nitrogen (and other essential nutrients) is in the soil. The forest floor, with its leaves, needles, and decomposing organic matter, contains another 5 percent of the nitrogen, and all the standing vegetation the remaining 5 percent. Thus, removing all the standing vegetation completely would remove 5 percent of the ecosystem's plant nutrients. Nitrogen is replenished at a rate of a few pounds per acre per year in precipitation (air polluted with nitrous oxides yields even more nitrogen in the precipitation). In contrast, tropical rain forests that have climates suitable for year-round growth have most of their plant nutrients in the vegetation. The soil is relatively sterile, and most plant nutrients are derived from decomposing and recycled plant matter that falls to the forest floor. Tree harvesting in tropical forests can remove significant amounts of nutrients if the nutrient-rich leaves and bark are not left on-site (wood has relatively low nutrient concentrations, which is why wood is not a particularly palatable food except for termites, fungi, and wood borers).

Soil acidity, measured as pH, influences the availability of essential and toxic elements as well as the ability of a plant to take up certain essential nutrients. The acidity of a soil also affects soil microorganisms, whose decomposition activity affects the amount and availability of essential nutrients like nitrogen, phosphorus, and calcium and of toxic elements like boron. Forest soils are generally slightly acidic, a condition to which conifers are well adapted. Highly acidic soils are often associated with iron, copper, or gold mine tailings. Highly alkaline soils are rare in California forests except in serpentine rock areas.

Productivity of the soil in terms of plant growth, or biomass, can increase over time as organic matter increases and more rock weathers into soil, but these changes do not occur within the scale of a human lifetime. Productivity can be improved by management practices such as adding organic matter, fertilizing, and tilling, but these activities are generally too expensive to carry out over large areas of forestland. Although it is difficult to improve the productivity of forestland, productivity can definitely be reduced through poor management. Once reduced, it is difficult to restore. Threats to the soil's productivity include soil compaction, nutrient depletion, and soil erosion. Good forest management practices can minimize these threats.

PLANT IDENTIFICATION

To really know your forest, identify the major species of plants and animals living there. Many good resources are available for doing this, including published and Internet guides and the input of knowledgeable neighbors or professionals. When identifying plants, take care to note any that may be listed as threatened or endangered, as well as those considered to be pests. Also, it is important to know the scientific name of a plant because the common name is sometimes given to two or more different plants, for example, "red fir" has been used for *Pseudotsuga menziesii* (Douglas-fir) as well as for *Abies magnifica*. For scientific names of common forest plants, see table 1.

A tree is a woody perennial (living more than one season) plant that usually has a single trunk. Trees are identified primarily by their leaves, bark, flowers, and shape. They can be categorized as softwoods, conifers, or evergreen versus hardwoods, deciduous, or broadleaf. Conifers are cone-bearing trees with needle-shaped or scalelike leaves. Their cone characteristics, the number and length of needles in a bundle, and their bark texture and pattern can be used to identify them. Broadleaf trees can be deciduous or evergreen; in California all native broadleaf trees are hardwoods such as oak, alder, madrone and tanoak. Broadleaf trees are most readily identified by their leaf shapes and acorns or fruits.

A shrub is a perennial woody plant that usually has multiple stems. Some plant species can grow as either shrubs or small trees depending on environmental conditions. Shrubs are most easily identified by their leaf shapes and fruits. Several California shrub genera such as the *Ceanothus* and *Manzanita* have many species that are difficult to distinguish from each other.

Table 1. Common and scientific names of plants

Common name	Scientific name
big leaf maple	*Acer macrophyllum*
bitter cherry	*Prunus emarginata*
black cottonwood	*Populus trichocarpa*
black oak	*Quercus kelloggii*
California bay	*Umbellularia californica*
canyon live oak	*Quercus chrysolepis*
ceanothus	*Ceanothus spp.*
coast live oak	*Quercus agrifolia*
coast redwood	*Sequoia sempervirens*
dogwood	*Cornus nuttallii*
Douglas-fir	*Pseudotsuga menziesii*
grand fir	*Abies grandis*
gray pine	*Pinus sabiniana*
hazelnut	*Corylus cornuta*
huckleberry	*Vaccinium ovatum*
incense cedar	*Calocedrus decurrens*
Jeffrey pine	*Pinus jeffreyi*
juniper	*Juniperus occidentalis*
lodgepole pine	*Pinus contorta*
manzanita	*Arctostaphylos spp.*
mountain hemlock	*Tsuga mertensiana*
mountain mahogany	*Cercocarpus betuloides*
mountain misery	*Chamaebatia foliolosa*
oaks	*Quercus spp.*
Pacific madrone	*Arbutus menziesii*
poison oak	*Toxicodendron diversilobum*
ponderosa pine	*Pinus ponderosa*
red fir	*Abies magnifica*
rhododendron	*Rhododendron macrophyllum*
salal	*Gaultheria shallon*
sugar pine	*Pinus lambertiana*
tanoak	*Lithocarpus densiflorus*
white alder	*Alnus rhombifolia*
white fir	*Abies concolor*
whitebark pine	*Pinus albicaulis*
willow	*Salix* spp.

Many annual and perennial herbaceous plants grow in California forests. Common favorites tend to be the showy wildflowers we all love to see in the spring. These plants are best identified when the flowers are blooming. There are many excellent flower guides; it is best to find one written for your region.

Ferns are an ancient group of plants that lack flowers and seeds. They have fronds (leaves), rhizomes (roots), and a rachis (central stalk) (fig. 12). At certain times of year the underside of the fronds bear sori, the reproductive bodies containing spores. The pattern of sori as well as frond shape are identifying features of the ferns.

Although often overlooked, lichens and mosses are important members of forest ecosystems. Lichens, found on the surface of rocks and trees, are often confused with mosses. Lichens consist of a fungus and an alga that live together in a mutually beneficial arrangement called symbiosis. The fungus provides shelter and moisture for the alga, while the alga manufactures food through photosynthesis. Lichens are very hardy and can withstand extreme cold, drought, and sunlight. Some lichens can live on bare rock, where they produce acids that break down the rock, aiding in soil formation. Some lichens are very sensitive to air pollution; the presence or

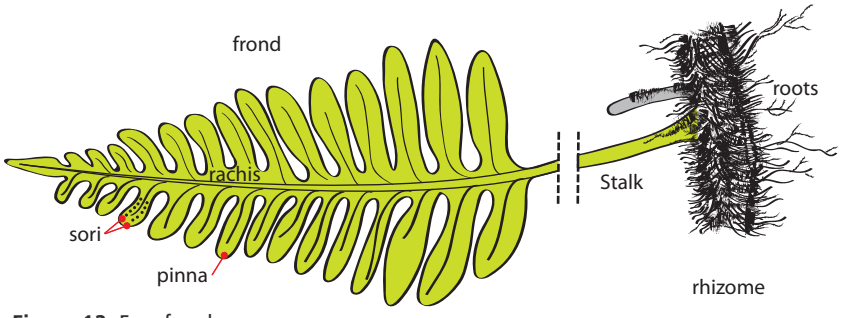

Figure 12. Fern frond.

absence of these sensitive species can help you determine your air quality. Some lichens have a third symbiont, a nitrogen-fixing bacteria that can transform atmospheric nitrogen from an inorganic compound to an organic one useable by plants . Lichens are identified by their forms, colors, and habitat. Mosses are primitive green plants that grow primarily in moist habitats, in riparian areas, or in the shady understory of forest trees. Species identification is difficult and requires some expertise.

Neither lichens nor mosses injure the trees or plants on which they grow. They have neither roots nor vascular systems that invade the plants. They are merely attached to the plants (epiphytes), not parasitic on them as mistletoe or some fungi can be. Neither moss nor lichen grow only on the north side of trees.

A number of common plants do not fit easily into the above categories. These include horsetail, cattail, grasses, sedges, and rushes. Learning to identify these plants, when they flower, and which habitats they prefer can be challenging, but generally is a fun and rewarding experience.

ANIMALS IN THE ECOSYSTEM

Wildlife is an especially fascinating component of the forest, one that many landowners are eager to encourage, or in some cases discourage. Animals depend on plants for their food, shelter, nesting places, refuge, and other elements necessary for survival. Therefore, the composition and structure of the plant community largely determine which animals can be found there. The place where a plant or animal lives is its habitat; what it does in that habitat, its role or function in the community, is its niche. Complex plant communities tend to have more habitats and niches available to support more types of animals. Most animals are associated with specific plant communities and habitats that provide food, water, hiding cover and protection from weather, and nesting or reproductive areas. The best way to manage forestland for these wildlife species is to provide the type of habitat they require.

Most natural forests contain a variety of habitat types: wetlands, meadows, trees of different ages and sizes, snags and fallen logs, various plant communities, and physical features. These provide a mosaic of habitats that can be used by different animals. Each species requires a variety of habitat elements to survive.

A diverse wildlife population is essential to a healthy forest. Wildlife provides vital functions for the forest—they control insect populations, pollinate plants, and aid in seed dispersal. Predators keep the herbivore population in check, protecting the forest from overgrazing. Burrowing animals such as rodents and earthworms aerate the soil and recycle nutrients. Squirrels bury acorns, in effect planting oak trees. Plants and animals in a forest community have evolved complex interdependent relationships that are mutually beneficial and necessary for a healthy forest ecosystem.

Interactions between and among Species

The complex interactions between and among plants and animals in an ecosystem can be positive, negative, or neutral depending upon our management goals, what we are trying to create or achieve. An example of a positive interaction is that of trees and mycorrhizae (fungus root). Mycorrhizae are fungi that bond with plant roots and assist host plants in obtaining water and nutrients by growing faster and into a larger soil volume than the roots can alone. Mycorrhizae also provide host plant roots with antibiotic defense from soilborne diseases. In exchange, the fungi receive carbohydrates from the tree's photosynthesis. This type of mutually beneficial association is called symbiosis. Negative interactions are also important in defining the forest ecosystem. One important example is competition. Competition occurs in nature for any factor that is in limited supply, including space, sunlight, water, nutrients, food, mates, habitat, and so on. The

Two Survival Strategies: Specialist versus Generalist

Giant sequoia is something of a specialist ecologically. Limited to a small number of groves, it requires specific conditions to grow and reproduce successfully. Its shallow but extensive fibrous root system grows best in deep, well-drained sandy loams. It prefers moderate climate sites, such as drainage bottoms and meadow edges. Adequate soil moisture throughout the dry growing season is critical for successful regeneration of giant sequoia, although seedlings do not survive in wet soils. Regeneration depends on an occasional intense, large-scale fire to open the cones and create a seedbed for the young seedlings to survive. Light intensity, frequent fires are also necessary to thin out the more shade-tolerant but fire-intolerant white firs that compete with young sequoia seedlings for light and soil moisture.

Douglas-fir is something of a generalist. Widespread throughout the West, it thrives in a variety of habitats, soil types, and environmental conditions. Its moderate shade tolerance allows it to grow in the understory and respond well when light and moisture become available by thinning or the death of competing trees. Older trees develop a thick, fire-resistant bark.

ability to outcompete others for the necessary life requirements is a key to survival for plants and animals. The forest practice of thinning young trees decreases competition for sunlight, water, and nutrients and increases the remaining trees' survival and growth, as well as their resistance to insect and disease attack.

Species can be highly adapted for very specific conditions (specialists) or can tolerate a wide range of conditions (generalists). Specialists have an advantage when conditions are stable; they can often outcompete the generalists in their limited habitat. However, when conditions change, specialists may have trouble surviving and adapting to the new conditions.

DECOMPOSERS

Bacteria, mold, fungi, some insects, and other small and often overlooked organisms play an extremely vital role in any ecosystem. They are the recyclers, responsible for breaking down the bodies of plants and animals into their nutrient elements, making them available to plants. As these tissues decay, they become dispersed into fragments called organic detritus. Organic detritus is a food source, improves soil texture, and provides nutrients to the community. Nutrient-rich leaves decay more quickly than nutrient-poor wood.

In forests in the western United States, wildfire is an important decomposer of plants. In tropical rain forests and eastern hardwood forests with year-round moisture, biological decomposition plays a large role in reducing plant and animal material to nutrient elements that return to the soil for uptake by plants. Many western forests have extended dry seasons when it is too dry or too hot for biological decomposition to proceed rapidly. Biomass accumulates to the point where it will carry a fire. Human fire suppression efforts in the twentieth century have limited the extent of frequent, low-intensity wildfires and have allowed forest fuel to build up to the point where large, intense, catastrophic wildfires are occurring that cannot be easily suppressed.

BIODIVERSITY

Biological diversity, or biodiversity, is the variety and abundance of life forms, processes, functions, and structures of plants, animals, and other living organisms in an ecosystem. Biodiversity can be assessed at the level of the gene pool, species, community, ecosystem, or region or landscape (multiple ecosystems). Each level of biodiversity has three components: compositional diversity, or the number of elements within the system at that scale; structural diversity, or the variety of patterns or organizations within a system; and functional diversity, or the number of ecological processes within a system. The effects of changes in biodiversity thus depend on the scale and the aspect of biodiversity being considered. Changes in species diversity and habitats are often used as indicators of the health of an ecosystem.

Young forests usually have a greater number of individual species—often generalists and weeds—than do mature forests. As a consequence, they may have a higher level of biodiversity as measured by the number of species. But older forests support some species that cannot survive in younger forests due to the species' more complex habitat requirements. Older forest characteristics include decaying logs, shrubs, a variety of tree species, snags, and often a multilayered canopy that supports a community of

canopy dwellers. Some wildlife species such as northern spotted owl and Pacific fisher are highly dependent on old-forest habitat and have been reduced in numbers because this habitat has become increasingly scarce. In the case of the northern spotted owl, it has effectively become an emblem for old forests, even though in California it has been shown to survive in younger forests as well.

The example of the northern spotted owl illustrates the problem inherent in the concept of biodiversity. Biodiversity must be understood in the context of scale and level of biological organization. In some circumstances, managing to maximize one aspect of biodiversity, such as species diversity, may take a tremendous toll on certain plant or wildlife species. As a general rule, managing for biodiversity at the landscape level is most feasible and sustainable, that is, creating a diversity of different habitats over a relatively large geographic area will provide the most ecological benefits over the long term.

ENERGY FLOW THROUGH AN ECOSYSTEM

All living things need energy to survive. Solar radiation from the sun is the source of energy that supports most natural ecosystems. Through photosynthesis, green plants convert light into chemical energy (carbohydrates) that supports the production of wood, leaves, branches, fruit, seed, and so on. Herbivores get their energy by eating plants, carnivores by eating other animals, and decomposers though the breakdown of plants and animals. Through decomposition, nutrients are made available to the soil flora and fauna and energy (in the form of heat) is released to the environment. Each step in this chain is called a trophic level. In natural communities this complex chain is often called the food web. As energy flows from the sun through an ecosystem, at each step some of the energy is lost to the environment in the form of heat during metabolism and decomposition.

Follow the Energy through an Ecosystem

Energy flows through an ecosystem by many pathways. A tree absorbs sunlight through its leaves and converts it to chemical energy (i.e., carbohydrates and plant tissues) through the process of photosynthesis. Some of that energy is stored as cellulose and carbohydrates in the trunk, roots, fruit, and leaves for the tree's later use or is used to support the process of gathering more sunlight. The tree respires, burning sugar to produce energy for cell functions. An animal, such as a deer, browses the foliage for its energy needs. When leaves or branches fall to the ground, decomposers—worms, insects, and fungi—take over, breaking the leaves down to smaller and smaller components that can eventually be taken up by the roots again as nutrients. A robin might eat the worm that helped decompose the leaves; a hawk could then feed on the robin. The fungus that grew on the worm's castings could form a mushroom, which is eaten by a squirrel that is eaten by a fox. When the fox dies, its body feeds scavenger insects and fungi.

CHEMICAL CYCLES

While energy flows one way through the system requiring constant input from the sun, other processes cycle elements around and around with no net gain or loss of the element, just transformation or change in its form.

Nitrogen, an essential element for life, is an important example. The atmosphere is approximately 78 percent nitrogen. Despite its abundance, gaseous nitrogen (N_2) cannot be used by plants and animals directly. It must be transformed, or fixed, into ammonium (NH_4). Nitrogen fixation occurs naturally in two ways: a small amount is produced by lightning, but much more is produced on land by special types of bacteria. Nitrogen-fixing bacteria are found in soil or water or in swollen tissues, called nodules, on the roots of some plants (such as legumes and ceanothus) or in some species of lichens. These plants and bacteria have formed a mutually beneficial (symbiotic) relationship where the bacteria gets water, nutrients, and protection from the plant in return for supplying the plant with a source of fixed and biologically available nitrogen.

Once nitrogen enters a plant it is transformed into proteins and other compounds necessary for plant tissues and functions. When animals eat the plants, they incorporate the nitrogen into their own tissues. Eventually, the nitrogen in proteins and tissues is released by decomposers, where it can go through a decomposition process called

denitrification that turns the usable nitrogen back into nitrogen gas, which then returns to the atmosphere.

Low natural rates of fixation often make nitrogen the limiting factor in plant growth. This limitation can be overcome with the use of nitrogen fertilizers, but application of too much fertilizer can cause water quality problems. Nitrogen fertilizers are highly soluble and may run off into rivers, lakes, and streams, causing pollution. Nitrogen oxides, a product of automobile exhaust and burning fossil fuel, can create smog and can fall as acid rain. In Southern California, such nitrogen-rich rain is fertilizing some ecosystems and changing their composition and productivity, often to the detriment of the native plants that tolerate naturally low levels of nitrogen. On the North Coast there is increasing evidence that the returning spawning salmon are an important source of nutrients for those ecosystems, bringing nitrogen and other elements harvested from the ocean back to terrestrial watersheds, where they spawn and die along the river banks to decompose or be eaten by other animals.

Other chemical elements are cycled through ecosystems in similar ways. These include carbon, hydrogen, oxygen, nitrogen, phosphorus, calcium, and potassium. These chemicals are absorbed by plants from the soil or air; the plants are then eaten by animals, and eventually decomposers break them down, returning the elements to the soil or water and carbon dioxide to the air.

Any element in short supply may be the limiting growth factor for a plant or animal. For example, calcium is often deficient in serpentine soils, which limits the species of plants that can grow there. Some plants and animals have evolved the ability to survive in these otherwise "hostile" environments.

WATER CYCLE

In California, with its Mediterranean climate and annual drought period, water is the most important factor limiting plant growth and ecosystem productivity. The water (hydrologic) cycle dramatically shapes the environment (fig. 13). It begins when water evaporates from oceans, lakes, rivers, and other water bodies. In addition, water moves from the soil through roots and stems to the leaves and then to the atmosphere, a process called transpiration. Water in gaseous form (water vapor) in the atmosphere con-

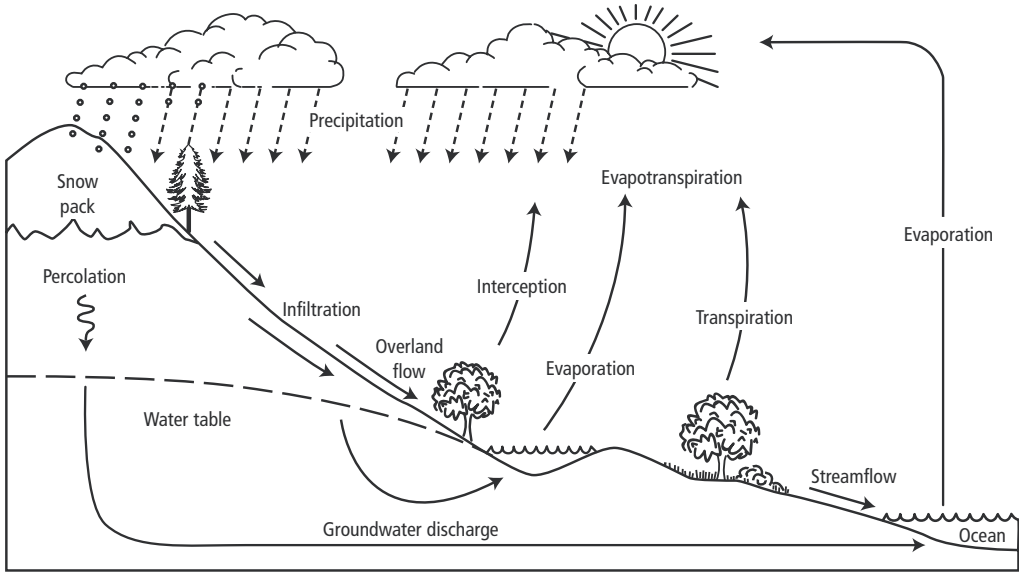

Figure 13. The water, or hydrologic, cycle.

denses into clouds as it rises and cools, eventually falling as precipitation. When precipitation reaches the ground as rain or snow, most of the water that is not absorbed by the soil and plants returns to streams and lakes and eventually reaches the ocean. Some is stored as groundwater.

SUCCESSION

In studying forest communities, patterns of plant development emerge. One of these is known as succession, the somewhat predictable and often lengthy sequence in which one community replaces another, ending in a climax community that is self-perpetuating. For example, after a fire or other large-scale disturbance, the first plants to reestablish themselves tend to be grasses and various herbaceous species that grow quickly in direct sunlight. These give way to larger shrubs (e.g., chaparral species such as manzanita) that grow more slowly but eventually shade out the grasses. The chaparral plants may grow so densely they exclude other species for a long time, perhaps decades. Trees such as pines need sunlight to grow. If there is an opening in the chaparral the trees can get above it in a few years, shading out the chaparral, which requires sunlight. The reforestation technique of removing brush for the first few years after planting to "release" young seedlings is actually a practice to speed the successional process along to the next stage.

Succession may include changes in soil chemistry as well as species composition. After a fire, when nitrogen in the soil may be deficient, plants that can grow in low-nitrogen conditions have an advantage. Plants such as lupines or alder, which contain nitrogen-fixing bacteria in their roots, are often pioneer species. As these first pioneer plants in an open, cleared site grow and die they decompose, releasing their organic matter and nitrogen to the soil. This allows species that require more nitrogen to grow in that place.

While succession is often thought of as a well-ordered process, in looking at the total ecosystem you may find many variations in the pattern. Variations in succession occur for a number of reasons, including special soil conditions, microclimate, disturbance, and random chance. The size, severity, and timing of disturbances can vary a great deal. For example, a wildfire burns with varying severity depending on the time of day, wind speed, and air temperature and humidity, creating some areas where trees are killed by a high-intensity fire and plant succession starts over and other areas where many trees survive a lower-intensity fire and the forest does not start anew. Or, insects or disease may attack and kill a particular tree species (bark beetles, root diseases, and dwarf mistletoe are often tree-species-specific), naturally thinning the forest to the advantage of the trees and plants that are unaffected by the disturbance. Consequently, in any forest landscape we may see a mixture of vegetation, including nonforest stages of succession. This mosaic of habitats occurs in any natural ecosystem.

DYNAMIC ECOSYSTEMS

Ecosystems are constantly changing. Forest succession is the more or less orderly change over time as plants grow larger, taller, and more extensive and out-compete other plants for light, water, and nutrients, suppressing or killing them. Disturbance is an expected though usually unpredictable part of any ecosystem that occurs naturally in the form of fire, flood, insect and disease damage, wind throw, and other natural events. Many common forest practices mimic natural disturbance to some extent. For example, prescribed burns introduce fire into the ecosystem in a controlled manner, and timber harvest opens up the forest floor to sunlight.

Fire is a significant form of disturbance in California forest ecosystems. Many California forests are adapted to fire and have trees, plants, and animals with struc-

tures and reproductive cycles that tolerate fire of a certain frequency and severity. In the Sierra Nevada, mixed conifer forests have adapted to frequent (every 10 to 20 years), low-intensity surface fires that tend to kill small trees, grass, and brush but do not kill the larger, thicker barked trees. Some fire-adapted brush species resprout following fire, giving them an advantage over species that grow from seed and take a few years to become established. Fire also releases the seeds of trees and plants that need fire to germinate, cleans the forest floor of accumulated duff and litter, destroys insects and disease-causing organisms, thins smaller trees, releases nutrients from plant tissue into the soil, and produces mosaics of habitat in the forest.

Disturbance opens up the forest canopy, allowing the establishment of new plants, in effect setting succession back to an earlier state. However, in many of our forests disturbance size and severity has increased beyond the historic natural range due to human influence. Roads, dams, logging, fire suppression, and prescribed burning can have a negative effect on the forest. In particular, wildfires have become larger and more severe since 1900, when we began to successfully suppress small fires. A forest that historically would have burned with relatively low intensity every 20 years has built up 100 years' worth of fuel and now burns with great intensity and rapid spread.

Although disturbance is natural and necessary, there is a matter of scale. Humans perceive as "natural" (and prefer) disturbance that occurs on a small scale, in patches in the forest. When disturbance occurs over vast areas of the forest, more time is required for recovery. Intense fire, for example, may change the soil chemistry or make the soil impermeable to water, which can cause erosion. If all the seed trees are killed over a large area, it takes longer for new trees to become established and longer for the associated wildlife to return.

ECOLOGICAL FUNCTIONS

The forest ecosystem is more than the sum of its parts. As a whole, the ecosystem performs a number of functions, or services, with benefits far beyond its borders. Through photosynthesis, forests release oxygen to the atmosphere and store carbon in wood, producing the oxygen we breathe and ameliorating some of the causes of global warming. Forests can moderate local and regional temperatures. Water is filtered and purified through the soil and litter of forests. The rate of water runoff is decreased, preventing floods and increasing the amount of water that percolates through the soil to underground aquifers. Forest vegetation protects soil from erosion. Forests support the organisms that keep the food web intact. They stabilize stream banks and provide cooling cover, large woody debris, and food sources for fish. These and other functions are part of the life support system of our planet.

USING ECOLOGICAL CONCEPTS FOR MANAGEMENT

To manage the forest as an ecosystem that provides services and life support functions consider the following management strategies.

- Reduce soil disturbance in all your activities.
- Recruit and retain some logs, snags (standing dead trees), and debris in the forest to provide habitat and nutrients to the soil.
- Protect riparian areas by providing functional habitat buffers along streams.
- Arrange harvest units so as to provide corridors for animal use.
- Provide structural diversity appropriate to your forest type.
- Reintroduce fire where practical.

RESOURCES

Most private forestland has a National Forest in its vicinity. The Forest Service has a wealth of information on forest ecology, soils, climate, and other environmental conditions that you may find relevant to your forest and its management. It is best to visit local Forest Service offices to find out what is available; for the location of your local office, visit the Forest Service's Pacific Southwest Region Web site at http://www.fs.fed.us/r5/.

Numerous texts and popular books and articles focus on California forest ecology. These can be accessed through university libraries or through in Internet search for "California forest ecology."

The California Native Plant Society (http://www.cnps.org) has many publications that will assist you in identifying plants on your property.

The Natural Resources Conservation Service may have soil maps that include your property; see http://www.ca.nrcs.usda.gov/ and http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx.

Visit the California Biodiversity Council Web site at http://ceres.ca.gov/biodiv/ to find out more about challenges of protecting and preserving California's natural heritage.

Finally, your local California Department of Forestry and Fire Protection (CAL FIRE) (http://www.fire.ca.gov) and Department of Fish and Game (DFG) (http://www.dfg.ca.gov) staff will be well-informed about forest ecology, timber harvest impacts, and related matters. The CAL FIRE Forest and Resource Assessment Program (FRAP) has a tremendous amount of mapped and published information; find them at http://www.fire.ca.gov.

BIBLIOGRAPHY

Alt, David, and Donald Hyndman. 2000. Roadside geology of Northern and Central California. Missoula, MT: Mountain Press.

Barbour, Michael, Bruce Pavlik, Frank Drysdale, and Susan Lindstrom. 1993. California's changing landscapes: Diversity and conservation of California vegetation. Sacramento: California Native Plant Society.

Belzer, Thomas J. 1984. Roadside plants of Southern California. Missoula, MT: Mountain Press.

Buchsbaum, Ralph, and Mildred Buschbaum. 1972. Basic ecology. Pacific Grove, CA: Boxwood Press.

Clarke, Charlotte Bringle. 1977. Edible and useful plants of California. Berkeley: University of California Press.

Hickman, James C., ed. 1993. The Jepson manual: Higher plants of California. Berkeley: University of California Press.

Johnston, Verna R. 1994. California forest and woodlands: A natural history. California Natural History Guides 58. Berkeley: University of California Press.

Lanner, Ronald M. 1999. Conifers of California. Los Olivos, CA: Cachuma Press.

Niehaus, Theodore F. 1976. A field guide to Pacific States wildflowers: Washington, Oregon, California and adjacent areas. Boston: Houghton Mifflin.

Powers, R. F., ed. 1990. Sustaining site productivity on forestlands. Oakland: University of California Division of Agriculture and Natural Resources Publication 21481.

Weeden, Norman F. 1996. A Sierra Nevada flora. Berkeley: Wilderness Press.

What tree is that? A guide to the more common trees found in the Western U.S. Nebraska City, NE: National Arbor Day Foundation. Order from the National Arbor Day Web site, www.arborday.org.

Online Guides

Calflora, California wildland plants Web site, http://www.calflora.org/index0.html.

CalPhotos: Plants, UC Berkeley CalPhotos Web site, http://calphotos.berkeley.edu/flora/.

Natural Resources Conservation Service Plants Database, http://plants.usda.gov/.

What Tree Is That? Online tree identification database, National Arbor Day Foundation Web site, http://www.arborday.org/trees/treeID.cfm.

ENGLISH–METRIC CONVERSIONS

English	Conversion factor for English to Metric	Conversion factor for Metric to English	Metric
Length			
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FOREST STEWARDSHIP SERIES 4

Forest History

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Your forest is the result of a long history of physical, biological, and cultural events that have shaped the land and created the plant and animal communities found there. Disturbances at various scales, from geological ones like volcanoes and glaciers to local ones such as fires and forest practices, have interacted with biological forces of plant and animal development and succession to make your forest what it is. This publication highlights some of the major events and eras that have influenced California forests. A historical context is useful to obtain a better understanding of your forest, to help envision what it may have looked like in the past, and to help you predict what the future might bring. It also serves as a reminder that forests are dynamic: what we see now is simply a snapshot in historical time.

Objective

Understand the important influences of historical natural and cultural events on California forests.

Competencies

- *Understand that the forest we see today is the end result of numerous natural and cultural disturbance events.*
- *Become familiar with major shaping events in the history of California forests, including Native American practices, the Gold Rush, railroad land grants, creation of forest reserves, the World Wars, and the passage of numerous environmental laws.*
- *Learn how to find information about the history of your property.*

Related Forest Stewardship Series Publications

- *Forest Ecology (ANR Publication 8233)*
- *Vegetation Management (ANR Publication 8236)*

UC PEER REVIEWED

GEOLOGICAL HISTORY

California natural history includes a great variety of natural activity. Glaciers, volcanoes, earthquakes, floods, and winds have helped build the physical landscape we see today. Geological processes created the mountains, plains, and valleys of California, with their varied elevations and topography. These in turn affect the climatic patterns in the state, most importantly the rain and snow in the Coast Range, Klamath and Cascade Mountains, and the Sierra Nevada, and the rain shadow and dry conditions east of them. Because soil develops from the underlying parent rock and soil characteristics, it varies with the rocks present in a given area. For example, volcanic soils found in the Cascade Range are different from the granitic soils of the Sierra Nevada, and the soils in these areas differ markedly from each other. Soil characteristics also affect the potential for landslides and erosion. Climate, topography, and soil type are major determinants of where different tree species can grow.

CLIMATE

Much of California has a Mediterranean climate characterized by cool, moist winters and hot, dry summers. This type of climate is found only in a few other areas of the world: around the Mediterranean Sea and in South Africa, Chile, Australia, and New Zealand. A Mediterranean climate supports vegetation and wildlife that are able to survive an annual drought period with little or no rainfall and the periodic wildfires fostered by those periods of drought.

Climate appears to go through long-term cyclical changes. California has experienced at least six major cool periods over the past 2.4 million years when glaciers covered large regions of the state and intervals of warmer weather caused the glaciers to retreat. Forest species and communities change in response to climatic variation. Some forests, like the Monterey pine forests of the Central Coast, are remnant populations of what were once extensive forests. In the last 150 years California has experienced a warm, moist period compared with the rest of the millennium; this may partially account for the increased vegetation growth seen throughout the state. Warmer periods also correspond to increased wildfire activity.

NATIVE CALIFORNIANS

When Europeans first came to California they believed they had found a vast untouched wilderness. On the contrary, this was a highly managed environment, much of it maintained by and dependent on the intentional activities of native peoples who had lived here for centuries (fig. 1). It is now believed that some of the remarkable diversity found in California ecosystems is actually the result of these management activities.

The most widely used management tool was fire. Native Californians were skilled in the use of low-intensity fire. Fires were set for a number of reasons: to stimulate new plant growth for food and basketry, to create mosaics of habitat to attract desired animals, to destroy disease organisms, to reduce fuel and prevent major forest fires, and to clear the understory vegetation for easier travel and as protection from enemy ambush. Frequent low-intensity fires killed small trees, effectively stopping forest development and thus maintaining meadows, oak woodlands, and native prairie grasslands. Studies have shown that the distribution of some plant species, such as black oak, can be explained only by their continued maintenance through fire by Native Californians.

In addition to fire, the native peoples employed a number of other management techniques: they sowed seeds, transplanted shrubs and small trees, pruned plants, weeded, and constructed ditches and diverted water for irrigation and erosion control. Use of resources also had an effect on the land. In digging for roots, soil was aerated, which encouraged desirable plants, harvesting of basketry material stimulated plant growth. Native Californian societies also had numerous rituals and rules that limited harvesting of natural resources.

Beginning about 150 years ago, the Native Californian population was decimated by European-American immigrants. About one-third of the population, approximately 100,000 people, died between 1848 and 1855. With the cessation of Native Californian management, the number, range, and diversity of many native plant species and habitat types has declined. The impact of Native Californian management on our forests continues to this day.

Figure 1. Territorial boundaries of California Indian tribes. Most boundaries closely followed topographic and watershed boundaries in pre-Columbian times. *Source:* Heizer and Elsasser 1980, reprinted with permission.

LIVESTOCK GRAZING

Sheep, cattle, horses, and in some areas goats and pigs were grazed throughout the Sierra Nevada from the rancho era (early 1800s) and more expansively through the Gold Rush to the middle of the twentieth century. This caused extensive changes in vegetation and wildlife habitat. Sheep, which John Muir referred to as "hoofed locusts," appear to have caused the most extensive changes; numbering in the millions, there was no limit on grazing before 1900. The animals completely denuded many areas, resulting in severe erosion. Changes in vegetation included replacement of native perennial plants with annual species in upper-elevation hillsides and

Figure 2. Hydraulic mining, 1860–1870, Trinity County. Streams were diverted through flumes, ditches, and pipes to monitors (nozzles) to wash gold-bearing gravels into sluce boxes for separation of the gold. *Source:* Eastman's Originals Collection Group 117, Special Collections, University of California Library, Davis, reprinted with permission.

Figure 3. Central Pacific Railroad land grants (white sections) form a checkerboard private ownership pattern with national forest (green sections) along Interstate 80 and the railroad right of way from Sacramento to Reno. *Source:* Courtesy USDI Bureau of Land Management, 1989.

meadows. In addition, many shepherds set fire to the undergrowth as they left the forests in the autumn to ensure new growth for the following year. Changes wrought by the unregulated grazing are still visible in the Sierra Nevada.

MINING AND RELATED ACTIVITIES

The 1849 California Gold Rush caused significant changes to the California landscape, especially in the Sierra Nevada. The population increased significantly as people came from all over the world to find gold. Rivers were dammed and rerouted to expose the gold underneath. New mining techniques required water diversion on a large scale. Placer mining washed gravel from hillsides into wooden troughs to recover the gold. Pits and heaps of discarded rock can be found along stream bottoms in the Mother Lode counties of the central Sierra Nevada foothills. Large dredges mounted on barges mechanized the mining process, leaving tailings in rows of heaps of washed gravel and stones. Hydraulic mining used high-pressure streams of water to sluice down entire hillsides, sending incredible amounts of sediment into waterways, altering river systems and causing flooding downstream and the sedimentation of San Francisco Bay. This practice ended in the 1890s through federal legislation demanded by downstream communities and farmers affected by the sedimentation and flooding caused by mining activities. The scars and changes from the mining period are still highly visible in the Sierra region (fig. 2).

During the mining era, lumber was milled for water flumes, mine timbers, fuel, and building material. The need for wood caused the first extensive cutting of the Sierra forests in the 1850s to 1870s. The second-growth forests that regenerated have grown and since been harvested in many areas during and after World War II. Some of the largest, oldest trees in the Sierra Nevada today date back to those events.

RAILROAD ERA

Between 1850 and 1870, 10 percent of the area of the lower 48 states was used to pay for, build, and operate the transcontinental railroad and telegraph systems. Railroad corporations were given millions of acres of public land, much of which they sold to timber, mining, and other interests. The checkerboard pattern of the railroad land grants can still be seen on the California land ownership map (fig. 3).

Figure 4. Logging by horse team in the coast redwood forest. Logging roads and trails were often located in a streambed. The effects of this practice are evident in streams to this day. *Source:* Ericson Collection, Humboldt State University Library, reprinted with permission.

Railroad construction harvested the forests east of Lake Tahoe for railroad ties, bridges, trestles, and fuel. Construction of snowsheds over the railroad tracks crossing the Sierra Nevada required 300 million board feet of lumber, and another 20 million board feet per year was required for annual maintenance (in comparison, current annual timber growth in the northern Sierra Nevada is about 2 billion board feet). Completion of the transcontinental railroad across the Sierra in the 1860s opened up markets in the eastern part of the country to California lumber. The lumber industry grew between 1890 and the 1920s, when more than 80 railroad logging companies were operating, opening up formerly inaccessible private forestland to development. Railroad logging primarily harvested pine and redwood; fir and cedar were used for fuel. Many of today's forest roads follow the gentle, even grades of these logging railroads.

LOGGING IN THE COAST REDWOOD REGION

The logging of the coast redwood forests started in the late 1800s, beginning with oxen to move logs and progressing to steam (donkey) engines and railroad logging by the 1930s, in much the same pattern as the other forests of the Pacific Northwest. This method of harvesting resulted in the clearing of entire watersheds and generally progressed from the easily accessed coastal forests up through the inland watersheds. The coastal rivers and streams were used as transportation corridors for the logs, resulting in environmental damage that remains with us today in the form of sediment-loaded streams and degraded salmon habitat (fig. 4). Many current timber harvesting plans must address the cumulative impacts of past harvesting practices and implement mitigation measures to offset the potential environmental hazards posed by the combination of past and present management practices.

WORLD WARS I AND II

Better technology and transportation, principally the use of steam engines, increased logging efficiency in the early 1900s. The demand for lumber increased during World War I, and timber companies constructed spur tracks throughout the Sierra forests to facilitate logging. Demand decreased during the Depression, then picked up again during and after World War II with new timber access roads being built through California forests. Many of the roads through the forest that exist today are a remnant of this period. These logging roads increased access to forests and encouraged development and housing in the forest, creating today's wildland-urban interface. Between 1940 and 1960, timber harvests in the state grew from 2 billion to 6 billion board feet per year.

FIRE AND FIRE SUPPRESSION

Fire has always played a major role in the development of California forests. The frequency of natural fire varies by forest type, but it is thought to be between 10 to 20 years (based on fire scar analysis), except in the moister North Coast redwood forest. Natural fires are generally caused by lightning, but Native Californians burned more

Figure 5. The Beaver Creek Pinery (Ishi Wilderness, Tehama County) has continued to experience frequent, low-intensity ground fires because it is so isolated and difficult for fire fighters to get to. Also, being in a wilderness, managers have been interested in allowing natural processes like wildfire to proceed unhampered unless they pose a threat to life or property. This photo was taken in the 1990s, 5 years after the last wildfire burned through the stand, which is thought to represent the Sierra Nevada forest structure prior to the extensive fire suppression efforts of the twentieth century. For scale, note the people in the center of the photo. *Source:* Courtesy Carl Skinner, USDA Forest Service, Pacific Southwest Research Station.

frequently than would be produced by lightning strikes, in some places annually. In the Sierra Nevada this frequent burning produced a forest dominated by fire-resistant pines (fig. 5).

In the early 1900s, fire suppression became the official policy: timber was too valuable to burn and forest communities were at risk. This policy overlooked the essential ecological role that wildfire plays in the forest ecosystem and also disregarded the fact that, over time, fire suppression allows fuel to build up to levels that increase the risk of uncontrollable fires. Problems with the unnaturally dense forests of today include:

- an increased susceptibility to forest insects and diseases because trees are stressed by competition for limited water
- displacement and reduction of understory plants because of dense shade
- conversion of shrub habitats and other foraging areas to conifer thickets
- displacement of deciduous vegetation by conifers, particularly in riparian areas
- reduction and loss of mountain meadows to conifer encroachment
- reduction in habitat diversity of more open and nonforested wildlife habitats

REGULATION OF FOREST PRACTICES

Gifford A. Pinchot, the first chief of the U.S. Forest Service and an early conservationist, wrote in *A Primer of Forestry* (1885) that

> next to the earth itself the forest is the most useful servant of man. Not only does it sustain and regulate the streams, moderate the winds, and beautify the land, but it also supplies wood, the most widely used of all materials. Its uses are numberless, and the demands which are made upon it by mankind are numberless also. It is essential to the well-being of mankind that these demands should be met. They must be met steadily, fully, and at the right time if the forest is to give its best service. The object of practical forestry is precisely to make the forest render its best service to humans in such a way as to increase rather than to diminish its usefulness in the future. Forest management and conservative lumbering are other names for practical forestry. Under whatever name it may be known, practical forestry means both the use and preservation of the forest.

Because of public concern about unsustainable and destructive resource consumption, the state and federal government became involved in conservation issues in the latter part of the nineteenth century. In 1884, a court decision limited hydraulic mining because of the damage caused downstream by flooding and sedimentation. In 1885 the State Board of Forestry was created to address problems of poor regeneration of cutover forests, large fires, and grazing-related erosion. Federal forest reserves and national parks were created in the 1890s. The U.S. Forest Service was created in 1905, and under the direction of Gifford Pinchot, the forest reserves were redesignated as national forests.

Stewards of the Past

California is rich in history. Much of the historical record, especially of the prehistoric past, lies in the ground. These sites contain information that is precious and irreplaceable. This information is rapidly disappearing, often destroyed inadvertently through activities that could be avoided with proper knowledge and care.

Landowners who have historic or prehistoric sites on their property are the stewards of the past. In their safekeeping is the guardianship of these records for future generations to learn from and experience history. Landowner responsibility goes one step further. Knowledge of the past is considered part of the heritage of all Californians. For this reason, cultural resources are protected by law.

Protected resources include both historic and prehistoric artifacts as well as locations of cultural significance to local Native Americans that do not necessarily have visible features. Important heritage values may include logging camps, emigrant trails, homesteads, and Gold Rush mining towns; ancient Native American villages, campsites, milling stations, quarry locations, and petroglyphs; and sacred places such as sacred peaks, ceremonial dance grounds, trails, guardian trees, cemeteries, and gathering areas.

Where to Look

Archaeological sites are often found in predictable locations, although there are exceptions. Most sites occur near sources of fresh drinking water. Where streams meander through alluvial valleys, the most likely location is often on the edge of the hillslope on slightly higher ground. Sites often occur in or along the margins of natural openings; they may be found along ecotones, where different plant communities come together.

Regional patterns vary. The most obvious indicator of archaeological sites may be Franciscan chert (a rock used in arrow and spear points) in northern California or bedrock mortars (for grinding acorns and grain) in the Sierra Nevada. The presence of oak trees is a good indicator, as they provided Native California people with their staple food—acorns.

Statewide, one of the best ways to identify an archeological site is to learn to recognize middens. Middens are refuse heaps that may contain broken tools, burned bones, charcoal, waste flakes, cooking stones and broken equipment. Middens can usually be identified by localized soil color change (usually black or darker than surrounding soil); an ashy, greasy feel to the soil; or a dark film of fine, sticky dust stains the hands if the soil is dry. Middens often occur in areas such as stream terraces, near springs, or on ridgetops where a camp might have been.

Another important archeological feature is the housepit. These usually circular depressions are remnants of structures or dwellings, usually found in open areas in oak woodland or forests. Characteristics include the occurrence as a cluster of pits on a flat bench near water; and the presence of midden or artifact scatters, an earthen rim, and large rocks

Continued on page 7

Several important laws for forestry were passed in the 1970s. At the national level, these included amendments to the Clean Air and Clean Water Acts as well as the Endangered Species Act. At the state level a number of environmental laws were enacted as well, most notably the Forest Practice Act of 1973, which has resulted in the most comprehensive set of forestry regulations in the United States and arguably in the world.

Tax laws can greatly influence forest practices. Prior to 1976 California had an annual ad valorem (percentage of value) property tax on the value of standing timber on each parcel, encouraging intense harvesting of forests to remove the taxable assets and reduce the property tax. Harvesting 70 percent of the timber value would eliminate the tax until merchantable-sized timber regrew. Since 1976 California timber tax law has changed to a yield tax on timber only at harvest, a tax of about 3 percent of the harvest income. This effectively eliminated the incentive to harvest timber simply to reduce property taxes.

RESOURCES FOR LEARNING ABOUT THE HISTORY OF YOUR FOREST

Every forest has its own history—the history of settlement, resourceuse, local fire and other disturbances, and other events and changes. These historical events may be small compared to regional or statewide occurrences, but at the individual forest scale they can be as important as major events.

Researching the history of your property will help you understand its present condition. Have there been fires? Where did they originate? You could use this information to prioritize where you should establish fuel breaks. If you plan on commercial timber harvest, you will have to document historical and cultural sites in the timber harvest plan. Learn more about the history of your own forest:

- Investigate the history of your property. There are probably many people still around who can tell you about the recent history of your property and the surrounding area. Talk to neighbors and long-time residents to learn about previous property owners, forest practices, timber harvests, insect pest outbreaks, fires, windstorms, floods, and other major disturbances, as well as local events, and other information. Look at old maps, records, and newspaper articles.
- Study your property. Look for clues about past history in the forest itself. Examine stumps: count the rings to determine the age of trees when felled, look at spacing between the rings for clues about climate and

Continued from page 6

sometimes found inside the pits or around its perimeter. Housepit depressions in northwestern California are usually rectangular.

Prehistoric rock art can include petroglyphs (designs pecked, scratched, or ground into the rock) or pictographs (painted designs).

In the Sierra Nevada, bedrock milling stations can be found. These are circular holes or depressions ranging from 3 to 6 inches in diameter that generally occur in clusters on flat-topped rocks or outcroppings. Pestles that exhibit wear on their end(s) may also be present. In addition, grinding basins, or metates, may be seen as oval depressions with polished surfaces.

Map Features of Historical Sites

Many historical clues can be found in a 7.5' USGS quadrangle map. In California forests, look for

- *stream terraces, midslope benches, or ridgetops*
- *flat areas along streams*
- *places where two streams come together, especially the point of land immediately upstream from the confluence*
- *trending ridges, which were used as travel routes through the mountains*
- *springs near ridgetops or ridgetop saddles (a low, flat area between two points of higher ground)*
- *place names such as "Indian Bar," "Arrowmakers Ridge," and so on*
- *historic mines and ranches (these may be historic homesteads in addition to camping places chosen by Native Americans)*
- *margins of interior valleys*

Further Information

For more information on the Forest Practice Rules for the Protection of Cultural Resources, visit the California Department of Forestry and Fire Protection (CAL FIRE) Web site at *http://www.fire.ca.gov/thp/rsrc-mgt.php.*

growth rates, and look for fire scars. Try to visualize what the forest used to look like (fig. 6).

- Find out more about the cultural history of the area. Look in the historical section of the local library for books, talk to the local historical society, and visit the local museum. Look up old newspaper articles to learn what happened in your area.
- Historic photos can show changes in usage, roads, and vegetation. Libraries and government agencies may have old photos. Also check with your local historical society. Aerial photos are available from the Natural Resources Conservation Service (NRCS) (http://www.nrcs.usda.gov/) and Farm Services Agency (http://www.fsa.usda.gov/FSA/webapp?area=fsahome&subject=landing&topic=landing) for private lands, and from the Forest Service (http://www.fs.fed.us/) for National Forest and adjacent lands. Private companies sell aerial photos. County assessor offices may have old maps that show timber inventory and plant cover.
- Access archaeological records. It is possible that an archaeological survey has already been conducted on your property. The most comprehensive source of information on known sites and previous surveys is the California Historical Resources Information System (CHRIS) (http://ohp.parks.ca.gov/default.asp?page_id=1068), the state database maintained by the California Office of Historic Preservation (OHP). CHRIS is administered by eleven Information Centers throughout the state where staff will carry out archaeological record searches for a fee when requested to do so in writing by an authorized person. If no survey has been done, the Information Centers maintain lists of consultants qualified to do archaeological field work in the area.
- Learn about the geological history of your area. Talk to a geologist or do some research at the local library.

Figure 6. A tree's life history can be observed in its rings. This tree cross-section shows annual rings on a 6-inch diameter white fir *(Abies concolor)*. Growing in the shade of larger trees, under great competition for light and moisture, the tree grew slowly for 30 years, as can be seen by the inner 30 rings. About 20 years before the tree was cut it was damaged by fire or logging, creating a scar on one side of the stem. That disturbance killed competing trees and subsequently, this tree grew more rapidly in diameter, producing wider rings. *Photo:* Gary Nakamura.

BIBLIOGRAPHY

Heizer, R. F., and A. B. Elsasser. 1980. The natural world of the California indians. Berkeley: University of California Press.

ENGLISH–METRIC CONVERSIONS

English	Conversion factor for English to Metric	Conversion factor for Metric to English	Metric
inch (in)	2.54	0.394	centimeter (cm)
board foot (bd ft)	0.0027	423.78	cubic meter (m^3)

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FOREST STEWARDSHIP SERIES 5

Tree Growth and Competition

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Understanding how trees grow is the key to assessing the condition of the trees on your property and the potential of your site to grow the kind of forest you want. The trees on your property are engaged in a constant competitive struggle with each other and with other plants for water, sunlight, and nutrients. The plants that are winning this struggle are best adapted to the site's environmental conditions; these are the most healthy and vigorous plants on the site. The most successful plants may not always be trees. Getting to know the species, their tolerances, and the health of the trees on your site is a critical first step in understanding how best to manage your property.

Objective

Understand how trees grow as individuals and as part of a forest in order to facilitate evaluation of the effects of management alternatives.

Competencies

- Learn tree requirements for growth and survival, basic tree physiology and functions, and how competition for sunlight, moisture, and nutrients affects trees of different species.
- Understand that forests are shaped by competition between trees and develop predictable patterns and structures over time, with important implications for wildlife and biodiversity.
- Understand that management practices such as thinning can promote tree health and growth and enhance forest productivity.

Related Forest Stewardship Series Publications

- Vegetation Management (ANR Publication 8236)
- Forest Ecology (ANR Publication 8233)
- Forest Regeneration (ANR Publication 8237)

TREE PHYSIOLOGY

Each part of a tree plays an important role in maintaining the tree's health and vigor (fig. 1). The tree crown is comprised of its branches and leaves. Photosynthesis occurs in the leaves and produces all the sugar (energy and building material) that the tree uses to grow and perform other functions necessary for survival. The tree's crown is essentially its food-producing factory, but the crown also casts shade that can stifle the growth of other plants competing with the tree for light, water, and nutrients. The roots anchor the tree and absorb water and nutrients necessary for tree survival and growth. The trunk, or stem, supports the crown and houses the circulation system that conducts water up from the roots to the leaves and distributes sugar (sap) produced by the leaves or needles. This circulation system has two components: the sapwood, or xylem, and the phloem (fig. 2).

The sapwood carries water and nutrients up from the roots of a tree to its leaves or needles. Sapwood is created by the cambium, the tree's stem cell tissue that produces all the trunk's growth. The cambium produces a new layer of sapwood (a tree ring) and a new layer of bark each year. Heartwood forms when inactive sapwood is replaced by newer sapwood. Heartwood is not living tissue. It gives the tree's trunk its strength and stiffness. The inner bark, or phloem, carries the sugars made in the leaves or needles to the branches, trunk, and roots. The outer bark, or cork layer, reduces moisture loss and protects the tree from mechanical damage, disease, heat, cold, and fire.

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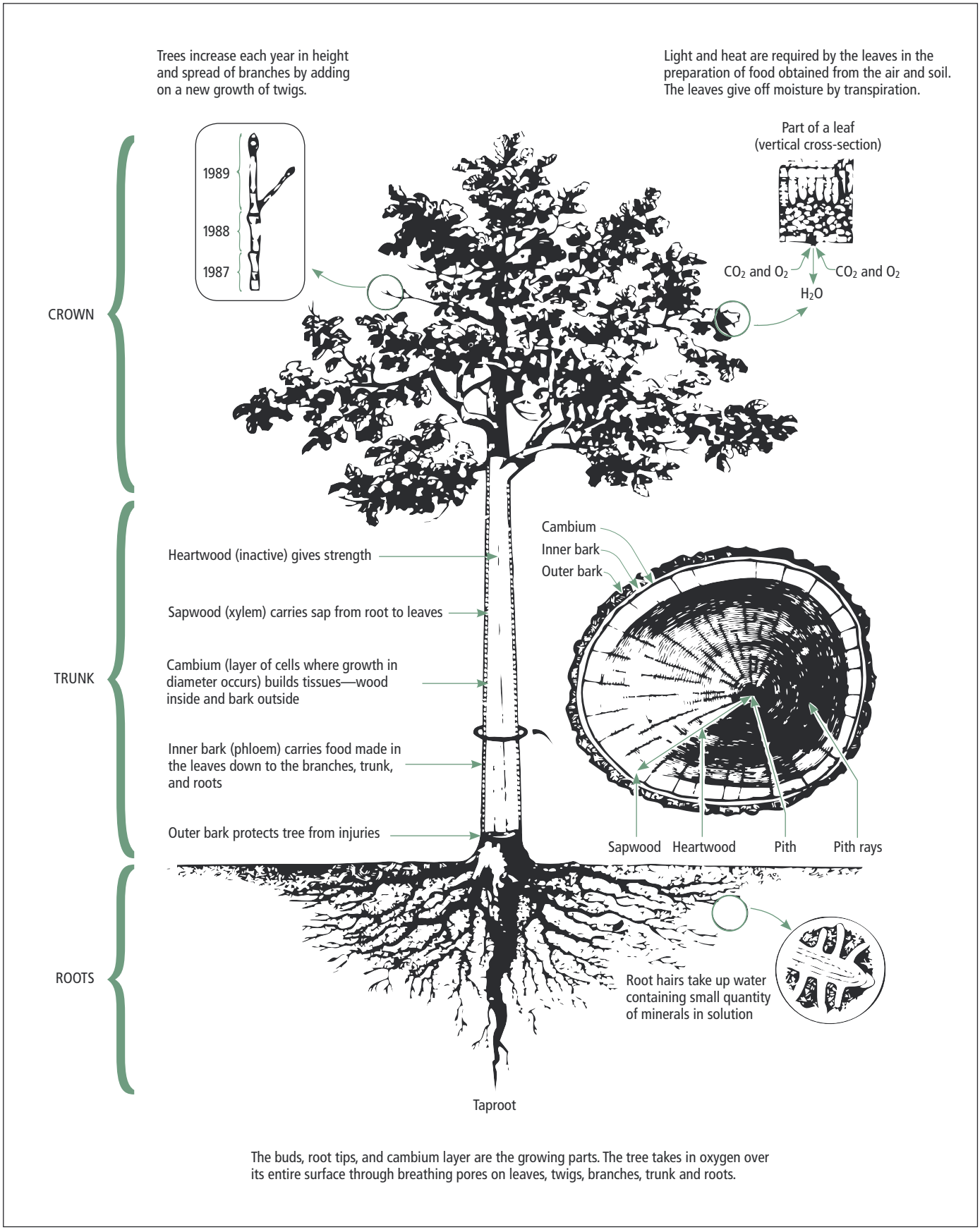
Figure 1. How a tree grows. *Source:* U.S. Forest Service.



The buds, root tips, and cambium layer are the growing parts. The tree takes in oxygen over its entire surface through breathing pores on leaves, twigs, branches, trunk and roots.

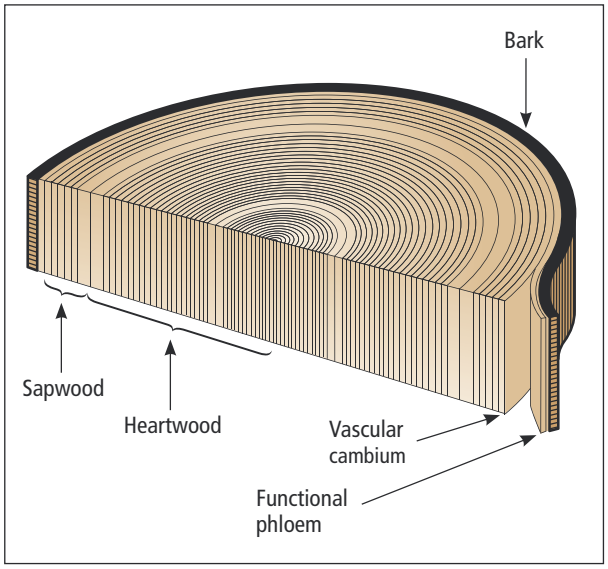


Figure 2. Cross-section of a hardwood dicot tree trunk. The outer bark, or cork, protects the tree from losing moisture, insulates against cold and heat, and wards off insects. The inner bark, or functional phloem, is conductive tissue that moves photosynthate sugars (sap) from the leaves to the rest of the tree. As the phloem ages and dies it becomes cork and part of the outer bark. The vascular cambium is a thin tissue of stem cells that eventually become the phloem and sapwood. The sapwood, or xylem, conducts water and nutrients from the roots to the leaves and branches. As the inner rings of the sapwood age they fill with chemical compounds, lose their conductive properties, and become heartwood. Heartwood provides structural support for the tree and can produce rot resistant lumber like redwood.

TREE NEEDS

Trees must obtain adequate amounts of sunlight, water, air, and nutrients in order to survive and grow.

Sunlight

Like all plants, trees convert sunlight energy into sugars (chemical energy) through the process of photosynthesis. The tree burns, or respires, the sugar to produce the energy necessary for all its growth and physiological processes.

Trees compete with each other and with other plants for the sunlight available on a site. When trees get overtopped and shaded by others, their access to sunlight is reduced or eliminated. As a result, the growth of overtopped trees slows or halts. Depending on the species, trees may eventually die after being overtopped.

The leaves on branches that are shaded conduct only a limited amount of photosynthesis but still cost the plant energy, nutrients, and water to maintain. These branches generally die and get knocked off by wind or snow in a process called self-pruning after they can no longer maintain themselves. Some trees (e.g., white fir) are better able to photosynthesize at lower light levels than others (e.g., ponderosa pine), and may retain their lower, shaded branches. Eucalyptus is an example of a widely planted tree that self-prunes, and dense stands of eucalyptus often have high fuel loads as a result.

Forests that have closely spaced trees may be unhealthy because too many trees are competing for the available sunlight and moisture. As a result, no individual tree receives enough light or water to grow well and some forests may actually stop growing and stagnate, with photosynthesis just matching the respiration and no surplus sugar available for growth. These forests are very vulnerable to disease, fire, drought, and other threats because the individual trees are weak and unable to resist these stresses. Increasing the spacing between trees by removing some trees (thinning) increases the amount of light and moisture received by the remaining trees and therefore increases their health, growth, and resistance to stresses.

Water

Trees, like other plants, require water. Water is drawn in through the roots and pulled up through the tree to the very top and tips of each branch. In addition to providing metabolic water, this stream also carries minerals and nutrients essential for plant growth. Ninety-five percent of the water used by a tree or plant is evaporated to cool the leaves, while the remainder is used in physiological processes such as photosynthesis and respiration. During photosynthesis, a tree opens small pores in its leaves called stomata to allow carbon dioxide to enter and oxygen to exit. Water vapor is also lost when the stomata are open through a process called transpiration. This loss of water from the stomata pulls water up from the roots to the leaves in the top of the tree through vessels in the xylem. If there is not enough soil moisture to replace water lost through transpiration the tree must close down its stomata and stop photosynthesis and growth.

Inadequate soil moisture can cause yellowed or withered foliage, decreased growth rate, premature shedding of leaves or needles, and dead branches. Moisture stress also makes trees more susceptible to attack by insects or disease. For example, a common syndrome in California forests begins with a period of drought during which trees become vulnerable to attack by bark beetles, followed by extensive tree mortality. This syndrome was evident in Southern California mixed conifer forests in the late

1990s. High-value landscape trees near homes and recreational areas can be irrigated to alleviate moisture stress. To be effective, water must be applied for a sufficient time and in sufficient quantity to penetrate the soil and reach deep roots. This is not practical or economically feasible for a forest. The most practical treatment for forest trees is to ensure that they have adequate water by alleviating overcrowding and competition for limited water through selective thinning.

Nutrients

Trees require the macronutrients nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), and sulfur (S) in relatively large amounts (pounds per acre per year) to thrive. Eight other elements are required in such small quantities (ounces or less per acre per year) they are called micronutrients: iron (Fe), manganese (Mn), copper (Cu), zinc (Zn), boron (B), molybdenum (Mo), cobalt (Co), and chlorine (Cl).

Nutrients play critical roles in plant physiological processes including photosynthesis, cell growth, nitrogen fixation, protein synthesis, respiration, water absorption, and root growth. Plants grow best when these elements are present in sufficient quantities, and they suffer from deficiencies when these elements are scarce. The quantity of these elements in forest soils is related to their presence in the soil-forming rock and to contributions from decomposition of organic matter (roots, leaves, branches) or atmospheric deposition. Plant-available nitrogen is present in precipitation; in air-polluted areas, unnaturally high levels of nitrogen (NOX, nitrous oxides) in the precipitation may upset the nutrient cycles of ecosystems on which it falls.

Nutrient availability is rarely a problem for California forests, except where soil has been severely disturbed by compaction, erosion, or wildfires, or on serpentine soils (soils that developed from serpentine rock). A few common visual symptoms of nutrient deficiency are stunted tree growth, discolored yellow foliage, premature death of buds and foliage, death of needle tips, and poorly developed root structure. These symptoms may commonly be observed in trees growing on road cuts in the nutrient-poor subsoil. If you observe signs of nutrient deficiency in groups of trees it is reasonable to suspect either unusual soil conditions (e.g., serpentine soils), root disease or root damage, or past land use impacts. Nutrient deficiencies can be treated with fertilizers after diagnosis but this is rarely done in forest stands. If individual specimen trees appear to be suffering nutrient deficiencies, your local UC Cooperative Extension or Natural Resource Conservation Service office can assist you with diagnosis and treatment.

Air

Trees must take in carbon dioxide through their stomata for photosynthesis. They also take in oxygen and water through their roots. About 90 percent of tree roots are found in the upper 3 feet (1 m) of soil. These include specialized feeder roots found in the first foot of soil, where water and air are most available. Depending on soil conditions, roots may extend horizontally 2 to 3 times the width of the tree crown. Think of a tree as a long-stemmed wine glass with a wide base.

The roots of most tree species are colonized by beneficial fungi called mycorrhizae. These fungi increase the roots' ability to absorb water and minerals and offer some protection from root diseases. Soil compaction can restrict root growth, reduce soil water storage capacity, disrupt fungal associations, and cause root death. The soil behaves like a sponge, with water and air stored and transmitted through the pores between the mineral particles. Compaction can reduce the size and number of these pores, thus reducing soil water storage and air transmission. This damage impedes the ability of tree roots to absorb moisture and exchange gases. Trees growing on compacted soils may have many of the same symptoms as those suffering from moisture stress. Construction, logging and road building equipment, and unmanaged domestic livestock

can cause soil disturbance and compaction around tree roots. In campgrounds and other recreation areas, foot traffic and vehicles can cause significant compaction.

Soil compaction and disturbance can be avoided by careful planning when conducting construction or forest operations with heavy equipment. Protective measures during construction include fencing around trees to exclude heavy equipment, bridging roots when trenching, removing fill, and minimizing grading. Protective measures during timber harvest operations include using designated skid trails and specialized low ground pressure equipment (wide tracks or tires), minimizing wet weather traffic, operating equipment over logging slash and organic matter, and tilling compacted soil after harvest operations are completed.

TOLERANCE OF ENVIRONMENTAL CONDITIONS

Trees are constantly competing for available sunlight, water, and nutrients. Each species has evolved its own adaptations for survival in this competitive environment (table 1). They have different tolerances to environmental conditions and changes and consequently have competitive advantages and disadvantages.

Shade Tolerance

One of the most important characteristics of any tree species is its ability to grow under partially shaded conditions. Shade-intolerant trees grow quickly in sunny conditions but slow down once they are overtopped and shaded by other trees. Overtopped trees may eventually succumb to insects or disease. Ponderosa pine is a good example of a shade-intolerant species. Its growth slows to half its normal rate when 50 percent shaded, and it is likely to die in full shade.

Shade-tolerant trees, on the other hand, can grow and survive in full sun as well as in the shade of other trees. However, the price for this adaptation is that they usually cannot regenerate as easily or grow as quickly in full sun conditions as shade-intolerant trees. White fir is a good example of a shade-tolerant species. White fir seedlings cannot survive as well or grow as quickly in full sun as ponderosa pine seedlings. Since firs are shade tolerant, however, they often regenerate after shade-intolerant trees have shaded a site and can survive and grow in the shade of other trees for some time. When overtopping trees die and allow more sunlight in, white firs can continue to grow and replace them in the overstory. The life strategy of shade-tolerant trees is to outlast shade-intolerant trees rather than outgrow them.

Table 1. Comparative tolerances of common California trees, listed from most tolerant to least tolerant

Shade	Drought	Fire	Snow damage
white fir	Oregon white oak	ponderosa pine	red fir
red fir	California black oak	Douglas-fir	white fir
Douglas-fir	Jeffrey pine	sugar pine	Jeffrey pine
sugar pine	ponderosa pine	white fir	Douglas-fir
incense cedar	lodgepole pine	incense cedar	sugar pine
lodgepole pine	incense cedar	lodgepole pine	ponderosa pine
ponderosa pine	Douglas-fir		
black oak	sugar pine white fir red fir		

Trees exhibit a range of shade tolerance. Species like Douglas-fir are considered intermediate in tolerance. While they do best in full sunlight, trees with intermediate tolerance can survive in the shade and thrive if more sunlight becomes available. Very few species survive best in shade; Pacific yew is one example.

Drought Tolerance

Drought tolerance is the ability of a tree to survive under conditions of limited soil moisture. Drought tolerance is based on how well a tree can access soil moisture during dry times and its ability to control moisture loss through its leaves. Adaptations to water loss include waxy or hairy leaf surfaces, vertically oriented leaves minimizing the area receiving direct sunlight, lighter colored leaves to reflect light and heat, and stomata that close with moisture stress and are sunken or located on the underside of the leaf.

Fire Tolerance

Fire tolerance is the ability of a tree to survive fire. Generally, trees are more fire tolerant if they have thick bark and deep roots. Thick bark protects the living tissues of the tree, and deep roots are not as vulnerable as shallow roots that are closer to the heat on the soil surface. Mature trees with fewer lower limbs (self-pruned) are also more able to survive because they are less likely to transmit a ground fire up into their crowns.

Cold and Snow Load Tolerance

Cold tolerance is the ability of a tree to withstand frost or cold temperatures. Snow load tolerance is important at higher elevations. Conifers with short, flexible branches can generally shed heavy snow loads. Deciduous trees avoid both cold and snow by losing their leaves each fall, shedding their frost susceptible and snow accumulating tissues.

COMPETITION

A tree's genetic makeup determines its tolerance to environmental conditions. For example, a shade-intolerant drought-tolerant ponderosa pine is better suited to a sunny, dry site than a white fir, which is shade tolerant and drought intolerant. If planted at the same time, ponderosa pine seedlings would survive better and outgrow the white firs and come to dominate the site.

As trees compete within the forest, some capture most of the site's light and moisture and become the largest and healthiest trees, while others die or grow very slowly. The success of a tree in competition with others can be judged by the size and shape of its crown (fig. 3). Dominant trees have crowns that extend above the general level of the canopy. They receive full light from above and partial light from the sides. Codominant trees have crowns at the level of the canopy. They receive full light from above but little from the sides. Intermediate trees have small crowns crowded into the general level of the canopy that receive some light from above but none from the sides. Suppressed trees have small crowns below the general level of the canopy and receive no direct light. Wolf trees have crowns nearly the full length of the tree because they have grown in completely open conditions, with full lighting all around. The lower branches continue to receive plentiful sunlight and so are retained rather than being discarded through self-pruning. Wolf trees can be aesthetically beautiful trees, but they tend to be too large limbed for high-quality lumber.

The management implications of tree growth and competition are profound. Forest harvesting that removes suppressed and intermediate trees retains those with the healthiest crowns that have the most potential for future growth. Conversely, harvesting only the biggest, healthiest trees (called high grading) often leaves behind unhealthy, suppressed trees with reduced potential for future growth. Removal of tree

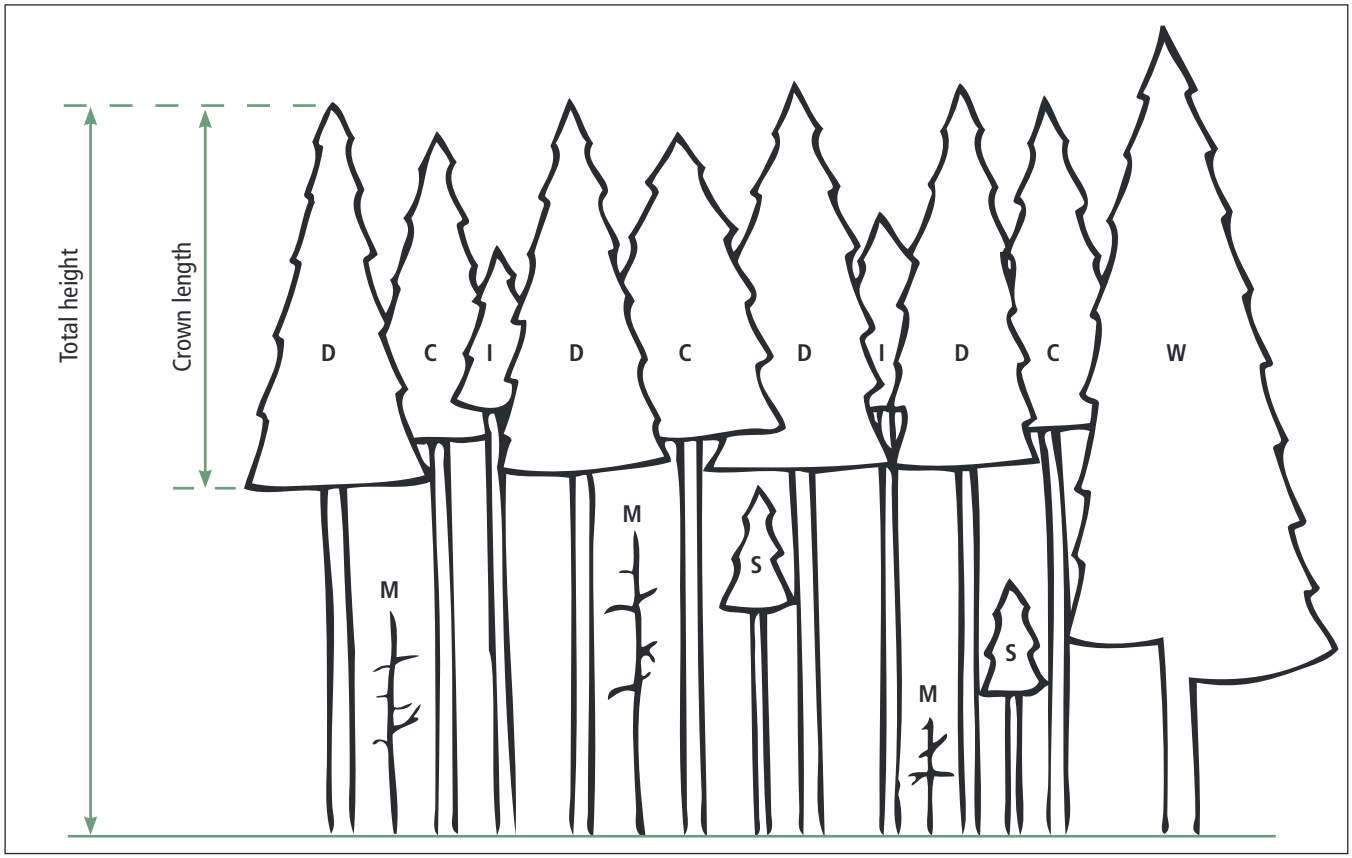
species that are most tolerant of site conditions can leave behind those least-adapted to the site, reducing the potential of the site to maintain a healthy forest over time.

FOREST DEVELOPMENT

The development of a forest over time is called succession. In an ideal forest, succession would proceed steadily over time from bare ground to herbaceous plants to woody shrubs to fast-growing shade-intolerant trees to a climax forest. Forests in the real world do not follow this ideal course. Actual forest development is a result of myriad factors: climate, soil, competition, and the species present; events that occur, including natural disturbances such as fire, windstorm, insects, or disease; and human activities such as harvesting and fire exclusion. The forest that develops on your property is a product of all these interacting factors.

For example, cooler, shady sites at middle elevations in the Sierra Nevada would favor the growth of shade-tolerant drought-intolerant white firs. With frequent fire, however, the thin-barked white firs, which tend to hold their branches, are likely to be killed. However, ponderosa pine, which has thick bark and rapid self-pruning, tolerates frequent low-intensity fires quite well. Given an adequate seed source, open areas where firs are killed are more likely to reforest in ponderosa pine. Frequent low-intensity fires promote ponderosa pine growth and domination of the site over time, despite climate conditions that would favor white fir in the absence of fire. If the owner of this site selectively harvests ponderosa pine and prevents fire, the young white fir left behind in

Figure 3. Effects of competition within a stand. *Key:* C = codominant, D = dominant, I = intermediate, M = mortality, S = suppressed, W = wolf tree.



the forest understory will respond to the increased sunlight and reclaim the site. This has occurred over much of the Sierra Nevada and has created mixed conifer forests with a high proportion of white fir and less ponderosa pine than was historically present.

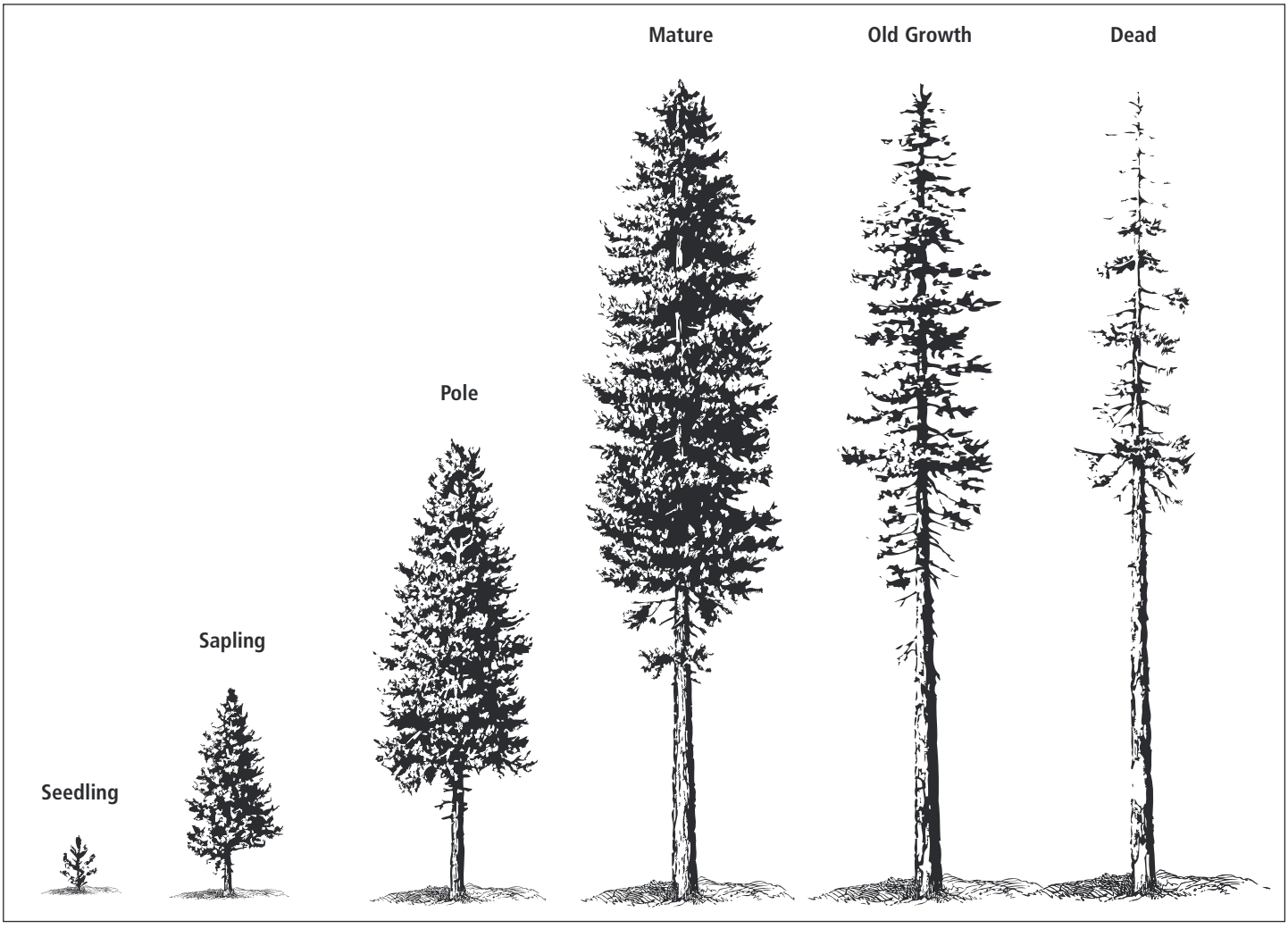
STAND DEVELOPMENT

A group of trees growing together under similar conditions (soils, slopes, and species composition) and managed in the same way is called a stand. Forests are comprised of stands, which may be defined in many ways on the basis of species composition, age, or location. Like the forest as a whole, stands grow in a somewhat predictable manner through a series of stages. These stages include stand initiation, stem exclusion, understory initiation, and old growth (fig. 4).

Stand Initiation Phase

After a significant disturbance such as an intense fire or clear-cut harvest, a new stand will establish through planting or natural seeding of the area. The stand initiation phase is the period in which new trees are becoming established on a site. This typically takes from 20 to 50 years, depending on various factors at the location. Planting reduces the time for stand initiation. With no control over competing vegetation, shrubs and grasses can capture available moisture and reduce seedling survival and slow tree growth, increasing the amount of time for stand initiation.

Figure 4. Stages of tree and forest stand development.



Stem Exclusion Phase

Once the site is fully occupied by trees and they begin to compete with each other, the stand is said to be in the stem exclusion phase. This phase can continue for 50 to 150 years, during which dominant trees shade out less-competitive trees and very few new plants can successfully become established on the forest floor. Stems are excluded because the trees already on site are utilizing all the available sunlight, moisture, and nutrients.

Understory Reinitiation Phase

Eventually some of the trees in the stand die, leaving openings for new tree seedlings, shrubs, and herbs to establish in the understory. This phase is called the understory reinitiation phase.

Old Growth Phase

In an old-growth stand there is a balance of older trees dying off and being replaced by new trees growing up from the understory. Older trees with large branches and cavities, dead trees, rotted and partially rotted large wood debris on the ground, and a highly developed forest canopy are all characteristics of old-growth stands.

Although wildlife is found in forests at every stage of stand development, wildlife found in old-growth forest is of particular concern to forest managers. Old-growth wildlife species are dependent on the complex structure found in old-growth forests, including large trees, snags (standing dead trees), intermediate-size trees, downed logs, and forest canopy. These old-growth characteristics are difficult to recreate in a young stand. The northern spotted owl is one example of a species that depends on old growth. The owl does not build its own nest cavity and so requires large old trees or snags with cavities to nest in; it requires intermediate-size trees for roosting and downed logs for nesting and cover for the small mammals the owl preys on. Managing a forest to maintain old-growth tree species requires leaving as much of this structure intact as possible.

While the owl requires old-growth stands for nesting habitat, it feeds on wood rats and other animals that live in brush fields and less dense stands within foraging distance of the nesting stand. Thus a diversity of forest stand conditions across a landscape is required for spotted owl and other wildlife.

MANAGEMENT IMPLICATIONS

The management implications of the differences in tree growth characteristics, tolerances, and stand or forest development patterns are innumerable. As a rule, the astute forest manager will "work with nature" when planning and implementing practices. For example, thinning and stand improvement prescriptions should be based on favoring the best-growing trees of species that are most suited to the site in question. When visualizing the desired future forest, it is necessary to have a clear picture of the potential of the site. It is impractical, for example, to expect shade-intolerant species to successfully regenerate and grow in the absence of sufficient light. For this reason, silvicultural systems have been generally adopted for specific forest types. A useful exercise for any forest landowner is to seek out examples of stands and forests in the forest type that is natural for their property that can represent feasible target conditions for their future forest.

The forest landowner should also recognize that under natural conditions, forests are not uniform in structure, function, or appearance. That is, they are comprised of stands in different stages of development, and within a forest there can be "too much" of any stand type. Managing for diversity across the landscape usually yields more benefits in terms of productivity, wildlife habitat, and other values than does managing for any single stand condition.

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FOREST STEWARDSHIP SERIES 6

Forest Vegetation Management

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There is both an art and a science to forest stewardship. At the core of stewardship is the management of vegetation, which includes management of young and old trees, shrubs, and herbaceous plants. Whether your goals are to manage for an economic return from timber harvesting, maintain or enhance wildlife habitat, improve aesthetics, restore the forest, maintain a certain stand characteristic, or recover from a specific event such as a wildfire, wind, or ice storm, it is important to understand how different vegetation management strategies can help accomplish your goals. In the field of forestry, vegetation management is generally called silviculture.

Objective

Understand how forest vegetation can be managed to achieve your goals and objectives.

Competencies

- *Understand that landowners have the responsibility to protect and maintain public trust resources.*
- *Observe how "letting nature take its course" can produce many unintended consequences.*
- *Become familiar with silviculture: the art and science of producing, tending, and harvesting a forest.*
- *Learn that choosing a silvicultural system for your forest requires understanding the advantages and disadvantages peculiar to each system and how they relate to your goals and site conditions.*
- *Realize that the more clearly you can define and describe your goals and objectives, the more likely that you will be satisfied with your forest after a harvest.*
- *Discover the variety of cost-share programs that may be available to help you fund forest management and restoration projects.*

Related Forest Stewardship Series Publications

- *Forest Ecology, ANR Publication 8233*
- *Forest History, ANR Publication 8234*
- *Tree Growth and Competition, ANR Publication 8235*
- *Forest Regeneration, ANR Publication 8237*
- *Stewardship Objectives and Planning, ANR Publication 8248*
- *Laws and Regulations Affecting Forests, Part I: Timber Harvesting, ANR Publication 8249*
- *Economic Considerations in Forest Stewardship, ANR Publication 8251*
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UC PEER REVIEWED

PUBLIC TRUST RESOURCES

Even though land may be privately owned, managing natural resources requires an understanding of your responsibility to protect "public trust" resources. These resources are protected for the benefit of the people of the state. Public trust resources include (but are not limited to) air and water quality, wildlife, and certain environmental resources such as tidelands and wetlands. Many laws apply to natural resource management on private lands to ensure that these public trust resources are not degraded. As a result of these laws, certain vegetation management activities are either prohibited or restricted. Protection of public trust resources, for example, is the principle underlying the Forest Practice Act and the regulations of the state and regional water quality control boards that aim to protect water quality and the beneficial uses of water while allowing timber harvesting or forest management.

STYLES OF MANAGEMENT

Trees grow and die with or without our management, but the number of trees on every acre and the ratio of live trees versus dead trees can be influenced by management. Some people may consider that the best strategy is to let nature run its course and not decide which trees should survive or regenerate. This style of management is "passive," in contrast to an "active" style that seeks to directly influence forest stand density and health. Although in the short run, letting nature take its course may seem to have few adverse consequences, in the long term it can have profound effects on a forest. This is because the natural processes themselves have already been altered at scales

well beyond a single forest property. Many people are beginning to recognize that because of years of fire suppression and passive forest management, many forests have become overly dense. This has resulted in stressed trees, disease outbreaks, and dominance of tree species that reproduce in crowded, shaded conditions. California's forest evolved with and depended on fire to keep the forests healthy and diverse. Changes in vegetation and wildfire risk due to fire suppression have radically affected millions of acres of forestland in California, and the frequency, intensity, and scale of natural fires have changed as a result. Safely restoring natural fire processes to a single property or an entire landscape requires active management. In the absence of fire, it is possible to thin trees to reduce competition and create openings so that shade-intolerant or sun-requiring tree species can grow. Another example of altered processes concerns invasive plants. Without active management, a landowner may stand by and watch streams, fields, and forests become overwhelmed by aggressive exotic plants.

This publication presents active management methods that can be used to effectively develop desired forest conditions. Be aware that although these methods have proven useful, applying them to your forest should be considered to be an experiment. Many landowners develop their own personalized approach to vegetation management after years of trial and error. Consider the methods provided here as conceptual approaches to be refined and modified for application to your specific forest and management objectives. While the majority of information presented here relates to forest management that may lead to commercial harvest, the vegetation management concepts apply equally to noncommercial or restoration activities.

SILVICULTURAL SYSTEMS AND METHODS

If your management style is active, you are probably already practicing silviculture—the science and art of producing, tending, and harvesting a forest. A silvicultural system is the plan of treatments for a forest stand over its entire life, including the establishment of a new stand after harvest.

Silvicultural systems are named on the basis of the number of age classes in the forest (one or two to several) and the method used to regenerate (or establish and grow) the forest. "Even-aged" silvicultural systems use clear-cutting or reserve a limited number of "seed" or "shelterwood" trees to achieve the establishment of new seedlings. Clear-cut areas are commonly planted with seedlings, while seed tree and shelterwood areas are usually expected to regenerate naturally. Both yield a new stand of trees that are all the same age or a two-storied stand of seed trees and seedlings (after successful establishment of seedlings, seed or shelterwood trees are commonly removed). In contrast, "uneven-aged" systems generally use harvesting of individual trees or groups of trees to develop a number of age classes in the forest. These systems may seek to maintain continuous mature forest cover while allowing for some regeneration. These systems are based on the method of regeneration and include associated treatments for different stages of stand development, such as thinning, pruning, and managing competing vegetation.

Silvicultural systems should be chosen on the basis of forest type, site conditions, and management objectives. The legally permitted systems in California are described below. The chosen system must be adapted for application to a specific property. In many cases, especially on larger properties, a mixture of silvicultural systems will be used.

Any entry into a forest stand with heavy equipment can cause long-term damage if reasonable protective practices are ignored. This discussion assumes that silvicultural systems are designed and executed properly, with full consideration for local conditions.

Even-aged Management

"Even-aged" is not a very descriptive term for the results obtained from clear-cutting, seed tree, or shelterwood harvesting. In a given even-aged stand, after harvest and regeneration, the trees will be roughly the same age and size. But, over a large property or landscape, numerous sites may be harvested at different times to create a multitude of age classes in the forest. Clear-cut harvest units cannot exceed 20 acres (about 8 ha) in California, and harvest units retaining seed or shelterwood trees are also limited in size.

Clear-cutting

In clear-cutting, all or most of the trees in a stand are cut at the same time (fig. 1). The average stand age before harvest may be 60 to 80 years, depending on the productivity of the site and the forest type. Nursery-grown (planted) seedlings are generally used to regenerate the stand, though seeds from surrounding trees or the sprouts from stumps, as in the case in redwood, may be relied upon.

Clear-cutting provides an open environment that is most suitable for the establishment and subsequent growth of species that are intolerant of shade. However, on harsh sites (such as those with limited water availability, thin soils, or south-facing aspects), clear-cutting can create conditions that planted seedlings are incapable of surviving. After harvest, clear-cut sites are commonly prepared for planting by either broadcast-burning debris and slash or by piling and burning.

Clear-cutting changes wildlife habitat. The habitat that is created after planting depends on whether shrubs and herbaceous species populate the site, whether and how they are controlled to reduce competition with seedlings, how fast the planted seedlings grow, and other factors. As a general rule, clear-cutting creates early-successional habitats that are suitable for wildlife such as deer and elk that use grass, herbaceous, and shrub food sources. Other species such as rabbits and gophers that can have negative effects on seedlings may also benefit from the habitat created. As the new stand matures, the habitat will change, and the wildlife species and their use patterns will change as well. For example, a recent clear-cut may provide food sources for deer, while the same stand after 10 or 20 years stand may provide deer with cover and breeding habitat.

As with all silvicultural systems, clear-cutting has its advantages and disadvantages. One great disadvantage is the appearance of a recent clear-cut. The forest changes abruptly from a mature stand to a very young one, and logging debris is usually evident. Other potential disadvantages include negative impacts on wildlife habitat and potential soil erosion. A major emphasis in the review of timber harvest plans (THPs, the permit used to commercially harvest trees in California) that propose clear-cutting is to minimize or mitigate these and other potential impacts.

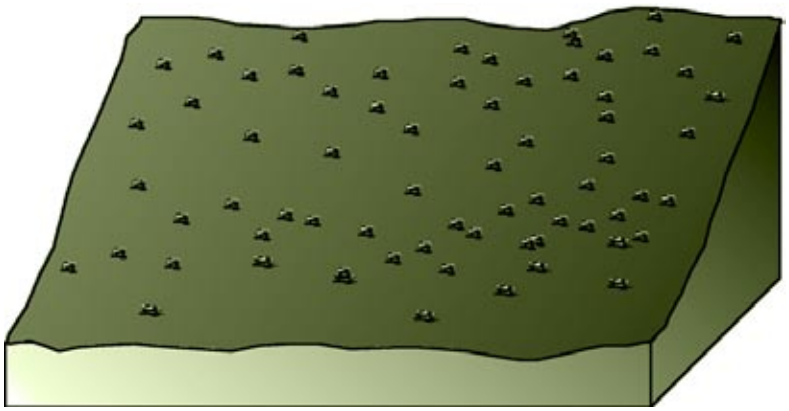

Figure 1. Clear-cut immediately after harvest. No trees are left standing.

The advantage of clear-cutting is efficiency. It is relatively easy to delineate a clear-cut block on the ground, and there is a reduced chance of damaging reserved trees. Clear-cutting is sometimes used to restore a stand to a higher level of timber productivity after a history of poor management. That is, when faced with an existing stand of low-value defective trees and undesirable species composition, a forester may decide to essentially start over by clear-cutting and planting a more desirable mix of species. Another distinct advantage of clear-cutting is that road access is limited to the immediate time of harvest and planting, after which

Figure 2. Sites clear-cut in conformance to today's forest practice rules from an on-the-ground and aerial viewpoints. These rules specify the maximum size of clear-cuts, require mitigation measures for stream and wildlife protection, and stipulate regeneration practices. *Photos:* Courtesy UC Blodgett Forest Research Station.

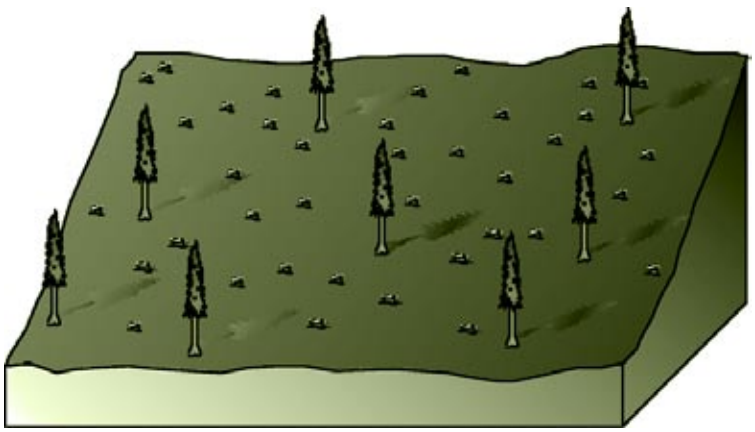

Figure 3. Seed tree selection immediately after harvest.

roads may be closed until access is needed again for operations such as intermediate treatments and fire suppression. Since roads are a major source of sediment on forestland, this can be an environmental benefit.

Today's clear-cuts in California rarely resemble the clear-cuts that may have been permissible even a decade ago. Environmental restrictions specified in the California Forest Practice Rules have generally been adopted to retain islands of trees within clear-cuts, widening buffers along streams, and preserving important individual wildlife trees and snags (fig. 2).

Seed tree

The seed tree silvicultural system is an even-aged regeneration method that removes most of the stand while leaving a few desirable trees to produce seed for the next stand (figs. 3 and 4). The quality and distribution of the seed trees and the timing of the harvest are important considerations when using this system.

The seed tree system is generally used for shade-intolerant species that regenerate best in full sunlight. Site preparation is often required to remove logging debris and competing plants and to create a seedbed before the new stand becomes established.

Seed trees are usually removed not long after the regenerated trees are well established. If too much time elapses, the young trees can be damaged when the seed trees are removed. Seed tree silviculture has similar advantages and disadvantages to clear-cutting. Natural regeneration by seed trees often results in a clumpy distribution of seedlings. As they grow, thinning may be required to minimize competition and address spacing needs. Planting may be required to obtain all of the species desired or to supplement natural regeneration.

Shelterwood

The shelterwood system is often used when the species to be regenerated requires protection from direct sunlight to become established (fig. 5). Depending on the initial condition of the stand, harvesting can be done in two or three stages to regenerate the stand. The objective of the initial harvest is to improve the vigor and seed production of the remaining trees and to prepare the site for new seedlings. The reserved trees provide shade and shelter from extreme conditions (fig. 6).

Figure 4. Site where the seed tree method was applied. Today's clear-cuts often resemble seed tree harvests because some trees must be left on a clear-cut site for wildlife habitat and other purposes. *Photo:* Gary Nakamura.

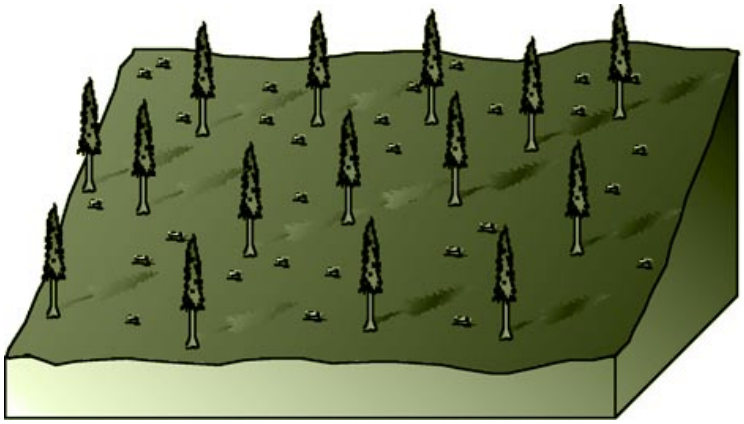

Figure 5. Shelterwood stand immediately after harvest.

Figure 6. Shelterwood harvests are similar to seed tree harvests except that shelterwood leaves more trees standing. In either case, the remaining trees should be of good quality since they will produce the seed for the next crop. Shelterwood is often applied on harsh sites where some shade is necessary to encourage seedling establishment and survival. *Photo:* Courtesy UC Blodgett Forest Research Station.

Once regeneration is established, subsequent harvests remove the shelterwood trees and allow regeneration to develop an even-aged stand. The shelterwood system favors species that naturally regenerate in partial shade. Because the shelterwood trees are removed in several stages, there is less dramatic visual impact until the final harvest. As with the seed tree method, natural regeneration by shelterwood can result in a clumpy distribution of seedlings. As seedlings grow, thinning may help minimize competition. Shelterwood may be applied on harsh sites in combination with planting.

Modifications to traditional systems

In California at the present time, the traditional even-aged silvicultural systems described above are rarely used. For example, in clear-cutting, trees or groups of trees are often left standing to provide habitat for wildlife. This is sometimes termed a "partial retention" or "variable retention" harvest (fig. 7). In other cases, seed or shelterwood trees may be left standing because they contribute habitat or perform other desired functions. Most of these alterations to traditional even-aged silvicultural practices have arisen in response to concerns about impacts on wildlife, aesthetics, and water quality.

Uneven-aged Management

The main difference between an even-aged forest (fig. 8), in which numerous forest stands may have been harvested at different times and at different ages and sizes, and an uneven-aged forest is scale. That is, even-aged harvests are generally conducted on stands of up to 30 acres (about 12 ha). Uneven-aged harvests are conducted on the scale of individual trees or small groups of trees, which are usually less than a few acres in size and can be distributed over a larger area. An uneven-aged forest is comprised of trees in many age and size classes in close proximity to each other. Frequent, periodic cuttings establish and maintain this structure. The possibility that residual trees will be damaged by repeated harvesting operations requires especially careful logging operations.

Figure 7. Variable retention harvest, showing regeneration and larger trees left for wildlife. *Photo:* Gary Nakamura.

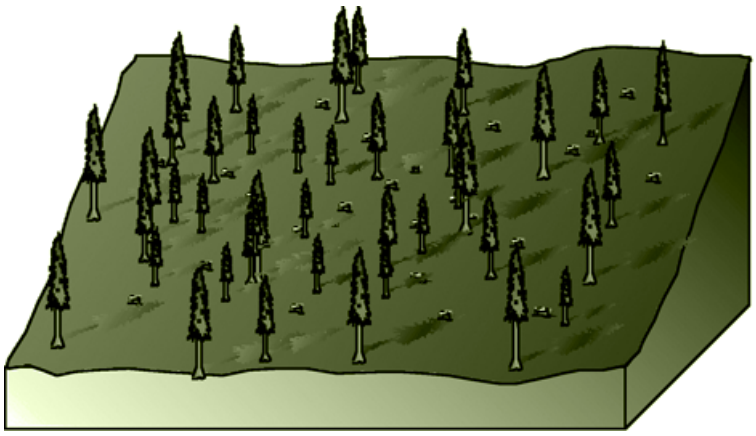

Figure 8. Uneven-aged management immediately after harvest.

Uneven-aged management has advantages and disadvantages over even-aged management. For example, because the openings in the canopies are smaller in size (< 2 acres, or about 1 ha), it is assumed that impacts to wildlife with be lessoned. A potential disadvantage is that frequent harvesting requires the creation and continual maintenance of roads, and these roads are used more often (e.g., every 10 to 20 years) than in even-aged management (e.g., 30 to 80 years). Also, uneven-aged stands generally tend to be more vulnerable to crown fire. They often have diverse multistoried canopies that constitute both excellent wildlife habitat as well as combustible fuel ladders. Additionally, harvests can be more frequent, providing a more regular income stream, but they may bring a lower return per harvest.

Single-tree selection

In single-tree selection, a forester evaluates individual trees for harvest based on stand management needs and landowner objectives. Seedlings (or sprouts in the case of redwood) develop where forest canopy openings and suitable seedbeds are provided. Single-tree selection is usually applied to forest types comprised of shade-tolerant species capable of regenerating and growing in the shade of overstory trees (fig. 9).

Because of the small opening sizes, many people like the aesthetic qualities of single-tree selection, and to the untrained eye it can be difficult to know that harvesting has been done at all. Single-tree selection can provide continuous forest cover that may be of benefit to certain wildlife species. It also reduces temperatures and provides shade that can help limit invasive plant establishment and survival. The main environmental issue that must be considered is the impact of multiple entries and continual road usage. Single-tree selection is labor intensive. Marking individual trees for harvest takes considerable time, and falling and logging must be done carefully to avoid damaging the reserved trees.

Species may not reproduce equally well in a forest managed by single-tree selection. For example, in mixed Douglas-fir and coast redwood forest, single-tree selection favors the sprouting redwood rather than the less shade-tolerant Douglas-fir. Over large areas, single-tree selection can lead to reduced species diversity while increasing stand structural diversity.

If applied incorrectly, single-tree selection can lead to “high grading”: harvesting the best and most valuable trees and leaving less-valuable trees behind. A primary objective of single-tree selection should be to leave the stand in a better productive condition after harvest by removing less-desirable trees, those with poor form, or those injured by insects or disease, while leaving the best trees to grow on the site.

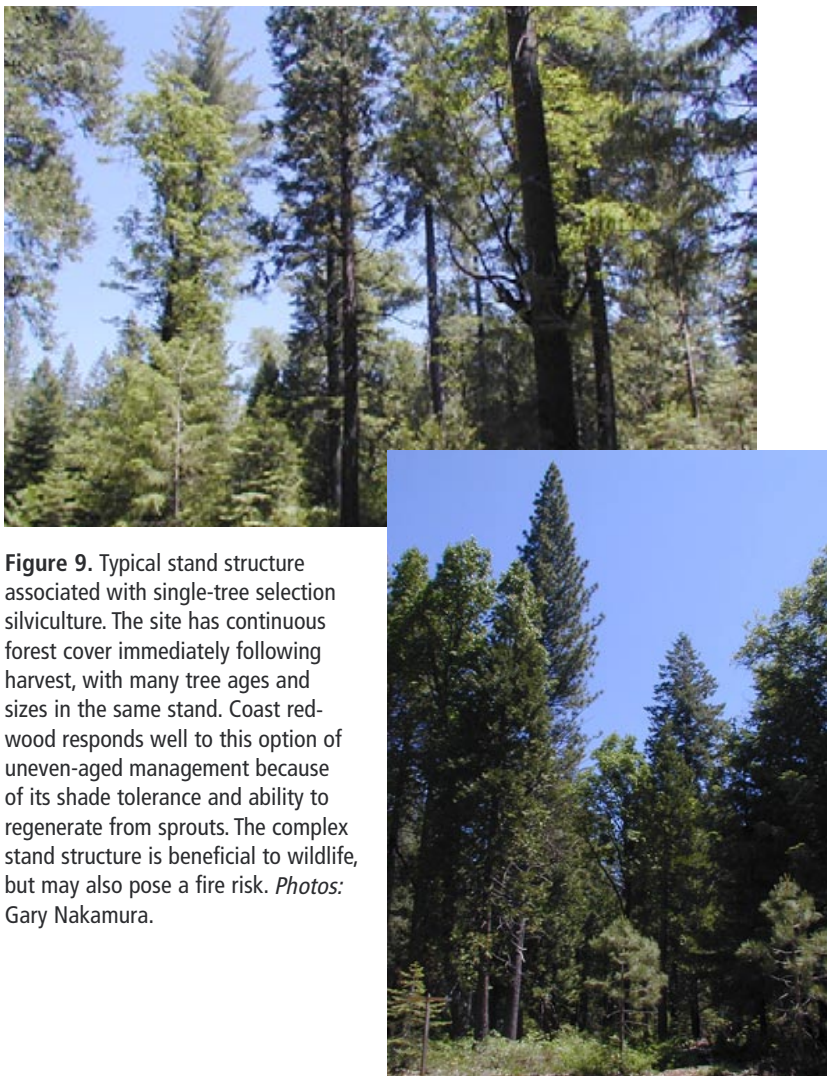

Figure 9. Typical stand structure associated with single-tree selection silviculture. The site has continuous forest cover immediately following harvest, with many tree ages and sizes in the same stand. Coast redwood responds well to this option of uneven-aged management because of its shade tolerance and ability to regenerate from sprouts. The complex stand structure is beneficial to wildlife, but may also pose a fire risk. *Photos:* Gary Nakamura.

Group selection

The group selection method involves harvesting small groups rather than individual trees. The openings created resemble very small clear-cuts; in California the openings must be less than 2.5 acres in size (about 1 ha). Because the openings are small, trees on the edges typically influence the regeneration in the opening. Group selection is usually applied to forests where the dominant species are intermediate in shade tolerance. It is similar in most respects to single-tree selection, with the exception that by harvesting groups, it is somewhat easier to minimize damage to residual trees and regenerate shade-intolerant species, particularly pines. Practically speaking, most people using uneven-aged systems use a combination of single tree and group selection.

Intermediate Treatments

The purpose of an intermediate treatment is to improve the growth, quality, composition, or vigor of a stand. Unlike the regeneration goals for even- and uneven-aged systems described above, intermediate treatments are not expected to produce regeneration of new trees. Rather, they are intended to improve the survival, vigor, and growth of existing trees.

Competition control

Competition control involves removing shrub, grass, and herbaceous plants that compete with tree seedlings and saplings for moisture and light. Although most commonly associated with management of even-aged plantations, it can be used to enhance the survival of natural regeneration in an uneven-aged system. A variety of control practices are used, including selective herbicides, manual control of brush, and girdling of unwanted trees. Competition control is best applied in the first 10 to 15 years after establishment and is often used in the first 2 to 3 years after regeneration has become established.

Competition control is sometimes combined with other methods, including the use of fencing, repellents, traps, and tree shelters to prevent depredation by rodents, deer, and livestock. In some forest types, such as Douglas-fir or pine, control of animal damage is almost mandatory.

Thinning

Thinning can reduce competition between trees and accelerate growth in those trees that remain (fig. 10). In California, thinning is categorized as either commercial (removing valuable trees) or precommercial (removing trees that are too small to have commercial value). In even-aged plantations, thinning achieves the desired spacing between crop trees. Other variants of thinning include thinning dominant and codominant trees or thinning smaller trees with crowns below the dominant trees.

Figure 10. Effects of competition on diameter growth. All the cross-sections are 6 inches (15 cm) in diameter. Figure 9A is ponderosa pine, 70 years old, growing under high competition for moisture, light, and nutrients at 1,000 trees per acre (2,470 per ha); diameter growth and ring width slow with age. Figure 9B is ponderosa pine, 9 years old, growing under low competition of 300 trees per acre (740 per ha); diameter growth has been accelerating. Figure 9C is white fir, 50 years old, growing under competition the first 30 years (the inner 30 rings). Twenty years ago, this tree was damaged by a harvest that removed the competing trees around it, releasing it to grow more quickly. Note the scar from logging damage. *Photos:* Gary Nakamura.

The obvious question is, how do you select which trees to take or leave? The answer depends on the species in question, management objectives, and site conditions, among other factors. Rules of thumb in thinning include the following.

- The first thinning should be done early in the life of a stand, before the competition begins to severely limit stand growth. Generally, precommercial thinning of plantations is done in the first 10 to 15 years and is repeated one or more times until the trees reach a merchantable size.
- In the first thinning, trees that demonstrate the best growth (height) should be retained. A later thinning is often done when tree crowns begin to touch. This later thinning is based on a spacing that allows for crown expansion until the next thinning will occur.
- In some cases, thinning is coupled with limb pruning to improve the quality of wood produced by minimizing knots. Care must be exercised to not overprune so that crop trees have relatively full crowns to maximize growth.
- Trees with less than one-third of their total height in live branches rarely respond well to thinning.
- Trees with poor form or showing evidence of damage, insects, or disease are usually removed.
- Later precommercial and commercial thinning is intended to increase diameter growth on residual trees by providing adequate growing space. Thinning should not be confused with uneven-aged management, in which the goal is regeneration to create a balanced distribution of tree sizes. Commercial thinning is generally associated with even-aged management as a way to capture the value of mortality until the stand matures.

Especially in stands that are naturally regenerated, thinning can improve stand composition and favor the most desirable species. The choice of species depends on the landowner's objectives for timber, wildlife, aesthetic appeal, or recreation. Many trees that have little to no timber value might be reserved to favor these other purposes.

One way to gauge the health of a tree is to look at its crown ratio, the percentage of the total height of the tree that is in live branches (fig. 11). Dominant trees have about a 50 percent crown ratio; codominants, about 40 percent; intermediates, about 30 percent; and suppressed trees, about 20 percent. Open-grown "wolf" trees have a crown ratio of about 80 percent. Larger crown ratios mean that a tree can capture more

sunlight and produce more food. Once a tree has less than a 33 percent crown ratio, it usually cannot be released from competition. Trees with low crown ratios are more susceptible to insect attacks.

Wolf trees use up too much space for timber production goals. But as they die and decompose, wolf trees can make excellent snags for wildlife. Some species, such as white fir, can survive as suppressed trees and can respond if surrounding trees are removed. Others, such as ponderosa pine, do not survive well as suppressed trees and will not respond consistently to thinning.

Sanitation and salvage

Sanitation is the removal of insect-attacked, diseased, or damaged trees in order to maintain or improve the overall health of the stand. Natural events such as fire, windstorms, and ice storms may kill or break trees in a forest. Salvage is the removal of only trees that are dead, dying, or deteriorating because of damage from fire, wind, insects, disease, flood, or other causes. Salvage provides for the economic recovery of trees before the total loss of their wood product value. Sanitation and salvage may be combined into a single operation. Sanitation-salvage harvests are exempt from filing a timber harvest plan if they harvest less than 10 percent of the forest volume per acre.

ACHIEVING YOUR GOALS

The silvicultural methods you choose for your property depend in large part on your goals. Clearly defined goals and objectives help you create the forest structures that meet your needs. Your registered professional forester can help you decide which silvicultural systems are most appropriate. Often, the actual prescription for a property will be a blend of treatments. The more clearly you can define and describe your goals and objectives, the more likely it is that you will be satisfied with your forest after the harvest.

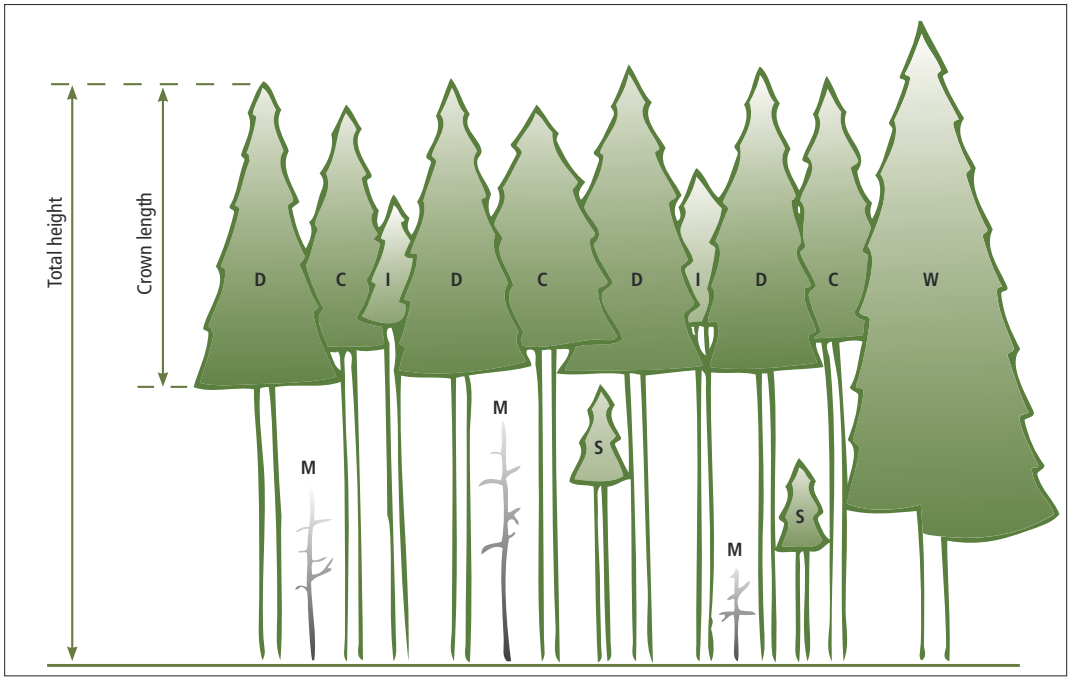

Figure 11. Effects of competition within a stand. *Key:* C = codominant, D = dominant, I = intermediate, M = mortality, S = suppressed, W = wolf tree.

Restoration

Many landowners state that restoration is an important goal. Does this mean restoration to a healthier condition? To a forest that contains a certain kind of wildlife habitat? To a pre-European-settlement forest condition? To a forest that does not contain exotic species? The better you can define restoration the better you will be able to meet your goals.

Forestry restoration

If you have lands that have been heavily cut, your restoration goal might be to establish a healthy, mature forest. One way to do this is through a series of selection cuts or thinnings that allow the trees to increase in size, improving stand structure.

Riparian restoration

Restoring riparian areas could include a number of overlapping projects. Some might focus on keeping stream temperature down by planting trees to provide shade; these trees can also help improve bank stability. In some cases, you might put large woody debris or large rocks in strategic locations to protect banks from erosion or to help create pools for fish. Bioengineering projects using living material, such as willows, can stabilize stream banks and filter sediment.

Erosion control

Projects to reduce erosion often focus on getting water back into natural streams. Water can be diverted by roads or skid trails. Erosion can also occur on areas denuded of vegetation.

Oak woodland restoration

Restoring oak woodlands could include projects such as preventing or controlling conifer encroachment as well as planting oaks.

Control of exotics

You may want to reduce or eliminate species that are not native, such as starthistle or broom, on your entire property or only on a portion of it.

Wildlife habitat enhancement

You can encourage certain species (such as deer and elk) or a type of animal (waterfowl) to use your land, or discourage certain species, for ecological or personal reasons. You can do this through managing elements such as the habitat, the kinds of trees and shrubs in the forest, and the availability of snags, downed woody debris, and year-round water. To start with, you need to know which species you are managing for and their habitat requirements. It is not possible to manage for every species on every acre, as each wildlife species requires different habitat needs.

Recovery after wildfire

Restoration after a fire could include planting trees, spreading grass seed, and erosion control, confirming that drainage structures are intact and evaluating burned trees for the likelihood of survival.

Fuel Reduction

Consider removing understory shrub and suppressed trees, and limbing trees to eliminate fuel ladders that could carry a fire into the crowns of the green overstory trees.

Planning

Whatever your restoration goals, you will want to develop a plan for meeting them. Your Registered Professional Forester will be able to help you define your goals and get you thinking about what to cover in your plan. They should also have contacts with local agency representatives and be able to recommend contacts for more information.

Plans for restoration work range from the very simple ("I just want to get this darned starthistle out!") to detailed plans that outline decades-long strategies for creating, restoring, and maintaining desired conditions.

RESOURCES

Public Agencies

Several public agencies can offer information or assistance on vegetation management issues and restoration.

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PUBLICATION 8237

FOREST STEWARDSHIP SERIES 7

Forest Regeneration

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An essential part of forest stewardship involves the careful planning and management of young trees and seedlings. When an opening has been created in the forest canopy, either from timber harvest or following a natural disturbance event such as windstorm or fire, there is an opportunity to influence what plants or trees will become established and thrive. In some situations, natural regeneration will occur in the opening when nearby trees drop seed, reducing the need to plant. In other situations, planting seedlings may be of value. Ensuring adequate regeneration and sustained productivity is at the heart of any scientific silvicultural system.

Objective

Understand the fundamental steps involved in successfully regenerating or restoring a forest.

Competencies

- *Know the differences between natural and artificial regeneration.*
- *Know the essential steps in preparing and planting a forest site.*
- *Be able to choose the right planting stock for your site.*
- *Understand the practices needed to enhance survival and growth of planted trees.*

Related Forest Stewardship Series Publications

- *Tree Growth and Competition, ANR Publication 8235*
- *Forest Ecology, ANR Publication 8233*
- *Forest Vegetation Management, ANR Publication 8236*

The California Forest Practice Act requires that landowners regenerate their forest after a timber harvest or leave it in a stocked condition with reserved trees. It is required that a stand have a minimum number of trees within 5 years following harvest, and stand conditions are monitored by a California Department of Forestry and Fire Protection (CAL FIRE) inspector. Planning before harvest will go a long way toward reducing costs and quickly securing adequate regeneration, as today's seedlings will become tomorrow's crop trees.

METHODS OF REGENERATION

Natural regeneration from seed requires adequate seed production, successful germination, and seedling growth. These requirements are subject to the effects of weather, site conditions, competition between species, predation, and plain chance. While natural regeneration may be the least expensive option for establishing a new stand after harvest or other disturbance, it is not the most reliable method. Of further consideration is that natural regeneration can create a new forest that does not have the most desirable species composition. For example, in the Sierra Nevada, if the goal is to promote pine seedling establishment, open areas will be required, as pine needs direct sunlight to become established. This is in contrast to white fir, which tends to become established in the shade of other trees. Additionally, stocking may be uneven: portions of a site may be fully stocked or overstocked with new seedlings, while other areas may have few seedlings. Successfully attaining natural regeneration from seed is more difficult for many forest types and tree species than the term "natural" implies. An exception is for coast redwood, which sprouts from its stumps. In this case, regeneration by sprouting can be all that is required to fully stock a stand after harvest.

In contrast, artificial regeneration involves sowing seed or planting seedlings to regenerate the stand. Artificial regeneration is used if natural regeneration is not feasible or if it produces unacceptable results. It may also be used to ensure a desired species composition, to establish a stand with superior genetic traits, or to give the young trees a better chance to survive in the face of adverse environmental and biological agents.

UC PEER REVIEWED

The standard artificial regeneration method in California is planting nursery-grown seedlings, as this allows for control of spacing, species, and genetic composition. The key to a successful planting project is proper planning, which should begin about a year in advance of the actual planting.

GETTING READY: SITE PREPARATION

There are many obstacles to growing trees from seedlings. Seedlings are subject to depredation by wildlife or livestock, are exposed to drought and frost, and are vulnerable to disease and insect attack. Whether they are planted or come from naturally germinated seed, seedlings need all the help the planter can give them.

The greatest challenge is making sure the seedlings have adequate soil moisture and nutrients. This is especially critical in California, with its Mediterranean climate characterized by long, rain-free summers. All the moisture that seedlings will have for survival and growth must be stored in the soil. Seedling roots grow slowly and take a while to find stores of water and nutrients in the soil. Shrubs, grasses, or weeds can compete with the seedlings for very limited water and nutrients. The goal is to give the planted seedlings the advantage.

If numerous plants are already growing on the chosen planting area or if there is too much woody material, some form of site preparation should be considered. Site preparation creates a suitable seed bed of mineral soil for germination of naturally produced seed. (Most conifers require mineral soil for successful seed germination.) Furthermore, site preparation can create access for crews or locations for planting, and it can remove competition from unwanted tree, shrub, and herbaceous plants. It can be done to varying degrees depending on environmental constraints. For example, a site may be only partially cleared to accommodate access for planting while retaining coarse woody debris and soil cover to prevent erosion. A variety of mechanical, chemical, and fire-related techniques are available, depending on the environmental conditions, forest type, and regulatory constraints.

Machine Site Preparation

Bulldozers or various devices attached to a bulldozer or farm tractor can be used to assist in regeneration projects by knocking down shrubs, pushing woody debris aside, or crushing dead trees. These machines perform best on flat or gentle slopes and should not be used on sites with steep slopes or erosive soils. Machines may compact soils, so it is best to use them when soils are dry. Assuming that the site is suitable, machine use can be an effective way to clear unwanted debris and vegetation, expose mineral soils, and potentially reduce fire hazard.

Machine site preparation produces cleared areas with interspersed piles of debris. These piles may be burned or left to decompose. It is critical that the amount of soil included in debris piles be minimized to reduce loss of productive topsoil. Unburned piles may serve as habitat for small animals that, depending on landowner objectives, can be considered an asset or a liability. Landowners who wish to encourage wildlife such as quail or rabbits might want to leave the piles. However, those who do this should plan for some seedling losses from small rodents that like to eat seedlings.

Controlled Burning

Used with care, controlled burning is an inexpensive method to reduce debris, eliminate piles of brush, and provide suitable seedbed or planting conditions. Controlled burning also reduces fire hazard by consuming fuels. However, burning alone may not be effective for complete site preparation, in part because fire can encourage the regeneration of certain undesirable shrub species. For example, seeds of Scotch broom, ceanothus, or manzanita can remain viable in the soil for 40 years or more until fire breaks seed dormancy and allows these shrubs to germinate and quickly occupy an area. A few years after a controlled burn it may be necessary to control unwanted brush to give the planted trees an advantage.

Cool, low-intensity fires are best. Hot fires may have undesirable effects on physical and chemical soil properties by removing soil nutrients and making the soil less permeable to water, potentially increasing runoff and erosion. Generally, most burn prescriptions for site preparation are intended to remove not all debris on the soil surface but just enough to allow access for planting. "Broadcast" burning of this type is not usually used on sites where natural regeneration is the only source for the new stand.

Controlled burning is not for the novice, although a landowner may be able to burn slash or debris piles. A professional forester and local fire officials must be consulted before attempting controlled burning. Controlled burns require a fire permit and a plan to control the fire should it escape. You may be required to submit a written smoke management plan or air pollution control plan that describes which direction you expect the smoke to go. In some areas, the local air resources board may collect a per-acre fee for burning. If the fire escapes, the landowner may be held legally liable for all damages and suppression costs related to the escaped fire.

While there are challenges involved in using fire as a site preparation tool, fire can be highly effective and very cost-efficient when used carefully. Fire is the tool of choice for site preparation in many commercial operations.

Chemical Site Preparation

Herbicides can be used to reduce competition from undesirable tree, shrub, and herbaceous plant species, especially in follow-up treatments. Herbicides do not provide all that is required for adequate site preparation; they simply kill unwanted vegetation. Other methods, such as machine clearing or controlled burning, must be used to clear debris and dead vegetation. Herbicides may be cost-effective for vegetation control, especially for large areas. Herbicides are generally applied using a backpack sprayer, though they can be directly injected into a stem of an unwanted shrub or tree or can be sprayed from a helicopter.

Warning: Use Chemicals Cautiously

- Pesticides and herbicides are poisonous. Always read and carefully follow all precautions and safety recommendations given on the container label.
- Store all chemicals in the original labeled containers in a locked cabinet or shed, away from food or feeds, and out of the reach of children, unauthorized persons, pets, and livestock.
- Confine chemicals to the property being treated. Avoid drift onto neighboring properties, especially gardens containing fruits or vegetables.
- Dispose of empty containers carefully. Follow label instructions for disposal. Never reuse containers. Make sure empty containers are not accessible to children or animals.
- Never dispose of containers where they may contaminate water supplies or natural waterways. Do not pour down the sink or toilet. Consult your county agricultural commissioner for correct ways to dispose of excess pesticides. Never burn pesticide containers.

You must use the correct herbicide at the proper rate and at the right time. Federal law requires that every herbicide be registered with the U.S. Environmental Protection Agency (EPA). The regulations require that all herbicides be labeled with information that tells the user how to safely and effectively apply the product. The user is required by law to read and follow the instructions on the label. In many instances, herbicides can be used only by a licensed pesticide applicator with a permit. Your county agricultural commissioner can provide information on the registration of different chemicals used in the forest and permits that may apply. Laws vary by county. Some counties do not allow aerial application.

STOCK SELECTION

If natural regeneration is to be relied on, it is extremely important that the best available parent trees be saved from harvest to provide seed. These trees should have good form and vigor, full crowns, and dominance in the stand.

Selecting stock for planting is an entirely different matter. Seedling survival depends on how well the species and seedling are adapted to the site. Adaptability depends on elevation, aspect, available moisture, and local soil conditions. When selecting planting stock, it is preferable to choose species already growing on or near the site. If possible, contract with a nursery to grow seed collected from the site, as the trees currently growing there are best adapted to the unique conditions of the property.

When buying seedlings, refer to the tree seed zones that have been established by CAL FIRE (fig. 1). These zones match seeds and seedlings to local conditions. The seedlings selected for planting should come from the same tree seed zone and same elevation as your planting site.

Seedlings are available from a variety of private and CAL FIRE nurseries. When ordering seedlings, specify your seed zone, county, nearest town, and elevation of the planting site. Large (10,000+) orders for seedlings can usually be contracted one or two growing seasons in advance of planting, depending on the type of stock being ordered.

Two types of seedlings are generally available: bare root and containerized. Bare root seedlings are grown outdoors in a nursery bed and are harvested by carefully lifting the seedlings from the nursery bed just before your planting date. The roots of these seedlings must be kept moist and cold until planted. Bare root nursery stock must be planted while the plants are dormant to avoid damage to the roots.

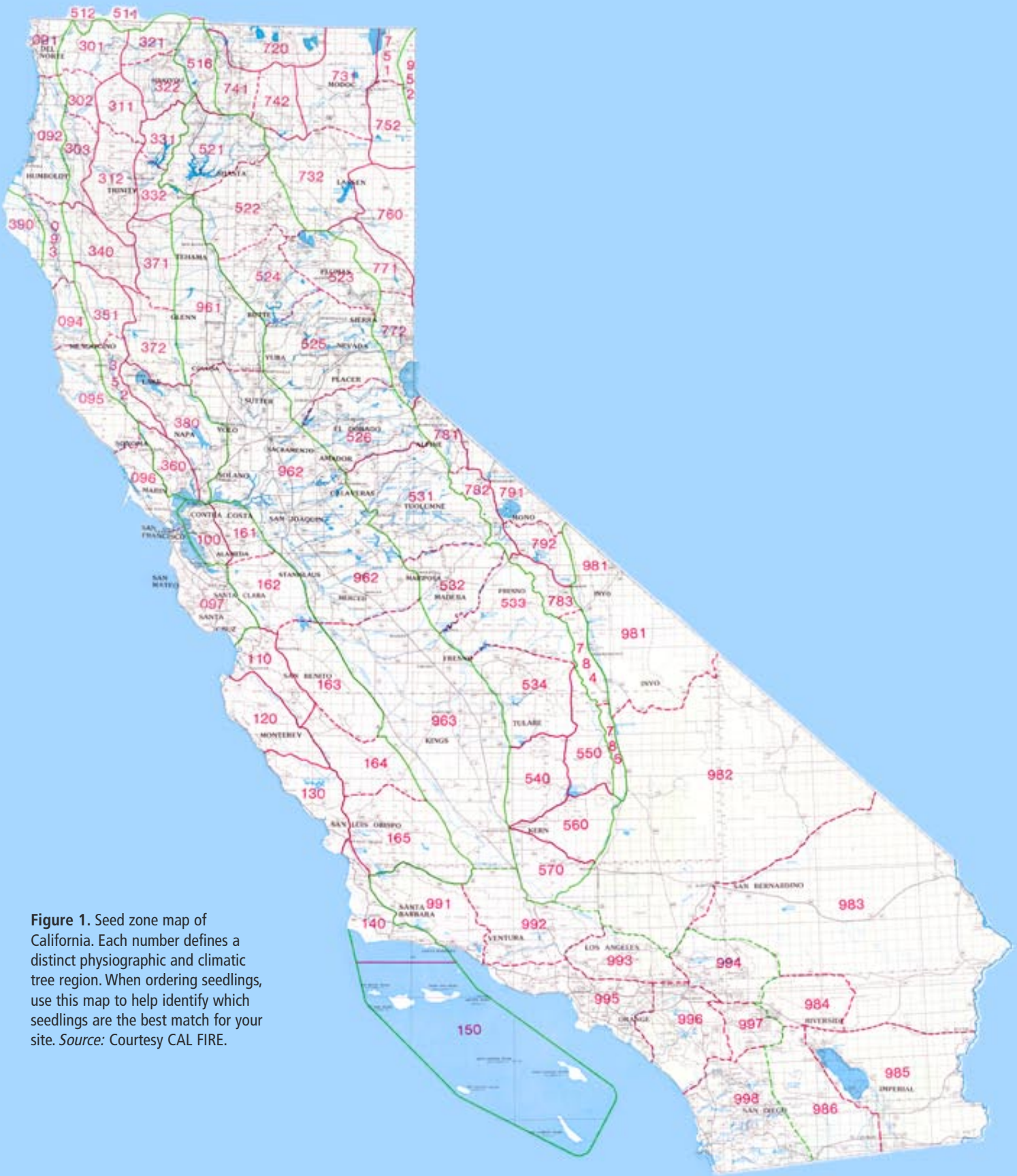

Figure 1. Seed zone map of California. Each number defines a distinct physiographic and climatic tree region. When ordering seedlings, use this map to help identify which seedlings are the best match for your site. *Source:* Courtesy CAL FIRE.

Nursery catalogs list bare root planting stock as 1-0 (said as "one-oh"), 2-0, 2-2, or some other combination of two numerals. The first numeral refers to the number of years the tree spent in the nursery bed. The second is the number of years spent in a transplant bed. Therefore, 2-2 stock is 4 years old and quite large. Trees that come directly from a seedbed (1-0, 2-0, 3-0) are called seedlings. Those that come from a transplant bed are called transplants. A rule of thumb is to use transplants on harsh sites and seedlings for easier sites. Transplants cost more because it takes more time and labor to produce them. Your particular site conditions determine your stock type. Typically, 2-0 or 1-1 stock is planted to regenerate most stands.

Planting stock should be evaluated when it is picked up from the nursery. Seedlings must be dormant and the buds firm with no evidence of new growth or shoot elongation. White root tips should be less than 1¼ inch long. A moldy or a sour odor is likely a result of improper storage, and these seedlings should not be planted. If you strip back the bark of the stem and root system on a couple of trees, the inner bark should be moist and glistening white. If it is yellow, brown, or has brown spots, the stock is badly damaged and has little survival potential.

Proper care of your planting stock is essential for seedling survival. Keep the roots moist and the trees cool (from 32º to 36ºF, or 0º to 2ºC) and out of the sun, including during transportation from the nursery to the site. Plant as soon as possible after receiving the seedlings. If you must store the trees for more than 3 days, heel in the seedlings by planting them temporarily in a soil trench in a cool, shaded place in the forest. You can store the trees this way for 7 to 10 days. An alternative is to use a large refrigerator to continue cold storage. The idea is to keep the seedlings cool and prevent them from breaking dormancy and growing new roots before the seedlings are planted.

Containerized seedlings have been grown from seed in a plastic container filled with a special soil mixture. Containerized seedlings are usually produced in a greenhouse under a carefully controlled environment. These seedlings can be planted during the growing season because their roots are protected in the growing medium.

Containerized seedlings are usually more expensive than bare root stock; however, they can be grown in a shorter time, 4 to 8 months, thus reducing the lead time involved in the planning process. Containerized seedlings may be easier to plant in rocky soils where it is difficult to open an adequate hole for the larger bare root seedlings. Evaluation of containerized stock is similar to that of bare rootstock.

TIMING

The best time to plant varies with the type of planting stock, soil conditions, climate, and location in the state. Before planting, the soil should be moist to a depth of at least 12 inches. This will require about 2 to 4 inches of rainfall for most timber soil types. The soil temperature at a depth of 3 inches should be 40ºF (4.5ºC) or higher and on a warming trend, with additional rain expected. These moisture and temperature requirements are essential for root growth to occur and for sufficient soil moisture to support the seedling through the dry season.

Many people prefer to plant during a light rain or drizzle. Avoid planting during extended warm and dry periods, or when frost or extreme winds are likely. At higher elevations, plant when the snow is gone and the chance of frost is minimal.

In California's Sierra Nevada and the eastern side of the Coast Range, planting conditions are usually optimal in late winter to early spring. On the warmer west side of the Coast Range, planting can begin as early as late fall, once the rains have saturated the soil, and can continue through to late winter.

STOCKING AND SPACING

The number of seedlings to plant depends on the size of the planting area and the spacing. Spacing is a function of the products you expect to harvest and your objectives. Timber is usually grown at spacing from 8 by 8 feet (680 trees per acre [tpa]) to 12 by 12 feet (300 tpa). Closer spacing is necessary if poor survival is expected. The Forest Practice Act requires stocking of at least 300 tpa within 5 years following a harvest. Ponderosa pine, Douglas-fir, and incense cedar usually have very high survival rates, greater than 80 percent, so overplanting to achieve 300 tpa is probably not necessary. Christmas trees are planted closer, commonly 5 by 5 feet (1,240 tpa) or 6 by 6 feet (1,210 tpa), because they will not need to grow to mature trees.

Calculating the Number of Seedlings Required

The following steps will help you determine the number of seedlings you will need.

- Calculate the number of square feet per tree for the desired spacing. For example, a spacing of 10 by 10 equals 100 square feet per tree (10 × 10 = 100).
- Obtain the number of trees per acre by dividing the number of square feet in 1 acre (43,560) by the number of square feet per tree.
- Obtain the total number of trees needed by multiplying the number of trees per acre by the number of acres in your planting area. Nurseries usually sell trees in lots of 100 or 500 trees, so round up the number that you need.

Example

- Number of square feet per tree: 10 × 10 = 100 ft^2/tree.
- Number of trees per acre: 43,560 ft^2/acre ÷ 100 = 435.6 tpa.
- Number of trees required: 435.6 × 20 acres = 8,712 trees.

PLANTING TECHNIQUES

Various hand tools, power tools, or machines can be used for planting. Planting bars, hoe-dads (also called western planting tools), shovels, and mattocks can be used with easily worked soil. The hoe-dad is generally best in rough terrain with rocky soils (fig. 2). Power-driven augers are used to dig holes in compacted soils or soils with a hardpan. The

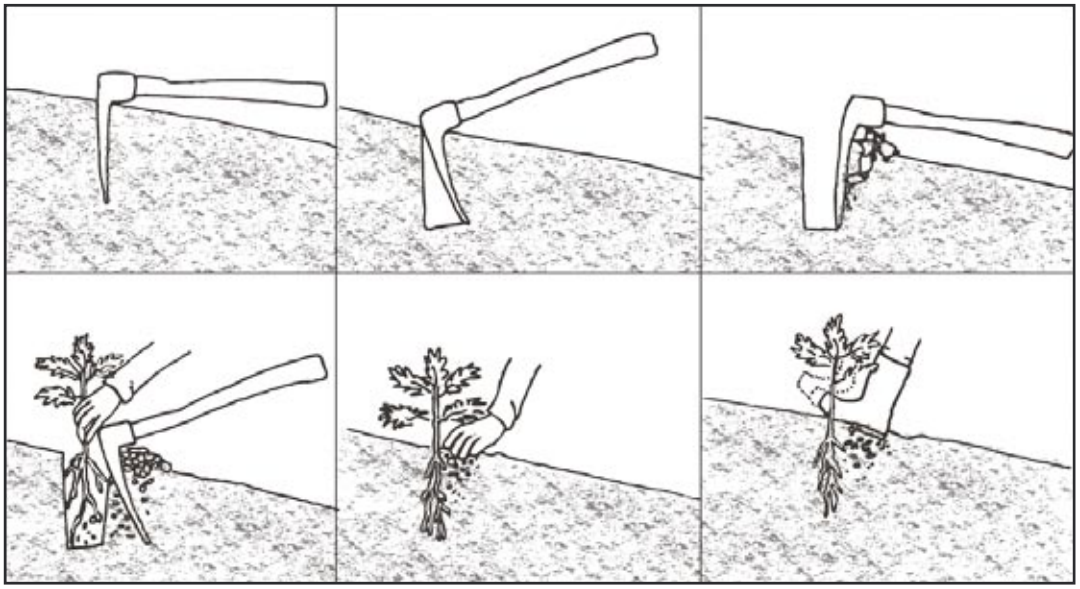

Figure 2: Planting technique using a hoe-dad.

use of planting machines is limited to fairly level sites with good site preparation. These machines are cost-effective only when planting large areas that can justify the move-in and equipment costs.

Whichever technique is used, care of seedlings and proper planting is of paramount importance (fig. 3). The roots should always be kept moist, with no more than 50 to 100 seedlings in the planting bag at one time. Each seedling should be planted erect at the depth it was planted in the nursery—to the root collar. The roots should be properly placed, making sure they are pointing downward in the planting hole. Kinked roots or roots planted in a bent J shape will strangle themselves in a few years. Air pockets should be eliminated by firming the soil around the roots.

Careful consideration should be given to the location where you plant the seedlings. They should be planted outside of the dripline of large conifer trees. Perfect spacing may not be that important or practical. If possible, scrape away the grass around the planting hole or choose locations that have less grass or brush for the seedling to compete with. On dry or exposed sites, choose locations that provide some natural shade, such as on the north side of a stump or other woody debris. Plant directly into the mineral soil. avoid locations with large amounts of woody materials in the soil, as these materials will dry out over the summer and make air pockets.

Planting should be followed by regular regeneration surveys to check seedling survival and to plan for any replacement trees. Survival of planted seedlings can vary considerably from year to year. Assess the need for releasing trees from competing vegetation or protecting them from animal damage. Regeneration surveys should be completed after the first and second year at least, and every other year until year 10. Competition from surrounding vegetation can severely limit seedling survival and growth.

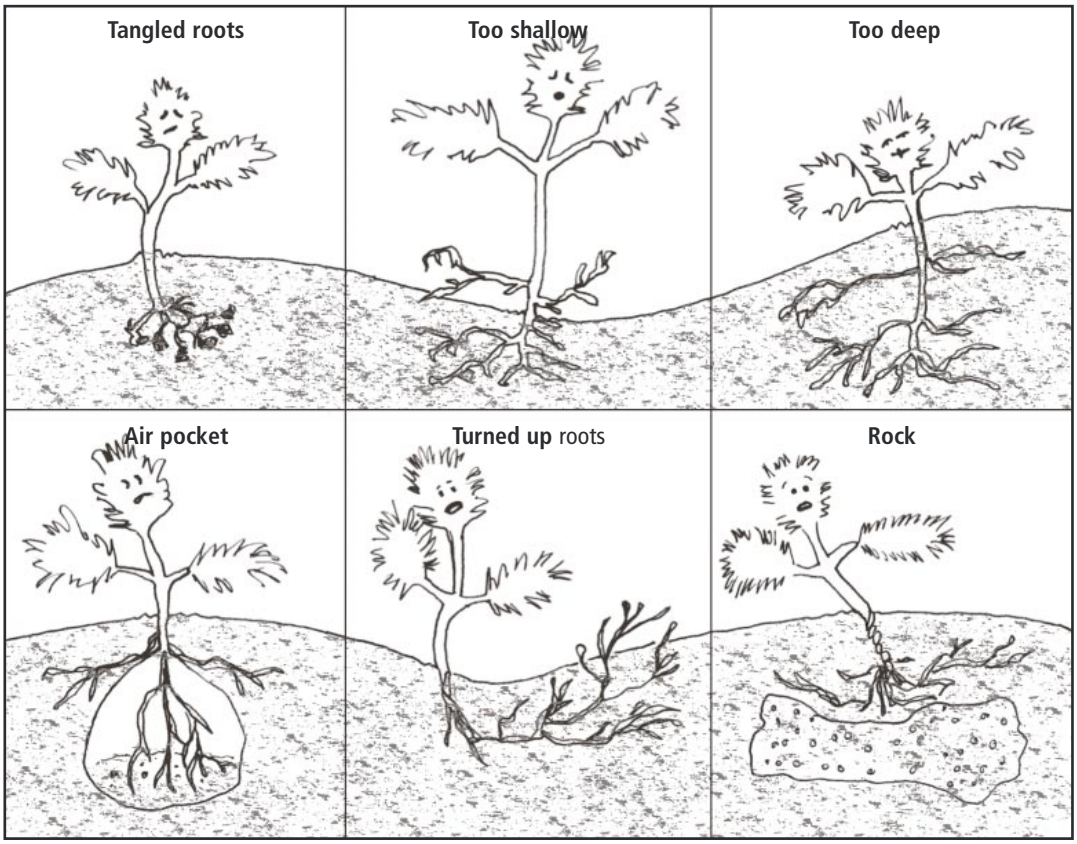

Figure 3: Avoid planting problems.

Release from competing vegetation is commonly done by hand-scalping grass or herbaceous plants around the seedling or by using herbicides to control brush. Safety is an important consideration in handwork, as working with sharp tools or machines on steep sites can be dangerous. If there are a large number of acres to treat, herbicides maybe preferable, as they are less expensive and are often more effective at controlling competing vegetation. However, herbicides have disadvantages. If not chosen or applied appropriately they can harm the planted trees. They may be harmful to nontarget organisms, and there can be water quality, wildlife, and human health concerns over their use. All herbicides or pesticides must be used properly, according to label instructions, and only after consideration of all treatment options.

Once your seedlings have been successfully planted, in many parts of the state young trees need to be protected from browsing by deer or wildlife. Plastic mesh sleeves that eventually degrade in sunlight can protect seedlings from browsing. Small tubes of deer repellant attached to the seedling have also been used successfully. Liquid repellants sprayed on individual plants are not very successful, as the repellant usually needs to be reapplied after each rain.

SUMMARY

The use of natural regeneration to create a new stand after harvest or to reforest sites is constrained by several factors, including availability of seed trees, seed production, weather, suitability of the seed bed, and competition from existing vegetation. To improve the chances for successful natural regeneration, plan to prepare the site and implement follow-up treatments to control competing vegetation. Planting represents a large investment that is carried over the life of a stand. However, a successful plantation can increase the value of your property to potential buyers, while providing habitat and other ecological benefits to your forest. It is in your best interest to

- plan regeneration operations carefully
- prepare the planting site
- take proper care of the planting stock
- closely supervise the planting crew
- follow through with regeneration surveys, indicating replanting and competition control where necessary.

The success of the planting effort depends on each of these steps and can only be as successful as the weakest link in the planting process.

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METRIC–ENGLISH CONVERSIONS

English	Conversion factor for English to Metric	Conversion factor for Metric to English	Metric
Length			
inch (in)	2.54	0.394	centimeter (cm)
foot (ft)	0.3048	3.28	meter (m)
acre (ac)	0.4047	2.47	hectare (ha)
square foot (ft^2)	0.0929	10.764	square meter (m^2)

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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.

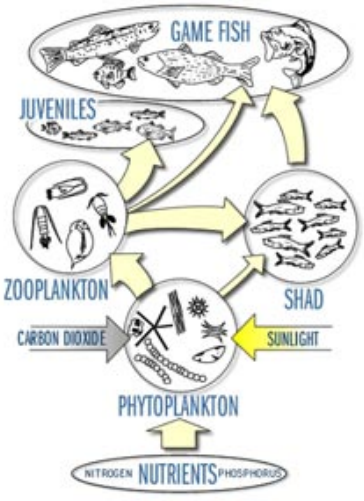

Figure 3. Diversity can be expressed by analyzing the number of animals that partition various resources found in a forest freshwater aquatic setting. *Source:* Courtesy Water on the Web, http://WaterOntheWeb.org, University of Minnesota-Duluth.

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.

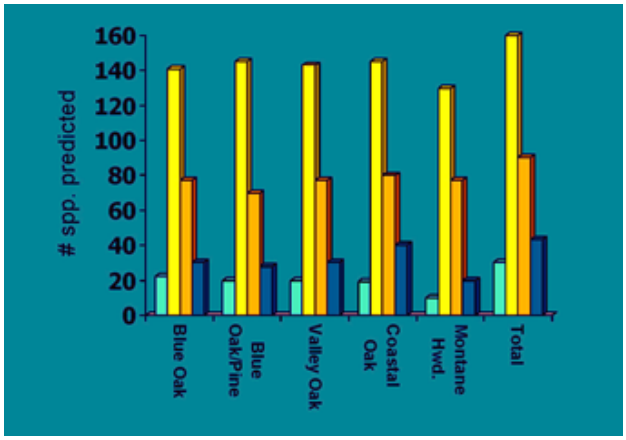

Figure 5. The diversity and overlap of wildlife species found in different oak woodlands across the state.

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

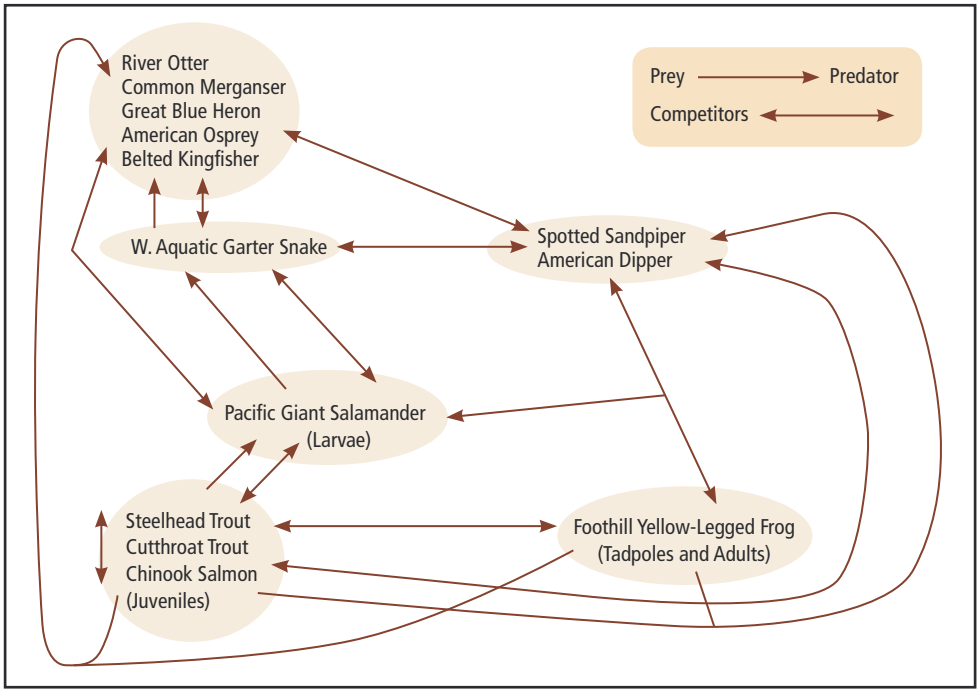

Figure 7. Relationships among groups of species in a forest can be quite complex, as illustrated by this food web developed for a perennial creek in the coast redwood region in Del Norte County.

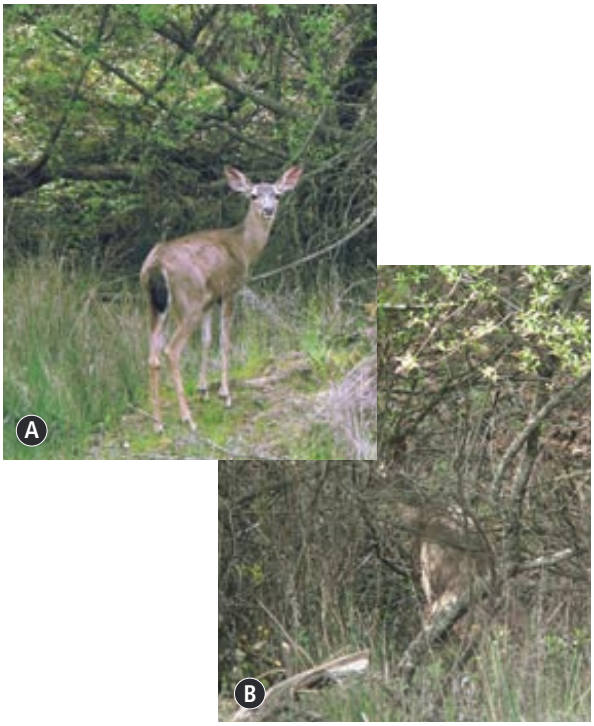

Figure 8. A deer browsing in the open (A) is quite visible and vulnerable to predators. Stepping into the forest just a few feet (B), the deer's coloration and form give it hiding cover and make it difficult to see. *Photos:* Gary Nakamura.

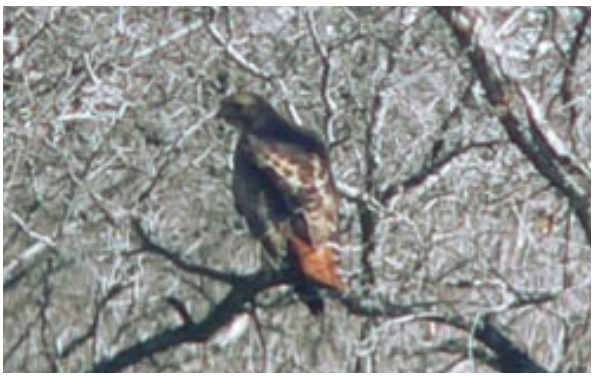

Figure 9. Snags can come in many shapes, sizes, and species. They offer nesting and roosting sites to a variety of species such as this red-tailed hawk in a blue oak. *Photo:* Gary Nakamura.

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.

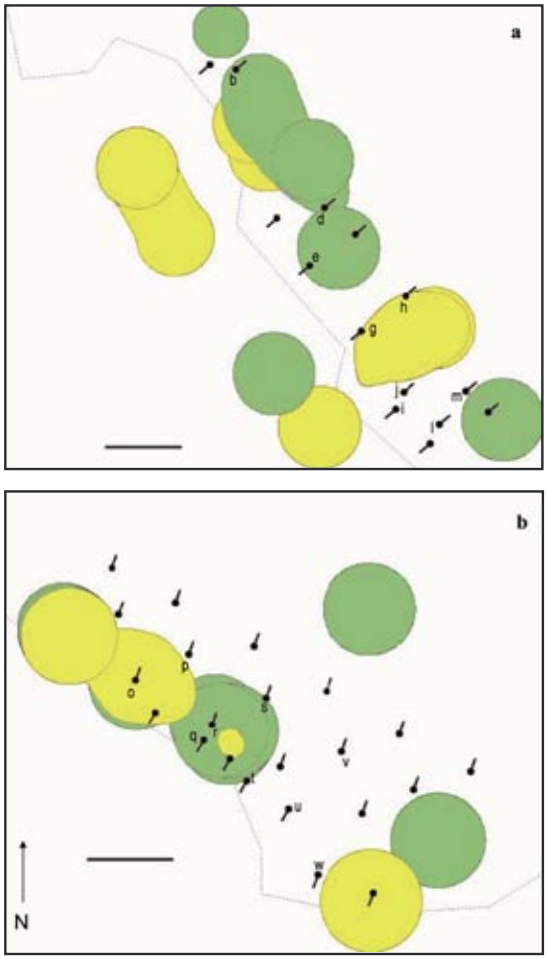

Figure 12. The "space" used regularly by animals is referred to as their home range. Home ranges for different individuals can readily overlap across many habitat elements. This is an example of individual deer mice (*Peromyscus* spp.) home ranges. A creek is denoted by a dashed line. Microphones and 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).

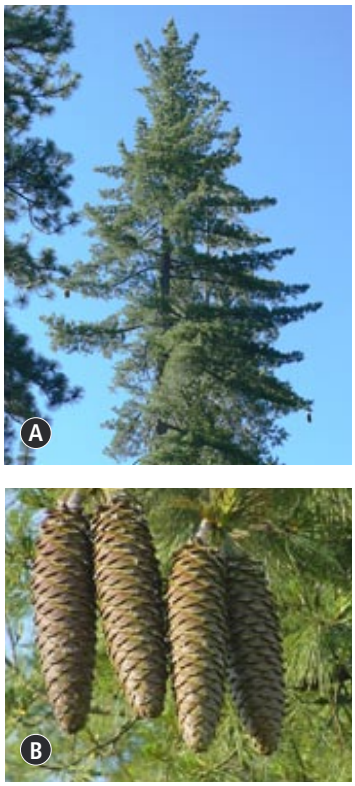

Figure 18. A: Sugar pines (center tree) are a prominent component of a Sierra mixed conifer forest and provide an important food source for many seed-eating species *Photo:* Gary Nakamura. B: Cones, which can grow to 18 inches long as shown here, hang from the tips of the branches. *Photo:* Richard Sniezko,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

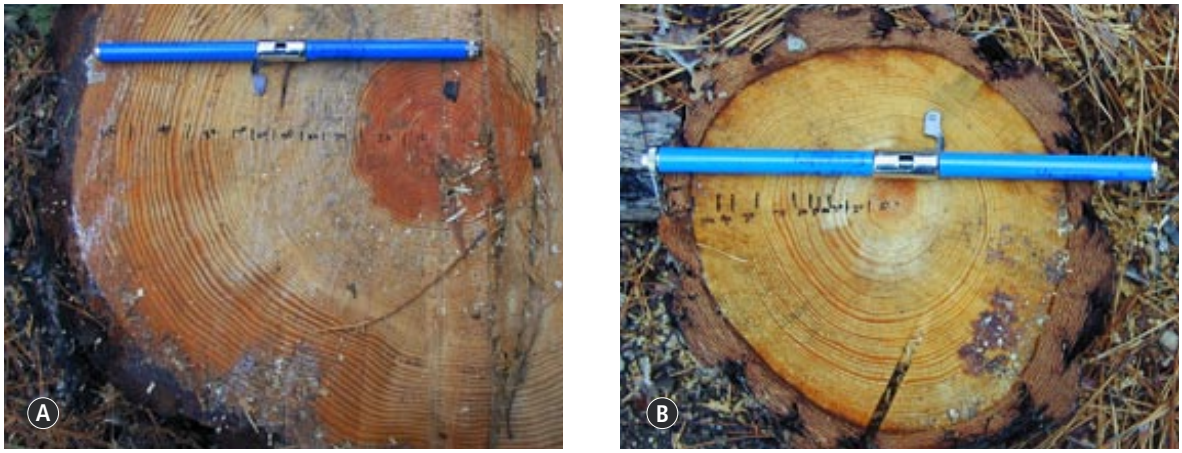

Figure 28. The size of a tree is not a good indicator of tree age because the growing conditions (light, water, nutrients) control growth. A: Ponderosa pine, 100 years old. The blue increment borer is 12 inches long (shown for scale). *Photo:* Gary Nakamura. B: This ponderosa pine, also 100 years old, 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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FOREST STEWARDSHIP SERIES 9: Forest Streams

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Stream channels add diversity, beauty, and excitement to forested property. Streams and the riparian vegetation associated with them also supply important habitat for many species of aquatic and terrestrial wildlife (fig. 1). In order to preserve these important functions and maintain healthy streams, it is important to first understand the role of stream channels in the landscape and how streams change over time.

Objective

Understand the role of streams, creeks, and rivers in the landscape in order to maintain them in healthy conditions on forested property.

Competencies

- *Understand how current stream channel conditions reflect watershed inputs of sediment, water, and woody debris as well as human disturbance.*
- *Know how human uses and activities can affect stream channels.*
- *Learn that streams can be protected and restored to ecologically functional levels by managing inputs of sediment, water, and woody debris and by maintaining riparian vegetation.*

Related Forest Stewardship Series Publications

- *Riparian Vegetation, ANR Publication 8240*
- *Forest Water Quality, ANR Publication 8241*
- *Laws and Regulations Affecting Forests, Part I: Timber Harvesting, ANR Publication 8249*
- *Laws and Regulations Affecting Forests, Part II: Activities Other Than Timber Harvesting, ANR Publication 8250*
- *Fish and Fish Habitat, ANR Publication 8242*
- *Forest Roads, ANR Publication 8247*
- *Technical and Financial Assistance, ANR Publication 8253*

THE ROLE OF STREAMS IN THE LANDSCAPE

Natural streams are formed over a geologic time scale of thousands of years. Their main function is to move water, sediment, and woody debris from higher to lower points in watersheds, often over long distances.

At the watershed level, streams or parts of streams are often divided by function into source, transport, and response areas, or reaches. Source areas are the steep upper-elevation locations where sediment is produced (fig. 2). Transport areas are the parts of a stream system where sediment and water move from higher to lower elevations. Response reaches are places where sediment and other products collect in the watershed.

UC PEER REVIEWED

Figure 1. A healthy stream, such as the one shown here, has diverse instream habitat that usually consists of alternating fast water (riffles) and slow-moving deeper pools. Cover is provided by boulders, overhanging vegetation, and large wood. Riparian vegetation is continuous and dense and water quality is good. *Photo:* Richard Harris.

Stream functions are in part determined by whether streams flow year-round (perennial), go dry for part of the year (intermittent), or flow only during periods of rainfall or snowmelt (ephemeral). Generally, ephemeral and intermittent streams are located in source areas or serve a transport function. Perennial streams may have all three functions—source, transport, and response. Although perennial streams clearly have the greatest potential to support wildlife and aquatic life, the linkages among streams of all types means that healthy habitat depends on healthy streams throughout the watershed.

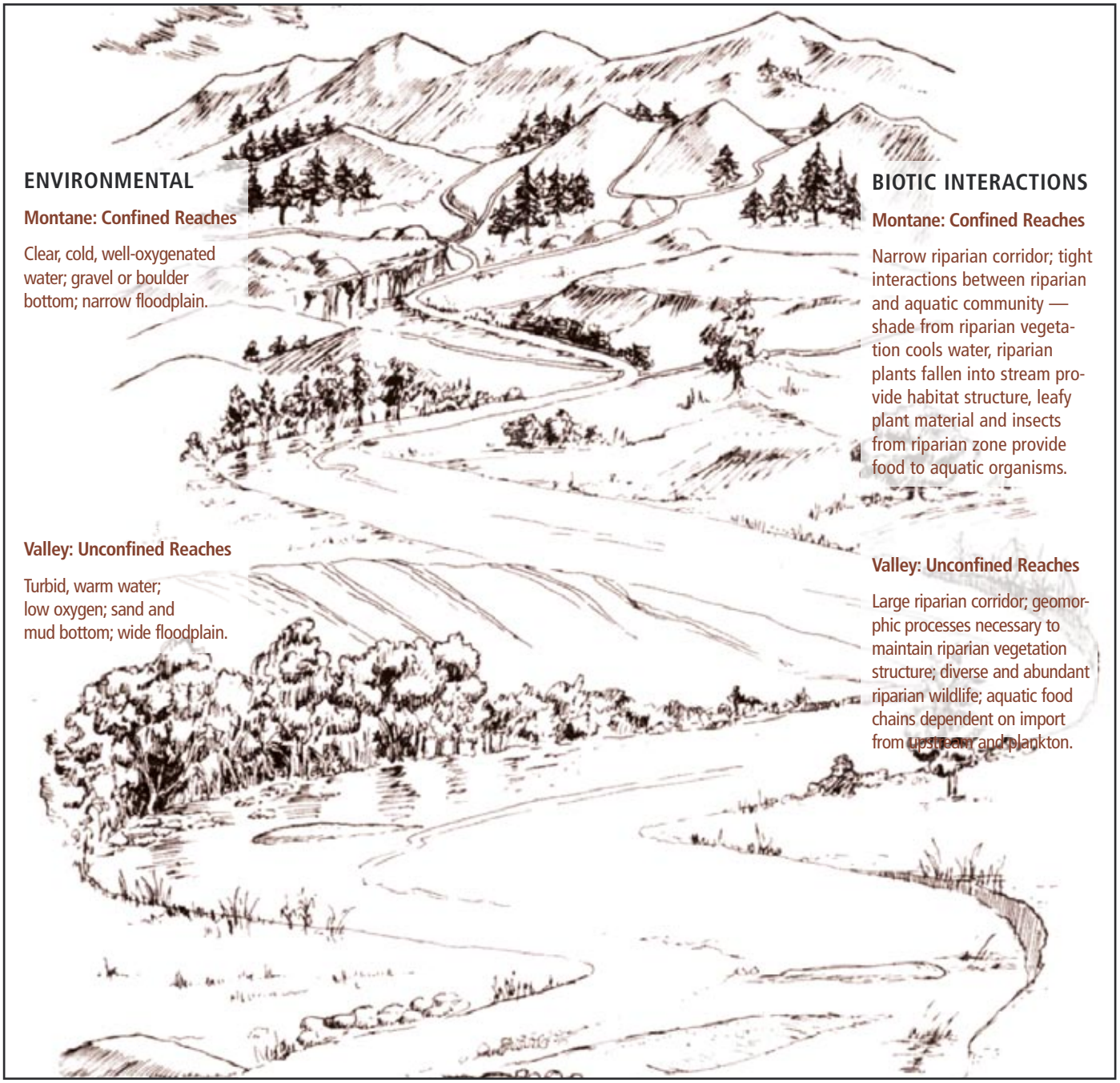

Figure 2. Variation in stream ecosystems from mountainous to valley portions of a watershed. Upper parts of watersheds tend to have simple communities and cold-water fishes like trout. Lower watershed areas tend to have complex communities and warm-water fishes. *Source:* Redrawn from *California's Rivers: A Public Trust Report* (Sacramento: California State Lands Commission, 1993), p. 230.

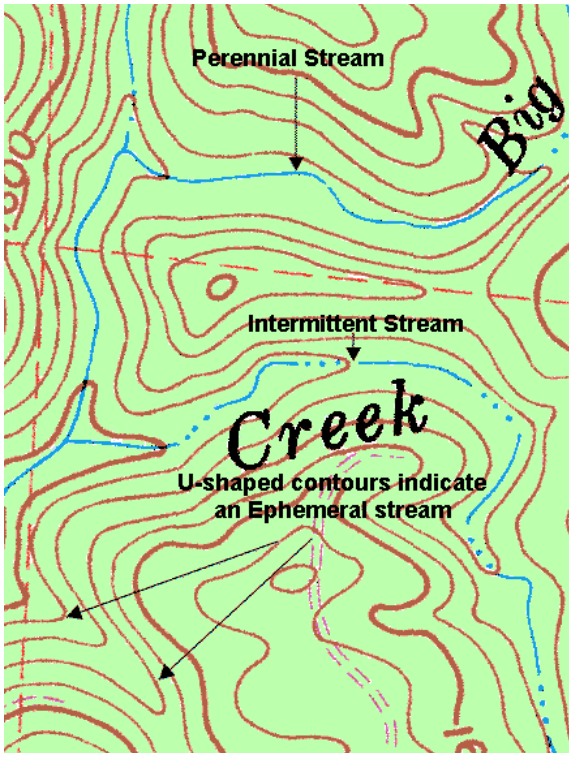

Figure 3. On topographic maps, streams are often depicted as solid blue lines if they are perennial or dashed blue lines if they are intermittent. Ephemeral streams may not be indicated at all and can be located only by careful inspection of contour lines on maps.

STREAM CLASSIFICATION

Streams are described in many ways. On topographic maps, they are often depicted as solid blue lines to indicate they are perennial or dashed blue lines if they are intermittent (fig. 3). Ephemeral streams may not be indicated on a contour map at all; as a general rule, topographic maps do not show the majority of the streams on a property, because most streams are ephemeral. Careful examination of the contour lines on a map can indicate where ephemeral streams may be, yet when seen in the field, they may barely be evident. Nevertheless, ephemeral streams are important for delivering sediment and wood to lower watershed reaches.

Streams can be classified in other ways besides flow regime. Several classification systems are used in California. Some systems distinguish streams by physical characteristics such as channel slope, channel width, and stream bed substrate. People involved in scientific investigations or stream restoration planning commonly use these systems. Other systems are based on regulatory requirements. In California, several agencies use a system that classifies streams on the basis of flow, presence of aquatic life, and uses. The resulting classes are used to prescribe protection during activities such as timber harvesting.

A landowner may find scientific classification to be a useful tool for management planning. Stream classification can be used to determine existing conditions relative to a natural, undisturbed state; for prescribing restoration needs; and for evaluating sensitivities to uses. If your property contains perennial streams, there is a high likelihood that the stream has been classified, and often, the aquatic habitat on perennial streams has been classified as well. You can find out whether and how your streams have been classified by contacting your local California Department of Fish and Game (DFG) office.

THE STREAM AND ITS FLOODPLAIN

In cross-section, a stream may include one or more channels that convey flow and one or more adjacent deposits (fig. 4). These adjacent deposits are known as the floodplain, an area that is inundated by water when the capacity of the stream channel is exceeded. Not all streams have floodplains. For example, streams at high elevations may be steep and narrow and incised in bedrock with no floodplain at all. To have a floodplain, a stream must have sufficient available materials (sand, silt, gravel) and flow. Consequently, streams with extensive floodplains are mainly found at lower elevations.

A stream builds a floodplains as it erodes its bed and banks and deposits the material elsewhere. The classic example of floodplain building is the point bar on a meander bend where the stream erodes one side of the channel and deposits the material on the opposite side (fig. 5).

The capacity of a stream channel is referred to as its bankful discharge, the maximum volume of water a channel can carry before it overtops its banks and inundates its floodplain. The position of the bankful discharge in a stream channel can often be determined in the field using physical indicators such as breaks in slope, drift lines,

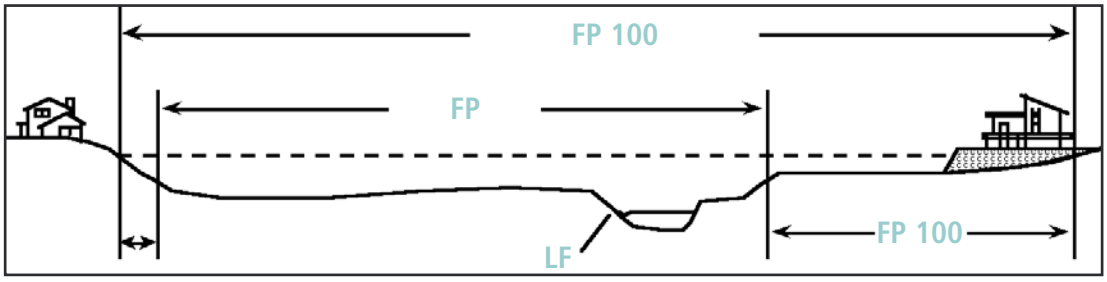

Figure 4. Cross-section of a floodplain indicating the low-flow channel (LF), floodplain or floodway (FP), 100-year flood level (dashed line) and 100-year floodplain (FP 100).

and changes in soils or vegetation. The current shape of a channel is largely a reflection of the "work" (erosion and deposition) done by the bankful discharge. When discharges exceed channel capacity, steeper streams without floodplains often undercut steep upland slopes, sometimes triggering landslides.

Because streams and their associated floodplains are exceptionally sensitive to land use impacts, they are the focus of many regulations affecting forest uses. All perennial streams, with or without floodplains, may support fish and other aquatic life. Changes in watershed conditions such as fire, timber harvesting, or road construction may directly or indirectly affect streams.

STREAM CHANNEL COMPLEXITY

Fish and other aquatic organisms have evolved to thrive in stream channels with particular sediment, water, and debris loads, as well as particular channel shapes and bedforms. In general, more complex channels with a variety of pools (slow water) and riffles (fast water) provide the best aquatic and cold-water fish habitat. Channels at higher elevations may have a stepped profile, with rock outcrops creating deep pools. At middle elevations, streams may have steps formed by rock or accumulations of large wood that create a

Figure 5. Rush Creek, Mono Basin, Inyo County. The breadth of the floodplain extends between the two steep slopes. The channel braids and meanders across the floodplain over the course of time. The entire flooplain is subject to inundation during a large flood. *Photo:* Richard Harris.

diversity of pools (fig. 6). At lower elevations, pools tend to form in locations scoured by concentrated flows at meander bends. Structural controls such as wood accumulations and rock tend to be less prominent in larger, low-elevation streams.

FISH HABITAT FEATURES

Not all landowners have streams that support fish, but even ephemeral streams may support amphibians such as salamanders and frogs. Some of these creatures are protected under state and federal endangered species acts. Consult with your local DFG office to determine whether streams or other wetlands on your property may support amphibians.

Stream characteristics important for fish include physical features such as pools and riffles, bed substrate, and riparian vegetation. Rocks and large pieces of wood create pools and riffles and provide cover for fish. In riffles where the surface flow is turbulent, the flowing water delivers insects for food, provides cover from predators, and allows the water oxygen content to be replenished.

Plunge pools are formed where water falls over a boulder or log, scouring a deep hole. Logs, root wads, boulders, and stream banks can cause backwater pools to form as water swirls around the obstacle. Juvenile and adult fish often hide in both plunge and backwater pools.

The quality and size of bed substrate may determine whether fish can spawn at a particular location. For example, trout and salmon require clean gravel substrate for nesting. If the bed substrate is too large or has an overabundance of sand and silt, spawning may be unsuccessful.

The vegetation on, near, and overhanging the water, known as riparian vegetation, provides plant materials that are consumed by aquatic animals and also provides shade that helps keep streams cool during the summer.

THE EFFECTS OF HUMAN DISTURBANCE ON STREAMS

Human disturbance that changes the amount of water, sediment, or woody debris in a channel or removes riparian vegetation will most likely make channels chronically unstable, impair water quality with sediment, or reduce channel complexity—all of which degrade fish habitat (table 1).

Figure 6. Although this forest stream may look damaged and unhealthy, large woody debris plays important roles by stabilizing channels, creating habitat for fish and invertebrates, and storing sediment. *Photo:* Richard Harris.

Table 1. Channel modifications and impacts on fish habitat

Modification	Impact
dams or other diversion structures	migration barriers, loss of spawning and rearing habitat
reservoirs or other impoundments	altered flows, loss of downstream sediment discharge
levees and dikes for flood control	loss of side channels and floodplain function, decreased channel length, reduced habitat complexity
channel straightening, hardening, or relocation	loss of habitat features such as pools and sources of spawning gravel
dredging	reduced habitat complexity, disruption of bottom substrate
stream bank protection (rip-rap)	reduced pool scouring, potential for downstream erosion
roads next to streams	loss of side channels, impacts on riparian vegetation and water quality
road crossings (e.g., culverts)	migration barriers, reduced habitat complexity, potential for downstream erosion
sand and gravel mining	potential for sedimentation or erosion, reduced habitat complexity

For example, dams and artificial impoundments slow stream flow and cause heavier sediment particles, such as gravels, to settle out above the dam. As a result, channels below the dam will have less gravel than in a natural system, reducing the quality of habitat for fish spawning.

Roads constructed next to streams can act as dikes or levees that cut off the stream from its floodplain and confine floodwaters to the channel. Since the water cannot disperse over a floodplain, it speeds up, gathers power, and erodes banks downstream from the road. Road construction in upper watershed areas near intermittent and ephemeral streams can cause downstream impacts. Roads can also deliver sediment to streams and change drainage patterns. In effect, a road system can act as an artificial extension of the natural drainage system. These effects move through the system from upper to lower watershed areas, eventually affecting perennial streams.

Avoiding Channel Impacts

The best way to avoid impacting streams is to avoid changing them from their natural state.

- Keep heavy equipment out of streams.
- Minimize road construction in riparian areas.
- Minimize road crossings over perennial and intermittent watercourses.
- Look for alternatives to relocating or straightening stream channels by redesigning construction projects.
- Consider alternatives to conventional culverts for stream crossings.
- Avoid installing riprap on stream banks, since this may cause downstream erosion.

Removal of riparian vegetation weakens stream banks, allowing them to erode more easily during floods. These stream channels may migrate at an excessive rate or erode adjacent upland slopes, both of which cause excessive sedimentation that can reduce the quality of fish habitat by filling pools and gravel beds with fine sediment.

PERMITS REQUIRED FOR CHANNEL MODIFICATIONS

The regulatory controls affecting streams are complex and vary according to the type of stream and the activities proposed. A landowner anticipating activities that would affect any stream is advised to consult with the local DFG office to determine whether permits are required. Generally, four agencies have regulatory control over perennial, intermittent, and ephemeral streams.

- DFG regulates activities that may affect instream life or habitat.
- The California Department of Forestry and Fire Protection (CAL FIRE) regulates timber management activities that may affect any type of stream.
- The Regional Water Quality Control Boards (RWQCBs) regulate activities that may affect water quality or quantity.
- The U.S. Army Corps of Engineers (USACE) regulates activities that may affect wetland or riparian conditions or waterway navigability.
- The National Marine Fisheries Service (NMFS) or the U.S. Fish and Wildlife Service (FWS) may also have jurisdiction on streams that support (or could support) threatened or endangered fish species.

Landowners wishing to carry out projects such as road building and culvert installation in active stream channels may be required to obtain a Streambed Alteration Agreement (known as a "1603 permit") from the CDFG and a permit from the USACE (known as a "404 permit"). Cities and counties may have their own permitting requirements if the road is intended for residential or public uses. Each agency typically requires mitigation measures to reduce the impact of a project on the channel, associated fish and wildlife habitat, and water quality.

CAL FIRE enforces the California Forest Practice Act and its implementation rules. Commercial timber harvesting requires a permit from CAL FIRE Many of these rules protect streams and associated riparian vegetation and include requirements for riparian buffer strips, prohibitions on allowing sediment or logging slash from entering streams, and standards for construction of logging roads. CAL FIRE's regulatory process includes participation by other agencies such as the DFG and RWQCB to ensure that their concerns are addressed.

The RWQCBs require permits for discharges of foreign materials into perennial streams. They also enforce water quality standards for beneficial uses in watercourses.

MAINTAINING HEALTHY STREAMS

The way to keep streams healthy is to maintain or restore the natural level of water, sediment, and woody debris in the channel and to maintain associated riparian vegetation.

Management Techniques

Sediment

- Proper planning of earth-moving operations can reduce sedimentation.
- Confine earth moving to dry months and use erosion and sediment control measures during rainy months.
- Retain vegetation buffers near work areas to filter out sediment.
- Install roads well away from streams and adjust drainage structures to get the water off the road as quickly as possible.
- Any water that carries sediment should be drained into vegetative filters.
- Properly size and align culverts to reduce risk of failure; install "fail-safe" culverts wherever possible.

Woody debris

- Limit the removal of large wood from streams and floodplains to the amount absolutely necessary for protecting structures.
- Carefully plan harvests from riparian forests to ensure an adequate supply of large woody debris.
- Consider planting and managing for conifers where appropriate and possible in order to increase woody debris available to the stream in the future.

Riparian vegetation

- Maintain buffers of riparian vegetation along stream banks that are protected from human disturbance.
- Restrict forest management activities such as road construction or harvesting in this buffer area to minimize changes in stream channels.

Water

Changes in the runoff from your property can affect stream channels. Installing roads and culverts and removing vegetation often trigger these changes. Roads and commonly used in-slope drainage ditches interrupt the runoff of water from hillsides and bring it to streams more quickly. Culverts installed in streams redirect flow and may cause erosion when improperly sized and installed. Removal of upland vegetation allows more water to reach streams rather than being taken up by plants.

Sediment

Earth-moving operations on your property may increase sediment input to streams and affect their condition. Road construction and improperly conducted timber harvest can deliver excess sediment to streams. Locating gravel or dirt roads too close to streams also creates a source of chronic sediment input. Undersized or improperly aligned culverts may fail during storms and deliver sediment to streams while damaging the road as well.

Woody Debris

In the past, clearing or harvesting forests along streams removed sources of large woody debris that would fall into channels. California's current forest practice rules specify retention requirements for large woody debris. Clearing the stream channels in order to "improve" streams or protect roads and bridges deprives the stream of its natural inputs and can change habitat values.

Vegetation

Removing riparian vegetation weakens stream banks, allowing erosion during floods. Stream channels may then migrate excessively, erode their beds, and dewater surrounding lands. This degrades both fish habitat and water quality. Loss of shade can increase stream temperature during the summer months when fish and other aquatic life are vulnerable to heat stress.

IMPROVING AND RESTORING STREAMS

In some cases, maintaining the natural balance of stream inputs on your property may not be enough to protect your streams. Some streams may already be suffering from human-induced impacts throughout the watershed. They may be degraded to the point that they cannot become healthy without active management efforts. The degradation could be a consequence of past management on your property or the result of actions elsewhere in the watershed, since water, sediment, and woody debris come from the

entire watershed upstream from your location. In order to maintain stream health at one location, all lands upstream must be considered. Stream and watershed protection is by definition a broad-scale effort.

Working Cooperatively

Cooperative stream and watershed protection efforts have increased over the last few years. Landowners have formed watershed councils or organizations to work on stream protection as groups. Some RCDs work with associations of landowners on large-scale conservation problems, and the RCDs may be involved in coordinating landowners for stream protection. Contact your local RCD or University of California Cooperative Extension office for more information on cooperative conservation efforts in your area.

Watershed and stream restoration projects are active measures taken to improve streams and return them to a healthier, more natural state. Restoration projects can be quite diverse, seeking to change land use, improve channel conditions, reduce sediment input, or increase riparian vegetation or large woody debris (fig. 7). Projects such as planting riparian vegetation, upgrading roads, and revegetating upslope areas can be quite successful in improving local stream or watershed conditions.

Figure 7. Large wood is often placed in streams as a means of restoring habitat for fish, as has been done at this site on the Gualala River in Mendocino County. The logs are marked to allow their location and movement to be monitored. *Photo:* Gary Nakamura.

RESOURCES

Several programs in California provide cost sharing for projects aimed at watershed or stream restoration. On the coast, these include the Fisheries Habitat Restoration Grant program administered by DFG. There and elsewhere, funding is also available from other agencies such as the Natural Resources Conservation Service (NRCS) and CAL FIRE. To find out about these and other programs, contact your local University of California Cooperative Extension, DFG, or CAL FIRE offices.

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FOREST STEWARDSHIP SERIES 10

Riparian Vegetation

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Areas immediately adjacent to rivers and streams are known as riparian areas, and the vegetation that occurs there is called riparian vegetation. Riparian vegetation is often quite distinctive when compared with upland vegetation because it is comprised of plants adapted to high soil moisture (fig. 1). For example, in areas where uplands are dominated by coniferous forest or grassland, riparian vegetation may consist of deciduous trees and shrubs including cottonwood, willow, alder, and sycamore. Riparian communities in the western United States can resemble the hardwood forest communities of the eastern and southern parts of the country.

Objective

Understand the ecological functions of vegetation found along watercourses (riparian vegetation) in order to maintain and protect those functions on your property.

Competencies

- *Understand the ecological functions of riparian vegetation and wetlands along streams.*
- *Ability to use riparian buffer strips to protect ecological functions from land use impacts.*
- *Familiarity with the requirements for riparian buffer strips during forest management under California law.*

Related Forest Stewardship Publications

- *Forest Streams, ANR Publication 8239*
- *Fish and Fish Habitat, ANR Publication 8242*
- *Laws and Regulations Affecting Forests, Part I: Timber Harvesting, ANR Publication 8249*
- *Laws and Regulations Affecting Forests, Part II: Activities Other Than Timber Harvesting, ANR Publication 8250*

ECOLOGICAL FUNCTIONS OF RIPARIAN VEGETATION

Riparian vegetation performs important ecological functions. These include serving as terrestrial and aquatic habitat, stabilizing stream banks, providing shade to streams, and providing large woody debris to increase complexity of in-stream fish habitat.

Terrestrial Habitat

Healthy riparian vegetation is a critical component of habitat for many terrestrial wildlife species. For example, many birds are common visitors to riparian forests. These include songbirds that feed on insects; herons and cranes that feed on fish and frogs; and hawks, eagles, and osprey that feed on fish. Migratory birds such as waterfowl and some songbirds use riparian

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Figure 1. Riparian vegetation is often distinctively different from surrounding upland vegetation. The boundaries of a riparian zone can be inferred from the presence of species such as willows, alders and cottonwood. *Photo:* Richard Harris.

areas for resting, feeding, and breeding habitat. Most small carnivores, such as foxes, will use the water's edge in their search for food. Riparian zones can also serve as important corridors of movement for larger wildlife such as deer and bear.

Aquatic Habitat

Riparian vegetation provides habitat for insects, some of which fall in the stream and become food for fish. Plant litter derived from riparian vegetation can be the largest source of nutrients to the stream. Vegetation overhanging stream banks also provides cover for small fish. Overhanging branches or toppled trees can trap debris and can alter stream flow patterns, creating refuges for fish during high flows.

Stream Bank Stability

The large and fine roots of riparian vegetation stabilize stream banks, reducing bank erosion and preventing excessive widening of the stream channel. During high stream flows, riparian vegetation may slow and dissipate the energy of floodwaters, reducing erosion from these events. Riparian vegetation may act as a filter in some locations, trapping sediment and pollutants from upslope sources.

Shade

The temperature of stream water varies according to season. During the summer when stream flow is low, heat from the sun (solar radiation) reaching the water surface can dramatically affect water temperature. Increased stream temperature in turn, can adversely affect coldwater fish and other aquatic life. Shade provided by riparian vegetation reduces inputs of solar radiation, helping to maintain cool water temperatures and to moderate temperature fluctuations (fig. 2).

Large Woody Debris

Large woody debris (LWD) includes tree stems, roots, and branches that enter the stream as a result of tree mortality, bank erosion, wind throw, or large floods. Large wood provides fish with cover to escape from predators, serves as a refuge during high stream flows, and creates rearing habitat. Large wood in streams obstructs and diverts flows in complex patterns, slowing water and changing its depth, helping to form pools (fig. 3).

Figure 2. Shade provided by riparian canopy overhanging a stream helps maintain lower water temperatures during the summer and fall and benefits resident fish and other aquatic life. *Photo:* Richard Harris.

Large woody debris also creates storage sites for sediment in all types of stream channels. In smaller streams, single pieces of large wood spanning the channel can be the primary factor keeping sediment from moving downstream. In larger streams, LWD is transported downstream and often accumulates in debris "jams." These jams act as escape cover for fish and storage sites for sediment, which can provide spawning gravel for fish. LWD on floodplains and gravel bars on large streams provide escape habitat for fish at high flows when floodplains are inundated, and they also promote streamside forest development.

HUMAN-INDUCED CHANGES IN RIPARIAN VEGETATION

Although change occurs naturally in riparian communities, many human activities have caused dramatic and widespread changes well beyond the norm. Agriculture, livestock grazing, mining, forestry, and urban and residential development near water bodies can all lead to removal or reduction of riparian vegetation and the impairment of its ecological functions.

Once riparian vegetation is removed, it no longer serves to shade water, provide food for aquatic organisms, maintain stream banks, provide a source of large woody debris, or slow or filter runoff to streams. The result is degraded water quality and fish habitat. For those reasons, maintenance of riparian vegetation is a critical element of almost any type of land use.

ECOLOGICAL FUNCTIONS OF WETLANDS

Wetlands are distinguished from riparian vegetation primarily because they are mostly comprised of herbaceous plants such as sedges, rushes, and grasses. Trees and shrubs that are present are adapted to a permanent high water table and saturated soils.

Figure 3. Large woody debris (LWD) helps stabilize stream channels, create habitat for fish and other creatures, and store sediment. Accumulations such as the one in the figure are especially important because they tend to provide beneficial functions for a long time. *Photo:* Richard Harris.

Wetlands can be associated with stream systems or may be found in upland areas with no obvious connection to streams. The mountain meadow is a common example of a wetland often associated with a stream. Spring-fed wetlands or bogs are usually not associated with streams.

Vernal pools (shallow pools that form only during the rainy season) are a special type of wetland that is found in grassland, oak woodland, and prairie landscapes with little topographic relief. They are essentially depressions in otherwise flat terrain. They are uncommon in most forests and will not be discussed further here.

Wetlands along streams are inundated at high flows (fig. 4). These wetlands slow floodwaters, allowing sediments and pollutants to settle out. Vegetation in wetlands can assimilate nutrients, including some toxins, thereby protecting downstream water quality. Wetlands intercept, delay, and store surface water runoff and reduce the severity of downstream flooding. Wetlands are often dependent on groundwater and are indicative of underlying aquifers. Wetlands also discharge water to streams during periods of low flow, extending the season of stream flow during dry summer months. Because wetlands are able to store water and make it available in the dry summer months, they provide critical habitat to many aquatic and terrestrial wildlife species.

CHANGES IN RIPARIAN VEGETATION AND WETLANDS

Riparian vegetation naturally changes over time and may establish in new areas under favorable conditions. For example, newly deposited gravel and sand bars may be colonized

Figure 4. Spring-fed and other wetlands are common on many forested lands and are protected under current forest practice rules during timber harvesting operations. The occurrence and size of mountain meadows such as the one shown have been reduced due to a combination of hydrologic impacts, grazing, fire exclusion, and invasion by conifers. *Photo:* Gary Nakamura.

by willows or other plants that may gradually capture sediment from floodwaters, causing the bar to get larger and higher above the stream. As the willows get older, other plants such as sycamore or oak may establish and eventually overtop the willows. In heavily forested regions such as the North Coast, vegetation changes over time (i.e., succession) may lead to the establishment of a riparian community dominated by conifers like redwood.

Floodwaters can sweep away entire riparian communities, leaving bare gravel or sand bars. When this happens, the development of the plant community from pioneer plants such as willows to later-successional species like cottonwood, oak, or redwood begins again.

RIPARIAN BUFFER STRIPS

Buffer strips are areas of vegetation left beside a stream or lake to protect against land use impacts. For example, a fence may be installed at the landward edge of a riparian community to create a buffer between the stream and livestock. Buffer strips are also used to protect streams during forest harvesting operations. Whether or not harvesting is permitted within the buffer strip, well-designed and managed buffers can contribute significantly to the maintenance of aquatic and riparian habitat and the control of pollution. Riparian buffer strips are designed to protect the ecological functions associated with riparian vegetation. In addition, they help protect aquatic and riparian plants and animals from upland sources of pollution by trapping or filtering sediments, nutrients, and chemicals from forestry, agricultural, and residential activities.

On private forestland in California, legal requirements are imposed during timber harvesting to protect the ecological functions associated with riparian vegetation and to maintain water quality. The California Forest Practice Act requires maintenance of riparian vegetation in buffer strips called watercourse and lake protection zones (WLPZs). How WLPZs are defined and maintained must be specifically described in a written timber harvest plan filed by a Registered Professional Forester (RPF) with the California Department of Forestry and Fire Protection (CAL FIRE).

California defines four classes of watercourses (I, II, III, and IV) on the basis of the watercourse's use (see box). WLPZ width is determined by the watercourse class and the steepness, or slope, of the adjacent land draining to the watercourse.

Watercourse Class	Description
I	Perennial streams that contain fish or are domestic water supplies.
II	Perennial streams that do not contain fish but do contain other aquatic life or are within 1,000 feet (305 m) of a Class I stream.
III	Watercourses that do not support aquatic life but have the potential to deliver sediment to a Class I or II stream.
IV	Human-made streams for domestic, agricultural, or hydroelectric supply or for other beneficial use.

As of 2007, WLPZs for Class I watercourses ranged from 75 to 150 feet (23 to 46 m) on each side of the watercourse, depending on slope and region of the state. On Class II watercourses, WLPZs ranged from 50 to 100 feet (15 to 30 m). Along Class III and IV streams, equipment exclusion zones (EEZs) or equipment limitation zones (ELZs) are required to prevent equipment from operating near the watercourse. Buffers are established on a case-by-case basis for these watercourses. Alternative prescriptions for Class I and II watercourse WLPZs are allowed on a site-specific basis if they provide at least as much protection as the standard WLPZ.

The specific WLPZ requirements for timber harvesting are subject to change, and it is always advisable to consult with an RPF or the CAL FIRE to determine current regulatory requirements. Because of the importance of the streamside zone, regulations are stringently enforced.

In California, there is no state law equivalent to the Forest Practice Act for protecting riparian zones from infringement by other uses. Consequently, regulatory controls are left up to local jurisdictions, primarily counties. Agricultural uses, including rangeland grazing in riparian zones, are regulated in only a few counties.

RESOURCES

Several educational and cost-share programs promote riparian protection as it applies to agricultural uses. Educational programs are offered through the University of California Cooperative Extension (UCCE). The California Department of Fish and Game (DFG) and the Natural Resource Conservation Service (NRCS) administer cost-share programs for landowners seeking to protect and restore riparian zones by excluding livestock and other measures. To find out about these and other programs, contact your local UCCE, DFG, or CAL FIRE offices.

Riparian Forest Restoration

While few people agree on just how much large woody debris is needed in a stream, many biologists feel that most California streams need more. The present deficit is in large part a result of past policies advocating the clearance of LWD from streams. Currently, most clearing of wood from streams is limited to that required to prevent damage to roads and stream crossings.

Riparian forests are critical for supplying new LWD to streams. However, many riparian forests have few large trees because of conversion of timberland to agricultural and residential use, as well as timber harvesting conducted before the current forest practice rules were instituted.

To reverse LWD deficiencies, a landowner can manage the riparian forest to promote recruitment of LWD. Most LWD falling into streams comes from within 100 to 200 feet of the stream. Depending on the size of the stream, you may want your riparian LWD recruitment zone to be equal in width (on each side of the stream) to the height of the tallest tree that might realistically fall into the watercourse. Growing large trees as potential sources of LWD may require active management, such as planting conifers, controlling competition, and thinning. Actively managing riparian zones must be done with caution to minimize soil disturbance and leave a good shade canopy intact. Indiscriminate removal of LWD from streams or floodplains can destabilize streams and reduce habitat values, so this should be avoided.

In the long term, creative management of riparian forests offers the most promise for improving conditions. However, on some streams, reintroduction or placement of logs in the channel may provide a short-term solution until natural recruitment processes recover. The novice should not attempt to do this. Your local DFG staff can provide advice and guidelines for placing wood in streams. Cost-sharing programs are often available for these projects.

Rural residential uses are prevented from adversely affecting riparian zones in some counties by ordinance and in all counties through implementation of the California Environmental Quality Act (CEQA). Before engaging in activities that may affect riparian zones, a landowner should contact the local county planning department.

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FOREST STEWARDSHIP SERIES 11

Forest Water Quality

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The purity of fresh water is of vital importance to humans, fish, and wildlife. Since forest management and other land use activities have effects on water quality, it is important to understand what water quality actually is, how it is measured, and how to protect it.

Objective

Understand natural and management effects on forest water quality and the concept of nonpoint source water pollution control.

Competencies

- *Define water quality in relation to the beneficial uses of water.*
- *Learn components and measures of water quality.*
- *Understand the concept of nonpoint source water pollution.*
- *Gain familiarity with regulations requiring control of nonpoint source pollution and the methods of pollution prevention through use of best management practices.*
- *Understand issues to consider when developing water sources.*

Related Forest Stewardship Series Publications

- *Forest Streams, ANR Publication 8239*
- *Riparian Vegetation, ANR Publication 8240*
- *Laws and Regulations Affecting Forests, Part I: Timber Harvesting, ANR Publication 8249*

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WATER QUALITY

The quality of water is measured and expressed in many ways. Common indicators include clarity (turbidity), chemical composition (presence or absence of pesticides, nutrients, petroleum products, etc.), bacterial content (presence or absence of bacteria harmful to animals and humans), and temperature (in relation to tolerance levels of organisms living in the water).

The quality of water for human consumption is extremely important, but other uses have water quality requirements as well. Legal standards have been defined to protect water quality based on these requirements.

Beneficial Uses

California and federal laws and regulations define various beneficial uses of water. Each beneficial use requires its own level of water quality. Beneficial uses of water include

- drinking water
- sustaining fish and aquatic life
- irrigation and livestock
- industrial uses
- swimming, water contact sports, and boating
- navigation
- hydropower generation

Drinking water must be of a much higher quality than water used for irrigation or most industrial purposes. The quality of drinking water is impaired by the presence of bacteria, odor, color, and toxic substances that affect human health, but it is not directly affected by water temperature. Water temperature does, however, influence the suitability of water for cold-water fisheries. A human disturbance that increases temperature, such as riparian vegetation clearing, can reduce water quality for fish but might not affect water quality for other purposes. The uses of water for this variety of purposes are legally defined as beneficial uses.

Natural Variation

Water quality varies naturally over time and from place to place, and is determined at a specific time and place in a watershed by the combined effects of natural watershed processes and human activities. For example, water temperature in a small stream naturally increases during the summer when stream flow is reduced. Human or natural disturbances to riparian vegetation that reduce shade on the stream can exacerbate this effect.

Watersheds with soils prone to erosion have higher natural levels of sediment suspended in runoff and stream water than watersheds with less-erosive soils. Soil texture and cohesiveness, along with topographic slope, determine the potential for erosion. Generally, soils most likely to erode tend to be sandy, poorly consolidated, and found on steeper slopes, such as the decomposed granite soils found in many parts of California. Other fine-textured soils, such as silts and clays, may also be very erosive, especially when barren or disturbed. Even moderate levels of human disturbance in watersheds with highly erosive soils may increase sediment loads to levels that impair beneficial uses because sediment is naturally high anyway (fig. 1).

WATER POLLUTION

Water is considered polluted when it is no longer suitable for one or more beneficial uses. Water pollution comes from either "point" or "nonpoint" sources. Point source pollution enters a water body at a known place and typically involves a known quantity and type of pollutant. An example is wastewater discharged by a sewage treatment plant directly into a stream. This type of impairment can be controlled by measures at the source.

Nonpoint source pollution (NPS) comes from sources dispersed over a large area, rather than from a single point. For example, a number of development sites, parking lots, pastures, irrigated fields, and timber harvest sites dispersed throughout a watershed can combine to cause water pollution in a stream. Nonpoint source pollution is more difficult to control because it does not come from a single point and may cause impairment only as a cumulative effect of many activities.

Figure 1. Some watersheds are naturally more erosive than others, and streams draining them have high natural sediment loads. Stream bank erosion commonly occurs when riparian vegetation has been eliminated and when stream sediment loads are high. *Photo:* Richard Harris.

Types of Nonpoint Source Pollution

Point source pollution is rare in forested watersheds, but nonpoint source pollution is relatively common and can result from typical forest management activities. Excessive sediment, bacterial contamination, excessive nutrients and low levels of dissolved oxygen, and elevated water temperatures, and toxic contamination are types of water pollution that may come from nonpoint sources. Controlling nonpoint source pollution has become increasingly important because control of point source pollution alone is not enough to protect or restore water quality in many watersheds.

Sediment

Excessive fine sediment in a stream is a good example of nonpoint source pollution. A stream may have excessive sediment due to the combined contributions of many land uses within a watershed, such as road construction, urban development, cultivated agriculture, and timber harvesting. Reducing sediment is complicated because landowners in many locations may be involved.

Sediment is an essential component of healthy streams; it forms channel features such as point bars and floodplains that are sites for recruitment of riparian vegetation. Sediment inputs are also required to form spawning gravels and rearing habitat for fish. However, excessive sediment may be harmful to aquatic life particularly if it is in the silt- and clay-size ranges. In streams where fish occur, excessive fine sediment may bury eggs and newly hatched fish.

The amount of sediment in a stream varies naturally according to the rock types and soils through which a stream flows. Some streams have high sediment loads while others, such as streams flowing through bedrock, have very low sediment loads.

Causes of sediment impairment in forested watersheds include erosion resulting from poorly constructed roads and stream crossings, uncontrolled grazing, clearing of riparian vegetation, winter use of roads not designed for use in wet periods, and timber harvesting (fig. 2).

Figure 2. Use of unsurfaced roads in the winter can lead to erosion and sediment delivery to streams. *Photo:* Courtesy Angela Wilson.

Does my stream have a sediment problem? Look for:
- streams with little riparian vegetation and barren banks
- streams that become muddy after rainstorms and take a long time to clear up
- A stream that leaves your property muddier than when it entered

Bacteria

Coliform bacteria endanger the use of water for swimming and drinking. These bacteria are found in the wastes of warm-blooded animals, including humans, livestock, and wild mammals and birds. Coliform bacteria typically make their way into water bodies in above-ground or belowground runoff that has been contaminated by sewage, animal feedlots, or grazing animals. Once these bacteria enter water bodies, most settle to the bottom and become attached to sediment particles. When bottom sediments are disturbed, coliform bacteria can be resuspended and continue to affect water quality.

Does my stream have a bacteria problem? Look for:
- streams with unrestricted access by livestock
- streams with manure, sewage, or septic tanks in their 100-year floodplain
- streams that smell of manure or sewage

Nutrients and Dissolved Oxygen

Nitrogen and phosphorus are necessary for the growth of algae and aquatic plants. These plants serve as the primary food source for aquatic insects and macroinvertebrates that in turn are the primary food sources for fish. The concentration of dissolved oxygen (DO) in water is a result of many factors including water temperature, water movement, and velocity. Water can hold more dissolved oxygen at low temperatures than at higher temperatures. Fast-moving water incorporates atmospheric oxygen as it splashes. This is observable as points of whitewater in stream riffles and rapids. Dissolved oxygen in the water column is essential for aquatic life: oxygen is absorbed by fish and insects and used by bacteria to break down or decompose plants.

When excessive nitrogen and phosphorus enter a water body they may stimulate the growth of an overabundance of algae and aquatic plants. This can lead in turn to an oxygen deficiency in the water, because as the algae die and decompose the decomposing organisms consume the available oxygen. Eventually, a slow-moving stream, lake, or pond may be transformed to a marsh or wetland through this process.

The eventual transformation of lakes, ponds, and some portions of streams into marshes or wetlands is a natural process. When the process is accelerated because human sources increase the rate of nutrient input it is called “cultural eutrophication.” Human sources of excessive nitrogen and phosphorus include discharges from municipal sewage treatment plants, fields with heavy applications of fertilizers, and animal waste storage areas. Water pollution control regulations have evolved over time largely in response to observations of cultural eutrophication in major water bodies.

Even without excessive nitrogen and phosphorus inputs, excessive organic matter in a stream, lake, or pond can impact aquatic life especially when temperatures are too high. Either excessive nutrients or high temperatures can reduce dissolved oxygen levels. One reason for restrictions on the amount of logging debris that can enter a stream is to prevent depletion of dissolved oxygen.

Does my stream have a nutrient or dissolved oxygen problem? Look for:
- streams with green water
- streams with thick, stringy clumps of vegetation
- streams with heavy, dirty, brownish, slimy material coating underwater objects

Temperature

Fish such as salmon and trout need cool water temperatures and high dissolved oxygen content at all stages of their life cycle. Water that is too warm or contains too little oxygen may cause fish to become diseased, halt spawning, reduce the survival rate of eggs, reduce the growth and survival rates of juveniles, increase competition for limited habitat and food, and reduce the ability of the fish to compete with other species.

Water temperature is affected by air temperature, water volume, stream channel shape, and incoming solar radiation. The temperature of water fluctuates along with air temperature, although to lesser extremes. Streams with a lot of water in them tend to stay cooler than those with only a small amount. Wide, shallow streams generally have higher temperatures than narrow, deep streams. Shade cast by riparian vegetation onto stream water blocks incoming solar radiation and helps prevent the water from heating. The main causes of temperature impairment (water that is too hot) are reduced stream flow (either natural or due to diversions) and removal of riparian vegetation (fig. 3).

Does my stream have a temperature problem? Look for:
- streams with very few trees or other plants along their banks
- streams with excessive water removed during the summer
- streams with wide shallow channels

Figure 3. Diversions of streamflow must be authorized by the State Water Resources Control Board, Division of Water Rights, to protect downstream beneficial uses. *Photo:* Richard Harris.

Toxic Substances

Toxic contaminants are chemicals from natural or human sources that are harmful to humans and wildlife. These can include pesticides, chemical toxins, and metals. Although there are exceptions, such as properties that have mining "tailings" with high levels of toxic metals, the principal potential toxic pollution problem on forest properties is pesticides. Pesticides are intended to selectively eliminate certain organisms, but when they are improperly applied, they may directly or indirectly affect others. For example, herbicides are commonly used on forest properties to control unwanted vegetation. If applied at too high a level or if herbicide "drifts" to water bodies, there may be unintended impacts on aquatic plants and animals. Several frog species have been shown to be especially susceptible to poisoning by certain herbicides.

Does my stream have a toxic contamination problem? Look for:

- streams with very little aquatic life
- streams flowing through areas treated frequently with herbicides and pesticides
- streams with chemicals or fuel stored within their 100-year floodplains

Judging Water Quality by Analysis of Macroinvertebrates

Aquatic macroinvertebrates, which are animals without backbones such as insects, worms, and snails, are a major food source for many fish. Biologists sometimes use their presence, absence, or species composition as an indicator of water quality and fish habitat suitability. Macroinvertebrates are quite sensitive to the effects of human disturbances such as excessive nutrients, increased water temperature, and excessive sedimentation.

Surveying for Macroinvertebrates

Macroinvertebrates may be surveyed at varying levels of precision and complexity, depending on need. Informal surveys can be done by nonprofessionals using keys to identify the major types of macroinvertebrates. Collect the organisms by disturbing the stream bottom while holding a net downstream of the disturbed area. Empty the net into a large flat container of water. Small creatures in the water and attached to rocks or pebbles in the pan can then be identified using photographs or a key. Your local California Department of Fish and Game (DFG) staff can provide instructions on how to conduct a simple survey for macroinvertebrates.

The macroinvertebrate species that are most sensitive to pollution and human disturbance include mayflies, stoneflies, and caddisflies. These are also the species most used by fish as a food source. Species that are tolerant to pollution and human disturbance include aquatic worms, leeches, blackflies, midges, and snails.

The assemblage of invertebrates, that is, the relative abundances of pollution-sensitive versus pollution-tolerant species, found in a stream can be used to infer its water quality. Finding many aquatic worms, leeches, and snails and very few mayflies, stoneflies, and caddisflies implies that the stream has low water quality for cold-water fisheries. Although collecting and identifying macroinvertebrates may be difficult, consider conducting a simple survey (see box). You might also inquire at the local DFG office to determine whether any related information is available for streams on your property.

CONTROLLING NONPOINT SOURCE POLLUTION

Prevention is the best strategy for controlling nonpoint source pollution. Many forest-based activities, including timber harvesting, road building, construction, mining, livestock grazing, recreation, fire suppression and fuels treatments, and prescribed fire can produce nonpoint source pollution. Management practices that reduce or avoid creation of nonpoint source pollution are known as Best Management Practices (BMPs). BMPs focus on preventing erosion, using pesticides in an environmentally safe manner, reducing storm runoff, and protecting streams and other water bodies. Many BMPs have been developed and are relatively straightforward to implement.

What you can do for water quality

Pollutant	Best Management Practices (BMPs) or preventive measure
Sediment	Maintain riparian vegetation buffer strips during forest harvesting operations to minimize sediment in runoff.
	Restrict livestock access to stream banks and beds.
	Maintain good vegetative cover on slopes to minimize runoff, erosion, and potential for landsliding.
	Prevent road drainage that carries sediment from discharging directly to streams.
	Maintain and inspect roads to eliminate any chronic erosion sources.
	Close and storm-proof unused roads.
	Conduct earth-moving operations in the dry season only, and use erosion and sediment control measures during the rainy season.
Temperature	Maintain riparian vegetation to provide shade to the stream.
	Maintain adequate stream water levels to keep temperatures low by reducing water withdrawals during the summer.
	Maintain natural channel shapes so flow is not spread out and heated.
Bacteria	Maintain dense riparian vegetation buffer strips to intercept contaminated runoff and prevent it from reaching streams or lakes.
	Restrict livestock access to streams.
Nutrients	Exclude livestock and domestic animals from water bodies and wetlands or riparian areas, using fencing if necessary.
Dissolved oxygen	Maintain or upgrade septic systems on your property to ensure that they are working properly.
	Minimize the use of fertilizers.
	Minimize placement of organic matter such as grass clippings or tree trimming debris in streams.
Toxics	Minimize use of herbicides, pesticides, rodenticides, and fungicides.
	Avoid burning or burying garbage that contains toxic compounds, including televisions, refrigerators and cars. Dispose of these properly at a supervised land fill.

The federal Clean Water Act of 1972 requires control of both point and nonpoint source water pollution. In California, enforcement of water quality standards is the responsibility of the State Water Resources Control Board (SWRCB) and nine regional water quality control boards (RWQCBs). The RWQCBs have adopted Basin Plans that identify the beneficial uses of water in California and establish standards for water quality to maintain these uses. They issue permits to restrict the discharge of point source pollutants into a water body. They are increasingly involved in the regulation of nonpoint source pollution as well. For example, timber harvesting is subject to specific regulatory procedures that require implementation of BMPs.

TIMBER HARVEST PLANNING

The California Department of Forestry and Fire Protection (CAL FIRE) is required to protect water quality from degradation due to forest management activities. CAL FIRE does this by requiring landowners to file timber harvest plans (THPs) or nonindustrial timber management plans (NTMPs) prepared by registered professional foresters. THPs contain a listing of the BMPs that will be used during a timber harvest to protect water quality. RWQCBs participate in the review of THPs and may require additional BMPs. These must be implemented during the harvest. Landowners who do not control nonpoint source pollution during harvest may be cited.

TOTAL MAXIMUM DAILY LOADS (TMDLs)

The U.S. Environmental Protection Agency (EPA) and the SWRCB implement a total maximum daily load (TMDL) program to reduce nonpoint source pollution. Under this program, all states must identify and prepare a list of waters that do not meet water quality standards. The list includes hundreds of water bodies in California, each of which has particular pollutants that are impairing water quality. Streams and rivers in California support many beneficial uses of water and as a result have different levels of impairment due to nonpoint source pollution. The water quality and reasons for impairment are given in table 1.

Each state must prioritize and target water bodies for development of TMDL documents that describe a goal and strategy to attain the desired water quality. TMDL reports are regulatory tools that include a description of the total allowable level of the pollutant(s) in question and allocates loads to individual sources or groups of sources. Landowners with property in the vicinity of listed and prioritized impaired water bodies may face water quality protection requirements in addition to those enforced through other means such as timber harvest plans. To find out if your property is in a watershed that either has or is scheduled for a TMDL, contact your local RWQCB.

DEVELOPING WATER SOURCES

Forest landowners often desire to develop the water available on their property for drinking water, irrigation, stock ponds, or fire control. Laws controlling the use of water are fairly complex in California and are administered by the SWRCB as well as county environmental health departments.

In general, anyone may dig a well on their property provided that the proper permits are obtained. It may also be possible to withdraw water from a stream passing through a property utilizing "riparian rights." Any withdrawals or new stream diversions may be subject to regulation by the SWRCB Division of Water Rights. Wells are typically subject to permit requirements by each county's health or environmental health department to ensure that they are properly located and designed. Water in springs and standing pools that have no natural outlet belong to the landowner and may be used without obtaining a permit from the state. Owners of land along streams must share the stream's water and are subject to many legal considerations. Check with the SWRCB Division of Water Rights before diverting stream or spring water. Your county health or environmental health department will also have requirements you must meet if the purpose is domestic use.

Water development is also regulated by the DFG. Since diverting water from a stream alters the amount of water in the stream available for fish or other aquatic life, the diversion may require a streambed alteration agreement from the DFG. Wells that pump water from the streamside zone are considered to alter the stream water available for fish and may also require a streambed alteration agreement.

Table 1. Regional water quality

Region	Reason for impairment								
	Timber	Agriculture	Livestock grazing	Recreation	Mining	Storm drains	Municipal waste	Septic runoff	Land development
North Coast	X	X							
San Francisco Bay		X			X	X	X		X
Central Coast	X	X				X	X		X
Los Angeles		X				X	X		
Central Valley		X			X	X	X		X
Lahontan			X	X	X	X	X	X	X
Colorado River Basin		X					X		
Santa Ana		X				X	X		
San Diego		X				X			

Ponds do not necessarily require a DFG agreement since water may not be diverted from a stream. But if a pond will store water for more than 30 days, landowners must acquire a water right through the Division of Water Rights. The county planning department may also require a permit.

RESOURCES

The main sources of information on water quality and water pollution control are the Regional Water Quality Control Boards (RWQCBs). In addition to regulating water quality, their staff can assist you in diagnosing a water quality problem or abating a water quality violation in your watershed.

Other important sources of information and technical assistance include the California Department of Forestry and Fire Protection, county environmental health departments, Resource Conservation Districts (RCDs) and the Natural Resource Conservation Service (NRCS). Always contact local offices of state and federal agencies to obtain advice from staff familiar with your area.

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FOREST STEWARDSHIP SERIES 12

Fish and Fish Habitat

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Streams that flow through forested areas often contain some of the best fish habitat in California. However, people's activities in forests can reduce the quality of this habitat. To prevent unintended effects of human actions, it is important to know a little about fish and their needs.

This publication focuses on cold-water fish such as trout and salmon because they are most commonly associated with coastal and montane forests. These fish require aquatic habitats with year-round water temperatures below 68ºF (20ºC), high levels of dissolved oxygen, clear water, and a stony or gravelly substrate (streambed). They are common in small and large perennial streams, although they may spawn in intermittent streams. Cold-water fish are also found in larger lakes and ponds at higher elevations (fig. 1).

Warm-water fish can tolerate higher water temperatures of up to 80ºF (26ºC) or even more for short periods, as well as lower oxygen levels and muddy bottoms. Typical warm-water fish include bass, perch, and catfish. Warm-water fish are commonly found in ponds, lakes, and large streams. They are also found in places where cold-water fish would normally exist but where the existing temperature and water quality prevent their occurrence.

Objectives

Understand salmonid habitat needs and how these depend on proper forest and land management to maintain water quality, stream channel habitat, and riparian vegetation.

Competencies

- *Learn the habitat requirements and biology of anadromous and resident salmonids, including salmon and trout.*
- *Recognize that water quality, channel features, channel substrate, and riparian vegetation are critical components of aquatic habitat for fish.*
- *Become familiar with the protection of aquatic habitat quality during forest management and other land uses through best management practices and the use of riparian buffer strips.*

Related Forest Stewardship Series Publications

- *Riparian Vegetation, ANR Publication 8240*
- *Forest Ecology, ANR Publication 8233*
- *Laws and Regulations Affecting Forests, Part I: Timber Harvesting, ANR Publication 8249*
- *Forest Streams, Publication 8239*
- *Forest Water Quality, ANR Publication 8241*
- *Technical and Financial Assistance, ANR Publication 8253*

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SALMONID BIOLOGY

Two general classes of salmonid fishes inhabit California's forest streams: year-round residents and anadromous residents. Year-round salmonids live in the stream for their entire life cycle. Anadromous salmonids spend much of their life cycle in the ocean but are hatched, reared, and return to spawn in fresh water streams. The four anadromous salmonid species in California are chinook salmon, coho salmon, steelhead trout, and coastal cutthroat trout. In recent years, chum salmon have also been found in California, even though their natural range was thought to be farther north.

Salmon life cycles are complicated and vary from species to species. In general, they have three important life stages: eggs, young fish (juveniles) that live in fresh water and then migrate to the sea, and adults. Adults migrate back from the ocean to their natal streams to spawn. These spawners deposit eggs and bury them in gravel nests called redds. The embryos incubate and hatch in the redd and emerge as "fry" after they have consumed

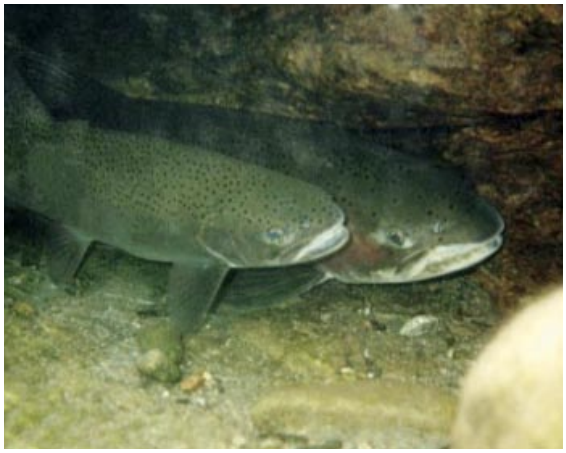

Figure 1. Steelhead trout in the Trinity River, below Lewiston Dam. The dam prevents access to miles of suitable spawning habitat upstream. *Photo:* Richard Harris.

their yolk supply. The timing of fry emergence is determined by water temperature during incubation. Normally, fry emerge in the spring, and, depending on the species and stock, the young fish can remain in fresh water streams or lakes 1 to 2 years before migrating to the ocean.

Coho salmon remain in their stream-rearing habitat for up to a year after emerging from the redd. They then spend 2 years in the ocean before returning to freshwater streams to spawn and die. Steelhead trout may stay in a stream for 1 to 3 years and then live in the ocean from 1 to 4 years. Up to half of all adults do not die after spawning; they return to the ocean and may spawn again. Young cutthroat trout spend up to 2 years in fresh water before migrating to the sea. Those found above migration barriers on coastal streams live out their lives in fresh water. Chinook salmon vary considerably in the length of fresh water rearing they require, a built-in flexibility that can limit the degree to which stream habitat or flow changes can impact this species.

In addition to the four species of anadromous salmonids described above, ten species and subspecies of native resident trout and four species of non-native resident trout are found in California (table 1). Although several of these fish (e.g., brook trout) can tolerate slightly warmer water conditions than the anadromous salmonids, they are all cold-water fish that require excellent water quality.

Resident salmonid adults spawn in fine gravel under conditions similar to those used by anadromous salmonids. Kokanee salmon and brook trout can spawn in streams or at lake margins. Many resident juvenile salmonids frequently live out their lives in the immediate vicinity of their birthplace; others may move downstream to larger streams or, like kokanee salmon, migrate to a lake environment.

AQUATIC HABITAT QUALITY

Salmonids require abundant insects or small fish as a food source, clean cold water, escape and hiding cover, and a gravelly channel substrate for spawning. Water quality, channel features, channel substrate, and riparian vegetation are all critical to maintaining quality aquatic habitat in streams. The health of the entire aquatic ecosystem is important to fish.

Water Quality

High dissolved oxygen content and cool water are critical to maintaining salmonids and the aquatic insects they feed on. Cold-water fish, amphibians, and insects can tolerate only relatively narrow ranges of temperature. Temperature also affects the amount of dissolved oxygen in the water, which in turn affects the ability of organisms to respire. Most aquatic creatures cannot live in water that has a low dissolved oxygen content. Low dissolved oxygen is often associated with stagnant water or water that has been enriched with nutrients or decaying organic matter.

Channel Substrate

Channel substrate refers to the rock or soil materials that make up a streambed. Salmonids must lay their eggs in a clean gravel stream bottom. The relatively large size of the gravel allows water to circulate and carry dissolved oxygen to the eggs. When the eggs hatch, the young fish hide from predators in the spaces between the gravel; if excessive fine sediment fills these spaces, the young fish are deprived of hiding places. Sedimentation can also smother insects that live in the channel bottoms and prevent

Table 1. Non-anadromous salmonid species in California

Species	Range	Biology	Subspecies
rainbow trout	Native non-anadromous form of steelhead trout. Most widespread and popular resident trout in California due to plantings.	Spawns in spring in cold streams (50°F, 10°C).	Coastal rainbow trout; Eagle Lake rainbow trout (capable of living in highly alkaline waters).
golden trout	Native; transplanted throughout California.	Adapted to high-elevation lakes and streams. Spawns in spring.	Volcano Creek golden trout; Little Kern River golden trout; Kern River golden trout.
cutthroat trout	Native non-anadromous form of cutthroat trout. Native to eastern side of the Sierra Nevada.	Spawns in spring in cold water.	Lahontan cutthroat trout (native to the Truckee, Walker, and Carson Rivers); Paiute cutthroat trout.
redband trout	Native; three remnant populations remain.	A close relative of the coastal rainbow trout.	McCloud River redband trout; Goose Lake redband trout; Warner Lake redband trout.
brown trout	Non-native but planted widely throughout the state.	Prolific fall spawner in high mountain lakes, reservoirs, and streams.	None.
brook trout	Non-native but planted widely throughout the state.	Spawns in fall and early winter. Tolerates warmer waters than rainbow trout.	None.
lake trout	Non-native; planted in Lake Tahoe.	Requires deep waters.	None.
kokanee salmon	Non-native; planted in Northern and Central California	Landlocked form of sockeye salmon.	None.
bull trout	Extinct in California.	A native species of char.	None.

water from carrying dissolved oxygen to eggs. The channel bottoms also provide a place for aquatic plants to root, including algae and plankton, which serve as food sources for insects and fish.

Channel Complexity

Channel complexity is the arrangement of bed forms in a stream. Generally, productive salmonid streams have equal proportions of fast water (riffles) and slow water (pools), slackwater side channel areas that provide refuge during high flows, and abundant shelter from predators and fast water (rocks, boulders, logs, and overhanging banks) (fig. 2).

The more diverse the spatial arrangement of material in the stream channel, the greater the diversity of the aquatic community and, generally, the better the habitat for salmonids.

- Rocks and large woody debris create pools and riffles in a stream.
- Riffles are areas of swifter flowing water where the surface is turbulent. The flowing water delivers insects for food, and the broken surface provides cover from predators. Riffles are also the "lungs" of a stream, where turbulent flow captures and incorporates oxygen from the atmosphere.
- Pools are formed where water falls over a boulder or log, scouring out a deep hole where juvenile and adult fish can hide.
- Logs, root wads, boulders, and protruding stream banks can cause backwater pools to form as water swirls around the obstacle. Juvenile steelhead are often found in low-gradient riffles, while juvenile coho salmon almost always live in pools formed by large wood.

Riparian Vegetation

Vegetation on, near, or overhanging the water provides plant materials that are consumed by aquatic animals. This riparian vegetation includes hardwood and softwood trees, shrubs, and even herbaceous vegetation. Plant roots stabilize banks, and the vegetative canopy shades the water, keeping temperatures low. Certain aquatic insects spend part of their life cycle in riparian vegetation; since adequate riparian vegetation is important to insects, it is also important to fish that eat these insects.

STATUS OF ANADROMOUS SALMONIDS

One of the major environmental issues in California is the status of anadromous salmonids. Anadromous salmonids have been declining in number in California and throughout the Pacific Northwest for several decades. Specific stocks of chinook, coho, and steelhead have been listed by the federal government (U.S. Fish and Wildlife Service or National Marine Fisheries Service) or the state government

Figure 2. Good salmonid habitat includes pools and fast-water riffles as well as a riparian canopy that provides shade, nutrients, insect habitat, and large woody debris. *Photo:* Richard Harris.

(California Department of Fish and Game) as threatened or endangered under applicable state or federal laws (table 2). Certain resident trout species, such as the Lahontan cutthroat trout, are also listed. Once a stock or species is listed as threatened or endangered, a recovery plan is developed and special measures must be taken to maintain the habitat quality for these fish.

Stocks of anadromous fish have declined due to a combination of human and natural influences. Human influences include urbanization, stream damming, water diversions, habitat modification, and fish harvest. Urbanization, agriculture, road construction and maintenance, and forestry have contributed excess sediment to streams, degrading the aquatic habitat. Stream clearing conducted years ago removed large woody debris from many stream channels, making the habitat less complex and less suitable to salmonids as well as other aquatic life.

Large and small dams have created complete or partial barriers to salmonid migration upstream and downstream. This has eliminated access by fish to many miles of spawning and rearing habitat. Harvest by commercial and recreational fishing and predation by exotic fish species have reduced the number of salmonids returning to natal streams to spawn. Hatchery operations have reduced genetic diversity among fish populations. Finally, fluctuations in climate and ocean conditions such as the El Niño effect can reduce ocean food supplies for salmonids and favor warm-ocean predators.

The California Forest Practices Act provides measures to protect against new direct impacts to fish habitat, water quality impacts, and depletion of large woody debris. However, many streams will not recover for decades from historical impacts, legacies from earlier management practices.

Table 2. Status of anadromous salmonids in California as of 2001

Species and location	Listing status	Location	Spawning	Population status
Sacramento winter run chinook salmon	California endangered 1989; Federal endangered 1994	Sacramento River and tributaries	spring and summer	stable as of 1999
Sacramento spring run chinook salmon	California threatened 1999; Federal threatened 1999	Butte, Chico, Big, Mill, and Deer Creeks	August–October	stable to declining as of 1999
Northern Coast coho salmon	Federal threatened 1997	North of San Francisco to Oregon border	October–January	unknown
Central Coast coho salmon	California endangered 1995; Federal threatened 1996 (south of San Francisco)	Humboldt County to Santa Cruz County	October–January	declining as of 1999
Northern Coast steelhead trout	Federal threatened 2000	Humboldt County to Mendocino County	Runs occur in winter, spring and summer	unknown
Central Coast steelhead trout	Federal threatened 1997	Russian River to Soquel Creek		
South/Central Coast steelhead trout	Federal threatened 1997	Pajaro River to Santa Maria River		
Southern Coast steelhead trout	Federal threatened 1997	Santa Maria River to Mexican border		
Central Valley steelhead trout	Federal threatened 1998	Sacramento and San Joaquin Rivers		

POTENTIAL IMPACTS OF FOREST MANAGEMENT ON SALMONIDS

Since a combination of factors has led to the decline in anadromous and some resident salmonid populations, action across a broad spectrum of society is needed to save these fish from further decline.

Forestland owners and managers play an important role in protecting and restoring salmonid habitat. Forest management, as well as urbanization and agriculture, can degrade salmonid habitat through direct impacts on water quality, channel complexity, channel substrate, and riparian vegetation. Road construction and culverts can create barriers to fish migration and can deliver excessive sediment to watercourses (fig. 3).

Reduction of riparian forest canopy can reduce stream shading, which may increase stream temperatures to a point lethal to fish. Management activities and point sources (such as legacy roads) that deliver excessive sediment to a stream may fill in spaces between particles of gravel on streambeds, reducing the oxygen supply to insects and young fish, which slows fish growth and increases mortality. Sedimentation can also change the physical form of stream channels and the habitats they provide, such as decreasing the number and depth of pools. Many activities, including stream clearing and fuel wood harvesting, can deplete a stream of its large woody debris.

Removal of riparian vegetation for any reason may adversely impact fish habitat. For example, removing plants whose roots strengthen the stream bank can lead to bank erosion and sedimentation. Also, runoff that is no longer filtered by streamside vegetation can cause more erosion and is likely to carry higher sediment loads directly into streams, increasing streamflow volume and sediment levels.

Anadromous trout and salmon may migrate many miles up and down streams during their lifetimes. Resident trout also move up and down streams to seek food, shelter, and spawning habitat. Culverts under roads can interfere with this migration, blocking passage by making fish jump too high, removing resting pools, and creating streamflow conditions that are too shallow or too fast.

Figure 3. Roads and stream crossings are the main sources of sediment that negatively impacts streams in California's forests. *Photo:* Courtesy Angela Wilson.

MAINTAINING AND RESTORING AQUATIC HABITAT

Avoiding impacts on aquatic habitat requires planning. Preventative measures should be taken both for streams occupied by salmonids and for watercourses upstream of salmonid habitat that influence downstream conditions.

Maintaining streamside management zones or riparian vegetation buffers are key strategies to protect aquatic habitat. Riparian buffers are required by any timber harvest plan (THP) in California and are advisable even for areas not subject to harvest. The California Forest Practices Act stipulates various streamside protection zones, depending on the type of stream. These streamside zones protect water quality by filtering runoff, stabilizing stream banks, contributing shade, and providing a source for large woody debris and other vegetative input to the stream. Managed properly, these zones can support essential habitat for a wide variety of terrestrial and aquatic plants and animals.

Best Management Practices (BMPs) are approved practices that minimize impacts from land uses. BMPs provide guidelines for proper construction and maintenance of roads as well as for retention and recruitment of streamside forest cover and future supplies of large woody debris. Specific BMPs, along with state and local rules, have greatly reduced impacts on a wide range of aquatic species in some watersheds. Improved practices have reduced erosion, improved water quality, and helped restore aquatic and wildlife habitat. For example, improved design and installation of culverts allows fish to pass more freely. The Forest Practices Act provides numerous BMPs to prevent or reduce the negative impacts of forest management on fish, such as excluding equipment from streamside zones and establishing standards for road and stream-crossing construction.

RESOURCES

The recognition that active restoration is needed if anadromous fish populations are to return to former levels has stimulated state and federal agencies to create a number of programs that share the costs for landowner restoration efforts. These agencies can also provide technical assistance on restoration planning. Efforts may include improvement of roads and stream crossings, elimination of barriers to migration, restoration of riparian areas, and enhancement of stream channel habitat. Contact your local Department of Fish and Game office for information on these programs. Other agencies and groups involved in restoration include the UC Cooperative Extension, U.S. Fish and Wildlife Service, Resource Conservation Districts, the Natural Resource Conservation Service, and local watershed councils.

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FOREST STEWARDSHIP SERIES 13

Threatened and Endangered Plants

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In common English usage the terms "endangered" and "threatened" are frequently interchanged, but these terms have specific legal definitions for regulatory purposes. They signify the perceived risk of extinction and determine the level of protection afforded a species. The formal definitions below are used in the federal Endangered Species Act (ESA) and/or California Endangered Species Act (CESA) or by federal agencies. Keep these legal definitions in mind as you read this publication.

Objective

Understand the laws, ecology, and current conditions of threatened and endangered (T&E) plant species in California and be introduced to management practices that can benefit these species.

Competencies

- *Know the legal definitions of threatened and endangered plant species and associated regulatory requirements.*
- *Understand the causes of endangerment.*
- *Locate sources of information to identify threatened and endangered species.*
- *Learn how to protect threatened and endangered species.*

Related Forest Stewardship Series Publications

- *Forest Vegetation Management,* ANR Publication 8236
- *Laws and Regulations Affecting Forests, Part I: Timber Harvesting,* ANR Publication 8249
- *Exotic Pest Plants,* ANR Publication 8244

UC PEER REVIEWED

DEFINITIONS

- **Endangered.** Any species, including subspecies, in danger of extinction throughout all or a significant portion of its range (the geographic area where the plant naturally occurs).
- **Threatened.** Any species likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.
- **Candidate.** A species for which regulatory agencies have sufficient information on its biological status and threats to be proposed as endangered or threatened under the federal or state endangered species acts, but for which development of a proposed listing regulation has not yet been done. These species are not protected but are monitored to prevent their extinction while awaiting listing.
- **Proposed Species.** Species that have been proposed for regulatory protection.
- **Rare.** A rare species can be broadly distributed but never abundant where found; narrowly distributed but not abundant; or narrowly distributed and not abundant where found. "Rare" is a legal classification under California law.
- **Sensitive.** The U.S. Forest Service (USFS) uses this designation for plant species that are known to occur or are highly suspected to occur on Forest Service lands and that are considered valid candidates for federal threatened or endangered classification.
- **Special Status Plants.** A designation used by the Bureau of Land Management (BLM) to include federally listed and proposed species; federal candidate species; state-listed species; and sensitive species. Plants considered to be at risk by the California Native Plant Society that do not meet any of the first three criteria are also considered to be sensitive by BLM in California. Sensitive plants receive the same level of protection as federal candidate species.

Figure 1. Threatened and endangered plants are often associated with specific microclimates and topographic or geologic conditions. For example, in generally arid regions, rare plants are commonly found in riparian habitats such as the one shown in this photograph from the eastern slope of the Sierra Nevada. In forested settings, they are often found at seeps and springs and on soils of unusual rock types such as serpentine. *Photo:* Richard Harris.

CAUSES OF ENDANGERMENT

The main reason plants become rare or threatened with extinction is that their habitat is either lost or irrevocably changed (fig. 1). Many species are naturally rare because they are geographically restricted to very limited habitats such as vernal pools (fig. 2). They are therefore inherently susceptible to local extirpation or extinction even under natural conditions when exposed to phenomena such as prolonged drought or wildfire. In some cases, plants may be associated with specific forest successional stages. Some species require early successional stages to survive: direct sunlight, low-growing plants, less competition. If there is a change in the natural disturbance regime, such as suppression of naturally occurring fire, these species may decline in numbers or disappear altogether from an area. Other species may depend on old-growth forest conditions. Loss of that successional stage eliminates their habitat and makes conditions unsuitable for their survival.

Figure 2. Vernal pool habitat supports a highly unique flora and fauna. Fifteen percent of the state's rare and endangered plant species inhabit vernal pools. *Photo:* Courtesy Loren Clark.

Other potential causes for endangerment include competition from other plants, predation, and even exploitation by humans, but the main cause that should concern a landowner is habitat change or habitat loss. Broadly interpreted, habitat change includes situations in which a natural habitat is altered by the introduction of exotic pest plants. Protection of habitat includes preventing exotic pest plant invasions (fig. 3).

STEWARDSHIP RESPONSIBILITIES

Although extinction is a natural process, the current rate of extinction around the world is one thousand times that which occurred before humans began to exert large-scale pressure on the world's ecosystems. And this rate is increasing. The major cause of these extinctions is habitat loss. The following are some of the many reasons for concern about the loss of plant species.

- **Natural diversity.** All living creatures, including humans, are part of a complex interdependent network. No species exists in isolation. We do not know enough about these complex systems to predict the consequences of extinction of any given species.
- **Medicine.** A large percentage of our medicines come from plant material or are synthesized from natural chemical compounds. For example, Taxol, a drug used in chemotherapy, is derived from western yew trees. Scientists have investigated only about 2 percent of the more than 250,000 known plant species for their possible medicinal values. Any species could be the key to effective treatment of disease.
- **Agriculture and industry.** Of the 80,000 species of edible plants, less than 20 produce 90 percent of the world's food. Some underutilized species could provide food, fuel, or goods for people of the world. Plants that have industrial uses include the jojoba, which produces oil comparable to that derived from sperm whale, or the guayule, a shrub that contains high amounts of natural rubber. In addition, some plants contain natural toxic compounds that can act as safe and inexpensive pesticides.

Figure 3. Exotic plants such as pampasgrass *(Cortaderia selloana)*, shown here invading an open area along a forest road, can occupy disturbed areas and reduce the available habitat for threatened and endangered plants that also require forest openings to survive. *Photo:* Richard Harris.

- **Environmental barometers.** Some species can warn of environmental problems because they are sensitive to changes in environmental quality. For example, ponderosa pine is sensitive to ozone (air pollution) and responds to exposure with needle color changes and decreased vigor.
- **Moral considerations.** Many people believe that every creature has intrinsic value and has a right to exist independently of its value to humans.

Monterey Pine Forests

Monterey pine *(Pinus radiata)* forests today consist of five limited, separate populations in California, considered relicts of the formerly large, continuous forests that blanketed the West Coast (fig. 4). While this species is of little commercial importance in the United States, it is the most widely planted pine tree in the world, with vast plantations in New Zealand, Australia, and Chile, where it is called radiata pine. Lumber and wood products made of radiata pine are being imported into California. These five remaining native populations in California and Baja California contain the entire naturally occurring repository of genetic material for the species. In addition, the Monterey pine forests in the cities of Monterey and Cambria have a special aesthetic value that translates into economic value for the tourist industry. Currently, Monterey pine forests in California are encountering a variety of serious threats: development, diseases and pests, genetic contamination, fire suppression, and old age. While this species has not been officially listed by state or federal agencies, it is being monitored.

REGULATIONS

Federal Endangered Species Act

The Endangered Species Act (ESA) was passed by Congress and signed into law by President Richard Nixon in 1973. 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 certain fishes, the National Marine Fisheries Service (NMFS).

In most cases, the ESA does not affect an individual's management of private property. It comes into play only when a project occurs on federal land or is a private action that requires a federal permit or federal funding. Only when one of these situations occurs is a consultation with the FWS required.

Threatened and endangered listing process

To determine if a species should be listed for protection under the ESA, the FWS evaluates five factors: the present or threatened destruction, modification, or curtailment of its habitat or range; overutilization for commercial, recreational, scientific, or educational purposes; disease or predation; the inadequacy of existing regulatory mechanisms; and other natural or man-made factors affecting its continued existence.

Critical habitat

The FWS considers protection of habitat to be essential for successful species conservation. Critical habitat has two components. It may include specific areas within the geographical area occupied by a species where physical or biological features essential to the conservation of the species occur, or areas that may require special management consideration or protection; and/or specific areas outside the geographical area occupied by a species at the time of listing when such areas are determined to be essential for the conservation of the species.

Taking

In the regulatory context, to "take" a species means to harass, harm (including significant habitat modification or degradation), pursue, hunt, shoot, wound, kill, trap, capture, or attempt to engage in any such conduct affecting a listed species. The ESA prohibits taking of federally endangered wildlife, but plants are not protected against taking. Instead, plants are protected through the prohibition of collecting endangered plants from lands under federal jurisdiction, and removal, cutting, digging, damage, or destruction of endangered plants on any other area in knowing violation of a state law or regulation. It is also illegal to transport (interstate or internationally), import, export, or sell or offer for sale endangered plants.

Figure 4. Monterey pine *(Pinus radiata)*. *Photo:* Gary Nakamura.

Recovery plans

The purpose of federal listing is to recover the species to the point where it no longer requires protection. To this end, the FWS develops recovery plans for endangered or threatened species. Recovery plans are blueprints that outline actions that can be taken by public and private agencies and individuals to help recover listed species. These recommendations are not binding. California recovery plans have taken a multispecies approach, treating a number of listed, proposed, and candidate species as well as some species of concern in a single plan.

Delisting

A successful recovery effort, discovery of new information, or extinction will result in delisting, in which a species is taken off the endangered list. According to the FWS, 7 plants and 26 animals had been delisted as of 2005. The Hoover's woolly-star *(Eriastrum hooveri)* has been proposed for delisting in California as new populations have been discovered.

California Endangered Species Act

The state of California maintains a separate list of endangered and threatened plant species. There are currently 218 species and subspecies of plants listed as rare, threatened, or endangered by the state. The California Department of Fish and Game (DFG) is responsible for conserving the state's threatened and endangered species.

The Native Plant Protection Act of 1977 gave the California Fish and Game Commission the power to designate native plants as endangered or rare, and to protect endangered and rare plants from taking. The California Endangered Species Act of 1984 expanded upon this and enhanced legal protection for plants. To align with federal regulations, the California Endangered Species Act (CESA) created the categories of threatened and endangered species. It converted all rare animals into threatened species, but did not do so for rare plants. Thus, there are three listing categories for plants in California: rare, threatened, and endangered.

CESA sets forth procedures by which individuals, organizations, or the DFG can request that a species, subspecies, or variety of plant or animal be added to, deleted from, or changed in status on the state lists of rare, threatened, or endangered species. The factors that contribute to determining the need to list a species include the present or threatened modification or destruction of habitat, competition, predation, disease, overexploitation by collectors, or other natural occurrences or human-related activities.

California Environmental Quality Act

California also has a strong law called the California Environmental Quality Act (CEQA), which provides protection of species and natural communities during the land use planning process. This law requires government agencies to consider and disclose the environmental impacts of projects and to avoid or mitigate these impacts wherever possible. CEQA comes into play in the case of timber harvest plans (THPs), wetland modifications, or other land use activities.

MANAGEMENT OF THREATENED AND ENDANGERED SPECIES

Landowners with vulnerable plants on their property (or potential habitat for those species) have a special opportunity to safeguard these unique species and in some cases actually contribute to the effort to avoid listing or to delist the species. Each species has its own unique needs and, therefore, requires its own specialized management approach. Typical management techniques may include removing invasive nonnative plants, excluding herbivores, restoring drainage patterns to an area, rerouting trails, changing the timing of livestock grazing, conducting prescribed burns, and other actions.

Within the scope of this section it is not possible to provide lists of all the threatened and endangered species that may occur in California's forested landscapes. A landowner can undertake research to develop a list of species potentially occurring on their property. The first step is to contact the DFG's California Natural Diversity Database (http://www.dfg.ca.gov/bdb/html/cnddb.html) to determine which species may be present around or on your property. From there, you can consult texts and plant identification manuals (such as the ANR Publication *Illustrated Field Guide to Selected Rare Plants of Northern California,* http://anrcatalog.ucdavis.edu/InOrder/Shop/ItemDetails.asp?ItemNo=3395) to familiarize yourself with the life history, habitat, and appearance of the species that may occur. Some manuals have photographic keys to help with identification. A landowner may also talk to botanists or other knowledgeable people to learn about the biology of those species and possible threats.

Timber Harvest Effects

A timber harvest might have no effect, an adverse effect, or a beneficial effect on threatened or endangered plant species, depending on whether or not the timber harvest is evaluated and planned to take into consideration the species' ecological needs (fig. 5). For example, some plants requiring openings and disturbance to survive and propagate can benefit from timber harvesting. This is well illustrated by the Shirley meadows star-tulip *(Calochortus westonii)* which is endemic to Sequoia National Forest. The ecological requirements of this species suggested that selective thinning of dense conifers could be accomplished when the plants were dormant in the fall, thus creating the more open, parklike environment favored by this species. Numbers of Shirley Meadows star-tulips have increased markedly under this prescription.

If threatened and endangered species are present on your property, you can take the following steps.

- Protect the physical and biological characteristics of their habitat, for example, by minimizing soil and water disturbance and changes to existing vegetation.
- Plan your activities to minimize direct and indirect impacts on the plants.
- Actively restore or enhance habitat to favor the species.
- Monitor the status of the species.

A landowner may enter into a Candidate Conservation Agreement, which is an agreement between the FWS and a property owner for proposed, candidate, and species likely to become candidates in the near future. The property owner commits to implementing voluntary conservation measures for the species covered in the agreement. In exchange, the property owner may receive assurances from the FWS that additional conservation measures will not be required and no additional restriction will be imposed if the species covered in the agreement become listed. The goal of these agreements is to reduce the need to list species.

Protection of rare plants may also be achieved through conservation easements. Certain state and federal programs will fund the purchase of conservation easements to protect important habitats. Conservation easements limit certain agreed-upon property rights, for example the right to develop, while allowing most other activities. They may provide a number of financial and tax benefits to the landowner.

Figure 5. English peak greenbriar *(Smilax jamesii)*, is a CNPS 1B plant, rare, threatened, or endangered in California and elsewhere, but it is not federally listed at this time. It is found along lakes and streams, in alder thickets, and moist mountain slopes at 4,000 to 8,000 feet elevation. Timber harvest practices in such locations can adversely affect the habitat for this plant. *Photo:* Gary Nakamura.

In some circumstances there may be voluntary arrangements between the FWS and cooperating landowners known as safe harbor agreements. Because many endangered and threatened species exist largely or solely on private lands, the FWS offers limits to future regulatory requirements (a safe harbor from future regulations) in exchange for agreements to modify management practices to enhance the survival of the endangered or threatened species.

RESOURCES

California Natural Diversity Database

The DFG maintains a "special plants" list consisting of approximately 2,000 native plant species, subspecies, or varieties that are tracked by the department's California Natural Diversity Database (CNDDB, see http://www.dfg.ca.gov/bdb/html/cnddb.html). These plants are either state or federally listed, proposed, or candidate species, or other species, subspecies, or varieties that are of concern due to reasons such as rarity, threats, or the species' close association with declining habitats; or they may be species for which more information is needed.

The CNDDB provides government agencies and the private sector with information to assist with good land use and resource management decisions. Customers can access the CNDDB in two ways: by purchasing RareFind, a menu-based program that allows access to all of the text information in the CNDDB and allows searches for individual counties, quadrangles, or species; or request the text and graphic information for a particular area. These are presented as a transparent overlay to a specific topographic map along with an accompanying text report on the rare elements.

The CNDDB is the primary means by which landowners can determine whether there are records of threatened and endangered species being present on or near their property. Foresters normally consult the CNDDB whenever they prepare a timber harvest plan. Absence of a recorded species on a property does not preclude the possibility that some are present since most of California has not been surveyed for threatened and endangered plants. It is a starting point, however, and if such plants are found nearby, that could mean they are present on your property.

California Native Plant Society Inventory

The California Native Plant Society (CNPS) publishes and maintains the *Inventory of Rare and Endangered Vascular Plants of California* in both hard copy and electronic versions (see their Web site at http://cnps.org/cnps/rareplants/). The inventory assigns plants to the following categories:

1A: Presumed extinct in California
1B: Rare or endangered in California and elsewhere
2: Rare or endangered in California, more common elsewhere
3: Plants for which more information is needed
4: Plants of limited distribution

Additional rarity, endangerment, and distribution codes are assigned to each species. The CNPS inventory was the basis for the CNDDB. The CNDDB is constantly updated by reports of species occurrences (or losses) by CNPS members and others.

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FOREST STEWARDSHIP SERIES 14

Exotic Pest Plants

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Exotic plants come into California on a continuous basis. Some are introduced intentionally as ornamentals or for other purposes; others stow away on ships, on the tires of vehicles, in packing material, or are introduced by other means. Most remain in limited populations in their new environment, but occasionally a species thrives too well, wreaking havoc on the native ecosystem. When exotic plants are successful in their new environment at the expense of native species and ecosystems, they are known as exotic pest plants or invasive weeds. Of the approximately 1,045 non-native plant species that have become established in California, fewer than 10 percent are serious threats, but even these few have dramatically changed the ecology of the state.

Objective

Understand the threats to native ecosystems posed by exotic pest plants and the various methods used to control them.

Competencies

- *Ability to identify noxious weeds and exotic pest plants that may occur on your property.*
- *Awareness of agencies responsible for exotic pest plant control.*
- *General understanding of how to control exotic pest plants.*

Related Forest Stewardship Series Publications

- *Forest Vegetation Management, ANR Publication 8236*
- *Threatened and Endangered Plants, ANR Publication 8243*
- *Forest Regeneration, ANR Publication 8237*
- *Forest Ecology, ANR Publication 8233*

DEFINING PEST PLANTS

A simple definition of a pest plant or weed is a plant that grows where it is not wanted. As every gardener knows, native plants can become weeds when they are growing in undesirable locations. Generally, exotic plants become pests because they are aggressive invaders of natural ecosystems; that is, they possess traits that make them better competitors than native plants. Such traits include being able to produce abundant, easily dispersed seed, be spread by vegetative means, quickly dominate disturbed sites, and grow rapidly once established. An exotic plant may also become a pest if it escapes the biological control agents that kept it in check in its native ecosystem. Ecosystems are complex associations of organisms that have evolved together over time with numerous checks and balances that limit the numbers of individual species. When an exotic pest plant is freed from its native control agents—insects, disease organisms, other competing plants, herbivores—it may reproduce unchecked in the new environment, changing the native ecosystem forever.

Exotic pest plants may simply outcompete native plants for nutrients, water, or light. Some may change ecosystem processes such as nutrient cycling, hydrology, wildfire cycles, and erosion rates. While many exotic species become established on disturbed sites, undisturbed ecosystems are also at risk. Rare native species are particularly vulnerable. About 180 of the state's rare plants are experiencing threats from exotic pest plants.

CATEGORIZING PEST PLANTS

Two widely recognized lists of pest plants in California have been developed, one by the California Exotic Pest Plant Council (CalEPPC) and the other by the California Department of Food and Agriculture (CDFA). The CalEPPC list includes a total of 76 species, of which 27 are on the A-1 list (Most Invasive Wildland Pest Plants: Widespread). The CDFA list, called the Noxious Weed List, divides non-native species into Type A, B, and C categories that are used to determine what action, if any, to use with each species when found. The CDFA list includes not only plants that are a problem for agriculture but also plants that are considered ecologically damaging. This list is a basis for regulation and control.

UC PEER REVIEWED

WHY SHOULD WE BE CONCERNED?

Exotic pest plant infestations can cause widespread problems in many ways.

Ecosystem Processes

Exotic pest plants can drastically alter the ecological checks and balances that have developed over thousands of years. Their growth and spread can alter fire regimes, making the frequency and intensity of wildfire more intense than it would be under natural conditions. This altered fire regime can cause major ecosystem changes. Some exotic nitrogen-fixing plant species increase soil nitrogen levels to the disadvantage of native species that have evolved in nutrient-poor soils. Some especially damaging exotic pest plants can invade and dominate aquatic habitats in streams and ponds.

Wildlife

Exotic pest plants may provide poorer habitat for wildlife species and livestock than their displaced native counterparts. For example, tamarisk and Russian olive thickets along rivers may replace native habitats dominated by cottonwood and willow. The native species provide far superior habitat for many bird and mammal species that coevolved with them.

Agriculture

Exotic pest plants create large economic losses for agriculture in both cropland and rangeland. They can reduce the production of forage for livestock by crowding out palatable species. Species such as St. Johnswort, Russian knapweed, and leafy spurge are actually toxic to livestock.

Biological Diversity

Competition from exotic pest plants is considered to be a factor contributing to the decline of many endangered plant species in California. Exotic plants can completely overtake natural plant communities. Virtually all California annual grasslands are predominately exotic species introduced with cattle by the Spanish. Some non-native species release substances in the soil that prevent reestablishment of native species. For example, tamarisk can increase the salinity of soils to the point that native willows and cottonwoods can no longer grow.

MAJOR FOREST EXOTIC PEST PLANTS

Forestland owners should be aware of the exotic pest plants that can harm their property. Some of the most common are described below.

Cape ivy (formerly known as German ivy) (fig. 1) and English ivy grow mostly in coastal watersheds. They form a dense blanket over everything, climb trees, and displace other plants by smothering them and cutting off their light. These plants can become so abundant that their weight will break the stems of shrubs and trees.

Brooms, including French, Scotch, Portuguese, and Spanish (fig. 2), have invaded ecosystems from coastal Southern California to the Sierra foothills and redwood forests. They have all the attributes of a successful weed: fast growth rate, broad physiological tolerances, and prolific seed production. Brooms commonly form impenetrable thickets that exclude other plants. They change the chemistry of the environment by fixing nitrogen and enriching the soil, modifying the environment for plant establishment and growth to their advantage.

Gorse (fig. 3) is a close relative of the brooms but with stiff spines that make it difficult to remove.

Yellow starthistle (fig. 4) is ubiquitous in California. This prolific seeder spreads easily and can be difficult to control. Additional important exotic pest plants common to forest lands include tree of heaven, eucalyptus (fig. 5), and pampasgrass (fig. 6). Tamarisk (fig. 7), purple loosestrife (fig. 8), and giant reed (fig. 9) are widespread in wetlands and riparian areas.

Figure 1. Cape ivy *(Delairea odorata)* is often found in riparian habitats in the northern part of the state. *Photo:* Joseph M. DiTomaso.

CONTROLLING EXOTIC PEST PLANTS

Prevention

Prevention is the most effective and least costly way to avoid pest plant problems. Some commonsense preventive precautions include

- plan work projects to minimize soil disturbance and reestablish vegetation quickly
- buy construction material from suppliers who guarantee their products to be weed-free
- wash vehicles and equipment before moving them to another area
- close unnecessary roads and trails where possible
- monitor your property to detect new weed populations while they are still small

Eradication

Eradication is practical and effective only when an infestation is small; it is almost impossible in widespread infestations (see sidebar 1 on next page).

Figure 2. French broom *(Genista monspessulana)* (left) and Spanish broom *(Spartium junceum)* (right) are exotic pest plants that have invaded forests and other habitats in California. Members of the pea family, the brooms can be identified by their bright yellow flowers. *Photos:* Joseph M. DiTomaso.

SIDEBAR 1
Attack Your Weeds Like a Wildfire

Awareness of the damage caused by noxious weeds is becoming widespread, but controlling these pests takes more than awareness—it requires constant vigilance and cooperative efforts.

If you want to concentrate your efforts where they will be most effective, consider this central principle of weed management: small infestations can be eradicated, large infestations can only be controlled.

The usual approach is to attack large areas of weeds first. The rationale is that small patches are not causing any harm now, so they can be ignored temporarily. But before we know it, the small patches have spread, and we are left with more large weed problems.

We must reverse our priorities and eradicate all small occurrences as quickly as possible. Weed management can be compared to fighting wildfires. Notice the similarities at right.

	Fire	Weeds
1. Build a fireline	One of the first actions taken when fighting a large wildfire is to build a fire line to contain the outbreak within a certain boundary.	Rather than a line on the ground, draw a line on a map delineating the current extent of large weed infestations. Commit to containing the infestation within this boundary.
2. Eliminate spot fires	Any fire that jumps the fireline has top priority and is eliminated as quickly as possible before it has the chance to spread. If allowed to spread, the results can be disastrous: firefighters may be caught between two outbreaks, two large fires will have to be fought rather than one, and many more resources will be needed.	When weeds escape from the boundary you have drawn, they should become top priority. Think of small isolated occurrences as backcountry spot fires. If they are located early and attacked aggressively they can be eradicated before they spread; if ignored they will likely become so large they may never be eliminated entirely.
3. Protect critical areas	Critical areas include places where people or structures are located.	Critical areas include pristine natural sites, critical wildlife habitat, productive rangelands, and rare plant and animal habitat.
4. Control the main outbreak	Often, an expensive investment in resources is required. Even with massive control efforts, large fires may not be stopped until the weather changes and rain or snow stops the fire.	Large infestations require long-term control efforts. Even with years of effort, these occurrences may never be completely eliminated. Unfortunately, their seed banks may be huge, and their natural controls are rarely available. They may require some level of control forever.

Source: Adapted from *Creating an Integrated Weed Management Plan: A Handbook for Owners and Managers of Lands with Natural Values* (Denver: Colorado Department of Agriculture, 2000).

Figure 3. Gorse *(Ulex europaeus)* plant and flowering stem. *Photos:* Joseph M. DiTomaso.

Physical Control

Physical control methods can be quite effective but are often overlooked because they are labor-intensive. Physical control is most practical with small infestations, but it is also very useful in sensitive areas where chemicals could damage resources, such as sites close to waterways. Physical methods can be highly selective, targeting only the pest species, but they can also cause soil disturbance. Methods range from pulling weeds by hand to using brush rakes on bulldozers. Two excellent hand tools are the Weed Wrench and the Root Jack. Mowing can also be an effective control technique for certain species at specific times of the year, especially before seed is dispersed.

Prescribed Fire

Fire can reduce weed infestations, especially in fire-adapted plant communities. However, in some cases fire can actually favor exotic pest plants. It is important to understand the biology of the native plants involved before using this method of control. Fire also involves the risk of escape. Prescribed burns should be done only under the direction of a trained fire manager. Contact the California Department of Forestry and Fire Protection for more information.

Mulching

Covering infested areas with mulch such as hay, manure, grass clippings, straw, sawdust, wood chips, rice hulls, black paper, or black plastic is another method of control. Mulching cuts off light, preventing plants from photosynthesizing, and can eliminate small infestations. The most effective mulches are black paper or plastic.

Solarization

Clear polyethylene plastic sheets placed over moist soil can kill un-germinated seeds of exotic pest plants. The sheets are kept in place for a month or more. Edges of the plastic must be sealed with soil or weights to retain the heated air in order to produce lethal heat and temperatures.

Figure 4. Yellow starthistle *(Centaurea solstitialis). Photo:* Joseph M. DiTomaso.

Figure 5. Eucalyptus *(Eucalyptus spp.)* has invaded the riparian zone of this stream. Once established, some eucalyptus can crowd out other native species because of their profuse sprouting and tremendous litter production. Eucalyptus also produces "allelopathic" substances in its roots and leaves that are toxic to some plants. *Photo:* Richard Harris.

Figure 6. Pampasgrass *(Cortaderia selloana)* is an aggressive invader of openings along roads and in harvest areas on the north coast. It is intolerant of shade and will be eliminated by establishment of a forest canopy. *Photo:* Richard Harris.

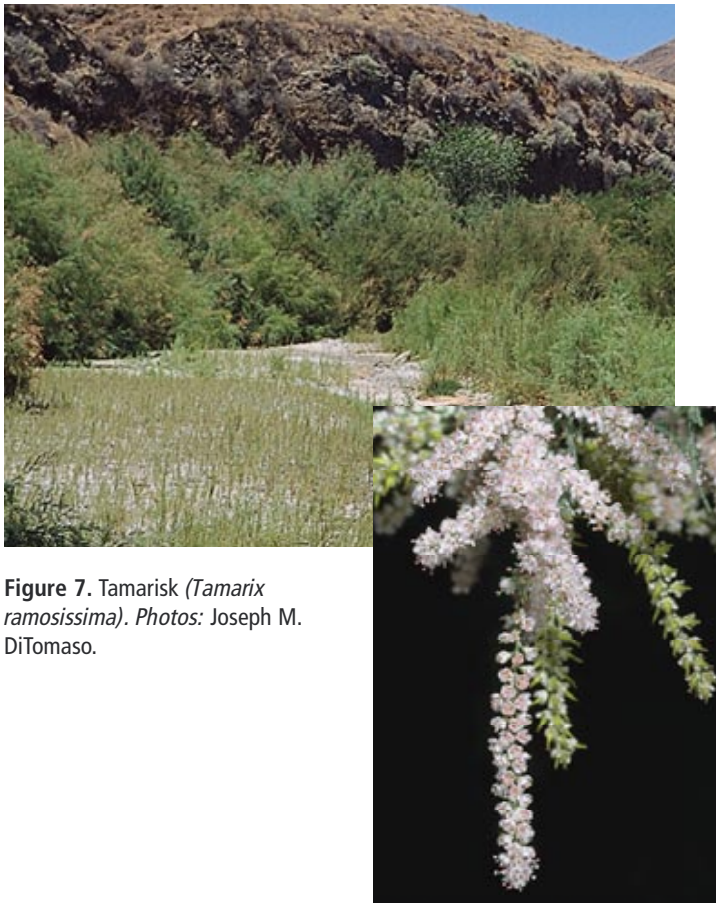

Figure 7. Tamarisk *(Tamarix ramosissima). Photos:* Joseph M. DiTomaso.

Biological Control

Biological control involves importing one or more natural enemies of an exotic pest plant to help control it in its new environment. This strategy can be very effective and self-sustaining when successful. On the other hand, major failures have occurred when an imported control agent attacks native species and becomes a pest in its own right. For this reason, careful studies, generally over many years, must be conducted before a biological control agent can be released. Another type of biocontrol involves mass release of pathogens that would not normally exist in numbers large enough to control a pest.

Competition and Restoration

In some cases native plants can outcompete exotic pest plants if they are given a little help. This can work in cases such as the reestablishment of a forest following harvest. Seedlings or cuttings should be collected from nearby sources to maintain the locally adapted plants.

Grazing or Browsing

Grazing or browsing by animals such as cattle, sheep, goats, geese, and chickens may control or suppress exotic pest plants in some cases, but in others these animals can promote undesirable species by spreading weed seeds in their droppings or exposing soil.

Chemical Control

Herbicides are chemicals that kill or inhibit plant growth. They can be very effective forms of weed control and are often the least expensive option when treating a large area. However, used inappropriately they may harm nontarget organisms. In some communities the use of herbicides is very controversial. All herbicides must be used with care and only after consideration of all treatment options. When choosing a herbicide, try to use one that is selective for the target plant and one that degrades rapidly after application. Choose an application method that delivers the pesticide to the target and avoids nontarget organisms. Avoid use near waterways. Mix a dye with the herbicide so that its coverage is visible. Follow all label instructions (see sidebar 2 on next page).

SIDEBAR 2
Warning: Use Chemicals Cautiously

- Pesticides are poisonous. Always read and carefully follow all precautions and safety recommendations given on the container label.
- Store all chemicals in the original labeled containers in a locked cabinet or shed, away from foods or feeds, and out of the reach of children, unauthorized persons, pets, and livestock.
- Confine chemicals to the property being treated. Avoid drift onto neighboring properties, especially gardens containing fruits or vegetables ready to be picked.
- Dispose of empty containers carefully. Follow label instructions for disposal. Never reuse containers. Make sure empty containers are not accessible to children or animals.
- Never dispose of containers where they may contaminate water supplies or natural waterways. Do not pour down sink or toilet. Consult your county agricultural commissioner for correct ways of disposing of excess pesticides. Never burn pesticide containers.

INTEGRATED WEED MANAGEMENT

No single control method will solve all exotic pest plant problems—each situation must be evaluated individually based on the biology and ecology of the threatened plant community. Generally, multiple management actions are required for effective control. Integrated weed management (IWM) is a strategy by which a combination of management techniques (biological, chemical, physical, and cultural) control a particular species or infestation efficiently and effectively with minimal adverse impacts to nontarget organisms. IWM differs from ordinary weed management in attempting to address the ultimate causes of weed infestation, rather than simply controlling existing weeds. Although focusing on the fundamental causes of weed invasion is more demanding than simply spraying existing weeds, the rewards can be far greater and are worth the effort if future weed problems are reduced or eliminated.

Figure 8. Purple loosestrife *(Lythrum salicaria)*. *Photo:* Joseph M. DiTomaso.

Figure 9. Giant reed *(Arundo donax)*. *Photo:* Joseph M. DiTomaso.

IWM is species specific, site specific, tailored to exploit the weaknesses of a particular weed species, and designed to be practical with minimal risk to nontarget organisms and their habitats.

DEVELOP AN EXOTIC PEST PLANT MANAGEMENT PLAN

Every landowner should have a management plan for controlling exotic pest plants. One reason for preparing and implementing such a plan is to be a good neighbor by being alert for new infestations and to control existing infestations while they are small and limited in extent. Control efforts are also much more successful if neighbors join together to prevent enlargement of infestations. Although private landowners and public land managers may have different perspectives, they share the common goal of protecting their property or management area from the negative effects of exotic pest plants.

Basic steps in developing an integrated exotic pest plant management plan are to

- describe the property
- inventory the property for exotic pest plants
- formulate management goals and objectives
- set priorities for management
- select management actions
- develop a monitoring plan
- control infestations

EXOTIC PEST PLANT PREVENTION BEST MANAGEMENT PRACTICES

Be Informed

- Become aware of the problem and spread the word that exotic pest plants are everyone's concern.
- Learn to identify high-priority species in the field so you can spot them while performing other land management activities. Learn to distinguish native species from exotic pest plants, especially native thistles.
- Report new infestations and those not previously found in the area to the local agricultural commissioner's office.

Detect Exotic Pest Plants Early

- Periodically inspect roads to detect new infestations on disturbed areas. Inspect ditch and stream banks where running water could spread seeds. Inspect high-traffic areas such as developed trailheads, parking areas, campgrounds, and other heavily used sites.
- Pay particular attention to riparian areas and salt licks that are heavily used by livestock and wildlife.
- Be extra vigilant where gravel or fill material is brought in from elsewhere. Exotic pest plant seeds in this material can start new infestations, and bare soil is ideal for establishment.

Limit Dispersal

- Don't transport flowering plants you cannot identify.
- Avoid transporting seeds stuck on clothing, gear, pets, or livestock.
- Place unwanted seeds in a plastic bag or similar container and dispose of properly.
- Avoid driving in infested areas. Inspect vehicles for seeds stuck in tire treads or mud on the vehicle. Don't clean infested vehicles in areas that are free of weed infestation.
- Inspect maintenance or other equipment for seeds before it enters the property. Require that such equipment be cleaned first to remove seeds before being allowed entry. Clean equipment (especially mowers) used in infested areas before moving it to another area.
- Always use hay, straw, or mulch that has been certified free of exotic pest plant seeds.
- Confine livestock for a day or two in a small, noninfested pasture before moving it to another noninfested pasture.
- Make sure that pack animals used in back country areas are fed hay that is certified free of exotic pest plant seeds. Before leaving an area, remove seeds from pack animals by brushing them thoroughly and cleaning their hooves. Post signs to this effect for visiting riders.
- If you find a small number of isolated exotic pest plants that have no flowers or seeds, pull them and leave them where you found them to dry out. If flowers or seeds are present, place the plants in a plastic bag or similar container and dispose of them properly.

Minimize Disturbances

- Restrict travel to established roads and trails whenever possible.
- Don't drive through infested areas.
- Limit the formation of social trails and dispersed campsites.
- Avoid leaving piles of exposed soil in construction areas. Cover exposed soil with plastic and revegetate with native species as soon as possible.
- If possible, spread material excavated during trail construction back on the trail instead of piling it on the side.
- Avoid overgrazing, especially in sensitive areas.
- Move salt licks frequently and keep salt in a shallow container to minimize soil disturbance.

Establish and Maintain Native Plant Communities

- Reseed drastically disturbed areas immediately after the disturbance ends. Native perennial grasses are especially valuable for reseeding.
- Defer livestock grazing on reseeded areas for at least one growing season to permit desirable plants to establish.
- Limit the use of fertilizers when reseeding; their use may favor exotic pest plants over native species.

RESOURCES

There is a growing awareness of the dangers of exotic pest plants to our California ecosystems, and numerous organizations have joined in the struggle to control these species. The California Native Plant Society, California Exotic Pest Plant Council, The Nature Conservancy, and numerous local groups are concerned with exotic pest problems. Some groups organize work parties that actually do control work.

Weed Management Areas (WMA) are local organizations consisting of private landowners along with city, county, state, and federal land managers that meet to coordinate work to control invasive weeds. All but five California counties now participate in the WMA program, which is generally initiated by a county agricultural commissioner's office. New legislation provides funding to WMAs that is being used for a variety of projects.

Bibliography

DiTomaso, J. M., and E. A. Healy. Weeds of California and other western states. 2 vols. Oakland: University of California Agriculture and Natural Resources Publication 3488. ANR CS Web site, http://anrcatalog.ucdavis.edu/InOrder/Shop/ItemDetails.asp?ItemNo=3488.

UC Integrated Pest Management Guidelines: Weeds. UC IPM Web site, http://www .ipm.ucdavis.edu/PMG/menu.weeds.html.

USDA Natural Resources Conservation Service (NRCS) PLANTS Database, http://plants.usda.gov/.

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FOREST STEWARDSHIP SERIES 15

Wildfire and Fuel Management

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Every forest landowner in California should be well aware of the warning "It's not if, it's when" a fire will affect your property. California's forests have evolved with fire, so living in the forest or managing forest lands means anticipating and preparing for fire. This publication gives you background information about fire and fuel management as well as some practices that can help reduce the risk of a catastrophic wildfire occurring on your property.

Objective

Understand the role of fire in forest ecology, what constitutes a fire hazard, and how to modify fuel to reduce fire hazard.

Competencies

- *Understand fire ecology and fire regimes: fire behavior, types of fires, and determinants of fire severity.*
- *Learn the natural resistance of trees to fire.*
- *Understand how fuel management can create defensible space and reduce the chance of wildfire in your forest.*
- *Be aware of local, state, and federal programs that can help develop and fund community and landowner fire hazard reduction projects.*

Related Forest Stewardship Series Publications

- *Forest Ecology, ANR Publication 8233*
- *Forest Vegetation Management, ANR Publication 8236*
- *Forest History, ANR Publication 8234*

FIRE REGIME

"Fire regime" is the characteristic frequency, extent, intensity, severity, and seasonality of fires within an ecosystem. Fire regimes vary regionally in California and have a great impact on vegetation types.

Fire frequency is commonly referred to as the "fire return interval," or the average number of years between fires at a specific location. It varies with climate, forest type, and in response to topography. Most fire scientists agree that before European settlement in California, natural fires occurred more frequently in most forest types than they do today. In some locations, Native Americans intentionally set fires to improve resource conditions for their purposes, for example, to reduce cover to facilitate hunting and to regenerate grasses, herbs, and shrubs for food and basket-making materials. Generally, the fire return interval for most California forest types has been considerably lengthened due to aggressive fire control over the past 100 years. Fires are ignited, but most are extinguished quickly before many acres have burned. A lengthened fire return interval affects forest stand conditions, fuel accumulation, and how intensely and severely future fires will burn.

The size of a fire is called its extent, usually measured in acres. Most fires affecting forests in California are small, on the order of an acre or less, because of our efficient fire suppression. Over the past few decades, there have been at least several fires every year that have affected immense acreages. The dramatic increase in the size of wildfires has been attributed in part to large fuel loads accumulated due to fire suppression activities.

Fires vary in their intensity (how hot they are) and severity (how much damage they do). At one extreme, a fire may be so intense that it completely destroys a forest stand, leaving nothing but bare soil. In actuality, even within a single fire, the intensity and severity of impacts are not uniform and differ from place to place. Many factors influence the intensity and consequent severity of a fire. These include fuel amount, or "loading," and fuel arrangement, topography, wind speed and direction, air temperature, and humidity. However, fuel is the only factor that a forest landowner can manage.

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FUEL

Fuels are characterized by their size, moisture content, flammability, and location. The size of the fuel determines how quickly it ignites (its flammability) and how long and how intensely it burns. Larger pieces of wood require greater heat to ignite but, once ignited, can continue to burn for a long time. Smaller pieces ignite more readily but burn quickly. Moisture content of fuel is influenced by whether the fuel is live or dead plants, the season of the year, and recent weather. Dry fuels ignite more easily and burn hotter. As described below (see the section "Fuel Profile," below), the location of fuel and the arrangement of fuel in space determine the type of fire that may be experienced.

There is a clear link between fire intensity and the amount of fuel present. If the time since the most recent fire exceeds the historic fire return interval by many years, excessive fuel may accumulate, and when a fire does occur, it can be quite intense. When there is a combination of exceptionally dry weather, high winds, high air temperatures, and high fuel loading, the most intense fires will occur.

TYPES OF FIRE

There are three main types of fire: surface fires, understory fires, and crown fires. Most forest fires in California are surface fires. They can be low intensity or high intensity depending upon the type and amount of surface fuels, the weather, and topography. Low-intensity surface fires, with flame lengths less than 4 feet, can be controlled with a fuel break line constructed by fire fighters using hand tools. Prescribed fires, or controlled burns, are designed to be low- to moderate-intensity surface fires.

Understory fires have longer flame lengths, up to about 10 feet. These fires are fed by surface fuels and the ladder fuels of small trees, brush, and the lower branches (up to 15 feet) of overstory trees. Ladder fuels are so called because they serve as a ladder for surface fires to climb into the crown fuels, creating crown fires. Bulldozers and aerial tankers are generally needed to successfully control understory fires.

Crown fires are the most intense, reaching into the crowns of trees. The fire has flame lengths more than 10 feet, and the behavior of the fire is unpredictable. Sometimes these fires can spread from tree crown to crown without even touching the ground. Direct control of crown fires is very difficult because of their intensity and high rate of spread. They can jump fire lines and quickly increase in size.

Though dramatic, crown fires independent of surface fires are rare in California forests. Most crown fires are supported by surface and understory fuels and fires that ignite the crowns. Fuels treatments should concentrate on surface and ladder fuels first, and crown fuels last if at all.

FIRE SUPPRESSION

Humans have influenced fire regimes for many centuries. Native Americans intentionally set fires to produce desired plants for medicine and food (e.g., acorns, hazelnuts, roots, and even grasshoppers), herd deer, and improve visibility and maneuverability for hunting and travel.

Early European settlers used fire primarily to clear land that had been logged. In some cases, attempts were made to convert forestland to pasture by clearing the trees and burning. Many fires were unintentional or naturally caused by lightning. In the 1900s, fire suppression became institutionalized both nationally and in California on both public and private lands. Fire suppression became much more effective after World War II when California forests became more roaded and accessible for fighting fires. Bulldozers, aerial tankers, chainsaws, smokejumpers, and other practices came into widespread use.

Fire suppression was instituted to protect people, property, and valuable forest resources from destruction due to both natural and human-caused fires. There is general agreement that it has been extremely effective. Recently, it has become clear that fire suppression has also allowed forests to become denser since it prevents the natural thinning that would otherwise have occurred with more frequent fires. Overly dense forests are more vulnerable to drought, fire, disease, insect attack, and other threats. This partly explains the surge in the total area burned and the size of individual fires over the past couple of decades and the perception that many forests are suffering extreme stress. Suppressing fires over time also means that the dead material in the forest is not regularly consumed, which contributes to the severity of a fire when it finally does occur. Accumulated material also ties up nutrients that would otherwise be recycled into the soil from the ashes of a fire.

RESISTANCE TO FIRE DAMAGE

Trees (and other vegetation) differ in their ability to withstand fire. Your management decisions should take into account the natural fire regime for your area and which trees are adapted to it (table 1).

Table 1. Resistance of mature trees to fire damage and mortality, in order of decreasing resistance

Coastal species	Interior species
coast redwood, tanoak	ponderosa and Jeffrey pine, Douglas-fir
Douglas-fir	sugar pine, white fir, grand fir
grand fir, white fir	incense cedar
mountain hemlock	western white pine
noble fir	lodgepole pine, western hemlock
western white pine	canyon live oak
lodgepole pine	black oak
western hemlock	
Sitka spruce, western red cedar	

Source: D. Minore, Comparative autecological characteristics of northwestern tree species: A literature review. USDA Forest Service PNW Research Station Gen. Tech. Rep. PNW-87 (1979), p. 39; Forest Service Web site, http://www.fs.fed.us/pnw/pubs/journals/pnw_1979_minore001.pdf.

A tree's resistance to fire is influenced by several attributes. Thick bark is the most important characteristic. During a fire, thick bark protects the living cambium tissue, just below the bark, from lethal heat. Bark thickness increases with tree age and size, and it varies with tree species. For example, a ponderosa pine has thicker bark than a white fir tree of the same age. Depth of rooting is also important. A tree that has shallow roots is vulnerable to having its roots charred in hot fires when ground temperatures increase significantly. The density of the forest canopy, flammability of the foliage, and the branching habits of individual trees greatly influence how a fire spreads and whether it will reach the crowns. Shade-tolerant trees such as white fir and incense cedar retain limbs and full crowns to the ground even when they are in the understory of other trees. If crowns extend to the ground this can facilitate the spread of fire.

FUEL MANAGEMENT

The first step in a fuel management project is to understand your fire hazard. Key considerations include defensible space around structures and the fuel profile, including surface, ladder, and crown or aerial fuel. Once you know the fuels, you can decide what kind of fuel management project, if any, is appropriate.

Making Your House More Fire Resistant

Few existing homes in the forest are designed and maintained to resist ignition and destruction in a wildfire. Most homes are ignited by embers and ash that fall on combustible roofs and combustible materials near homes (firewood stacked against the house, wood decks and fences attached to the house, landscape plants under eaves), and that enter vents under the house and eaves. These embers can fall up to a mile ahead of a wildfire, depending upon wind and topography, before you can see the flaming front.

When first ignited, fires are small and readily extinguished by firefighters. For this reason, firefighters must know where your house is, be able to get to your home quickly, and have defensible space around the home so they can safely defend it, and the wildfire must be moving slowly enough that it is not challenging many homes at the same time, overwhelming the firefighting forces available.

Wildfire rate of spread is an important fire behavior characteristic that can be modified with fuel reduction. The 2005 Manton Fire in Shasta County spread at a rate of 150 acres per hour, while the 2003 Cedar Fire in San Diego County spread at a rate of 5,000 acres per hour. Fire suppression forces were sufficient to cover homes in the Manton Fire, but they were not sufficient to cover the homes in the Cedar Fire because too many homes were challenged at the same time by the fast-moving fire. Fuel treatments in the forest and wild lands are designed to reduce fire intensity and rate of spread, giving limited fire suppression forces the time to get to homes challenged by the fire.

In terms of your home itself, the roof is the first thing to be made fire resistant. A Class A roof offers the best protection. Tile, slate, asphalt composition, and metal are fire resistant. Next, treat the vents in the eaves and under the house. These vents are designed to remove excess moisture from the house and prevent mold and decay, but they are also access points for embers and ash, which can ignite attics. Research is underway as to how to maintain proper venting for moisture control while excluding embers; in general:

- Inspect and maintain vegetation in the vicinity of soffit vents. Remove highly combustible plants.
- Clean vents on a regular basis to minimize buildup of debris in the screen mesh.
- Remove debris that accumulates on roofs and other areas that may expose vents if ignited. This includes the ground near crawlspace vents.
- Prepare vent covers that can be temporarily installed when a wildfire approaches your home. Vent covers can be built from plywood or some other solid substance that would provide short-term protection from embers and flame.

Finally, make attached decks and fences less ignitable by keeping them free of combustible materials during the fire season. If firewood is stacked against the house in the winter, move it away from the house during the fire season. Maintain the landscaping around the house to minimize ignition by embers by keeping it well watered and free of dead leaves and branches. If ignited, small, well-pruned plants generate less heat and are less able to ignite the siding or create embers. No plant species is fire resistant. All plants, even green plants, will burn under severe fire weather conditions if they have not been well watered and maintained.

For more on making your home fire resistant, see the Homeowner's Wildfire Mitigation Guide Web site, *http://groups.ucanr.org/HWMG/index.cfm*.

Defensible Space

Defensible space is an area created around a structure to reduce the transmission of fire to the home and improve the ability of firefighters to effectively fight the blaze. It provides a safe place from which to defend against an approaching wildfire and extinguish spot fires caused by embers on and around the home. Defensible space applies at the community scale as well. For a community, a defensible area has emergency vehicle access, emergency water reserves, street names and building identification, and fuel management measures. Fire suppression agencies also suggest the concept of survivable space. Developing survivable space prepares your home and property for wildfire under the assumption that fire fighters will not be present to defend it and suppress the fire.

Fuel Profile

The fuel profile is comprised of the surface, ladder, and crown fuels. All elements of the fuel profile should be considered when managing fire hazard, but the surface and ladder fuel have highest priority in terms of reducing fire intensity, rate of spread, and the potential for crown fire.

Surface fuel includes grasses, leaves and needles, small branches, logs, and stumps on the ground. Ladder fuel includes combustible materials (both live and dead) 6 to 15 feet above the ground, small trees and shrubs, and the lower limbs of overstory trees that could provide a path for a surface fire to climb up into the crowns; this includes living foliage and branches as well as any dead material, such as needles, caught up in the branches of other plants. Standing dead trees with many limbs near the ground are another example of ladder fuel. Dead limbs with no remaining foliage have less potential to carry the fire up into the live crown and are of less concern than are dead limbs with foliage.

When assessing your fire hazard, it is important to acknowledge that while some large decomposing logs and snags (dead trees) are needed to maintain good wildlife habitat, it is important not to have too many. Also, different fuel burns at different

rates. Pine needles are "flashy" fuel that ignite easily and burn quickly. Other fuel, such as logs, are very difficult to ignite but once ignited can burn and smolder for weeks or even months.

Fuel Management

Fuel management projects are designed to reduce fire hazard by removing or rearranging fuel. Fuel management projects can be applied to strips of land or to broad areas. When a fuel management project is applied to strips of land it is known as a fire break or fuel break. When creating a fire break, all of the vegetation is removed down to bare soil, leaving nothing to burn. Fire breaks are a minimum of 3 feet wide and are used to control low-intensity fires (hand lines). They are often used in grassland ecosystems, especially in Southern California. Generally, a fire break is three times wider than the fuel height, so a fire break may be quite wide, depending on the vegetation type and anticipated burning conditions. Fire breaks are often strategically placed along ridges and roads. Roads themselves can function as effective fire breaks.

Fuel breaks are strips of land in which vegetation, both dead and live, has been modified, but some trees and shrubs are retained. The purpose is to reduce the amount of combustible material so that when a fire burns into the fuel break, it will decrease in intensity, drop from the canopy to the ground, and slow its rate of spread. Areas treated in this manner are often referred to as shaded fuel breaks. Another term that is used to describe fuel breaks in forests is defensible fuel profile zone, or DFPZ. In a shaded fuel break (fig. 1) the trees are generally thinned so that their crowns no longer touch each other and are horizontally separated. Lower branches of overstory trees are pruned, reducing the ladder fuels. Shrubs and dead and down material is removed to reduce surface fuels. Not all small trees and shrubs need to be removed in a shaded fuel break, but the fuel reduction project should create horizontal space between small trees and nearby larger trees to minimize the transmission of fire. Shaded fuel breaks are most often placed strategically along roads and around structures.

Figure 1. A: Aerial view of a shaded fuel break in a mixed conifer forest. *Photo:* © Stephen M. Jolley. B: Ground view of a shaded fuel break in a mixed conifer forest. *Photo:* Gary Nakamura.

Fire breaks and fuel breaks can help fire suppression forces control a fire , but they may not be effective when conditions are extreme, such as on a hot, dry and windy autumn day. A forest landowner may want to consider managing the fuel over the entire forest to reduce wildfire intensity and rate of spread so that it is less severe and more easily suppressed.

Forest fuel management often includes forest thinning. Forest thinning is conducted in stands

Figure 2. A: Surface, ladder, and crown fuels create a condition that will carry fire from the surface up the ladder fuels and into the crowns of the larger trees. B: In this forest fuels treatment has removed the ladder fuels and pruned the lower limbs of the overstory trees. A crown fire entering this stand will drop to the surface, be reduced in intensity, and be more readily suppressed. *Photos:* Gary Nakamura.

with small-diameter trees (precommercial thinning, or PCT), or in stands with larger, commercially valuable trees (commercial thinning). Whether a tree has commercial value often depends on the milling capacity in the area. In either case, the purpose of forest thinning that emphasizes fuel management is to reduce surface, ladder, and crown fuels. An important additional benefit of thinning is that by reducing tree density a healthier, more vigorous reserve stand is created in which trees experience less competition for sunlight, water, and nutrients and become more resilient to drought and insect attack (fig. 2).

It is critical that surface fuel that results from the thinning activity, known as slash, as well as surface fuel that existed prior to the thinning be removed as part of the fuel management project. If you leave the slash behind, a fire may burn hot and fast through the fuel bed, killing trees that you chose to leave during the thinning. Take care to retain some of the organic matter on the ground so that erosion hazard is not increased. Treating the slash can significantly increase the cost of a fuel management project (see "Managing Debris and Slash," below). When conducting a fuel management project you may harvest some trees with commercial value to offset the costs of surface, ground and ladder fuel treatments.

In some cases the treatment of surface and ladder fuel can be accomplished by mastication, which is the mechanical chipping of trees and shrubs by mobile equipment and spreading it on the ground (fig. 3). The fuel is not removed, but its size is reduced, it is rearranged to be less flammable, and it is put in contact with the ground, where it can decompose more readily. A prescribed fire may be an effective treatment following mastication because the ladder fuel has been reduced and there is often a continuous layer of surface fuel to carry a fire.

A fuel management treatment may also include pruning, or removing the lower (live and dead) limbs of trees to reduce ladder fuel. Lower limbs should be pruned to a height of 8 to 12 feet. Care should be taken to not remove more than 50 percent of the live crown length of a tree. Conifer limbs should be cut flush against the stem (leaving no stub) so that the cut will heal over more quickly. Pruning small-diameter trees, 6 to 8

Figure 3. A: Manzanita brush and ponderosa pine before fuels treatment, Whitmore, Shasta County, California. B: The same forest following mastication of the brush, creating a less flammable fuel condition. *Photos:* Gary Nakamura.

inches in diameter, has the added benefit of producing higher-value logs with clear lumber. All the wood produced after the pruning will be clear, free of knots, and useful for high-value molding, doors and window frames.

Managing Thinning Debris and Slash

Vegetation management, whether it includes pruning, precommercial thinning, or commercial harvests can generate large amounts of waste material (slash) that is potential fuel for a fire. It is very important that this waste material is managed in such a way that it does not contribute to the fire hazard. The waste material can be modified in size and arrangement, burned, or removed from the site completely (table 2).

Mastication, described above, is one method for managing slash. Broadcast burning is a prescribed burn following a timber harvest. "Pile and burn" refers to gathering slash

Table 2. Fuels and slash management alternatives to reduce fire hazard

Treatment	Cost	Positive aspects	Negative aspects
mastication	high	very effective for nonsprouting brush no smoke long operating season alternative to herbicides can be used for large brush can combine with PCT	slope limitations high cost encourages sprouts increases flashy fuels
broadcast burning	low	very effective can use on steep slopes inexpensive imited operating seasonl	creates smoke potential for erosion often need to create fuel breaks
pile and burn	low	very effective low escape potential longer window of operation than broadcast burning can use equipment brought on-site for piling for other purposes	creates smoke potential for erosion limited by terrain (equipment limitations) potential for soil compaction
prescribed fire and underburning	low	very effective low cost large areas can be safely treated may decrease herbicide use by controlling timing of sprouting	potential for erosion smoke limited season risk of escape not a stand-alone tool
lop and scatter	high	less effective than the above no slope limitations allows for underburning	expensive increases flashy fuels

into piles with fire breaks around them, for a safer more controlled fire than a broadcast burn (fig. 4A) Prescribed fire and underburning are designed and conducted to treat fuels in stands of live trees without damaging them (fig. 4B). Lop and scatter cuts up the fuels and scatters it on the ground, lowering the fire hazard but not eliminating it

If you choose to pile and burn, follow these tips on how to burn safely. Call your local fire department first to find out if there are any special restrictions or requirements in your area.

- Burn on a "burn day" (call the local air quality management district to find out if it is a burn day). On a "no burn day," authorization for burning may be granted on a case-by-case basis by contacting the district directly.
- Keep dirt out of the burn pile as much as possible. This will help it burn completely and cleanly, with less smoke.
- Make sure your smoke does not become a nuisance to neighbors.
- Keep your burn pile under 4 feet in diameter; larger piles are subject to special rules. To keep piles this small, use multiple piles or feed material into burning piles by hand.
- Don't burn material over 12 inches in diameter.
- If you need to cover your pile to keep it dry, use black polyethylene plastic. All covering should be weighted down so that the covering will maintain its position in high winds or heavy rain.
- Locate piles in areas that will not result in damage to desired trees that were left following the thinning. If possible, locate piles outside the edge of the crown of remaining trees.

Regulations Affecting Fuel Management Projects

California Forest Practice Rules may apply to fuel management projects that include the removal of commercially valuable trees. If you sell, barter, or trade the logs or wood produced by a fuel management project, the project is subject to the Forest Practice Rules and a timber harvest plan (THP) will be required. The Rules are extremely detailed and complex, and you will need to hire a registered professional forester (RPF) to prepare the THP. The Forest Practice Rules do include exemptions from preparing a THP for landowners doing fuel management around their home. Consult the local CAL FIRE offices to determine whether your project qualifies for an exemption from THP.

Figure 4. A: Material thinned from the forest is piled for late-fall or winter burning, when the fire season is over, in Lassen Volcanic National Park. B: A prescribed burn is conducted when weather and fuel conditions will allow a safe, controlled fire. This fire is of low intensity, low flame lengths, and will not damage the trees but will consume the surface fuels and reduce fire hazard. *Photos:* Gary Nakamura.

Case Study: Oakhurst, Madera County

The mountains and landscapes of Oakhurst, California, have caused many to call this Eastern Madera County town the "Gateway to Yosemite." However, Oakhurst's forests and rugged terrain present special needs for catastrophic wildfire prevention. The local economy is shifting from logging and grazing to tourism-centered services. This shift has stimulated rapid population growth and an increase in the number of homes and businesses located in the wildland-urban interface.

Oakhurst faces a challenge that many California communities face: developing ways for citizens to protect their communities from wildfire while maintaining the beauty of their surroundings.

In a cooperative effort among several state and local government agencies, private professionals, and the public, Oakhurst was able to coordinate a fire prevention, fire suppression, and resource management program.

A permanent fuel break was the top priority. First, the steep and treacherous Deadwood Peak needed to be cleared of the dense and highly flammable manzanita that grew there. The peak was so steep that using tractors to clear it was impossible, and hundreds of hours were devoted to removing the brush by hand. Next, a controlled burn was conducted to eliminate the dense brush, leaving only the manzanita root system to prevent soil erosion. As the final step, 35,000 ponderosa pine tree seedlings were planted.

Another project, called "Trees for Oakhurst," was sponsored by the Madera County Chamber of Commerce. It included replacing trees that were cut down during construction along Highway 41. The 1,400 oak, sycamore, and evergreen trees that were planted by the community helped reduce noise and the effects of vehicular emissions, improved air quality, enhanced wildlife habitat, and restored the natural beauty of the area.

In a similar endeavor, government agencies, citizens, and local businesses contributed time and money to the Oakhurst River Parkway Project. This project worked to restore Oak Creek and the Fresno River to a level of stability that existed before intense development nearly destroyed them.

Local citizens and community organizations such as the Rotary Club, Chamber of Commerce, and Oakhurst Community Center played an active leadership role in these efforts. Other participating groups included the Coarsegold Resource Conservation District, California Department of Forestry and Fire Protection (CAL FIRE), USDA Agricultural Stabilization and Conservation Service, USDA Forest Service, California Department of Transportation, and Madera County Road Department.

Funding for many of the projects was secured through federal and state programs such as the Stewardship Incentive Program and Agricultural Conservation Program. For more information, see the Madera Fire Safe Council Web site, *http://www.maderafsc.org/*.

AFTER A FIRE

If a wildfire does burn through your property, begin recovery immediately. Immediate concerns include:

- control of soil erosion
- protecting your roads, particularly water crossings and road drainage structures
- assessing whether you can conduct a salvage timber harvest
- regenerating the forest and replanting if necessary
- understanding your economic losses and the applicable tax laws

For further information, see *Recovering from Wildfire: A Guide for California's Forest Landowners*, (UC Agriculture and Natural Resources Publication 21603), available from the ANR Communication Services Web site, http://anrcatalog.ucdavis.edu/InOrder/Shop/ItemDetails.asp?ItemNo=21603.

RESOURCES

Funding Your Project: State and Federal Programs

A number of state and federal programs can assist landowners with land management activities, including fuel reduction projects. Funding for these programs varies considerably from year to year. Two excellent guides are available from the Forest Stewardship Helpline, at 1-800-738-8733, or by e-mail at ncsaf@mcn.org:

- Cost Share and Assistance Program Directory for Individual California Landowners and Indian Tribes (2003), http://ceres.ca.gov/foreststeward/html/financial.html.
- The California Fire Alliance Community Resources Guide. This resource guide provides a brief summary of assistance available from various state and federal agencies to help tribes, communities, and other groups plan and implement community fire protection.

Fire Safe Councils

Fire Safe Councils are groups of people who come together to make their homes, neighborhoods, and communities fire safe; to discuss fire safety issues; and to determine actions to improve fire safety. They may also be involved in acquiring, funding, and administering grants to assist landowners and communities with fuel treatment projects. Membership may include representatives from public agencies, private organizations, companies, landowners, or interested citizens. Fire Safe Councils exist on the state and local levels.

The statewide Fire Safe Council is a partnership of dozens of public and private agencies and organizations. For more information on the statewide Council's publications and videos, visit their Web site at http://www.firesafecouncil.org.

Local fire safe councils are grassroots organizations that can be started by anyone. Participants might include interested citizens (landowners, neighbors), civic service organizations (Red Cross, Rotary Club), local business interests (Chamber of Commerce, forestry companies), insurance companies, environmental organizations (The Nature Conservancy, The Audubon Society), and county, state, and federal government fire districts and agencies. Examples of projects include

- planning cleanup days
- sponsoring a chipper to come through neighborhoods to treat fuels
- producing educational material
- sponsoring a seminar on designing and maintaining fire safe landscapes
- setting up demonstration gardens
- forming a speakers' bureau to give fire safe presentations
- organizing safety fairs or mock fire exercises
- sharing information and solving problems on public safety issues other than fire safety, including earthquake preparedness, emergency medical response, and so on.

The first steps in forming a council include the following:

- Identify potential members.
- Invite them to a meeting.
- Hold a meeting.
- Appoint a facilitator.
- Define area of concern and values at risk.
- List objectives and action items.
- Develop a plan and mission statement.
- Review the plan regularly.

Many local fire safe councils have established nonprofit tax status, enabling them to accept grants and financial donations. As a member of the California Community Forests Foundation, the California Fire Safe Council can accept monetary donations deposited to a California Community Forests Foundation fund. The California Community Forest Foundation charges a 10 percent administrative transaction fee. Local councils may make a similar arrangement with organizations such as local firefighter associations or local environmental groups who have already established nonprofit status.

Agencies

The following agencies can provide more information about fire safe actions to interested communities:

California Department of Fish and Game (DFG). A state agency that manages California's wetlands, wildlife habitats, and ecosystems. See the "State Government" section in a telephone directory or visit their Web site at http://www.dfg.ca.gov.

California Department of Forestry and Fire Protection (CAL FIRE). A state agency that provides fire protection and a multitude of fire-related and natural resource management services to state and private lands. Web site, http://www.fire.ca.gov.

Center for Fire Research and Outreach UC Cooperative Extension, Berkeley, Web site, http://firecenter.berkeley.edu/about.htm.

City or county public works or planning departments. These city and county agencies can provide information about building codes and other fire safe requirements.

Forest Stewardship Helpline. This service of the Forest Stewardship Program provides information and referral to landowners, resource professionals, and others. The Helpline is an excellent information clearinghouse, answering your questions about forest management—what to do, whom to call, where to go for more information, etc. Call 1-800-738-8733 or e-mail ncsaf@mcn.org.

Local fire stations. Local fire departments may have professionals to help communities identify fire hazards and implement loss reduction programs.

Natural Resource Conservation Service (NRCS). A federal agency with expertise in agronomy, natural resources, and civil engineering that helps communities identify problems before construction begins and can help burned areas begin the recovery process. See the "U.S. Government" section of a telephone directory or visit their Web site at http://www.nrcs.usda.gov/.

University of California Cooperative Extension (UCCE). The University of California has an extensive network of agricultural and natural resource education services. Look in your local "County Government" or "Farm Advisor" listings in a telephone directory or visit the UCCE Web site at http://www.ucanr.org.

US Fish and Wildlife Service (FWS). This federal agency can help with information about wildlife, endangered species, and other habitat questions. Web site, http://www.fws.us.gov.

ENGLISH–METRIC CONVERSIONS

English	Conversion factor for English to Metric	Conversion factor for Metric to English	Metric
inch (in)	2.54	0.394	centimeter (cm)
foot (ft)	0.3048	3.28	meter (m)
yard (yd)	0.914	1.09	meter (m)
mile (mi)	1.61	0.62	kilometer (km)

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FOREST STEWARDSHIP SERIES 16

Forest Pests and Diseases

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INSECTS

Insects are a natural and necessary part of a healthy forest ecosystem; most insect species are actually beneficial. They speed decay of dead vegetation, releasing nutrients for other plants. Many types of wildlife require insects for food. Bees and other insects pollinate forest plants. Some insects prey on other insects that are harmful to plants, keeping pest outbreaks in check.

Many insect populations experience a natural "boom-bust" cycle. Every year fertile adults or pupae survive the winter and emerge in the spring. They reproduce and increase in number through the summer and decline again in the winter. Environmental conditions and food availability control their populations. For those that feed on trees (leaves or sugars in the sap), food availability increases when the trees are under stress and are less able to defend against or rebound from insect attack. When susceptible trees are abundant due to prolonged stress, insect populations increase to the extent that food is available. After an initial "boom" period that may last for several generations, the insects reach a level that is no longer sustainable by the available food. The population then "crashes" until the next cycle begins again. The crash may be caused in part by a buildup in the populations of natural enemies of the insects (birds, predatory insects) who themselves are responding to an increased supply of food (insects). When insect outbreaks of this kind are widespread and prolonged, there can be immense amounts of tree mortality. More commonly, tree mortality due to forest insects is localized, limited to a few trees in a small area. In many cases, healthy trees can repel insect attacks or survive them.

Insects kill more trees annually than wildfire. However, they usually take their toll on individual trees or small groups of trees, unlike the spectacular large-scale destruction of forest fires. While insects may be the identifiable cause of tree injury and death, the underlying reason for insect damage is that trees are in poor condition due to stress. Stress is caused by drought, competition for resources among trees, or other environmental conditions. Insects challenge trees constantly, but generally only the stressed or unhealthy trees are successfully attacked and succumb. Maintaining healthy, vigorously growing trees is the best defense against insects.

Bark Beetles and Engraver Beetles

Bark beetles and engraver beetles, though only about the size of a grain of rice, are the most important forest insect pests in California. They enter trees by boring through the bark. Several species attack most of the commercial conifer species in California.

Objective

Understand that forest insects, animals, and diseases are natural and necessary parts of the forest ecosystem and that they become pests only when they reach excessive levels in a forest.

Competencies

- *Recognize the symptoms of damage to trees due to environmental stress vertebrate and invertebrate animals, and disease.*
- *Living in the forest: dealing with forest insects and pests*
- *Become familiar with integrated pest management strategies and practices.*

Related Forest Stewardship Series Publications

- *Forest Ecology, ANR Publication 8233*
- *Forest Vegetation Management, ANR Publication 8236*

UC PEER REVIEWED

Figure 1. A: Bark beetle damage. *Photo:* © California Academy of Sciences. B: Galleries of the western pine beetle. Larvae feeding on the inner bark (phloem tissue) of ponderosa pine create tunnels that disrupt sap and water flow in the tree. *Photo:* Gary Nakamura.

These insects generally attack stressed or weakened trees. They often work together: engravers may attack first, weakening a tree, followed by bark beetles, which can kill the tree. General reddening of the foliage in the tops of pine and fir trees is the most noticeable sign of successful bark beetle and engraver attack.

Female beetles lay eggs in tunnels they excavate beneath the bark (fig. 1). The eggs hatch and the larvae feed on the inner bark, disrupting the conductive tissue of the tree (phloem) and eventually girdling the trunk. Bark beetles can also carry a fungus that infects attacked trees, blocking the water-conducting tissues of the tree. Bark beetles attack trees near the base of a tree, while engravers are found near the top. The pattern of the tunnels made by the larvae is characteristic of the species of beetle. Removing a small piece of bark and noting the tunnel pattern can usually yield a positive identification.

Pitch tubes, small bubble-gum-like blobs of sap and sawdust that erupt on the bark of the tree, indicate bark beetle attacks (fig. 2). Pitch tubes are a tree's defense mechanism. If a tree is healthy and has adequate sap, it can often "pitch out" the invading beetle before the beetle can successfully lay eggs. If the tree is under stress or weak, it may not have sufficient sap to pitch the beetle out. In that case the beetle can successfully create an egg gallery and lay eggs. Beetles in successfully attacked trees emit a chemical scent, a pheromone, which attracts other beetles to the weak, susceptible tree, resulting in a mass attack that will kill the tree. Single, isolated beetle attacks are common and not lethal, but under stressful conditions such as a prolonged drought, many stressed trees can produce many beetles that generate mass attacks on trees.

Trees killed by bark beetles should be salvage-harvested quickly to minimize insect spread and to capture the tree's economic value before decay sets in. If the affected logs are not merchantable, remove the bark and cut and split the wood for firewood. This will dry out the inner bark and make the wood less palatable to insects.

Foliage Attackers and Other Insects

Insects that attack foliage weaken the tree by reducing the amount of food the tree can manufacture. Most trees can tolerate partial defoliation, though this may make them more susceptible to bark beetle attack. Repeated or total defoliation can kill a tree outright (fig. 3).

Figure 2. A: Pitch tubes on a pine tree. B: Close-up of pitch tube with bark beetle that was killed and pitched out. *Photos:* Gary Nakamura.

Figure 3. A defoliated white fir, the preferred host for Douglas-fir tussock moth in California, stands next to a red fir, a nonhost tree species. *Photo:* Courtesy Don Owen, CAL FIRE.

Foliage insects can be found while they are feeding. Look for damaged leaves and needles. Egg masses, usually small pouches or webs attached to protected spots on the bark or under branches and leaves, are easily detected.

Insects also attack twigs, buds, cones, and roots. Look for a decline in tree vigor or damage to the specific part. Be familiar with your forest and notice changes. Respond quickly to insect outbreaks.

Insect Control

Human attempts at insect control in forests are usually futile and may actually prolong an epidemic. Chemical or other insect control measures are expensive and often ineffective in forests because large areas must be treated and insects do not recognize property boundaries. While individual trees might be protected with insecticide treatments, only landscape trees are probably worth the cost and effort. Also, many insecticides are nonspecific, killing beneficial as well as pest insects.

Learn about insect pests specific to your area. Use strategies to prevent their occurrence or limit their effect. The key to preventing excessive damage to your forest by insects is to minimize stress to trees. This is only partly possible through management. Stresses due to prolonged drought are not preventable. What is possible is to implement silvicultural practices that promote healthy, vigorous trees. Techniques to consider include:

- Thin dense stands of trees to maintain good live crowns, improving the vigor of the trees.
- Remove high-risk trees (generally those with poor crowns and vigor) during harvesting operations.
- Plan all management operations to minimize damage to the remaining trees. Insects and diseases can invade trees through logging wounds.
- When available, plant seedlings that are resistant to insects and disease.
- Plant a variety of species where appropriate. Large areas of a single species are more susceptible to attack than stands of mixed species.

Figure 4 . *Oligoporus amarus* fruiting bodies on incense cedar, the only known host for this fungus. The fungus attacks the heartwood and causes pocket dry rot. It is usually found in trees older than 150 years old. The fungus enters through fire scars, large open knots, and broken branch stubs. *Photo:* Gary Nakamura.

DISEASES

A tree is generally considered to be diseased when it has a symptom such as discolored leaves, dieback in the crown, or fruiting bodies (fungus) on the stem. These symptoms may be caused by fungi, bacteria, parasitic plants and animals (usually insects), or by nonbiological agents such as smog, chemicals, wind, or extreme temperatures (frost, heat). To understand and properly address the problem the specific cause must be determined. This is not always so simple because a combination of factors can often cause the observed symptoms (fig. 4). As with insects, most biologically caused diseases are a natural and necessary part of the forest ecosystem. Fungi, bacteria, and insects break down and decompose organic matter, creating soil humus. They reduce fuels and return nutrients to the soil. These are essential functions of a healthy forest ecosystem.

What we consider a disease is a disturbance of the normal functions of a tree or the deterioration of its parts. When this disturbance occurs sporadically throughout a forest it goes undetected. When it occurs over large, continuous areas, it may be a disease problem that should be addressed.

Figure 5. The ponderosa pine on the far right has a thin crown and "poodle tailed" foliage, suggesting a root disease or other systemic problems causing earlier years' needles to drop prematurely. Pine needles are usually retained for 3 to 4 years on a branch before being shed. *Photo:* Gary Nakamura.

Diseases may be difficult to identify until they have clearly damaged the tree. If symptoms are observed, start with the obvious: Is there some environmental condition that is causing the symptom? For example, has there been recent equipment operation or grading near the tree? If several trees or an area of forest is affected, is there some pattern? For example, if only one species is affected, it might suggest a species-specific organism rather than a nonspecific environmental condition; or if mortality appears in a circular pattern, it might suggest a fungal root disease. Diagnosing the causes of symptoms observed in trees is much like a medical diagnosis. Many different causes may manifest similar symptoms. But, like bark beetles that have characteristic tunnel patterns, some diseases have very specific identifiable symptoms.

Heart Rots

Heart rots are the leading cause of wood decay. The fungi that cause the rot enter the tree through logging wounds, animal damage, dead branches, or any injury that damages the bark and exposes the inner part of the tree. Look for large, shelflike mushrooms (conks) on tree stems or for mushrooms in the soil around the tree (fig. 4). These are the fruiting bodies of fungi that cause disease and decay. Also, a hollow sound when you tap on the tree indicates heart rot. Preventing injury to trees is the most effective form of control. You may want to salvage-harvest damaged trees. During harvests, "rub" trees are often designated to sustain damage to protect other trees, and these rub trees are removed when the harvest is completed.

The presence of conks indicates significant deterioration inside the tree. The tree may be structurally unsound. If it poses a hazard to people or structures it should be removed. Where possible, trees with heart rot should be left for the wildlife habitat values they provide. They are easily excavated to make cavities for nests and they also make excellent snags.

Root Disease

Root diseases are fungal diseases whose symptoms show on the whole tree crown uniformly, as compared to insects, foliar diseases, and parasitic plants that tend to affect only certain parts of the tree. If all or most of the tree leaves or needles are yellowing, dying, or shedding for no apparent reason, root problems are usually the cause. Conifers retain their foliage for a number of years; needles on pines are usually retained for 4 or more years. Root problems may reduce needle retention to 1 or 2 years. This will make the crowns more open and thin and give branches a tufted or "poodle tail" appearance (see fig. 5).

Root diseases spread from tree to tree by root contact and fungal growth through the soil and are difficult to detect and even more difficult to control. Look for fruiting bodies (mushrooms) on and around the base of the tree. Bark beetles often successfully attack trees weakened by root disease. Thus beetles may be the immediate cause of death, but root disease is the ultimate cause.

Disease centers, in which a group of trees die, are another good indicator of root disease (fig. 6). Fungi grow in a radial pattern through the soil, creating fairy rings of mushrooms in your lawn and circular disease centers in the forest. Trees adjacent to dead trees are often infected, though they do not show symptoms until the next year when moisture stress finally browns the leaves. Some root diseases become established

Figure 6. The center of annosum root disease in a stand of white fir, eastern Shasta County. *Photo:* Courtesy Don Owen, CAL FIRE.

when fungus spores land on and colonize a freshly cut stump. One particularly serious root disease, caused by the fungus *Heterobasidion annosum,* can be prevented by powdering freshly cut stumps with borax (sodium borate).

Root disease can be managed in part by managing the species composition of the forest. Root diseases are typically host species–specific, affecting only one tree species. Increasing species diversity or reducing the relative proportions of susceptible species can reduce the incidence or extent of disease. Affected trees and sometimes trees around them of the same species that may have been infected should be removed to prevent further spread.

Rusts

Rusts are fungi that enter the tree through the needles. Rusts require an alternate host plant for the disease to complete its life cycle. Spores can travel hundreds of miles on the wind, so the alternate host could be far away.

The most destructive rust in California is the white pine blister rust that infects sugar pine and other pines in the five-needle white pine group. It is an exotic disease that was introduced to North America in the early 1900s on seedlings of eastern white pine from Europe. Symptoms are random flagging (dead, brown-needled branches) in tree crowns. Close examination of these branches reveals a spindlelike swelling of the branch filled with orange spores. Eventually, the rust will grow into the main stem and kill the tree or make the tree more susceptible to successful beetle attack.

The alternate hosts for white pine blister rust are currant and gooseberry. In the 1940s, control was attempted by eradicating the alternate host, but this proved ineffective because the eradication was incomplete and the gooseberry regenerated. Research is underway to find and produce sugar pine that is resistant to blister rust and would be safe to use in reforestation projects.

Sudden Oak Death

Sudden oak death (SOD) is caused by the fungus *Phytophthora ramorum* (fig. 7). Since its appearance in 1995, sudden oak death has killed tens of thousands of coast live oak, black oak, and tanoak trees in northern California. It can also infect leaves and branches of other plants that are carriers of the disease, including rhododendron, buckeye, madrone, manzanita, bigleaf maple, bay laurel, evergreen huckleberry, and redwood. Carrier species are not killed, nor do they display significant damage, making it difficult to detect infection and control disease transmission.

Sudden oak death has been found as far north in the state as Humboldt County and as far south as Big Sur in Monterey County. As of 2006, it had been identified in 12 California counties: Alameda, Contra Costa, Humboldt, Marin, Mendocino, Monterey, Napa, San Mateo, Santa Clara, Santa Cruz, Solano, and Sonoma.

Figure 7. Sudden oak death (SOD) has symptoms very much like other diseases: yellowing and browning of leaves. A: necrotic leaf spots; B: "burned" tips of conifers that are carriers of the disease; C: perhaps most distinguishing is an oozing of reddish-brown sap from oak tree trunks. *Photos:* Courtesy J. M. Davidson, S. Werres, M. Garbelotto, E. M. Hansen, and D. M. Rizzo, "Sudden Oak Death and Associated Diseases Caused by Phytophthora ramorum," Plant Management Network, July 7, 2003.

Bleeding or oozing of a thick, dark reddish-brown sap is the first symptom to appear on true oaks and tanoak. It typically occurs on the lower portion of tree trunks (below 10 feet) but has been found as high as 60 feet. On tanoak, the first symptom is the drooping and wilting of new growth. Beetles attack weakened trees. Wood-decaying fungi can be seen in the later stages of decline on the trunks of oaks and tanoaks.

Preventing the movement of infected leaves, wood, water, and soil are critical to slowing the spread of this fungus to other oak woodlands, such as in the Sierra Nevada foothills. Plant material and soil should not be moved from coastal areas. Any wood already moved outside the infested area should be burned. Visitors to coastal forests should clean their tires, shoes, and animals' feet thoroughly before leaving the area. Washing with soap and water, Lysol, or 10 percent bleach solution would be better, but any cleaning of mud, leaves, and organic material is helpful. Construction workers should wash equipment well and should not move dirt from one place to another. Ornamental plants that may be hosts, such as rhododendrons, should not be moved from infected counties unless certified to be free of the pathogen.

Dwarf Mistletoe

Dwarf mistletoe is a serious disease of western conifers. The infection can be identified by an erratic and profuse growth of branches in the crown known as "witches broom." Stem infections show swelling at the infection site. The plant itself is a cluster of yellow-green stems with a scalelike appearance similar to juniper, but with no leaves (fig. 8). Cut and remove affected trees that have evidence of dwarf mistletoe in the stem of the tree, as the stem will be weakened and subject to breakage above the point of infection. Pruning affected limbs may be sufficient in trees with dwarf mistletoe only in the branches.

Dwarf mistletoe is host species–specific. That is, ponderosa pine dwarf mistletoe infects only ponderosa pine, and white fir dwarf mistletoe infects only white fir. Dwarf mistletoe in tall trees cast their seeds down on understory trees, infecting those of the same species. Infected large trees are usually removed to prevent the infection of smaller trees. In an understory with mixed tree species, the nonhost species will not be infected.

Controlling Forest Diseases

Most of the general concepts used to control insects also apply to diseases. In fact, many diseases are transmitted by insects and are usually managed by controlling the insect carrier.

As with insect control, prevention through good forest management is the best method of disease control. Chemical control (except in limited areas, high-value nurseries, Christmas tree plantations, or ornamental plantings) is rarely cost effective. Consult with your forester, UCCE forestry or farm advisor, or California Department

Figure 8. Dwarf mistletoe in ponderosa pine. A: "Witches brooms" or "brooms" of wild branch and foliage growth caused by the dwarf mistletoe. Dwarf mistletow is a parasitic plant that lives on the photosynthate of the host pine tree, but it is not acutely lethal to the tree. Over time the tree will be weakened; broom-laden treetops and branches break off and create openings for fungal diseases and heart rots. B: Close-up of the dwarf mistletoe plant on a ponderosa pine branch. *Photos:* Gary Nakamura.

of Forestry and Fire Protection (CAL FIRE) service forester to learn about diseases you should be concerned about and strategies to prevent them. Christmas tree plantations, given their high value and limited area, may warrant more extensive control methods such as spraying fungicides or insecticides.

WILDLIFE PESTS

Most people live in or visit a forest for the aesthetic values found there. Seeing and hearing wildlife helps us to feel that the forest is "alive." However, forest wildlife can create conflicts with forest management goals.

In most cases, significant animal damage occurs in young plantations or affects young trees. Simply put, the smaller the tree, the greater the risk of damage from chewing, browsing, rubbing, or climbing. As a tree or plantation ages it can sustain higher levels of animal impacts and continue to survive.

Seedlings

Seedlings are at the highest risk of animal damage. Seedlings have little protection against or resistance to the damage that can occur from feeding by pocket gophers, voles, rabbits, and deer. Generally, the tree species most severely impacted by these wildlife species are the "whitewood" conifers (pines, firs, and Douglas-fir). Techniques that can inhibit feeding damage include TreeShelters, Vexar tubing, and chemical repellants. The tube-style products can generally protect small seedlings for several years until they outgrow the tube. The repellants, though effective, must be applied frequently (particularly during the rainy season) if they are to be effective. Mowing and tilling can also minimize damage from rodents by making the site less attractive to these animals. Care must be taken not to damage the seedlings with the machinery.

Saplings and Pole Trees

As a tree matures, it becomes less susceptible to damage from browsing and girdling as it grows beyond the reach of deer (about 5 feet high). Pocket gophers can still pose a threat to the root system, particularly of pine and fir trees. Regular monitoring should be conducted in plantations of these species to ensure that pocket gopher populations are not increasing and damaging the trees. Effective pocket gopher controls include trapping and toxic baits.

In forests dominated by ponderosa pine, porcupines can be a serious threat to intermediate-sized trees. These rodents can severely impact trees by feeding and gnawing on the bark, severing conductive tissue. Contact your local county agricultural commissioner's office to enlist their assistance in designing a management program to limit the damage from porcupines.

Saw Timber and Mature Trees

Once a tree has matured, most are not susceptible to serious animal damage, but there are exceptions to the rule. Mature Douglas-fir trees have been killed by pocket gophers feeding on their root systems. Mature pine trees can be seriously damaged by tree squirrels.

Figure 9. Bark stripping by black bear on saw-timber-sized redwood trees, Humboldt County. Bears strip the bark to access the sugars in the phloem and possibly to mark their territories. *Photo:* Greg Giusti.

Coast redwood trees are susceptible to damage from wood rats, tree squirrels, and black bear (fig. 9). Tree squirrels and wood rats can feed on the terminal leaders of mature pines and redwoods, creating unsightly, malformed trees. Black bear feeding damage to the bark of coast redwood trees from 11 to 20 inches in diameter at breast height often results in the death of the tree. In most cases, the damage is limited in its extent, and the trees usually survive. If a mature stand of trees is being impacted by these species, seek advice from local California Department of Fish and Game (DFG).

FOREST PESTS AND PEOPLE

Ticks and Lyme Disease

Lyme disease is a potentially debilitating and sometimes chronic infection transmitted to humans and other animals by certain ticks. Lyme disease is caused by the bacterium *Borrelia burgdorferi*. Within 1 to 2 weeks of being infected a "bull's-eye" rash may develop, with fever, headache, and muscle or joint pain (fig. 10). Some people have Lyme disease and do not have any early symptoms. Other people have a fever and other flulike symptoms without a rash.

Avoid being bitten by infected ticks (fig. 10). Whenever possible, avoid entering areas that are likely to be infested with ticks, particularly in spring and summer when nymphal ticks feed.

If you are in an area with ticks, wear light-colored clothing so that you can spot ticks more easily and remove them before they become attached. Wear a long-sleeved shirt and tuck your pants cuffs into your socks. You may also want to wear high-top rubber boots, since ticks are usually located close to the ground.

Applying insect repellents containing DEET (n,n-diethyl-m-toluamide) to clothes and exposed skin and permethrin (which kills ticks on contact) to clothes should also help reduce the risk of tick attachment. DEET can be used safely on children and adults but should be applied according to U.S. Environmental Protection Agency (EPA) guidelines to reduce the possibility of poisoning .

Since transmission of *B. burgdorferi* from an infected tick is unlikely to occur before 24 hours of tick attachment, check for ticks daily and remove them promptly. Embedded ticks should be removed by using fine-tipped tweezers. Cleanse the area with an antiseptic.

You can reduce the number of ticks around your home by removing leaf litter and piles of brush and wood around your house and at the edge of your yard. By clearing trees and brush in your yard, you reduce the likelihood that deer, rodents, and ticks will live there. Cleaning up the area around the house also reduces the fire hazard.

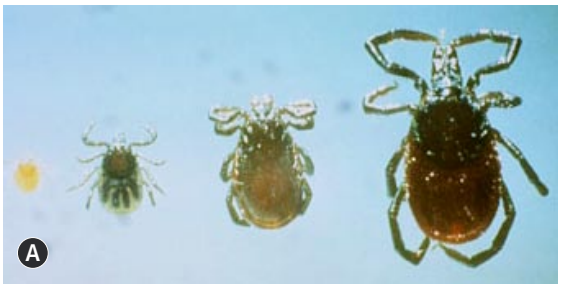

Figure 10. A: Left to right: Western black-legged tick larva, nymph, male, and female. *Photo:* R.S. Lane, Insect Biology, UC Berkeley. B: Erythema migrans, the skin rash common in the early stage of Lyme disease. *Photo:* © Ross Ritter, Potter Valley, CA.

Wasps, Hornets, Yellow Jackets, and Bees

Wasps, hornets, yellow jackets, and particularly bees are important and necessary parts of a healthy forest ecosystem. Although they become pests when they sting or bite us, our approach should be to avoid them rather than try to eradicate them. When you are in the forest, watch where you step, be aware of your surroundings, and listen for buzzing sounds.

Bald-faced hornets are black and white, build egg-carton gray paper nests in trees the size of footballs, and can be aggressive. If you do disturb hornets, you may be able to evade them by running a short distance, stopping, and slowly stepping to the side without creating an air disturbance, since hornets may continue following the air disturbance. However, it is best not to disturb hornets in the first place.

Yellow jackets, sometimes called meat bees, build paper nests underground and, when disturbed, come boiling up from the ground. The conventional wisdom is that the first hiker in a line arouses a yellow jacket nest, the second gets them angry, and the third one gets stung.

Honey bees are often seen in the forest when hives of bees that were used to pollinate orchards in the spring are brought into forests in the summer to feed on wildflowers.

A variety of wasp species live in the forest. Some, usually very small and unnoticed, lay their eggs in tree leaves and branches (usually oaks), creating galls of plant tissue. These galls can look like golf balls, small cones, or spiked balls in various colors. Galls are not lethal to trees.

INTEGRATED PEST MANAGEMENT (IPM)

One approach to controlling pests is known as integrated pest management (IPM). IPM is a strategy that takes the entire ecosystem into consideration and recognizes the valuable role that insects and disease play in a healthy forest. It focuses on long-term, systemic control of insects and diseases to prevent them from becoming pests that cause widespread and serious damage, through a combination of techniques including biological control, habitat manipulation, modification of cultural practices, and use of disease resistant varieties.

With IPM, pesticides are not applied routinely; rather, they are used only after monitoring indicates they are needed according to established guidelines. Treatments are made with the goal of affecting only the target organism. Pest control materials are selected and applied in a manner that minimizes risks to human health, beneficial and nontarget organisms, and the environment. IPM requires careful monitoring of the forest to determine whether a pest problem exists and whether the problem is intolerable and requires treatment. In many cases the "no treatment" option is found to be the preferred, most cost-effective approach.

RESOURCES

Several good sources of information are available on forest pests and diseases. The University of California Division of Agriculture and Natural Resources has online and printed publications on pests, disease, and integrated pest management that may be accessed through the ANR CS Web site, http://anrcatalog.ucdavis.edu/InOrder/Shop/Shop.asp. The California Forest Pest Council holds conferences and workshops on forest pests and prepares an annual forest pest report; see their Web site at http://www.caforestpestcouncil.org/. The UC Integrated Pest Management Program's has a Web site (http://www.ipm.ucdavis.edu/PMG/PESTNOTES) that provides free information on controlling ticks, Lyme disease and many other pests. The IPM publication on pest control in forests and rights-of-way, which would be of general interest to forest landowners, can be ordered at the ANR CS Web site given above.

An excellent reference on forest insects, diseases, and animal damage is *Pests of the Native California Conifers*, by David Wood, Thomas Koerber, Robert Scharpf, and Andrew Storer (University of California Press Natural History Guide Series No. 70, 2003). It can be found in many bookstores or ordered from the UC Press Web site, http://www.ucpress.edu/books/pages/9670.html.

The status and spread of sudden oak death is monitored by the interagency California Oak Mortality Task Force, http://www.suddenoakdeath.org/.

The California Department of Forestry and Fire Protection (CAL FIRE) produces a series of "Tree Notes" leaflets, many of which pertain to management of forest pests; see their Web site, http://ceres.ca.gov/foreststeward/html/treenotes.html.

ENGLISH–METRIC CONVERSIONS

English	Conversion factor for English to Metric	Conversion factor for Metric to English	Metric
Length			
inch (in)	2.54	0.394	centimeter (cm)
foot (ft)	0.3048	3.28	meter (m)
yard (yd)	0.914	1.09	meter (m)
mile (mi)	1.61	0.62	kilometer (km)

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FOREST STEWARDSHIP SERIES 17

Forest Roads

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Decisions regarding roads are among the most important that you as a forest landowner can make. Although roads are essential for the management of your forest, poorly located or poorly functioning roads can significantly and adversely impact water quality and plant and wildlife habitat and can cause erosion both on and off of your property. These roads are also expensive to maintain and repair. This publication provides an overview of the following topics:

- environmental impacts of roads
- types of roads
- drainage
- construction and reconstruction
- maintenance
- social and legal issues
- funding sources for roadwork

Objective

Understand the planning, construction, maintenance, and environmental impacts of forest roads.

Competencies

- *Evaluate the condition and suitability of existing roads.*
- *Anticipate and plan for new roads.*
- *Know the types of roads and the uses they support.*
- *Understand the environmental impacts of roads on watersheds, streams, and other forest resources.*
- *Understand how to improve the condition, drainage, and functioning of existing roads.*
- *Understand how to maintain roads to prevent their failure and to mitigate environmental impacts.*
- *Understand the legal issues associated with access and roads.*
- *Gain familiarity with the funding and implementation of road improvements and maintenance.*

Related Forest Stewardship Series Publications

- *Laws and Regulations Affecting Forests, Part I: Timber Harvesting,* ANR Publication 8249
- *Forest Streams,* ANR Publication 8239
- *Forest Water Quality,* ANR Publication 8241

UC PEER REVIEWED

ENVIRONMENTAL IMPACTS

Sediment Transport

Roads are the major source of soil erosion and stream sedimentation on most forest land. While some sediment transport into watercourses is natural and necessary for good riparian function, roads commonly deposit more sediment into streams than they should. Your goal should be to minimize to the maximum extent possible erosion from your roads. Sediment transport happens in many ways:

- Compacted road surfaces increase the rate, and therefore the erosive potential, of runoff.
- Ditches concentrate storm runoff and can transport sediment to nearby stream channels.
- Culverts can plug, causing fill washouts or gullies where the diverted stream flow runs down nearby roads and hillslopes (figs. 1 and 2).
- Landslides may be triggered by road construction on steep or unstable slopes (fig. 3). This can occur due to increasing the weight of soil on slopes through depositing road fills and pushing materials off the side of the road (side-casting), through undermining by road cuts, or through interception of groundwater.
- Unstable road fills or landing side-cast material may fail, even many years after the road was constructed.

Figure 1. Culverted stream crossings may plug during storms. Diverted stream flow then crosses the road and erodes the fill slope. *Photo:* Richard Harris.

Figure 2. In this case, a culvert located uphill from the one shown plugged and diverted stream flow and sediment down the road into the stream. *Photo:* © Angela Wilson; used with permission.

Figure 3. Stream undercutting at the base of the slope below the road caused this landslide. *Photo:* Richard Harris.

Other Impacts

- Roads are the primary source of nonpoint source pollution in rural areas. Nonpoint source pollutants from roads can include waterborne sediment, dust, and petroleum products.
- Roads divide forests into patches, reducing their habitat value for wildlife. They also act as barriers to wildlife movement.
- Roads provide access that may be used by trespassers. Roads that can provide access to trespassers should be gated and posted.
- Roads can act as conduits for invasive plants and animals such as weeds, livestock, and feral pets. Invasive plants brought into a forest as "hitch-hiking" seeds or propagules can colonize cleared roadsides.
- Roads increase the risk of wildfire since users may intentionally or unintentionally ignite roadside weeds.

Figure 4. This road has been surfaced with gravel to permit all-season use. Note armoring on stream crossing and dip in the road to prevent diversion of stream flow down the road if the culvert plugs. *Photo:* Richard Harris.

Figure 5. Seasonal-use roads often develop a cover of grass and forbs. This is beneficial for preventing road surface erosion during the winter. *Photo:* © J. Bawcom; used with permission.

As a general rule, landowners should try to keep the number, size, and extent of roads on their property to the minimum necessary to accommodate required uses.

TYPES OF ROADS

The type of road and its intended use determine many aspects of the road's design, construction, and maintenance.

A permanent road is used year-round. Culverts in permanent roads should be sized to accommodate 100-year storm events plus associated sediment and debris. Road surfaces in riparian zones or wet areas are usually rocked (fig. 4).

Seasonal roads are used for access only during the dry season. These roads are generally not rocked in riparian or wet areas (fig. 5). If culverts are permanently placed, they should be sized to accommodate 100-year storm events plus sediment and debris. The use of seasonal roads in the winter should generally be limited to low-impact vehicles such as ATVs, unless the ground is frozen.

Figure 6. Driving on unsurfaced roads during rainy weather can create ruts and potholes that are difficult to repair. *Photo:* © Angela Wilson; used with permission.

Temporary roads are used only for a short time and for a designated purpose, such as tractor (or skid) trails used for skidding logs. Drainage structures large enough to handle the water flow should be built at watercourse crossings during the time of use. A temporary road should not be used in the winter unless the ground is frozen.

It is important to understand what kind of road you have and limit your use of it accordingly. For example, during the winter, avoid using a seasonal road that is near a watercourse or that is not rock-surfaced or paved, to avoid creating ruts and gullies that can transport sediment into a stream and are difficult to repair (fig. 6). If you want to use the road for year-round access, upgrade it to a permanent road.

Existing Roads

Existing, or "legacy," roads are roads that were on your property when you acquired it. Many legacy roads are significant sources of sediment, "bleeding" sediment into watercourses every year. Do not assume that a road does not need work simply because it has been on your property for many years.

Factors that influence the stability of a road and its erosive potential include where the road is placed, when and how it was constructed, how it has been maintained, and the type of soil in the area.

Over the years, ideas have changed about good road placement, construction, and maintenance. It was once commonplace, for example, to drain road surface water into inside ditches that were run downhill for long stretches before discharging through a culvert cross-drain. Today, a more successful strategy is to out-slope the road where possible, continuously draining the road surface, and install cross-drains, such as water bars and rolling dips, where feasible. This minimizes reliance on culverts, which can plug with sediment or debris during a storm, leading to erosion and increased maintenance. (For more information and definition of terms, see the section "Drainage," below.)

The location of a legacy road is very important. Some locations, such as extremely steep or very flat ground, have inherent drainage problems and need constant maintenance. Likewise, certain soil types are particularly erosive, and even a well-designed road may need frequent maintenance.

Look for ways to improve your legacy roads to lower the maintenance required. If the road has severe, chronic problems, you might consider relocating key stretches. If you choose to abandon the road, try to ensure that problem areas will not continue to bleed sediment when the road is no longer used.

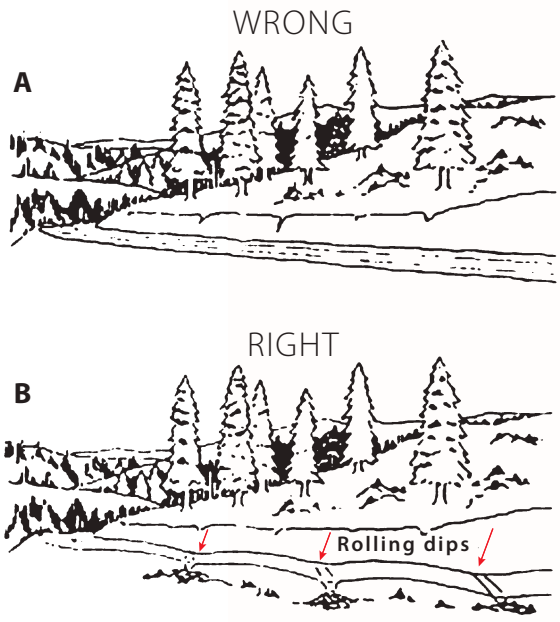

Figure 7. A: A road surface that is not properly drained will concentrate surface water runoff that will eventually erode the road bed. B: Out-sloping the road and installing rolling dips to drain runoff minimizes water concentration and erosion.
Source: Adapted from Weaver and Hagens 1994, p. 47.

DRAINAGE

It is impossible to overemphasize the importance of road surface and stream-crossing drainage in maintaining stable roads and protecting water quality. The goal is to make the road as hydrologically invisible as possible by making use of the natural drainage patterns when designing the system by which water will be removed from the road surface. In general, this means getting the water off the road as quickly as possible. Make sure you adequately plan for both road surface drainage and hillslope drainage. Proper drainage will mean less erosion and lower maintenance costs for you.

Road Surface Drainage

Road surface drainage includes water that originates from the road surface or the cut slope above the road surface. There are two main techniques for draining permanent or seasonal forest roads: they may be sloped towards the cut bank and drained by a ditch running at the base of the cut bank (in-sloped) or sloped towards the outside of the road (out-sloped) The ditches on in-sloped roads are drained under the road by cross-drain culverts, which are also called ditch relief culverts since they relieve the ditch of excessive flow. Out-sloped roads may simply drain

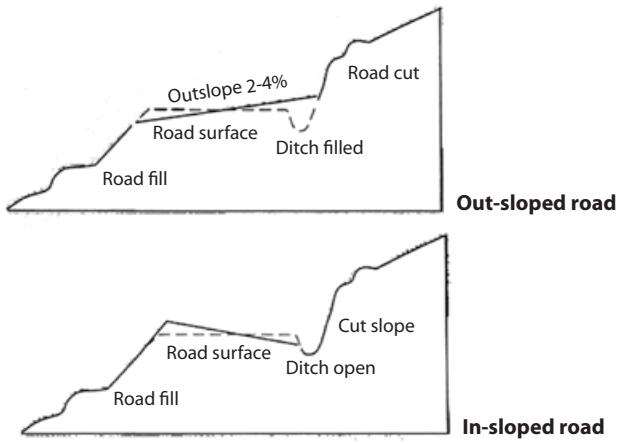

Figure 8. Out-sloped and in-sloped road cross-sections. *Source:* Adapted from Weaver and Hagens 1994, p. 47.

Figure 9. This ditch and road surface erosion was caused by inadequate spacing of ditch relief culverts. *Photo:* Susie Kocher.

water diffusely over the slope below the road, or they may be drained by depressions in the road called rolling dips (fig. 7).

Out-sloped roads have a gentle slope (2–3%) from the inside to the outside edge of the road (fig. 8). This provides for immediate drainage off the road surface. Under appropriate conditions, out-sloped roads are entirely adequate and are the preferred design for low-volume forest roads. They are not suitable on excessively steep or unstable terrain, in areas of high groundwater, or where the road is subject to black ice or otherwise treacherous driving conditions where out-sloping would move vehicles to the road's edge on turns.

Most major county roads and highways are in-sloped roads. In-sloped roads generally require a much higher level of maintenance than out-sloped roads. For example, the drainage ditches and cross-drain culverts must be kept clear of debris. Ditches are prone to erosion in some soil types. Cut bank sloughing and road surface erosion can block ditches during storms, causing ditch water to overflow, run down the road, and cause erosion. Gullies may be created at the outlets of cross-drains (culverts). In some cases, in-sloped or even crowned roads with ditches on either side are necessary, but whenever possible, a landowner is well-advised to use out-sloping for road surface drainage (fig. 9).

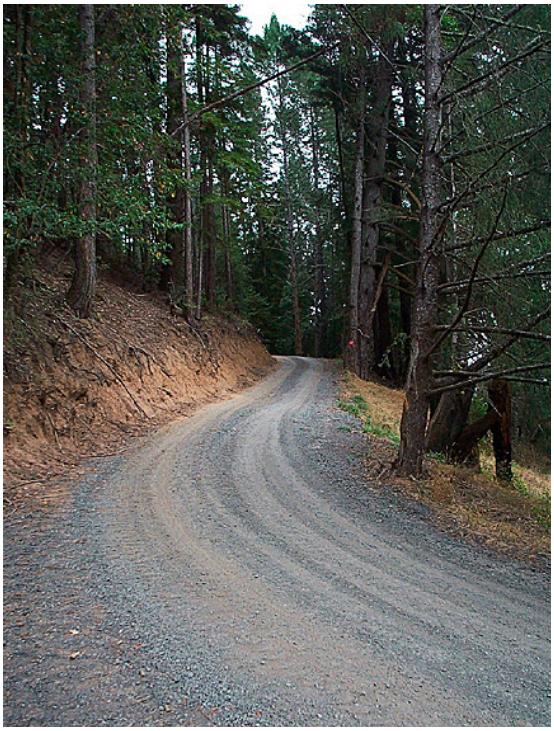

Figure 10. There is a gentle rolling dip in the middle of this picture of an out-sloped road. *Photo:* Richard Harris.

Out-sloped roads commonly use rolling dips to function as cross-drains (fig. 10). Rolling dips are essentially gentle, gradual depressions in the road grade. They get their name from the grade of the road rolling down and back up again, forming the dip. They can be used as a type of ford to drain small streams or springs across the road (fig. 11). In the case of road surface

Figure 11. This rolling dip has a gentle increase in grade going left to right and a reverse grade (where people are standing) to direct water off the road at the dip. *Photo:* Gary Nakamura.

Figure 12. Water bars and straw mulch have been installed on this seasonal road prior to the onset of the rainy season. Water bars drain road surface runoff to prevent erosion. They will be removed when the road is put back in use. *Photo:* © Angela Wilson; used with permission.

Table 1. Spacing recommendations for cross-drains and rolling dips on in-sloped and out-sloped roads

Road grade (%)	Spacing at soil erosion potential (ft)	
	Low	Moderate to high
0–3	400	250
4–6	300	160
7–9	250	130
10–12	200	115
12+	160	100

Source: Keller and Sherar 2003, p. 55.

runoff, the water running down the road is caught in the dip and drained to the side. Rolling dips should be drivable by ordinary vehicles with low clearance.

Temporary and seasonal roads are commonly drained with water bars (fig. 12). These erosion control measures are also used on skid trails after completion of timber harvesting to prevent erosion. Water bars are a combination of a dip and a hump of soil, acting much like a speed bump with a ditch just before or after it. They are erosion control measures, not intended for use on permanent roads or during wet weather.

The spacing of cross-drains and rolling dips is determined by the potential for soil erosion and the slope of the road (table 1). Either must be adequately sized to accommodate runoff from the road surface and other sources, such as intercepted groundwater or springs.

Water bar spacing on temporary roads and skid trails is prescribed in the state Forest Practice Rules when associated with a timber harvest. For other temporary roads or trails, spacing is determined by the potential for soil erosion and the slope (table 2).

Hillslope Drainage

Hillslope drainage includes water from streams, gullies, or springs that cross the road. The three basic ways to carry water across roads are bridges, fords, and culverts. A number of factors influence the type of structure you choose for a particular crossing. These include the size and flow regime of the source, the presence of fish, whether the crossing is permanent, the types of vehicles using the road, frequency of use, slope and stability of the channel, the cost of installation and maintenance, and legal requirements.

Table 2. Spacing recommendations for water bars on temporary roads and trails

Grade (%)	Spacing at soil erosion potential (ft)	
	Low	Moderate to high
0–5	250	130
6–10	200	100
11–15	150	65
16–20	115	50
21–30	100	40
30+	50	30

Source: Keller and Sherar 2003, p. 55.

Figure 13. Wet ford stream crossing. These are sometimes called "Arizona crossings." *Photo:* Richard Harris.

Bridges are a more expensive type of stream crossing than culverts or fords, though some portable bridges may be competitive in price with large culverts. Bridges are the best choice for large watercourses. Stream channels that are deeply incised with steep side slopes may require extensive preparatory work before a bridge can be installed. It is critical to adequately engineer bridges used for any vehicular traffic. Bridges may be temporary or permanent. Railroad flatcars are commonly used as bridge decks in both permanent and temporary road situations, as they can easily be hauled on lowboy trailers and moved from site to site.

Fords may be wet or dry. Wet fords cross running streams; they work well on small or medium-sized streams if the stream bottom is stable (rocks or coarse gravel) and traffic is light (fig. 13). Heavy traffic tends to disturb and pulverize the stream bottom, causing turbidity and sedimentation. Dry fords are less problematic but should still have a stable stream bottom. If construction work is required to establish the ford (for example, paving with concrete), wait until water is not flowing to do such work (fig. 14). Fords, particularly unimproved ones, are vulnerable to erosion. Fords should be armored with rock or a layer of coarse gravel. Do not construct unimproved fords in which the stream channel is filled with a substantial amount of soil and left without a protective layer of rock or surfacing.

Figure 14. Concrete ford on bedrock outcrop in perennial stream. *Photo:* © Angela Wilson; used with permission.

Culverts are corrugated metal or plastic pipes used at stream crossings. They must be properly sized (in diameter), based on the expected life of the culvert, local topography, local rainfall intensity, and other factors. Culvert sizing should be done by a qualified professional such as a registered professional

Figure 15. This box culvert will not permit fish passage because it is too high above the stream (excessive jump height for migrating fish) and the outlet velocity is too high (exceeds swimming ability of migrating fish). Any new culvert on a stream that supports fish must allow passage; many deficient culverts are being replaced. *Photo:* Richard Harris.

Figure 16. Rock has been installed at the outlet of this newly installed cross drain to prevent slope erosion or gullying. *Photo:* Richard Harris.

forester or engineer. In general, all culverts should be sized to pass the anticipated 100-year storm runoff plus associated debris and sediment.

Culverts must be installed at the correct angle (which affects culvert length and therefore cost), allowing for fish passage if fish are present (fig. 15). Debris control structures (trash racks) at culvert inlets and energy dissipaters (such as rocks) at culvert outlets are two key components of good culvert design (fig. 16). Plastic may be easier to work with and cheaper initially but it can burn in a fire, collapsing the road fill above it and requiring expensive reinstallation.

Install failsafe culverts. All culverts fail eventually, so you should install the culvert so that when it does fail, it does not divert the stream channel and cause erosion on the road surface or the road fill. This usually involves creating a critical dip at the crossing. A critical dip is a high point on each approach that is sufficient to contain the stream flow if the culvert plugs or fails and to keep the stream in the natural channel rather than flowing down the road (fig. 17).

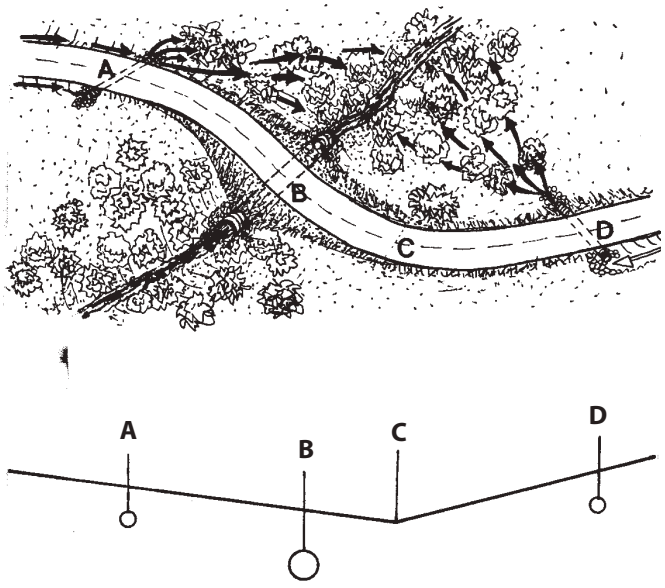

Figure 17. The proper installation of culverts and a critical dip at a stream crossing. If culvert B plugs, the stream will overflow road at low point C, washing out the road there but flowing back into the natural stream course rather than down the road to point D and beyond. *Source:* Weaver and Hagens 1994, p. 62; used with permission.

CONSTRUCTION AND RECONSTRUCTION

General Principles

Whether laying out a new road or working on an existing one, keep these general principles in mind. Minimize

- the total number of roads in your watershed; build only what is necessary to achieve your goals
- new road construction by using existing roads
- watercourse crossings
- cuts, fills, and the clearing of vegetation
- road work near watercourses, unstable areas, and steep slopes
- road width
- road gradient
- concentration of runoff on and from roads

Avoid earthmoving activities in the winter; do this work in the summer when stream flows are at their lowest level.

Washed-out Stream Crossings

Washed-out stream crossings are one of the most common problems of older roads. A crossing structure, usually a culvert, is washed out when its capacity to pass stream flow is exceeded during a peak runoff event and the flow erodes the fill and road surface (fig. 18). The structure may be completely uprooted and transported downstream or tossed to the side of the road. As mentioned above, all culverts may eventually fail, but preventative measures can be taken to minimize the risk of road and stream damage. Those measures include adequately sizing the culvert and maintaining culverts free of blockages by debris and sediment (fig. 19).

MAINTENANCE

Inspection and Maintenance Schedules

Roads and their drainage structures should be inspected at least once each year before the rainy season begins. Some structures are more likely to have problems than others.

Figure 18. This culvert plugged with debris during a storm. Although it is still in place, the swirling water and debris caused extensive erosion of the road and the adjacent old log landing. This type of failure is common on older "legacy" roads where crossings were not adequately designed to pass 100-year flows plus debris and sediment. In many cases, the culvert will be displaced and transported downstream.
Photo: Richard Harris.

Figure 19. This reconstructed stream crossing on an all-season road used for hauling timber illustrates many desired design features. The culvert is sized to accommodate 100-year storm flows plus debris and sediment. It is located at the base of the road fill at the elevation of the channel to prevent scour. The face of the crossing fill is armored with rock. The road has a critical dip to prevent diversion and is surfaced with gravel.
Photo: Richard Harris.

While you should inspect all your drainage structures, it helps to know where you will need to make an extra effort or where upgrades will be most effective. Consider keeping a journal to record your road maintenance activities. This can help you identify chronic problems.

What To Do—And What Not To Do

Road Use

The first rule of maintaining a stable road surface is to minimize use during wet weather. For permanent roads, this means avoid wet weather grading and use by heavy vehicles such as log trucks. On seasonal roads, any intense vehicular activity should be limited to dry periods. Seasonal, unsurfaced roads can be badly damaged by even occasional use during wet periods when the roadbed is soft. These road surfaces can be damaged almost as easily by a pickup as by a log truck. If unauthorized winter use is likely, seasonal roads should be gated during wet weather.

If vehicular traffic on a seasonal road is intense in the dry period, employ dust control and watering to prevent air pollution and the development of a deep, unconsolidated road surface. Standing water or ruts on permanent or seasonal roads indicate that the road surface is deteriorating.

Grading

On any road, grade only when necessary and only when material is slightly damp. Excessive grading causes erosion and increases road surface rock wear. Grading when road surfaces are dry promotes erosion. On out-sloped roads, make sure the grading does not build up berms at the roadsides that block drainage.

Some counties require grading permits. Check with your county planning and public works departments to find out whether your county has a grading ordinance and the threshold of earth movement that requires a permit.

Inspections

Schedule regular inspections. They can literally save thousands of dollars and minimize environmental damage by catching problems when they are small. In addition to your annual prewinter inspection, check your roads and drainage structures during or just after heavy rainstorms to clear culverts and see how the water is actually draining.

Figure 20. This extreme case of culvert blockage at a stream crossing was caused by a large storm event. All culverts should be inspected before and after storms to ensure that they are clear. *Photo:* © Angela Wilson; used with permission.

What to look for

- Culverts: Problems with culverts must be corrected before complete failure occurs (fig. 20). Almost all culvert maintenance can be done by hand or with a shovel and a chainsaw. Inspect inlets and look down the pipe. Clear debris and sediment that can block the flow of water. Inspect outlets. Straighten culvert ends that have been bent. Note locations where there is erosion at the outlet. At the culvert outlet, you may want to install energy dissipaters, vegetation, or large rock that will not erode with the expected flow.
- Fords: Look for signs of erosion where additional rock may be needed. Wait until low-flow conditions to make the repairs.
- Bridges: Look for bridge abutments that need repair. Remove or float downstream any debris such as logs or branches that are lodged in the bridge structure. Haul soil or debris away from the bridge—do not dump it into the watercourse.
- Water bars: Make sure water bars are intact and working properly. Check to see that water caught by the water bar is able to freely drain off the side of the road.
- Rolling dips: Check the outside edge of the dip. If there is erosion at the lip of the dip, plan to armor the lip with rock or bags of cement. Make sure grading has not created an outboard berm.
- Inside ditches: Clear vegetation or rocks that can block the flow of water. Often this can be done with a shovel. Strictly limit grading of ditches, as unnecessary grading causes erosion, undermines banks, and exposes the bottom of the cut slope to erosion.
- Cut slopes and fill: Look for rilling, slumping, and cracks on the surface or edge of the road (fig. 21). It may be necessary to place a load of rock at the toe of a cut bank slump, install additional drainage structures, or remove unstable materials with an excavator.

Figure 21. Cracks appearing in the road surface, especially at the edges of fills, are a sure sign of an impending failure or landslide. The horsetail growing in these cracks indicates that the source of the problem is groundwater seeping through the road bed. *Photo:* Richard Harris.

WINTERIZE YOUR ROADS

All roads—permanent, seasonal, and temporary—should be inspected and prepared for the rainy period. Winterizing consists of maintenance and erosion control needed to drain the road surface, ensure free-flowing ditches and drains, and open all culverts to their maximum capacity. Follow the inspection guidelines above. Once your roads have been winterized, gate and close those not needed for winter access.

SPOIL DISPOSAL

Spoil is soil and organic debris that is not used or needed as part of a road or landing. Spoil material is generated during road construction, reconstruction, and maintenance. Some spoil material can be spread out over the road, but too much will cause muddy conditions after the rains begin. Spoil material should never be side-cast near streams. Haul it to a stable site away from streams, and if possible stabilize it with mulch and vegetation.

SOCIAL AND LEGAL ISSUES

Access and Easements

An easement grants a legal right for another person to use specific land for a specific purpose. There are several types of easements. An easement is a property right, and ideally it will be deeded, or recorded in the deed, for the property.

If your property is located on a private road that passes through the property of another, you should have an easement that guarantees you the right to use the road in order to access your property. Several people can hold easements for the same road. Typically, everyone who shares the road contributes to road maintenance costs, but such an agreement is not part of the easement itself.

Some easements may not be recorded in the property deed. The most common type of unrecorded easement is a prescriptive easement. In California, if someone openly uses your road to access their property for 5 years with or without your permission, they can often get a prescriptive easement that will give them permanent use of your road. Gating and posting the road can prevent such an easement and give you the opportunity to come to some other agreement about road use and maintenance.

Another type of unrecorded easement is an easement by necessity. This applies when one parcel is landlocked by another. Whether a landlocked parcel has an easement by necessity depends on the intentions of the parties involved. It is not automatic; if there is a dispute, consult a lawyer who specializes in easement law.

If a property owner does not have an easement but wishes to use the road of another landowner, an agreement can be made. Often such agreements are made when one landowner wants to haul forest products, such as logs, over the property of a neighbor. Typically an amount, such as $10 per thousand board feet of lumber to be hauled, is agreed upon between the parties involved.

Road Associations and Road Maintenance Agreements

In many areas, groups of landowners form road associations to pay for maintenance of a road they share. As a member, you usually pay either a yearly amount or a portion of the bill for repairs as they are made. Groups vary in size and scale of activity. Check with your neighbors or a realtor for information about your local road association.

You might enter into a written road maintenance agreement as part of a formal or informal road association. Make sure that the terms of noncompliance are clearly spelled out.

Protecting Yourself

You can protect against prescriptive easements and trespass in a number of ways.

- Post signs that read "Posted" or "No Trespassing."
- Post a sign or make a written agreement that grants permission for another to use the road in a limited, clearly defined way.
- Block entry to trespassers by putting up a locked gate, especially to restrict wet weather use.
- Visit your property to make sure signs are still up, gates are intact, and there are no obvious signs of trespass.
- Offer to rent the property to a trespasser.
- As a last resort, call the police, hire a lawyer, or both.

Streambed Alteration Agreements

A landowner is required to contact the California Department of Fish and Game before performing any activity that would result in the diversion or obstruction of natural stream flow or the physical modification of the bed or banks of a stream or lake. A Streambed Alteration Agreement, required under the Fish and Game Code (§ 1600 et seq.), is often referred to as a "1603 permit." This covers projects such as installing culverts, bridges, fords, or rip-rap, or skidding logs across temporary crossings.

FUNDING SOURCES FOR ROADWORK

While most roadwork must be paid for by the landowner or road association, cost-share programs can help with these costs. These programs will pay a portion of the costs, if the work is done in accordance with the goals of the program. For roadwork to qualify for most cost-share programs, you must demonstrate how the roadwork will reduce the amount of sediment that will be transported into watercourses.

Contact local offices of the California Department of Forestry and Fire Protection, California Department of Fish and Game, and the Natural Resources Conservation Service to find out about cost-share programs and application procedures. These agencies can also assist you with diagnosing and solving road management problems.

REFERENCES

Keller, G., and J. Sherar. 2003. Low-volume roads engineering: Best management practices field guide. USDA Forest Service Conservation Management Institute. See the US Department of Transportation National Transportation Library Web site, http://ntlsearch.bts.gov/tris/record/ntl/24650.html.

Weaver, W., and D. Hagens. 1994. Handbook for forest and ranch roads. Ukiah, CA: Mendocino Resource Conservation District.

ENGLISH–METRIC CONVERSIONS

English	Conversion factor for English to Metric	Conversion factor for Metric to English	Metric
inch (in)	2.54	0.394	centimeter (cm)
foot (ft)	0.3048	3.28	meter (m)
yard (yd)	0.914	1.09	meter (m)
mile (mi)	1.61	0.62	kilometer (km)

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FOREST STEWARDSHIP SERIES 18

Stewardship Objectives and Planning

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FOREST STEWARDSHIP GOALS AND OBJECTIVES

The first step in managing your forest effectively is to define your goals, that is, your vision for your property. Your goals will be determined by you and your family. If others are involved in your land decisions, such as your heirs, extended family, or other partners, involve them in this planning process, too.

Goals are general statements. The number of goals you formulate should correspond with what you feel is necessary to communicate your vision. For example, one of your goals may be to reduce the fire hazard of your property, another might be to increase wildlife species diversity, and a third might be to generate income by enhancing the recreational values of your land. Whatever the goals, they should be based on your personal values and needs. They should also be realistic and within the potential of your property. Consequently, part of the stewardship planning process includes learning about your property.

1. Start with identifying your goals. Write them down to help you define, remember, and communicate them to others.
2. Prioritize your goals. This will help you figure out where to start and where to put your money and effort. You may find that some goals conflict with others. In that case, you will need to find creative solutions or compromises to reconcile them.
3. While goals are the general vision, objectives are the concrete steps you take to reach your goals. For example, if your goal is to increase habitat for deer, an objective may be to thin or burn some areas of your land to promote early-successional brushy vegetation. Be specific and include costs and a timeline when identifying objectives. Statements of objectives should identify specific quantities and times, such as "restore 12 acres of riparian vegetation by fall 2010." Specific statements will help you track your progress.

While the vision for your property is entirely up to you, advice from experts can be very helpful in determining what is possible and deciding how to best achieve that vision. You may want to consult with a forester, wildlife biologist, soil scientist, or other professionals to discuss your goals, applicable regulations, and various way to achieve your goals. Professionals can also provide an idea of costs for activities and may be able to help you find cost-share funding to accomplish them. Be sure to choose professionals who will listen to you and address your goals.

Objective

Understand the value of stewardship planning and how to prepare your own plan.

Competencies

- *Develop a management plan for communicating your goals and objectives to your family, agencies, and resource management professionals.*
- *Begin a long-term record of your management actions.*
- *Set priorities for action and understand the steps necessary to accomplish your goals.*
- *Update plans as conditions change.*

Related Forest Stewardship Series Publications

- *Laws and Regulations Affecting Forests, Part I: Timber Harvesting, ANR Publication 8249*
- *Laws and Regulations Affecting Forests, Part II: Activities Other Than Timber Harvesting, ANR Publication 8250*
- *Economic Considerations in Forest Stewardship, ANR Publication 8251*
- *Forest Taxation, Estate Planning, and Conservation Easements, ANR Publication 8252*
- *Professional Assistance, ANR Publication 8254*
- *Technical and Financial Assistance, ANR Publication 8253*

UC PEER REVIEWED

THE BIG PICTURE: LANDSCAPE-LEVEL PLANNING

After you have defined your goals and objectives, step back and consider the bigger picture. How do your goals fit together at the landscape level? Suppose you have two goals, one to reduce the risk of wildfire and the other to increase habitat for wildlife. If you plan to thin the forest for fire safety, how will that affect your goal to provide vegetative corridors for wildlife? Landscape-level planning looks at the entire property and takes into account all your goals and objectives.

Taking that concept a step further, now look at how your landscape planning fits in with the rest of the watershed and the region. What are the important issues and priorities in your area? How do your goals fit in with those?

TYPES OF MANAGEMENT PLANS

Several types of plans can help guide your land management decisions. The simplest you may prepare yourself. For timber harvest plans or management plans required for participation in cost-share programs, you will need to rely on the assistance of a registered professional forester (RPF).

Stewardship or Management Plan

The purpose of a stewardship plan is to put down on paper the most important aspects of your property's physical features, as well as your management philosophy, objectives, and vision for the future. Even if the plan is only a few pages of text and maps, it can provide important guidance and continuity in the management of your property. Most state or federal assistance programs require a management plan.

Timber Harvest Plan (THP) or Nonindustrial Timber Management Plan (NTMP)

A THP or NTMP is required when a landowner engages in commercial timber harvesting. Both of these are state-approved environmental review documents that must be prepared by an RPF. These plans generally discuss the timber and watercourse components of the property and a range of other important issues. Your broader vision, goals, and objectives are best written down elsewhere.

THE STEWARDSHIP PLAN

Stewardship planning takes into account the various resources present on the property (e.g., timber, fisheries, wildlife, botanical resources, watershed values, etc.), and the needs of present and future generations. A commitment to good stewardship is a commitment to manage the forest thoughtfully.

Why Create a Stewardship Plan?

Your stewardship plan is the blueprint that guides the management of your property. Analogous to a business plan for your forest, it helps you define where you are, where you want to go, and how best to get there. It is a creative document—a chance to combine your dreams with the practical framework needed to achieve them. The stewardship plan can guide you in making decisions and taking the actions that will fulfill your personal goals.

You can use your stewardship plan as the basis for applying for funding and preparing timber harvest plans. Although each of these requires its own set of information presented in a particular way, much of the information will be available at your fingertips from your stewardship plan. A stewardship plan can also be of assistance to any professionals you consult to help with bank loans, timber management planning, and the like.

A stewardship plan can be as simple or as complex as you wish to make it, depending on how you expect to use the plan and how much detail you feel is neces-

sary. Larger, more complex forests may require more work. No matter what level of detail you choose, none of the effort will be wasted. The knowledge you gain about your property will help in your day-to-day decision making. Articulating your goals will help guide your short-term activities to efficiently and cost-effectively achieve your long-term goals. It is also a wonderful way to communicate your vision to the next generation of managers of your property.

Nothing in a stewardship plan is set in stone; this is simply your own personal guide to your goals. As conditions change—in your life, in your goals, on your property, in the economy—you may want to adjust the plan accordingly. It is a good idea to revisit the stewardship plan on a regular basis, perhaps once a year, to keep the plan current and your management activities on track.

How to Organize Your Plan

Write your stewardship plan down: the process of putting the information on paper will help you clarify your thoughts. In addition, a written plan is the best way to share your ideas with your family, forester, banker, or others. Remember, however, that you are developing this plan for your own needs, so write only what you feel is necessary. Since forest stewardship plans are developed for a variety of reasons, there are a number of ways to write them. The comprehensive outline that follows contains many sections and topics. You may choose to include all of them or only those that address your personal goals and objectives. A forest stewardship plan is not a timber harvest plan. A timber harvest plan has specific regulatory requirements, must be written by an RPF, and is beyond the scope of what is presented here. If you have writer's block or a hard time putting words on paper, a well-organized list may be all you need to help you in your management planning. Ideas are more important than complex sentences and paragraphs. In the sections that follow, we offer a structure, specific subjects to consider, and sample language to stimulate your thinking process and serve as a template, as needed.

Sample Plan Outline

Cover page

- Date of plan.
- Landowner name, address, phone, fax, and e-mail.
- Tract name or number.
- Total tract acreage.
- Total forested acreage.
- Legal description from your deed.
- Latitude and longitude.
- Land use classification (zoning).
- Watershed.
- Fire protection district.
- Seed zone (California zone that describes compatible latitude and elevation for tree seed that is most suitable for your property–see *Forest Stewardship Series 7: Forest Regeneration*, ANR Publication 8237).

Introduction

- Explain the plan's purpose and how it relates to the landowner's values.
- Describe property and give a brief history of the land.

Description

- Landowner information.
- Legal description.
- Assessor's parcel number(s).
- Boundary map.
- Property corners.
- Adjacent property owners.
- Tax status.
- Maps of the property showing vegetation cover types, soil types, topography, access with roads and culverts, water features, and other resource sites. Aerial photos can be included.

Goals and Objectives

- Describe what you want to achieve on the property. Include goals, which are broad statements, and objectives, which are specific and measurable (see table 1 for ideas on possible goals and objectives). Repeat the following outline for all goals and their related objectives:

  Goal #1:

  Objective #1: Timeline for action and estimated costs

  Objective #2: Timeline for action and estimated costs

  Objective #3: Timeline for action and estimated costs

  Example:

  Goal: Increase water availability and storage in the northwestern side of the property for fire protection and other uses.

  Objective #1: By next year, develop a spring site and water storage capabilities. Estimated cost: $2,000 for 1,000-gallon storage tank, hose, fittings and spring box.

Vegetation

- Describe existing meadows and forest types, including riparian areas. Include a map of forest types. Give the following details for each type: acreage, species mix, density, site index, size class, age, elevation, slope, and aspect. Gather forest inventory data in as much detail as needed to make your decisions.
- List significant historical events for each stand: date of origin, planted or natural, past timber or product sales, timber stand improvements, reforestation, vegetation management, and loss events such as fire, insects, and diseases.
- Compile a list of management opportunities for each vegetation type.

Wildlife Habitat

- Species inventory, sensitive species, habitat components, special protection measures needed, and improvement activities needed. Record the presence and abundance of snags and downed woody debris. Describe recruitment and retention goals to enhance, maintain, or restore habitat.

Threatened and Endangered Species

- Identify any officially listed or potentially threatened and endangered plant or animal species that could be present on the property. This will likely require consultation with a wildlife biologist and a botanist. List activities to maintain or improve species habitat.

Soils

- Identify major soil types and their associated vegetation types, topographic and geological features, and characteristics such as site index and slope stability. Identify permanent skid trails to reduce soil compaction associated with timber harvest. Identify erosion, drainage, and other soil problems. Find the causes of problems and identify how they will be addressed.

Table 1. Example goals and objectives for forest property

Goal	Objective	Potential resources
Long-term Planning Goals		
Increasing certainty and sustainability (the long-term conservation and stewardship) for your forest	Discuss and write down family goals for ownership. Develop a management (stewardship) plan. Develop long-term relationships with a forester and other specialists. Develop an estate plan: contact a tax accountant and lawyer. Explore the benefits of a conservation easement: contact a tax accountant and lawyer. Identify cost-share funding possibilities. Develop an NTMP or other state-approved harvest permit. Explore incentive programs such as certification or carbon banking for your land.	Local land trusts *Preserving Family Lands in California,* http://www.californiaoaks.org/html/conservation.html *Estate Planning for Forest Landowners* (Haney and Siegel 1993) *Preserving Family Lands II,* http://www.stevesmall.com Timber Tax Web site, http://www.timbertax.org Cost Share Directory, http://ceres.ca.gov/foreststeward/html/financial.html Forest Stewardship Council, Tree Farm, Sustainable Forestry Initiative
Safety Goals		
Reducing fuel hazards throughout property and adjacent to structures	Get involved with the local fire safe community group. Learn how CAL FIRE and other local firefighters are likely to respond to a fire on your property. Develop an understanding of likely ignition points and wind patterns. Develop a fire response that includes • fuel breaks • property access and evacuation routes • water storage • fire-safing your home • thinning of understory; prescribed burns • creating defensible space adjacent to your home, other buildings, and other places of value	Fire Safe Council, http://www.firesafecouncil.org "Fire Safe Landscaping," CAL FIRE Tree Notes no. 17, http://www.ceres.ca.gov/foreststeward/pdf/treenote17.pdf *Home Landscaping for Fire,* UC ANR Publication 8228, http://anrcatalog.ucdavis.edu/pdf/8228.pdf
Conservation Goals		
Water quality protection, restoration, and/or enhancement	Inventory riparian areas for amount and species composition of the riparian canopy. Inventory quality and location of large woody debris. Inventory road conditions and interactions with streams. Monitor stream temperatures. Plant more trees where deficient. Develop a road management plan to • stormproof roads • remove any unneeded crossings and upgrade necessary ones • move roads if necessary • stabilize any human-caused erosion sources • remove or repair culverts that block fish passage, are undersized, or are falling apart • determine if you are in a TMDL-impaired watershed	*California Salmonid Stream Habitat Restoration* Manual www.dfg.ca.gov/nafwb/manual.html *Plant It Right,* http://wawater.wsu.edu *Handbook for Forest and Ranch Roads,* Mendocino County RCD, http://www.krisweb.com/biblio/gen_mcrcd_weaveretal_1994_handbook.pdf *Landowners Guide to Building Forest Access Roads,* http://www.na.fs.fed.us/spfo/pubs/stewardship/accessroads/accessroads.htm *Nursery Sources for California Native Plants,* California Geological Survey publ. OFR-90-04, http://www.consrv.ca.gov/CGS/information/publications/pub_index/issue_papers.htm *Forest Ecosystem Stewardship,* Oregon State University College of Forestry, $7, 541-737-4271
Soil protection, restoration, and/or enhancement; improving soil fertility	Develop recruitment and retention policy for snags and coarse woody debris inputs into soils over time. Prevent and minimize soil compaction in timber activities or other construction projects; designate permanent skid trails; designate least-impacting yarding equipment. Stabilize and revegetate erosive areas.	*Sediment Delivery Inventory and Monitoring,* UC ANR Publication 8014, http://anrcatalog.ucdavis.edu/pdf/8014.pdf
Wildlife protection, restoration, and/or enhancement.	Inventory wildlife species on your property; determine what was historically found there; determine which wildlife species you are managing for and those species' habitat requirements (e.g., enhance, maintain, and retain ecotones, oak trees, snags, downed wood, mosaics, etc.). Enhance structural complexity through thinnings. Encourage tree and shrub species diversity. Inventory condition of riparian migration corridors and connectivity between habitats. Plant conifers in riparian areas if deficient.	*Habitat Sweet Habitat,* Forestland Steward 10, http://www.ceres.ca.gov/foreststeward/pdf/newslettr10.pdf *Forest Ecosystem Stewardship,* Oregon State University College of Forestry, $7, 541-737-4271 *Riparian Forest Wildlife,* Montana State University Extension, $5, 406-994-3273

Goal	Objective	Potential resources
Protecting ecosystems from non-native species	Inventory and map exotic pest plants. Develop a Weed Management Plan. Take steps to control exotic weeds using integrated pest management strategies.	*Create an Integrated Weed Management Plan,* http://parks.state.co.us/cnap/IWM_handbook/IWM_index.htm Nature Conservancy, http://tncweeds.ucdavis.edu CalEPPC, http://www.caleppc.org California Native Plant Society, http://www.cnps.org/programs/conservation/exotics.htm
Protecting against pests and diseases	Inventory property for insects and diseases. Make plans to take remedial actions if needed.	CAL FIRE Tree Notes, http://ceres.ca.gov/foreststeward/html/treenotes.html
Protecting historical and pre-historical values	Inventory and protect prehistoric and historic resources older than 50 years.	CAL FIRE Archaeology, http://www.fire.ca.gov/ or http://www.indiana.edu/~e472/cdf/
Economic Goals		
Timber harvesting Increasing inventory and stand productivity Improving stand structure and the quality of future crop trees Enhancing the quality of hardwoods	If you do not have a forester, select one. Develop a harvest schedule to realize economic and ecological goals now and for future generations. • Explore timber stand improvement opportunities (precommercial thinning, pruning, commercial thinning, etc). • Determine if there are tree planting needs (understocked areas, planting to increase diversity, etc). Inventory property for species of interest that can be sustainably harvested. Explore certification options.	CAL FIRE for info on regulations, yield taxes, assistance programs, etc.; http://www.fire.ca.gov *Managing Your Redwood Forest,* IHRMP, http://danr.ucop.edu/ihrmp/allpubs.html
Firewood production	Develop markets for firewood.	*Guidelines for Managing California's Hardwood Rangelands,* IHRMP http://danr.ucop.edu/ihrmp/allpubs.html
Special products production	Determine which products there are markets for (greenery, mushrooms, etc.). Develop a marketing plan.	Contact state nurseries, at http://www.fire.ca.gov/php/rsrc-mgt_statenurseries.php
Other opportunities (e.g. develop recreational, hunting, photography, other potential uses)	Identify potential markets. Enhance potential features (create hiking trails, mountain bike trails, etc.), that follow guidelines for roads and protect water quality.	
Quality of Life Goals		
Aesthetics	Determine what is aesthetically pleasing to you. Potentially thin fuels in highly visible areas. Utilize thinnings to promote structural development and complexity so as to take on older forest characteristics. Establish retention goals in highly visible areas. Limb branches along hiking trails. Remove invading conifers in oak woodlands.	*Working Your Woods,* Institute for Sustainable Forestry, http://newforestry.org/publications/main
Protect or enhance special or spiritual places.	Identify and maintain places with significance to you. Develop a picnic area in your favorite place.	
Recreation	Enhance recreation potential (develop hiking or biking trails, hunting blinds, etc.).	
Landscape-scale Goals		
Integrate goals at the property, watershed, regional and community levels	Talk to neighbors, local watershed groups, or agencies to find out about local priorities and concerns. Determine if there are existing watershed recovery plans (e.g. TMDLs) or nearby habitat conservation plans (HCPs) and evaluate actions. Lay out your goals on maps or spatially within a geographic information system (GIS).	

Note: This table provides examples of timber and non-timber goals, objectives, and available resources to help stimulate ideas that may or may not be appropriate for your property. This list is certainly not complete, but it can be used as a starting point. Defining your ownership goals is perhaps the hardest part of owning forested land.

Roads

- Include a map of your road system. Identify road easements or existing encroachment permits, if needed to access county roads. Assess roads for problems and usage. Make recommendations for improving, developing, maintaining, and retiring roads to ensure good water quality and fish habitat. Take into account road locations; surface and road stability; stream crossings and potential for sediment delivery to streams; and culvert size, condition, and ability for passage of fish, if present. Identify water quality and soil productivity impacts associated with your roads and how these will be addressed.
- Identify whether each road provides seasonal or permanent access and whether you provide the essential maintenance. Identify road needs such as relocation, rebuilding, and resurfacing, and maintenance needs such as water bars, rolling dips, culvert cleaning, and ditching. Identify expected future road needs.

Water Resources

- Identify the boundaries of the main watershed(s) that contain your property. List the named streams (even if not present on your property) that drain the property and the next larger stream for each. Identify and map streams and springs. Identify water rights for both the property and registered domestic downstream water use. Identify easements for water rights. Assess and evaluate ponds for leakage and possible dike failure. Identify ponds and other locations for drafting water for fire protection.
- Identify riparian areas and wetlands and describe their vegetation, conditions, and opportunities for management or restoration. Consider opportunities for coordinated management with neighbors.

Forest Health

- Identify insect, disease, and animal damage, as well as wildfire issues and associated management strategies to resolve problems. Note on forest maps pest management concerns, fuel levels, and stands vulnerable to wind damage.

Fire Plan

- Determine what fire protection district the property is in and whether there is a local fire safe council. Provide a fire management plan that includes road accessibility, road width and turnaround locations, fuel breaks and other safe locations for firefighters, and evacuation routes. The fire plan should indicate locations for water drafting, volume of water supply, and compatibility with firefighter equipment (i.e., type and diameter of fittings of existing water storage tanks and hoses), fuel reduction plans, tree thinning, tree pruning, and creation of defensible space around structures. Note and map fuel levels in the forest.

Vegetation Management

- Describe your plans, if any, for timber harvest, including silvicultural treatments and systems and logging conditions.
- Describe local markets to buy your potential products and transportation to them.
- Discuss required permits, rotation and cutting cycle, allowable cut, cutting budget, and order.
- Describe the steps you will take to improve forest health, such as pest protection measures, stand improvement, and reforestation.
- Would forest certification or involvement in a carbon banking system be a benefit to you?

Agroforestry and Range

- Identify any resources, opportunities, and projected costs and revenues for a potential business plan.

Special Forest Products

- Note possible special forest products (greenery, mushrooms, carbon storage, hunting leases, etc.) available on your property and determine what markets exist. Develop a business and marketing plan.

Archaeological and Cultural Resources

- You are the steward of the past. Preserve family, community, and local history. Identify cabins, buildings, and prehistoric sites, and sites more than 50 years old. List measures needed to protect known resources. Contact the California Office of Historic Preservation (OHP) for more information and the California Department of Forestry and Fire Protection (CAL FIRE) for information on requirements to protect resources such as Native American sites, trails, cemeteries, homesteads, and other significant sites.

Recreation

- Identify recreational resources and describe opportunities. Identify trails on maps and assess their condition. Fire safety must be addressed in recreation planning. Include anticipated costs and revenues.

Aesthetic and Scenic

- Describe opportunities to meet your aesthetic and scenic objectives. Note scenic highways, parks, or rivers abutting the property. Identify management opportunities to improve aesthetics.

Forest Practice Rules

- All management recommendations must follow the regulatory rules. Identify what rules apply to your management plans, what permits are required, and the lead agency to contact.

Assistance

- Identify assistance needed to accomplish objectives and possible sources of financial, technical, and educational assistance. List contacts.
- Identify your RPF, certified public accountant, lawyer, and other professionals.

Taxes and Business Management

- Discuss your tax situation, including record keeping, current tax status, federal and state income tax, and land use classification. Have you made an estate plan? Is a conservation easement appropriate?

Summary of Resource Situation

- Describe resource situations and management opportunities for each management unit. These may include short- and long-term recommendations. Where applicable, address financial aspects, tax implications, estate planning, and assistance needed. Show timing and priority of management recommendations.

Measuring success in meeting your objectives

- How will you evaluate your efforts to meet your goals and objectives? Do you have a program for monitoring and adaptive management?

Appendices

- Maps, lists, pictures (including permanent photo points), etc.

Conclusions

Any type of management plan will be of great benefit to you now and into the future. Whether you are trying to acquire a bank loan, assistance program, state-approved harvesting permit, or estate plan, each begins with an understanding of your vision and

goals. Furthermore, this document becomes to basis to communicate to future generations.

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FOREST STEWARDSHIP SERIES 19

Laws and Regulations Affecting Forests, Part I: Timber Harvesting

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The many laws and regulations that affect private forestland management in California are designed to protect public trust resources such as soils, water, and wildlife while permitting uses of private property. They also stipulate certain practices to assure long-term forest productivity. Private forestland ownership and the practice of forestry on private lands have been significantly influenced by state and federal laws, regulations, and court decisions.

This publication reviews important state and federal laws pertinent to forest management. It describes situations in which permits may or may not be required and summarizes the permit issuance process for commercial timber harvesting. The presentation of this complex topic is brief; the reader is advised to consult with regulatory agencies and a registered professional forester (RPF) about specific issues and applications of the laws. For other non timber activities, such as homesite development, water development, and so on, see Forest Stewardship Series 20: Laws and Regulations Affecting Forests, Part II.

Objective

Understand and identify permits or other authorizations required for forest management activities involving timber harvesting.

Competencies

- *Familiarity with laws and regulations affecting forest uses.*
- *Familiarity with timber harvest planning under state regulations.*
- *Understand the responsibilities of landowners and their agents in complying with laws and regulations.*

Related Forest Stewardship Series Publications

- *Professional Assistance, ANR Publication 8254*
- *Stewardship Objectives and Planning, ANR Publication 8248*

PUBLIC TRUST RESOURCES

Although land may be in private ownership, it is still subject to legal protections of "public trust" resources. These resources are protected for the benefit of the public, that is, the people of California and the United States. The resources include but are not limited to air and water quality, wildlife, and certain environmental resources such as tidelands and wetlands. The many laws that apply to natural resource management on private lands are designed to ensure that these public trust resources are not degraded. As a result of these laws, certain management activities are either prohibited or restricted under specific circumstances. Protection of public trust resources, for example, is the principle underlying the Forest Practice Act and the regulations of the State and Regional Water Quality Control Boards that aim to protect water quality and the beneficial uses of water while allowing timber harvesting.

CALIFORNIA STATE LAWS

The state laws that apply to forest management, and more specifically, timber harvesting, are founded on two principles: ensuring the long-term productivity of forest lands and preventing adverse environmental impacts.

UC PEER REVIEWED

Z'berg-Nejedly Forest Practice Act (FPA)

The 1973 California Forest Practice Act is designed to protect, enhance, and restore California's timberlands. It is recognized as the most comprehensive forest regulation statute in the United States. The purpose of this law is "to achieve maximum sustained production of high-quality timber products while giving consideration to values relating to recreation, watershed, wildlife, range and forage, fisheries, regional economic vitality, employment and aesthetic enjoyment" (Public Resources Code § 4513b). The regulations authorized by this law define the size and location of harvest areas, as well as matters such as protection of riparian corridors and archaeological sites, timing of harvest during wildlife nesting periods, locations of roads, and operations during certain seasons to protect wet soils.

California Forest Practice Rules (CFPR)

The FPA is implemented through a series of regulations called the California Forest Practice Rules (CFPR). These are lengthy in scope and detail and provide explicit instructions for permissible and prohibited actions that govern the conduct of timber operations in the field. For example, the FPRs define the contents of a timber harvesting plan (THP). A THP is the formal environmental review document that must be prepared by an RPF and approved by the California Department of Forestry and Fire Protection (CAL FIRE) prior to any commercial harvesting of timber in the state. The rules cover the following major categories:

- THP review, appeal, and enforcement processes.
- Silvicultural systems and regeneration methods.
- Harvesting practices and erosion control.
- Site preparation.
- Watercourse protection.
- Sensitive watershed designation.
- Functional wildlife habitat and late-successional forest protection.
- Hazard reduction.
- Fire protection.
- Forest insect and disease protection practices.
- Logging roads and landings.
- Cumulative effects analysis.
- Long-term sustained yield plans.
- Special rules for specified counties and other areas.

The CFPR vary by region of the state. California is divided into three districts (Northern, Southern, and Coast), whose exact boundaries can be found in the California Forest Practice Rules.

A copy of the complete CFPR can be purchased at your local CAL FIRE office or obtained from the CAL FIRE Web site, http://www.fire.ca.gov/.

California Endangered Species Act (CESA)

The California Endangered Species Act (CESA) is similar to the federal Endangered Species Act (ESA), which is discussed later in this publication. CESA complements the ESA by prohibiting unauthorized "take" (e.g. hunt, pursue, catch, capture or kill) of birds, mammals, fish, amphibians, reptiles, and plants that are listed by the state as threatened, endangered or as a candidate for listing. CESA's definition of "take" is narrower than what is specified in ESA: it does not include the term "harm" or "harass," but it is interpreted to apply to indirect causes of death of listed species, such as through habitat modification or degradation.

A species can be listed as either threatened or endangered. The factors that contribute to determining the need to list a species as threatened or endangered include

the present or threatened modification or destruction of habitat, competition, predation, disease, overexploitation by collectors, or other natural occurrences or human-related activities.

CAL FIRE is required to consult with the California Department of Fish and Game (DFG), the US Fish and Wildlife Service (FWS), or the National Marine Fisheries Service (NMFS) to ensure that any action it undertakes is not likely to jeopardize any candidate or listed species or result in destruction or adverse modification of essential habitat.

Because many threatened and endangered species are found primarily on private lands, landowners may be subject to regulation under state or federal laws. Permitting procedures exist and are usually implemented as part of other permitting activities, such as THP approval. A list of all state and federal threatened or endangered species is provided at the DFG Web site, http://www.dfg.ca.gov/whdab/TEAnimals.pdf.

Porter-Cologne Water Quality Control Act

The Porter-Cologne Act is the primary vehicle for implementation of California's responsibilities under the federal 1972 Clean Water Act. It grants the California Water Resources Control Board (SWRCB) and Regional Water Quality Control Boards (RWQCBs) broad power to protect water quality. These agencies have the authority and responsibility to adopt plans and policies, regulate discharges to surface water and groundwater, regulate waste disposal sites, and require cleanup of discharges of hazardous materials and other pollutants.

There are nine RWQCBs throughout the state; each has a water quality plan for their region. As discussed below, state and regional board staff are involved in the review and approval of THPs. They are also involved in permitting forest management activities such as herbicide applications, and they enforce certain provisions of erosion control in watersheds subject to total maximum daily load (TMDL) restrictions.

California Environmental Quality Act (CEQA)

The California Environmental Quality Act (CEQA) fosters interagency coordination to review all projects that have the potential for significant environmental effects (including timber harvesting) and to enhance public participation in the planning process. CEQA requires preparation of environmental documents including environmental impact reports (EIRs) to disclose significant effects of proposed activities and identify measures to avoid and reduce environmental damage.

CEQA applies to any project that is undertaken by a state agency or with the support of a state agency, or when an applicant obtains a lease, permit, license, or entitlement from a state agency. It has been determined that a THP is the functional equivalent of an EIR. Consequently, as with an EIR, a THP must discuss all feasible alternatives and disclose to the public why a certain alternative is chosen.

FEDERAL LAWS

Endangered Species Act

The Endangered Species Act (ESA) was enacted in 1973 to curtail the extinction of threatened and endangered fish, wildlife, and plants by providing landowners with programs to encourage the conservation of listed and threatened species and the habitats they use. This Act was based on Congress' recognition that native species "are of aesthetic, ecological, educational, historical, recreational, and scientific value to the Nation and its people" (Title 16 United States Code § 1531(a3).

The ESA defines threatened species as those that, "although not presently threatened with extinction, are likely to become endangered species in the foreseeable future

in the absence of special protections and management efforts" (Title 16 United States Code § 1532(6). Endangered species classification also considers whether extinction of a species is likely "throughout all, or a significant portion, of its range" (Title 16 United States Code § 1532(20).

The ESA affects private landowners when a project involves federal funding or permitting. Implementation of ESA provisions is in some cases bolstered by the application of the California ESA. For most landowners in California, the ESA comes into play when THPs are proposed in habitats identified as critical for listed species.

Several programs are available to landowners under the ESA that encourage protection of threatened and endangered species. These programs offer landowners information, support, and funding for the conservation of listed species and their habitats.

For more information, contact the DFG at http://www.dfg.ca.gov, the FWS at http://fws.gov/endangered, or, for threatened and endangered anadromous fishes, the NOAA, Fisheries at http://www.nmfs.noaa.gov.

Clean Water Act (CWA)

Overall, the CWA is intended to restore and maintain the chemical, physical, and biological integrity of the nation's waters. Water pollution is caused by point and nonpoint sources. Point sources are associated with a specific and identifiable activity such as the pipe outfall from a sewage treatment plant. Nonpoint sources are associated with general areas or activities such as agriculture, timber harvesting, road systems, and urban areas, and as such, are inherently more difficult to identify and control. The Clean Water Act amendment to the Water Pollution Control Act in 1972 was the first federal legislation to address nonpoint source water pollution in its now-famous Section 208.

Over half of the pollution in the nation's water bodies is caused by nonpoint sources. Nonpoint pollution comes from diffuse activities such as agriculture, forestry, mining, urban development, and construction. Examples of nonpoint pollutants include excess fertilizers, herbicides, and insecticides from agricultural lands and residential areas; and sediment from improperly managed construction sites, cropland, forestlands, and roads.

Nonpoint source pollutants can have harmful effects on drinking water supplies, recreation, fisheries, and wildlife. In California, the agencies responsible for implementing the CWA are the California Water Resources Control Board and Regional Water Quality Control Boards (see the section on the Porter-Cologne Water Quality Control Act, above).

Many California streams have been listed under Section 303(d) of the Clean Water Act as impaired by pollution, even after application of pollution controls. In some instances the impairment is from nonpoint sources and has resulted in excessive sediment, temperature, or a combination of both.

For those waters that are impaired, states must establish a TMDL of pollutant discharge to a watercourse to ensure attainment of water quality standards. It is important to determine if your property is in a TMDL watershed. If so, your management plans should take into account the sensitivity of the watershed to ensure that your actions will not cause further impairment. To determine if your property is located within a TMDL watershed, contact your local RWQCB or visit the SWRCB Web site at http://www.waterboards.ca.gov/tmdl.

REGULATION OF COMMERCIAL TIMBER HARVEST

Any harvesting of logs offered for sale, barter, exchange, or trade or harvesting done as part of the conversion of timberland to a nontimberland use requires a permit pursu-

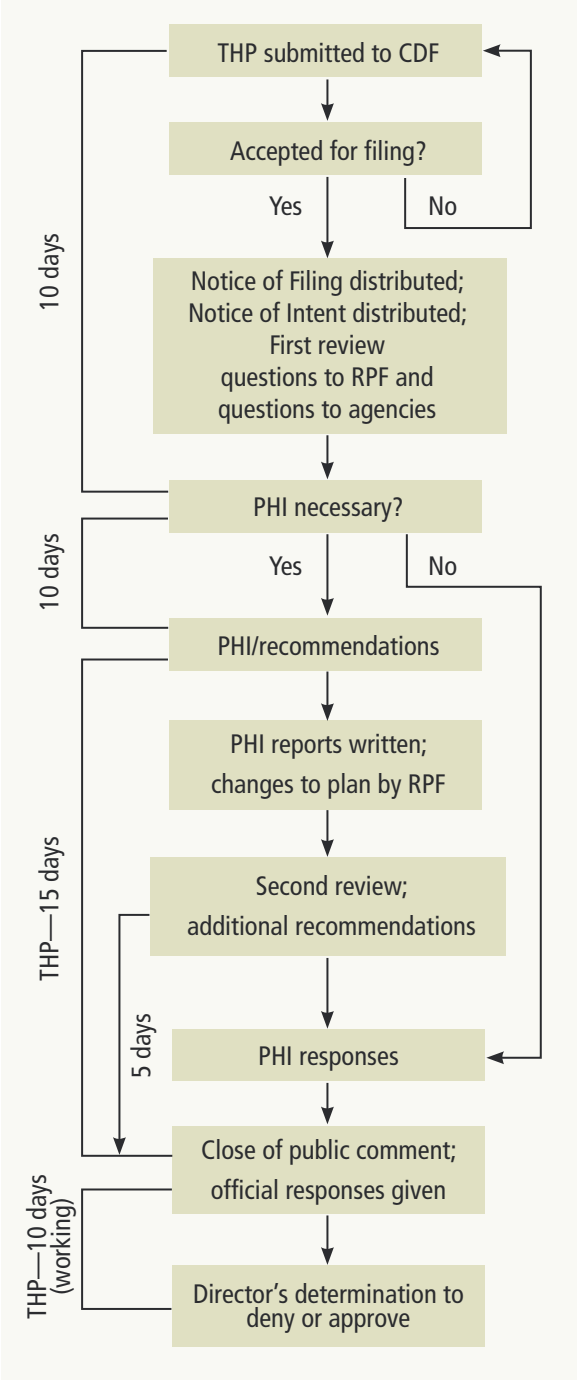

Figure 1. Flow diagram of a theoretical timber harvest permit review process from RPF submission of the THP to approval. *Source:* Courtesy CAL FIRE.

ant to the California Forest Practice Act. There are two main permits and some permit exemptions under special circumstances. A THP is required for a single commercial harvest. A nonindustrial timber management plan (NTMP) is a permit that applies to an entire property in perpetuity, subject to conditions incorporated into the permit. Rules and limitations apply to both permits. The permits are similar in that they both are functionally equivalent to an EIR under CEQA; each must conform to the FPRs in effect; and each must be prepared by a RPF licensed by the State of California.

Both the THP and NTMP describe existing conditions, proposed activities, impacts to environmental resources, and how those impacts will be minimized or mitigated. A great deal of emphasis is placed on adequate regeneration of growing stock (trees), protection of water resources (such as streams, ponds, and domestic water supplies), minimizing erosion, protecting archaeological resources, protecting wildlife, and ensuring that members of the public have an opportunity to comment on the proposed activities.

Either type of permit usually takes approximately 6 to 18 months to complete and process depending on the size and complexity of the proposed harvesting and the resources potentially affected. The cost for either is extremely variable, depending on the specifics of the situation such as the type of wildlife or botanical resources that may need to be surveyed for. The NTMP usually has higher initial costs but may realize some future cost savings once it is approved, since there is no need to prepare a separate THP for each successive commercial harvest.

A THP is valid for 3 years and can be extended for an additional 2, for a total life of 5 years. After that time, a new THP must be prepared to harvest timber on that property.

An NTMP is valid in perpetuity, requiring that CAL FIRE be notified before operations begin. The forester preparing the plan must conduct an inventory of the property and use that data to model the forest's future growth and ensure that harvest will not exceed growth over. Inventory reports must to be presented to CAL FIRE periodically. Thus, the NTMP is a type of sustained yield plan. An NTMP is available only to landowners who own less than 2,500 acres and limit management activities to certain practices.

The following discussion of the regulatory procedures applicable to commercial timber harvesting applies only to a THP. For further information on the NTMP process or on the FPR, see the CAL FIRE Web site at http://www.fire.ca.gov. For a flow chart that illustrates this process, see figure 1.

Timber Harvest Plan Review

After your THP is prepared, a notice of intent is posted at the public road nearest your plan area. This two-page notice must

be placed in a readily visible location and provide basic information about your plan, including a map. The notice is also submitted to CAL FIRE, the regulatory agency that enforces the FPR. CAL FIRE distributes the notice of intent to all neighbors within 300 feet of your plan boundaries. The notice is also sent to the local CAL FIRE ranger unit and to the county clerk, where it is made available for public review.

Filing and First Review

CAL FIRE reviews all THPs to ensure they are complete and in proper order. Plans that are accepted for filing receive a plan number. Plans not accepted are returned to the RPF, who will make the needed changes before resubmitting the plan.

After the plan is accepted for filing, a first review is held. This is an office review and is open to representatives from CAL FIRE, DFG, RWQCBs, the California Department of Mines and Geology, the California Department of Parks and Recreation, a state archaeologist, the county planning agency, and anyone else who has made a written request.

Agency representatives put together a list of questions and concerns, some for the RPF and some for agency personnel to answer. The RPF receives the list of first review questions and answers questions directed to them.

After the first review, a notice of filing is sent to the RPF, the plan submitter, public agencies with custodial responsibility for lands within 300 feet, the local CAL FIRE ranger unit, and the county clerk for posting in a public place.

From the time CAL FIRE receives your THP or NTMP, a total of 10 calendar days are allowed for filing, the first review, and a determination of whether or not a preharvest inspection is necessary. The public comment period opens during this 10-calendar-day period.

Pre-Harvest Inspection

In most cases, a preharvest inspection (PHI) is deemed necessary. Although CAL FIRE has 10 calendar days in which to schedule and conduct a PHI, most RPFs are asked to request an extension in order to accommodate the schedule of CAL FIRE and other agency inspectors.

PHIs typically take 1 or 2 field days to complete. The RPF meets staff from various agencies to discuss the specifics of the plan and together work out solutions to any issues that arise. The landowner may participate in this inspection process and can help in explaining the intent of the proposed actions and property history.

After the PHI, agency staff report their observations and recommendations. Sometimes a THP will have several PHI reports from different agencies. A copy of these reports and recommendations is sent to the RPF, who may agree to these recommendations or propose changes to them.

Second Review

Following the PHI, the review team agencies have 15 calendar days to draft their reports and conduct a second review of the plan. The second review is a second office review by agency personnel. The staff review the THP originally submitted, the PHI reports, the responses of agency personnel to first review agency questions, the responses of the RPF to the first review questions, and public comments received to date. The RPF may choose to attend the second review to be able to respond immediately to mitigation measures proposed by agencies for potential impacts.

The result of second review is a list of mitigation measures or other changes to the plan. These are sent to the RPF. If the RPF is in agreement with all the measures, the RPF signs each page and simply returns the signed pages to CAL FIRE. If the RPF is not in agreement, the RPF proposes changes to the measures. Any such changes typically further delay the plan approval process.

Public Comment

The public comment period begins when the plan is accepted for filing. Following the second review, public comment is accepted for 5 additional days. This may extend the total time from the end of the PHI to the close of public comment to more than 15 days.

Any member of the public may submit comments on the plan. At the end of the public comment period, CAL FIRE prepares official responses to written comments received. The comments and responses become part of the official file.

Director's Determination and Permit Approval

Following the close of public comment the director of CAL FIRE has 10 working days to determine whether the plan is in conformance with the FPR. If the plan is approved, a notice of conformance is sent to the people who received a notice of filing and to the reviewing agencies.

Timber operations may begin immediately after plan approval. Minor and major amendments may be added to the plan; major amendments require reopening the public comment period. CAL FIRE may conduct inspections during active timber operations.

Postharvest Requirements

After timber operations are completed, the landowner or plan submitter is responsible for postharvest activities and maintenance. Highlights of timber and timberland owner responsibilities include the following.

- Within 1 month after completion of operations, a work completion report must be filed with CAL FIRE.
- Restocking requirements must be met within 5 years after harvest. When restocking is met, a report of stocking form must be submitted to CAL FIRE.
- Erosion control devices must be maintained for 1 to 3 years after approval of a work completion report.
- Any change in ownership must be reported to CAL FIRE. The new owners must be informed about the stocking requirements.
- CAL FIRE must be notified within 5 days about the substitution of another RPF or change in RPF responsibilities.
- The landowner or RPF must provide a copy of the approved THP and amendments to the licensed timber operator (LTO) conducting the operation.
- CAL FIRE must be notified before site preparation activities begin.

When a Permit Is Not Required

In certain specified situations, exemptions, emergency notices and conversion exemptions allow landowners to harvest timber without preparing a THP (table 1). Note that all exemptions and emergencies require that the proper forms be filed with CAL FIRE. It is important to note that these are exemptions from filing a THP, and that the rules and regulations governing timber harvest, road construction, reforestation, watercourse protection, environmental protection, and so forth still apply. An RPF is required to sign some, but not all, of these exemption forms.

Table 1. Summary of exemptions allowed by forest practice regulations

	Purpose					
	Christmas trees	**Dead/dying/ diseased**	**Fuelwood/split products**	**Removal of fire hazard trees**	**Substantially damaged not for sale**	**<3 acre conversion**
Form (Section #)	RM-73 (1038ab)	RM-73 (1038ab)	RM-73 (1038ab)	RM-73 (1038c)	RM-73 (1038e)	RM-73 (1104.1a)
Acre limit	none	none; limited to 10% of the average volume/acre	none; limited to 10% of the average volume/acre	within 150 feet of permitted structure	none	<3 acres one-time/ ownership
Cut live trees	yes	no	yes	yes	no (see exception rules)	yes
Need RPF	no	no	no	no	no	yes
Trees marked	no	no	no	yes	no	no
Approval time	received by CAL FIRE before operations begin	received by CAL FIRE before operations begin	received by CAL FIRE before operations begin	5 working days from the receipt by CAL FIRE; wait for notice	5 working days from the receipt by CAL FIRE; wait for notice	wait for notice of acceptance; must have in hand before operations
Work completed w/in	1 year	1 year	1 year	1 year	1 year	1 year (logging); 2 years to complete conversion
Notify CAL FIRE	no	no	no	yes	no	no
Notify neighbors	no	no	no	no	no	yes
Permit posted	no	no	no	yes	no	yes
Silviculture limitation	none	can cut <10% volume	can cut <10% volume	some	must meet definition for substantially damaged timberland	none
Stocking report	no	no	no	no	no	work completion
Comments		many special rules; see 1038(b)	many special rules; see 1038(b)	strict slash cleanup required	many special rules; see 1038(b)	many special rules

Exemptions

- Harvesting dead, diseased, or dying trees where less than 10 percent of the average stand volume per acre is removed.
- Harvesting dead trees from damaged timberlands (for example, after a wildfire).
- Harvesting to create or maintain a firebreak.
- Harvesting Christmas trees.

Emergency notices

- Cutting or removing trees that are dead or dying as a result of insects, disease, parasites, or animal damage.
- Cutting or removing trees that are fallen, damaged, dead, or dying as a result of wind, snow, freezing weather, fire, flood, landslide, or earthquake.
- Cutting or removing trees that are dead or dying as a result of air or water pollution.
- Cutting or removing trees required for emergency construction or repair of roads.

Conversion Exemptions

- One-time conversion of land use of up to 3 acres (for example, from forest to a home site).
- Construction or maintenance of right-of-way by a public agency on its own or any other public property.

- Clearing of trees from timberland by a private or public utility for construction of gas, water, sewer, oil, electric, or communications rights-of-way, and for maintenance and repair of the utility and right-of-way.

Other Commonly Needed Permits Associated with Forest Management

Lake and Streambed Alteration Agreements (1600 Agreements)

The DFG regulates activities that may affect streams and other watercourses. The main purpose of regulation is to prevent changes to waterbodies that may adversely affect habitat for aquatic wildlife. The regulation process yields what are known as "1600 agreements." These are not permits, strictly speaking, but rather agreements between DFG and landowners that serve as conditions on the proposed activity. Many forestland owners will find themselves having to obtain a 1600 agreement in order to

- divert, obstruct, or change the natural flow of any river, stream, or lake (such as placing or replacing a culvert or repairing a road even if it is funded through a restoration grant)
- use materials from a streambed, such as gravel
- dispose of debris, waste, or other material containing crumbled, flaked, or ground pavement into any river, stream, or lake

When planning an activity that will require a 1600 agreement, a landowner must submit notification to DFG for evaluation and CEQA review. Before submitting the notification package and fees, it is a good idea to contact your local DFG office to discuss the proposed project and determine whether notification is necessary and whether there are any concerns regarding the project. DFG may suggest ways to reduce impacts to fish or wildlife before you submit your proposal. For more information see the DFG Web site, http://www.dfg.ca.gov/whdab/1600.html.

Smoke Management Plans (SMP): California Air Resources Board

In addition to the required burn permits issued by CAL FIRE, California's Smoke Management Program addresses potentially harmful smoke impacts from agricultural, forest, and rangeland management burning operations.

For forest landowners who want to burn vegetation, it may be necessary to develop a smoke management plan (SMP). These are required for all burn projects that are larger than 10 acres or are estimated to produce more than 1 ton of particulate matter. At a minimum, the following information is required for the plan:

- location, types, and amounts of material to be burned
- expected duration of the fire from ignition to extinction
- identification of responsible personnel, including telephone contacts
- identification and location of all smoke-sensitive areas

More information can be obtained at the California Air Resources Board Smoke Management Program Web site, http://www.arb.ca.gov/smp/regs/regs.htm.

ENGLISH–METRIC CONVERSIONS

English	Conversion factor for English to Metric	Conversion factor for Metric to English	Metric
inch (in)	2.54	0.394	centimeter (cm)
foot (ft)	0.3048	3.28	meter (m)
yard (yd)	0.914	1.09	meter (m)
mile (mi)	1.61	0.62	kilometer (km)
acre (ac)	0.4047	2.47	hectare (ha)
square mile (mi^2)	2.59	0.386	square kilometer (km^2)
pound (lb)	0.454	2.205	kilogram (kg)
ton (T)	0.907	1.1	metric ton (t)

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FOREST STEWARDSHIP SERIES 20

Laws and Regulations Affecting Forests, Part II: Activities Other Than Timber Harvesting

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UNIVERSITY OF CALIFORNIA
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Objective

Understand the laws and regulations affecting uses and activities other than timber harvesting on forest land.

Competencies

- *Understand which activities are regulated by state and local agencies.*
- *Familiarity with sources of information on regulatory requirements and procedures.*

Related Forest Stewardship Series Publications

- *Stewardship Objectives and Planning,* ANR Publication 8248
- *Forest Taxation, Estate Planning, and Conservation Easements,* ANR Publication 8252
- *Professional Assistance,* ANR Publication 8254
- *Technical and Financial Assistance,* ANR Publication 8253
- *Laws and Regulations Affecting Forests, Part I: Timber Harvesting,* ANR Publication 8249

UC PEER REVIEWED

If you own or manage rural property, are drilling a well, building a road, or developing a home site, you may be subject to a number of county, state, and federal laws and regulations. It is advisable to be informed about potential permitting requirements prior to committing a great deal of time to planning and design. In some cases, advance consultation with regulatory agencies will disclose mandatory standards that must be met for a project to go forward.

For any project involving land development, the first screening should be the zoning and general plan designations for the site. These will specify standards such as minimum lot size, setbacks, allowable building coverage, and so forth. Zoning and general plan designations can be determined through consultation with the county planning department.

This publication provides a very general summary of land management and use regulations. These regulations vary by county and region of the state. Therefore, a landowner should always check with local sources on the applicability of the various laws and regulations.

ACTIVITIES SUBJECT TO REGULATION

California counties have jurisdiction over home site, water development, road construction and maintenance, and development standards for properties. State agencies such as the California Department of Fish and Game (DFG), the State Water Resources Control Board (SWRCB), and Regional Water Quality Control Boards (RWQCBs) may be involved in activities affecting surface and groundwater and streams or ponds. Federal agencies will rarely be directly involved in land development or use except when listed threatened or endangered species are involved, or in the case of the Army Corps of Engineers, when specified wetlands may be impacted. Table 1 summarizes a variety of land management activities and who should be consulted in each case.

Table 1. Summary of possible project activities, financial assistance, resource considerations, and permits required

Activity	Required permits	Contact	Resource considerations	Availability of financial assistance
build a home or outbuilding	variable; at minimum, building permit	county planning and/or building department	geology, fire hazard, access, utilities, ecological impacts, property lines, etc.	no
install a septic system	septic system permit	county environmental health department	water pollution, soil conditions, slope	no
drill a well or develop a water source for domestic or irrigation use	wells commonly require permits; surface water development may require acquisition of water rights	SWRCB Division of Water Rights; county environmental health department	water quality for human health, water quantity	no
close or gate a road	none	depends on access agreements with neighbors	emergency and neighbor access	no
install or replace a culvert or bridge or divert a stream (fish not present)	county grading permit may be required; 1600 agreement; potential for permits from RWQCB and Corps of Engineers	county planning and/or public works or building department; DFG	water quality, fisheries and aquatic impacts	depends; cost-share programs are available for some activities
install or replace a culvert or bridge or divert a stream (fish present)	county grading permit may be required; 1600 agreement; potential for permits from RWQCB and Corps of Engineers; if listed fish species present, consultation with FWS or NMFS required	county planning and/or public works or building department; DFG	water quality, fisheries and aquatic impacts	depends; cost-share programs available for some activities
reconstruct a road, or grade or surface it	county grading permit may be required; disturbance >1 acre is subject to regulation by RWQCB to prevent nonpoint source pollution	county planning and/or public works or building department, DFG, RWQCB	sedimentation, fisheries and aquatic impacts, dust, fire access, weight of vehicles, water quality, sensitive species	depends; cost-share programs available for some activities
any activity in or near a stream	1600 permit	DFG (some counties have regulatory authority as well)	water quality, fisheries and aquatic impacts	yes
build a pond or lake	depends on size and water rights	SRWCB Division of Water Rights; DFG	water quality, sensitive species, sedimentation, dam strength	depends; cost-share programs available for some activities
mine gravel in a floodplain versus a quarry	surface mining permit from county; 1600 permit	county planning department; DFG	water quality, sensitive species	no
conduct a controlled burn or prescribed fire	burn permit; smoke management plan	CAL FIRE; local fire district	air pollution, liability for escaped fire	depends; cost-share programs available for some activities
reduce fuels mechanically	if for timber sale, a THP may be required	CAL FIRE	archeological, sensitive species, silvicultural issues, wildfire risk	yes

Table 1, cont.

Activity	Required permits	Contact	Resource considerations	Availability of financial assistance
reduce fuels with herbicides	permit may be required (depends on chemical used)	agricultural commissioner and/or RWQCB	archeological, sensitive species, silvicultural, wildfire risk and water quality	no
spray weeds	permit may be required (depends on chemical used)	depends on herbicide used; check with agricultural commissioner	silvicultural, wildlife, water quality	yes, if target is exotic
spray insects	permit required (depends on chemical used)	depends on pesticide used; check with agricultural commissioner	silvicultural, wildlife, water quality; disease management	yes, if target is exotic and an epidemic
hunt deer, elk, or bear	hunting license for regular season; depredation permit can be issued for out-of-season needs	DFG; county animal control	wildlife issues	no
control wildlife pests (skunks, squirrels, gophers, raccoons, moles)	none unless chemicals or traps are used that require permits	county animal control, county agriculture commissioner	sensitive species, population dynamics	no

RESPONSIBILITIES OF COUNTY, STATE, AND FEDERAL AGENCIES

County Agencies

Your local government contains many helpful resources, including

- planning departments that draft general plans, review development projects, evaluate lot line adjustments, and administer county ordinances and zoning
- building departments that issue building and grading permits
- environmental health departments that ensure water quality for new wells and domestic water sources
- agricultural commissioners that offer disease and pest management assistance, noxious weed control, and pesticide regulation

In most counties, resource conservation districts (RCDs) have been established. These are independent, often volunteer-run organizations that help coordinate activities among landowners and local, state, and federal agencies to promote conservation of land, water, forests, and wildlife. For more information, see the California Association of Resource Conservation Districts Web site, http://www.carcd.org.

The University of California Cooperative Extension (UCCE) has 64 California county-based offices that bring the University's research-based information to all California residents. More than 400 campus-based specialists and county-based farm, home, and youth advisors work as teams to develop and deliver practical solutions for local problems. Their efforts range from technical forestry, farm, and water conservation research to nutrition education. For more information, see the UCCE Web site, http://www.ucanr.org, and the UCCE Forestry Web site, http://www.CNR.Berkeley.EDU/departments/espm/extension.

State Agencies

California state agencies that may have oversight over your activities include the following.

- Air Resources Board (ARB), http://www.arb.ca.gov/, delegates air pollution control to local air pollution districts, which enforce air pollution standards, including issuing burn permits and regulating agricultural waste concerns.

- California Geologic Survey (CGS), http://www.consrv.ca.gov/CGS/, formerly known as California Division of Mines and Geology, evaluates seismic and slope stability issues for home, road, and timber harvesting projects.
- Department of Fish and Game (DFG), http://www.dfg.ca.gov/, conserves the state's fish, wildlife, and botanical resources. They regulate land management activities that affect these resources, such as harvesting timber, altering a stream by building a road, or hunting. In addition, DFG offers a number of assistance programs for landowners.
- Department of Food and Agriculture (DFA), http://www.cdfa.ca.gov/, promotes safety and trade for the state's agriculture through disease and pest management, noxious weed control, and pesticide regulation. The county agriculture commissioners (see above) are the local agents for the department.
- Department of Forestry and Fire Protection (CAL FIRE), http://fire.ca.gov/, provides fire protection and regulates timber harvest on the state's private forest lands. CAL FIRE offers a number of landowner assistance programs.
- Department of Pesticide Regulation (DPR), http://www.cdpr.ca.gov/, licenses and certifies pesticide dealers, pest control advisers, and pest control businesses and applicators. The county agriculture commissioner issues pesticide applicators permits.
- Department of Water Resources (DWR), http://www.water.ca.gov/, manages the water resources for all of California's water needs through coordination of water allocation.
- State Water Resources Control Board (SWRCB), http://www.swrcb.ca.gov/, protects the quality of the state's water resources and allocates water rights. They oversee nine regional water quality control boards (RWQCBs), which develop basin plans, implement total maximum daily loads (TMDLs), issue waste discharge permits, enforce water quality standards, and take regulator action against violators.

Federal Agencies

- NOAA's National Marine Fisheries Service (NMFS), http://www.nmfs.noaa.gov/, protects endangered and threatened marine life and marine mammals, along with the ecosystems upon which they depend, under the Endangered Species Act and the Marine Mammal Protection Act. For example, they manage the recovery of listed salmonid species at the federal level, but they are not substantively involved in the timber harvest permit process in California.
- U.S. Army Corps of Engineers (USACE), http://www.usace.army.mil/, oversees activities that take place in streams or wetlands regulated by the Clean Water Act.
- U.S. Fish and Wildlife Service (FWS), http://www.fws.gov/, conserves, protects and enhances fish and wildlife and their habitats under the Endangered Species Act. FWS is generally involved in the harvest permit implementation process for forest landowners when there are issues, for example, such as northern spotted owls.
- USDI Bureau of Land Management (BLM), http://www.blm.gov/, manages 270 million acres nationally of primarily nonforested public lands, mostly in the western United States. They can permit use of their land for activities such as grazing, mining, and recreation.
- USDA Farm Services Agency (FSA), http://www.fsa.usda.gov/, helps farmers conserve land and water resources, provides credit to disadvantaged farmers or ranchers, and helps farmers recover from disasters. They work closely with the Natural Resource Conservation Service (NRCS) to administer these assistance programs.
- USDA Forest Service (FS), http://www.fs.fed.us/, manages 190 million acres of forested public lands. There are 17 National Forests in California. They offer state and private forestry assistance programs and can permit use of National Forest land for activities such as grazing, recreation, and firewood harvesting.

- USDA Natural Resource Conservation Service (NRCS), http://www.nrcs.usda.gov/, formerly known as the Soil Conservation Service, works with private landowners, farmers, and ranchers to provide technical and financial assistance for soil and water resource conservation. They sponsor the county resource conservation districts (RCDs) and are responsible for the soil survey. NRCS soil surveys and maps are available online at http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx.
- US Geological Survey (USGS), http://www.usgs.gov/, develops topographical maps of the nation's land that can be purchased for your use.

THE VALUE OF PLANNING

It is a good idea for forest landowners to have a management plan. Even a very general plan will help you think through what resources you have, what your management objectives are, and the steps you need to take to meet those objectives.

There are many kinds of plans to help guide your land management decisions. The simplest you may prepare yourself or with input from agency personnel. For complex plans you may need to contract for the services of a registered professional forester (RPF).

If you prepare a forest stewardship plan addressing the management of your forest, it is of utmost importance to consider and accommodate all uses that you plan to make of your property. Siting of homes, roads, water systems, and other proposed uses should be designed to be compatible with forest management objectives.

ASSISTANCE PROGRAMS

Many assistance programs are available for landowners, sponsored by both the state and the federal government. Assistance is available in the form of cost-share programs; local, state, and federal agency programs; and free or low-cost publications for everything from forest and habitat improvement to fuel reduction projects. A number of state and federal grant programs also exist to encourage various kinds of restoration projects on private lands. Some programs are available to individual landowners, some to larger ownerships. Funding sources and availability change from year to year, so check periodically to see what is available.

In some cases, funding is made available only to groups. There are several ways you might qualify for such funds: as part of a watershed group, as a homeowners' association, as a local fire safe council, and so on. Again, your forester or public agency representative may be able to help you navigate the maze of requirements and show you how to qualify for a program appropriate to your needs.

Most counties in the state have a resource conservation district (RCD), many of which now have watershed coordinators who can help you. Each RCD is different, but all focus on the management of local natural resources. Typically, members of RCD boards are local natural resource managers from the public and private sector as well as private landowners and other interested individuals. RCDs sometimes have existing grants that you as an individual landowner can participate in. It is worth a call to your local RCD to see if they have any ongoing projects you might become involved in. For more information, visit the California Association of Resource Conservation Districts' Web site, http://www.carcd.org/wisp, or call the Forest Stewardship Helpline at 1-800-738-8733 or your local UC Cooperative Extension Office (for the office near you, see the UC ANR Web site, http://ucanr.org/ce.cfm).

The California Forest Stewardship Program (FSP) assists landowners in managing their forestland through education programs, information regarding cost-share programs, and a quarterly newsletter for family forest landowners, *Forestland Steward*, which is available for free online at the Forest Stewardship Program Web site, http://ceres.ca.gov/foreststeward/. Forest stewardship and other workshops and courses are listed in the *Forestland Steward* newsletter.

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FOREST STEWARDSHIP SERIES 21

Economic Considerations in Forest Stewardship

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UC PEER REVIEWED

Although you may own your forestland for various reasons, the fact is that your land is a significant financial investment. As with any large investment, it pays to learn about your options and then tailor your management to suit your needs. This publication briefly examines some of the more important economic considerations that may affect your management.

The first step in good economic management of your land is to understand what you can do with or produce on your land. This includes both timber and non-timber forest products and services. Whether you focus on timber or non-timber products, planning the management of your land will cost you time and money. Economies of scale will determine how extensive or detailed your planning should be. For virtually any property, a forest stewardship plan is essential to help you focus on your natural resources. It may be a very general plan, describing your property and what is on it, outlining future projects, and so on. The cost will depend on how detailed the plan is and how much of the work you are able and willing to do yourself. Some cost-share programs from state or federal agencies can help pay for these plans.

Objectives

Understand the economic aspects of forest ownership.

Competencies

- *Identify commercial forest products, both timber and non-timber.*
- *Understand the economic considerations in timber harvest planning.*
- *Understand the economic and environmental advantages of forest certification.*

Related Forest Stewardship Series Publications

- *Forest Taxation, Estate Planning, and Conservation Easements, ANR Publication 8252*
- *Laws and Regulations Affecting Forests, Part I: Timber Harvesting, ANR Publication 8249*
- *Professional Assistance, ANR Publication 8254*

TIMBER

Consider both existing and potential future timber resources and their values even if your objectives don't necessarily include harvesting timber. The monetary value of the timber was part of the price you paid for the property and will be part of the valuation of the property should you sell it, pay estate taxes on it, or restrict harvest with a conservation easement. Some trees will yield merchantable logs today, while others will yield merchantable logs in years to come. Trees that are yet to be established (either through planting or natural regeneration) will someday become merchantable.

For the short term, focus on what is merchantable now. To determine the quantity and quality of your timber, get help from a registered professional forester (RPF). The RPF will consider the species, size, quality, and location of the timber when estimating its value. Remember that log prices fluctuate widely from year to year and even within a given year. Your best sources for current local log prices are local RPFs and the log buyers at mills. For the longer term, talk to log buyers or your forester about what kinds of logs are most likely to hold their value into the future.

You might find it worth the time and expense to have a timber inventory done on your property. This means hiring a forester to provide you with a report that includes information on species present, with their numbers, timber wood volumes, and growth rates.

Based on the inventory, a forester can make a projection of future growth. It is probably wise to limit management decisions based on projected growth to a decade or two. Although growth can be projected a hundred years or more, growth models can provide only best guesses when done several decades into the future because they assume average levels of precipitation, insect and disease mortality, wildfire, and other unpredictable disturbances.

NON-TIMBER FOREST PRODUCTS

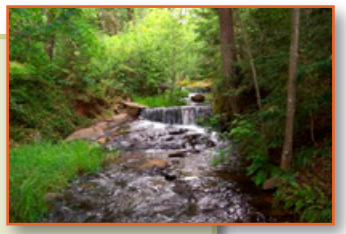
Products from your forest other than timber and firewood are called non-timber forest products (NTFPs). Your opportunity to develop NTFPs depends on many factors, including forest type, location, markets, and your interests. The commercial value of NTFPs in the Pacific Northwest exceeded $200 million in 2006.

Native plants have been the backbone of the NTFP industry from its beginning. Some of the most commonly harvested products are listed below with their general use.

Use	Forest product
florals	evergreen huckleberry, salal, swordfern, Oregon grape, holly
medicinals	foxglove, yarrow, Rocky Mountain juniper, stinging nettle, Pacific willow
edibles	evergreen huckleberry, salal, swordfern, Oregon grape, holly, black raspberry, trailing blackberry, thimbleberry, salmonberry
fungi	morels, yellow chanterelle, white chanterelle, king bolete, shitake, matsutake, oyster mushrooms
Christmas greenery	Douglas-fir, Pacific silver fir, grand fir, shore or lodgepole pine, western white pine, western redcedar
craft materials	western redcedar, red alder, bitter cherry, western yew, pacific willow, vine maple, Pacific dogwood, Oregon grape
arts	paper birch, Pacific dogwood, blueberry elder, kinnikinnick, red-osier dogwood, Labrador tea, Oregon grape
landscaping	western redcedar, Pacific dogwood, Oregon grape, western white pine, paper birch, pacific willow, grand fir, Douglas-fir, salal, evergreen huckleberry, alpine fir, western larch, ponderosa pine, yellow cedar

The NTFP industry continues to develop niche markets for a host of new products, including the following.

Use	Forest product
florals	beargrass, Oregon boxwood, vine maple, red-osier dogwood, redstem ceanothus, pacific willow, scotch broom, hardhack, oceanspray, common snowberry, hairy manzanita, western bog-laurel, red huckleberry, Pacific madrone, Methuselah's beard lichen, coastal reindeer lichen, twisted ulota moss, cattail moss, yellow moss, maidenhair fern, deer fern, scouring-rush
medicinals	some examples of the more than 172 plants are: balsam, poplar, balsam root, bleeding heart, huckleberry, bunchberry, California bay laurel, devil's club, false Solomon's seal, fireweed, Labrador tea, licorice fern, madrone, nettle, Oregon grape, pearly everlasting, kinnikinnick, valerian, western coltsfoot, wild ginger, prince's pine, St. John's-wort, pacific yew
edibles	cattail, nettle, mountain sorrel, wild licorice, miner's lettuces, lamb's quarters, shepherd's purse, red huckleberry, mountain bilberry, elderberry, cloudberry, ponderosa pine nuts, currant, salal, bracken fern, burdock, wild ginger
fungi	giant puff ball, shaggy mane, candy caps, coral pink, cauliflower mushroom, chicken of the woods, hedgehog
Christmas greenery	Rocky Mountain juniper, noble fir, alpine fir, lodgepole pine, incense cedar, Port Orford cedar, coastal redwood, American holly, sugar pine
craft materials	sugar pine cones, Sitka spruce cones, common scissor-leaf liverwort, Douglas' neckera moss, cattail moss, antlered perfume lichen, coastal reindeer moss, Methuselah's bear, western yew, western red cedar bark, vine maple, bigleaf maple shoots
landscaping	cedar stumps, moss, lichens, ferns, native shrubs, native wetland herbaceous plants, native flowers, native trees, native grasses



North Canyon Creek on Indian Rock Tree Farm in El Dorado County. The stream has been restored and improved to support trophy-sized rainbow trout. *Photo:* Richard Harris.

Indian Rock Ranch

If you were one of the approximately 10,000 annual visitors to the Indian Rock Ranch in El Dorado county, you know that this place is well cared for and cherished by owners Larry and Geri Hyder. This 34-acre farm employs 3 people full-time, plus the Hyders year-round, and 18 to 20 people during the busy Christmas season.

Indian Rock Ranch is largely a choose-and-cut Christmas tree operation. The ranch supports Larry's love for fly fishing. Larry offers expert instruction in fly tying and fly-fishing. The scenic location is popular for weddings and other events. The property also provides timber milled on-site, supplying the ranch's need for lumber. The Hyders also supply the bark for a reproduction of a native dwelling at the nearby Coloma State Historical Park.

It is difficult to believe that nearly 40 years ago when the Hyders first acquired Indian Rock, much of the property was a badly eroded hydraulic mine. North Canyon Creek had been diverted from its channel. All of the timber-size trees had been harvested.

Larry and Geri have since planted thousands of Christmas trees, growing many of the seedlings themselves. They have stabilized eroding slopes and restored and enhanced the portion of North Canyon Creek that flows through their property. Rainbow trout from 1 inch to 30 inches and weighing up to 15 pounds fill the stream pools that Larry has constructed.

When you walk the property with Larry, his pride of ownership is clearly evident. He challenges visitors to name the benefits of adding wood chips recycled from Christmas trees and landscaping to the soil: he can name at least 12. The restored creek is home to a large population of rainbow trout, and the beautiful location is a joy to see. For more information, see their Web site, http://www.indianrocktreefarm.com/.

A few high-value NTFPs can make for commercially viable ventures. At this time, however, most NTFPs can realistically provide only supplemental income. Economic success in NTFPs comes down mostly to marketing. Who will buy your product? Will you provide raw materials, finished, or partially finished goods? Having a good plan and business sense to adapt to changing markets is essential.

PERMITS FOR SELLING TIMBER

Years of care and growth are accumulated in a mature timber stand. The return from all those years of asset (tree) growth is frequently marketed in a single transaction. Too much is at stake to sell timber without having accurate information on the process, products, volume, and value of the timber, as well as efficient methods for protecting the environment.

Selling timber is complicated. California landowners must have an approved timber harvest plan (THP) prepared by an RPF to conduct a commercial timber harvest. The actual harvest is usually done by a licensed timber operator (LTO, or logger). The net value of the trees to the landowner, called stumpage value, is the delivered price at the sawmill reduced by harvesting and transportation costs as well as the costs for harvest plan preparation and permits.

The state Forest Practice Act allows timber harvesting to occur in three general ways: with an approved THP, with a nonindustrial timber management plan (NTMP), or with an exemption from a THP. These should not be confused with a forest stewardship plan, although many landowners have tailored their NTMP to be a forest stewardship plan. A THP is an environmental review document, much like an environmental impact report (EIR). It demonstrates that you are aware of the environmental impacts of your timber harvest and focuses on reduction and mitigation of those potential impacts. Though called a plan, a THP is actually a regulatory document, a permit to conduct timber harvest operations. As of 2006, a THP is valid for 3 years with up to two 1-year extensions. There are exemptions to filing a THP in the case of emergencies such as wildfire or other catastrophic events, or minimal-impact small-scale timber harvesting to reduce fire hazard around a home, and removal of dead, dying, or diseased trees. These are exemptions from filing a THP, not exemptions from environmental protection regulations for clean water and air, wildlife habitat, and so on. Approval of an exemption by the California Department of Forestry and Fire Protection (CAL FIRE) implies that all applicable regulations have been met.

Costs for THP preparation vary tremendously based on the scale and complexity of the plan and the environmental issues considered. A simple THP, with no streams, archeological sites, endangered species, or geological issues, will be an order of magnitude less expensive than a complex THP covering a large area.

As of 2006, there is probably no THP that costs less than several thousand dollars. A knowledgeable RPF can provide you with the best estimate of what a THP would cost. Ask several RPFs for competitive bids.

An NTMP is a long-term timber harvesting permit. In exchange for a great deal more up-front planning and limitations on the types of management activities allowed, landowners get an alternative to the THP that is valid in perpetuity. The NTMP can also be transferred with the sale of the property. To harvest timber under an approved NTMP, the landowner need only file a notice of intent to harvest (NOI). The main advantage to an NTMP is you can more readily sell your timber when markets are favorable while waiting out poor markets. Also the expense of a THP is borne only once.

If you choose to have an NTMP prepared for your property, it is extremely important that it reflect all of your stewardship objectives, not just commercial timber harvest.

Limited harvesting with an exemption is permitted for specific purposes such as salvage-logging dead trees, establishing or maintaining fire breaks, and dealing with emergency situations. While a few of these exemptions do not require the use of an RPF, most landowners are better off hiring one. In most cases, it is not in the best interests of the landowner to have the same person who logs the timber write the plan or an exemption.

STUMPAGE VALUE

The amount of money a landowner realizes from selling timber is called the stumpage price. It represents the value of the trees "sitting on the stump," that is, the price the sawmill will pay for logs delivered to the mill less all costs for harvesting and hauling. Stumpage prices vary on a day-to-day, seasonal, and yearly basis, as well as regionally. Many variables affect the price paid for standing timber, including the following.

- Species. In California, Port Orford cedar for export commands the highest stumpage prices by far, though the amounts sold and markets are very limited. Redwood is the next-highest-valued species, followed closely by ponderosa and sugar pine, then Douglas-fir. White and red fir are still valuable but less so than their mixed conifer associates. In recent years, incense cedar has become a valuable species as a substitute for redwood in fencing and decking. Most hardwoods have little timber value except for specialty markets. Species price varies widely with location and market demand.
- Quality and size. Large, sound trees with clear (knot-free) logs used for lumber generally bring the highest prices. Logs with specific traits (straight, little taper, sapwood thickness) that produce quality utility poles command a high price.
- Location. Distance to the mill and the quality of the roads are crucial factors affecting the price paid for stumpage. A log truck leaves the property loaded and returns empty. The driver is paid for both directions. Fuel and maintenance is only slightly higher for a loaded truck than an empty one, and the truck owner still has to pay expenses whether the truck is loaded or empty. The distance from your property to a mill and the time it takes to negotiate the roads there and back play a big part in how much you can realize from selling timber. Lower elevations, below the snow line, may make your forest accessible earlier in the spring when competition for logs may be keener and prices are higher because of demand.
- Size and volume. Low total volumes of timber on small acreages may not be profitable to log. There are fixed costs incurred regardless of the size of your property or the size of the harvest. Logging operations require high capital investments in equipment; move-in costs are the same whether one truckload of logs or 100 are harvested. THPs are expensive. On small properties with low timber volume, the cost of preparing the plan can exceed the value of the timber. Stumpage values generally increase with harvested volume and acreage because of economies of scale.

- Market competition. Competitive bidding between mills in an area improves the chance that a fair market value will be offered for timber. Some situations involving specialized products, unusual harvesting conditions, or poor markets may be better handled by negotiating with an appropriate buyer.
- Contract provisions. Restrictions placed on the harvest of timber may protect the site or the landowner, but they usually reduce the price paid for the stumpage. The best way to assure your property will look the way you want it to following harvest is with a well-written contract that has specific, objective measures of performance; it is your property and you should be satisfied with the results. However, be aware that loggers bidding on your job will charge for contract provisions that go beyond state forest practice standards geared to ecological rather than aesthetic conditions. One of the most common sources of tension between landowners and loggers is the amount and distribution of logging debris (slash) left after harvest. Legal requirements for fire hazard reduction may not provide a cleanup that meets the expectations of landowners who cherish their land. You should include contract provisions that address slash and other considerations important to you. Clear communications, in writing and followed up by supervision, is the best way to ensure that your expectations of the harvest will be met.
- Pricing. One reality of marketing timber, especially for landowners who might make a timber sale only once or twice in their lifetimes, is that it is difficult to get accurate, timely information on prices. This can be a very expensive lesson.

Softwood lumber is a commodity, meaning that once lumber size and species are considered all wood of a given species is similar: an 8-foot long Douglas-fir 2 by 4 has the same lumber characteristics whether it comes from your forest or Canada. Commodity prices fluctuate widely according to international supply and demand and seasonal fluctuation. There are no daily market price reports for stumpage, nor are there any government support prices for landowners. Both demand and price for many timber products fluctuate widely.

This lack of information is one of the reasons to hire a forester you trust to look out for your interests. You need to have a professional advocate who follows industry trends and local market conditions.

Questions To Ask Your Forester When Considering a Timber Sale

- Which trees should I sell?
- How do I market them?
- Are property and cutting boundaries well marked?
- What is the timber volume?
- How is the volume measured?
- What is the value of my timber?
- Are timber market prices going up or down?
- Are the trees financially mature?
- Who and where are the appropriate timber buyers?
- What sale method should I use?
- What laws do I need to consider?
- How should I reforest harvested areas?

MEASURING TIMBER VOLUME

Training and experience are needed to accurately estimate timber volume and value within standards accepted by local markets. Actual production volume is usually determined at the mill, but the volume of standing timber can be estimated using several methods.

You should have at least a basic understanding of how timber volumes are measured. A timber "cruise" is an inspection of the timber stand to estimate the volume of marketable timber present. This ranges from a walk-through "eyeball" estimate to a sophisticated statistical sample that takes detailed estimates on some trees and extrapolates that information to an entire property. Most often, the cruise is based on a systematic sample of trees on plots or strips representative of the entire property. This information is summarized in a table reporting numbers of trees by species and diameter.

Two measurements are usually needed on each tree to estimate timber volume: the diameter at breast height (DBH), 4.5 feet above the ground, and the tree's height. Tree height is gen-

erally recorded in terms of the number of 16-foot logs to a merchantable top of a specific diameter, or the actual top of the tree. Once the diameters and heights are known, tree volumes can be determined from volume tables. These tree volumes by species and DBH are expanded to the whole harvest area using estimates of the total number of trees by species and DBH.

Making square boards from a round log results in waste, though wood that doesn't make lumber is used for oriented strand board (OSB) or biomass energy. None of a log that comes to a mill today goes to waste. To account for this waste, various log rules are used to convert from gross measurements to a predicted net volume. There can be a great deal of difference between different log rules, so check to see which one your timber is estimated with. The state Franchise Tax Board uses Scribner Short Log scale, and that is the unstated standard in California.

MARKETING TIMBER

Being involved in selling your timber will bring the highest return with the greatest protection for your land. In most situations you will need to hire an RPF to help you market your timber. The RPF can handle many details, not the least of which is getting the best price for your timber and administering the timber harvest to achieve your goals and expectations. Use that professional's advice and experience wisely. Be well informed and aggressive in marketing. Buyers have more confidence in sellers who use a business-like approach.

Hire your own forester. Many logging companies have an RPF on staff and are willing to "take care of all of the paperwork." While this seems attractive, the forester is legally, ethically, and financially responsible to the person who is paying for their services. A forester paid by the logging company must work on behalf of the company's interests—not yours. Hire a forester you trust and who understands your needs and interests. Your needs and interests are best documented with a forest stewardship plan or forest management plan.

Make certain that your timber is ready to harvest. Are the individual trees large enough and plentiful enough to support a harvest? Will waiting a few years increase the value of the trees enough to justify waiting? To generate income from your forest without harvesting it, a short-term loan using timber as collateral could be less costly than a premature or inappropriate timber sale. You should get professional advice about various alternatives for the timing and intensity of the timber sale.

Being a commodity, the price of timber fluctuates widely. While over time the general trend is increasing timber values, the price can be highly volatile, so timing your harvest properly can result in significantly higher returns. For example, ponderosa pine went from $195 per thousand board-feet (MBF) in 1977 to $510 per MBF in 1990; however, in 1992 it went from $470 per MBF in January to $700 per MBF in July. Check the current timber market demand and recent trends. Landowners who are ready to take advantage of rising markets—those who have a plan in place—can make handsome returns. An approved NTMP would have allowed the landowner to take advantage of this brief price spike, while a THP would have taken months to process before a harvest could begin.

Obtain a good estimate of the volume and value of your standing timber to help you get the best return. Have the timber cruised to estimate its volume, quality, and value. It is surprising how many landowners offer tens of thousands of dollars in timber for sale without any estimate of just what they are selling.

Your forester may charge a daily or acreage fee, or may handle all sales-related activities on a percentage commission basis. A percentage commission provides a con-

sulting forester with a strong motivation to get the best price for your timber sale, although it could also encourage selling more timber or selling timber sooner rather than later. Daily or acreage charges might be less expensive, but they generally remain due even if no timber is sold.

In most timber sales, individual trees, or at least sale boundaries, should be clearly marked. Forest practice regulations require trees to be marked in some circumstances. Well-marked sales make it easier for the logger to bid accurately.

Inform adjoining landowners of any proposed timber sales to make certain that boundary and access road locations are acceptable. Neighbor notification is required as part of THP processing under the Forest Practice Act. Combining sales among neighboring tracts can sometimes increase volumes without substantially increasing logging costs, which could result in higher returns to the sellers.

Advertise the timber to all reliable buyers in the area. High-value products or tracts could attract buyers from far away. Buyers can best be notified by sending them invitations to bid on timber. Provide as much information about the timber, the tract, and contract restrictions as possible. Describe payment provisions, including any security deposits or performance bonds that will be required. Also include with the invitations copies of vicinity maps, plat maps, or aerial photographs indicating the location of the timber offered for sale.

Many marketing experts believe that sealed bids usually result in a higher offer than auctions or negotiated sales. Allow at least 1 month for buyers to make their own examinations or cruises before the sale is held. Reserve the right to refuse any or all bids. Consider hosting potential buyers at separate times. It could be a disadvantage to you for the bidder to know the identity of other bidders on the sale.

A written contract in which the rights and obligations of buyer and seller are detailed should be signed by all parties involved. Important restrictions and stewardship requirements should be included. You may wish to require a performance bond that is refunded to the buyer when all contract provisions have been satisfactorily met or used if necessary to correct contract violations.

The contract is used to pass title of the timber from the seller to the buyer. How this transfer is structured can influence federal and state taxes. Since everyone's tax situation is unique, it pays to consult an accountant prior to a timber sale. Be sure the accountant is familiar with timber-related transactions.

WAYS OF SELLING TIMBER

Common methods of selling timber include

- lump sum
- per unit delivered to a mill
- directly to the mill

Lump sum sales occur when you sell the standing trees to a logging company for a fixed price. This is rarely a good deal for landowners and in most cases should be avoided. Often the logger offers the landowner a fixed percentage of the price for the logs paid by the mill. Lump sum sales give the logger no incentive to do a good job; rather the focus is on cutting the best trees as quickly and cheaply as possible. Lump sum sales often leave a disappointed landowner and a messy job.

Lump sum sales are like telling a general contractor to build the best house possible for a fixed amount of money. When the house is built you hand over a check and take possession. Along the way you have little to no control over the design or materials that go into constructing the house.

Per unit sales occur when the landowner receives payment based on the volume scaled at the mill and verified by scale tickets. The agreement is usually for the landowner to receive a fixed price per thousand board feet delivered to the mill adjusted for species and log size. The logger sells the trees to the mill and the difference between what the mill pays and the landowner receives covers the logging and hauling cost and the logger's profit. Other costs associated with the harvest are documented in the contract. This method is used by most landowners.

To extend our constructing a house example, per unit sales would be like hiring a general contractor, giving them a careful plan, and paying along the way as certain aspects of the building are complete and the subcontractors paid.

Selling directly to the mill and contracting independently for either logging, hauling, or both is a popular method for sophisticated landowners with a lot of time and experience to manage a complex sale. As a landowner you make your best deal with a lumber mill, separately contract a logger, and pay the logger only for harvesting and hauling costs—usually at a fixed price per thousand board feet.

If this were building a house, the landowner would act as the general contractor, hiring subcontractors and paying them as their tasks are completed. The landowner is responsible for all scheduling and takes all the risk of the job coming in under or over budget.

CERTIFICATION

In the last several years, certification of well-managed forests has become increasingly popular. The idea behind certification is to provide some assurance to the public and consumer that the products from a certified forest are produced sustainably.

A number of organizations certify forests and foresters. These organizations vary in the parameters they evaluate as well as their level of rigor, cost, and scope. Some focus exclusively on forest management, while others also evaluate social and economic aspects such as selling logs to local mills, forest and mill working conditions, and maintaining good community relations.

Generally, certification involves a field verification, or audit, of the actual on-the-ground practices. In addition to time in the woods looking at everything from harvest sites to roads, the audit also includes a review of paperwork, such as management planning documents and harvest records. A written audit report is produced that goes on file with the certifier. Follow-up audits ensure that the certification standards continue to be maintained in subsequent years.

To date, the benefits of certification have been largely intangible. In some cases, auditors suggest or require certain practices that will improve the overall management of the forestry operation. As for financial benefit, while a few producers are able to obtain higher prices for logs harvested from certified forests, for the vast majority of participants the benefits are primarily personal and social. Certification can improve the image and credibility of a landowner, company, or forester. It also allows access into markets that demand certified products. However, at present, very few landowners actually receive a higher price for their certified timber.

It remains to be seen how the markets will respond to certified timber. There are some success stories. Certification may offer another way for you to market your timber. To sell your timber as "certified" requires that your logs go to a certified mill.

SUMMARY

Although selling timber can be confusing and complex, landowners can sell it successfully. Your timber sale may be your only chance to profit from the many years of annual growth and value that have accumulated in a mature timber stand. No single publication could cover all possible marketing situations, nor could it make you an expert timber seller. But there are questions you should ask and answers you should know. Hire an RPF before you sell your timber. Know what you are selling, when you are selling it, and how the sale is structured. Be an informed seller. Market your timber in a businesslike manner to get the most it will bring.

RESOURCES

To find registered professional foresters in your area, contact your local CAL FIRE office, which can be found in the state government offices listing phone directories under Forestry and Fire Protection Department. CAL FIRE has lists of both RPFs and LTOs. RPFs may also be listed in telephone directories under Foresters, Consulting. Further information on selected topics can be found below.

Non-Timber Forest Products

Everett, Yvonne. 1997. A guide to selected non-timber forest products of the Hayfork Adaptive Management Area, Shasta-Trinity and Six Rivers National Forests, California. USDA Forest Service, Pacific Southwest Research Station, General Technical Report PSW-GTR-162. Forest Service Web site, http://www.fs.fed.us/psw/publications/documents/gtr-162/.

McLain, Rebecca, and Eric T. Jones. 2005. Assessment of non-timber forest products. USDA Forest Service, Pacific Northwest Research Station, General Technical Report PNW-GTR-655. Forest Service Web site, http://www.fs.fed.us/pnw/pubs/pnw_gtr655.pdf.

Certification

The main certifiers active in North America are listed below. Note that different certifiers may operate under the same certification system. For example, both SmartWood and SCS use Forest Stewardship Council certification systems.

American Tree Farm System, 916-488-8322, http://www.treefarmsystem.org/.

American Tree Farm System, c/o American Forest Foundation, 1111 Nineteenth Street NW, Suite 780, Washington, DC 20036, Phone 202463-2462, Fax 202-463-2461, E-mail info@treefarmsystem.org .

Green Tag Forestry, National Forestry Association, 374 Maple E., Suite 310, Vienna, VA 22180, Phone 1-800-GRN-TREE, Fax 703-281-9200, E-mail info@greentag.org, Web site http://www.nationalforestry.net/.

Forest Stewardship Council (works through SCS and SmartWood), Phone 802-244-6257.

Forest Stewardship Council U.S., 1155 30th Street NW, Suite 300, Washington, DC 20007, Phone 202-342-0413, Fax 202-342-6589, E-mail http://www.fscus.org/.

Scientific Certification Systems (SCS), Phone 510-832-1415; Dr. Robert Hrubes, 2000 Powell St., Suite 1350, Emeryville, CA 94608, Phone 510-452-8007, Fax 510-452-8001, E-mail: rhrubes@scscertified.com, Web site http://www.scs1.com/.

SmartWood, Goodwin-Baker Building, 65 Millet St., Suite 201, Richmond, VT 05477, Phone 802-434-5491, Fax 802-434-3116, E-mail (general information requests and inquiries) info@smartwood.org.

ENGLISH–METRIC CONVERSIONS

English	Conversion factor for English to Metric	Conversion factor for Metric to English	Metric
inch (in)	2.54	0.394	centimeter (cm)
foot (ft)	0.3048	3.28	meter (m)
yard (yd)	0.914	1.09	meter (m)
mile (mi)	1.61	0.62	kilometer (km)
acre (ac)	0.4047	2.47	hectare (ha)

FOR FURTHER INFORMATION

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FOREST STEWARDSHIP SERIES 22

Forest Taxation, Estate Planning, and Conservation Easements

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Every owner of forestland should understand the different taxes that apply to forest ownership and forestry operations, including state and federal income taxes, property tax, and yield taxes (tax applied at the time of harvesting timber).

If you want to minimize your taxes, and you are willing to spend some time learning about tax law, doing some bookkeeping, and possibly hiring a qualified accountant to help out, the suggestions in this publication will likely apply to you. However, situations vary, and you should consult with a tax professional for specific advice. Enrolled agents (EA) are specialists in federal taxes, although not all are acquainted with forestry issues; they can be found in telephone directories under "Taxes: Consultants and Advisors."

Objective

Understand the variety and intent of taxation by federal, state, and local government as applied to forest properties.

Competencies

- *Understand the three main types of taxation: income, timber yield, and property.*
- *Become familiar with the basic principles of recordkeeping as related to forest taxation.*
- *Understand strategies for minimizing the taxes on forest properties and income.*

Related Forest Stewardship Series Publications

- *Professional Assistance, ANR Publication 8254*
- *Stewardship Objectives and Planning, ANR Publication 8248*

INCOME TAXATION

Taxation of income derived from forestry investments is a complex topic at both the federal and state levels. Tax laws, regulations, and guidelines are many, detailed, and technical. Tax legislation is subject to frequent change and judicial interpretation. This discussion is intended only as an introduction to a number of taxation concepts related to forestland in the state of California. The landowner is well advised to seek the advice of a professional tax consultant familiar with timber taxation.

Income taxes on timber revenues are complicated, especially in regards to capital gains treatment. Since income taxation was established in 1913, timber assets have gone from almost no treatment as capital gains to nearly full treatment. Recent legislation has further confused the issue.

For individuals, California state income taxes are generally similar to federal income taxes. However, some important differences are pointed out in the following discussion, and other differences may apply to your particular situation. Check the resources listed at the end of this publication and consult a professional tax consultant.

Capital Gains

Since timber is a long-term investment, it is a capital asset subject to capital gains treatment in income taxation. Capital gain is the difference between the selling price of a capital asset and its original cost, or basis. A capital asset is property held by the taxpayer. Capital loss occurs when the cost of an asset is greater than its selling price.

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The conditions under which forestry investments and income and loss are considered capital or ordinary are discussed later in this section.

A major difference between capital gain and ordinary income is the manner in which costs can be deducted from income. With ordinary income, costs are expensed, that is, deducted from income in the year that the cost is incurred. In contrast, capital expenditures, costs that give rise to capital assets, are considered an exchange of one capital asset (cash) for another (property). Thus, no outflow of assets occurs. Capital expenditures or costs cannot be deducted from ordinary income in the year that they occur. Capital expenditures are recovered for tax purposes when the capital asset is sold or timber is harvested. Expenditures are then deducted from the capital gains. Considering the time value of money, it is generally best to deduct costs from ordinary income in the year they occur. Expenditures are not increased to reflect inflation, that is, a $100 expense in 1950 is still just $100 in 2007 when the harvest occurs and capital gains are realized.

The advantage to capital gains treatment is that mid-term and long-term capital gain income is taxed at lower rates than ordinary income. Capital gains reported before 1987 are exempt from taxation. Capital gains income is not taxable for Social Security purposes as ordinary income. For retired people receiving Social Security benefits, when earned income exceeds certain levels, part of the Social Security benefits must be paid back. Capital gains income is not considered earned income in this calculation.

Another difference between capital gains and ordinary income is the treatment of losses. Capital loss occurs when the original cost (or basis) is higher than the selling price. A capital loss is first deducted from the capital gains of other transactions. Any remaining loss is deducted from other income, but not more than $3,000 can be deducted in any tax year.

A difficulty in assigning capital gains treatment to timber is that the product is essentially the factory that produces the product. This discussion summarizes considerations important to owners of nonindustrial private forestland.

Timber for capital gains purposes includes standing trees used for wood products. It also includes Christmas trees older than 6 years of age from seed. Timber does not include logs already cut, tops, limbs, stumps, chips, seedlings grown for transplanting, or live trees used for ornamental purposes.

The timber must be held for a period of 18 months or longer (as measured from the date of acquisition to the date of disposal) to be eligible for long-term capital gains treatment. For landowners who purchase their property as an investment, infrequent lump sum sales of timber are allowed capital gains treatment. In a lump sum sale, payment is made for the standing timber as a whole unit and not on a per unit cut basis. Payment is usually made before the timber is cut. These sales must be discontinuous and isolated. If the taxpayer makes a substantial effort to promote the sale, capital gains treatment might be denied. This type of sale is generally for owners who are not managing their property for timber.

Section 631b of the Internal Revenue Code (IRC) is of special interest to forest landowners who actively manage their forest as a business. This section affords capital gains treatment to the taxpayer who retains an economic interest in the timber. The seller must retain legal title to the timber until it is cut. The date of cutting is when the volume of the timber is first accurately determined. The seller must be paid on a per unit cut basis. When selling timber on the stump, your contract must state that you retain title to the timber until it is scaled and that you are paid on a per unit basis. A well-written contract is essential to demonstrate a retained economic interest in the timber.

Depletion Allowance

As timber is cut, the original capital investment, the basis of the timber, is reduced or depleted. Because the trees are rarely all cut at the same time, the original cost must be modified to give the adjusted basis. The adjusted basis is the original purchase price of the timber adjusted for addition or deletion of the capital of the property. The depletion allowance is deducted from timber sale receipts in calculating taxable income. In this way the original investment in timber is recovered. Depletion is calculated the same for California income tax as it is for federal income taxes.

To use the depletion allowance, the cost basis of the timber must be established. The cost basis is the fair market value of the timber at the time of acquisition. The cost of land and improvements are carried in a separate account. At the time of purchase or inheritance, the fair market value of the property is allocated between the timber and the land. These amounts can be estimated well after original acquisition. However, there is a cost in making such determinations. For most landowners, if the property was acquired more than 10 years ago, the basis may have been so small that the cost of calculating that original basis may exceed the tax savings. The more recent the purchase, the greater the justification of the expense to calculate the basis.

If more timberland is purchased, the original basis must be updated. Remember to allocate between the land and the timber. As timber is cut, the basis must be depleted to reflect the amount removed. The depletion unit is defined as: depletion unit ($/MBF) = total adjusted basis (timber value) ÷ total timber volume, where MBF = thousand board feet.

The depletion allowance is determined by multiplying the volume of timber removed by the depletion unit. The basis is then adjusted by subtracting the depletion allowance from the previous adjusted basis. Land and timber translations relating to these sections of the IRC (§§ 1221, 1231, 631a, and 631b) are documented on IRS Form T, Forest Industries Tax Schedules.

Record Keeping

Up-to-date records must be kept to accurately assess tax liability and take advantage of tax reduction provisions. Good records are also necessary to take advantage of cost share programs. A written management plan is a useful tool to establish these records.

Two basic accounting methods may be used: accrual accounting or cash accounting. With the accrual method, transactions are recorded as they occur. The date of payment is not considered. Transactions under cash accounting are recorded when cash is received or paid out. Either system may be used. For the small landowner, cash accounting is often the easiest. The accounting system consists of a transaction journal and a series of ledgers documenting various accounts and subaccounts. The transaction journal is a chronological listing of all transactions regarding the property. Each transaction is given a number, which is used to key to the various ledgers. The date, description, amount, intent, and other pertinent details are given. Other financial information, such as the results of a timber cruise, can be included.

Ledgers documenting the various accounts should be maintained. At a minimum, accounts should be established for land, timber, buildings, improvements, and Christmas trees, if appropriate. Subaccounts are established in some of these to give a more specific representation.

The timber account is usually divided into subaccounts for plantation, submerchantable timber, and timber. The plantation subaccount documents the costs of site preparation, seedlings, planting, planting tools, and some costs of releasing the plantation. As the seedlings reach the sapling stage, the plantation subaccount is closed and amounts are transferred to the submerchantable timber subaccount. Likewise, when

the timber becomes merchantable, it is transferred to the merchantable timber subaccount. For mature timber, both cost and volume data should be kept.

A similar series of accounts are kept for Christmas trees. Because they become merchantable faster than most other forest products, special rules apply.

Land, building, equipment, roads, and other assets should have a separate account. In short, any asset on which depreciation is taken or that may affect the adjustment of the basis should be included in the accounting system.

Expenses

Expenses may be capital, ordinary, or carrying charges. Capital expenses are related to obtaining or improving a capital asset. They are not deductible in the year they are incurred but are recovered when the capital asset is sold, that is, when timber is harvested. The expenses of a sale are costs that must be charged against capital gains.

Ordinary or current expenditures are deducted from income in the year they occur. Because of the time value of money, it is usually advantageous to write off costs as short-term expenses whenever possible, that is, deducting expenses from current income reduces taxes more than deducting those expenses from future capital gain because $100 in current expenses will be just $100 when the timber is harvested 50 years in the future. There is no increase in costs due to inflation. Whether expenses are capital or ordinary is frequently debated.

Carrying charges are ordinary expenses that may be capitalized at the election of the taxpayer. These costs are deductible, but in some situations, ordinary expenses—such as interest on mortgage, fire protection costs, or insurance—may be treated as capital expenses. Taxpayers who take a loss for the year and have no income to deduct expenses from or who take the standard deduction instead of itemizing deductions may benefit from capitalizing these expenses. Some taxes are deductible as ordinary expenses if itemized on your federal return. These include state and local taxes for real and personal property and income taxes. Federal income, excise, gift, inheritance, or estate taxes are not deductible.

Most of the costs of reforestation are considered capital expenses in that they produce a capital asset. These costs should be included in the basis for depletion. Brush removal within 2 years of planting is considered a cost of reforestation and should be capitalized.

Because reforestation is considered a capital expense, it has generally been a disincentive to small landowners to invest in their land due to the long holding period before these capital expenses can be deducted from capital gains income. In 1980, to encourage reforestation, Congress passed PL 96-451, allowing a 10 percent tax credit for planting and reforestation expenses to a maximum of $10,000 per year. Cost-share assistance receipts cannot be included in the total. In addition to the 10 percent tax credit, certain eligible expenses may be amortized over 7 years.

California tax law differs from federal tax law for reforestation expenses. Certain expenses may be amortized over 60 months (5 years), instead of 96 months (8 years). Election to amortize is decided by the taxpayer but must continue until fully amortized.

The costs of timber cruises (an inventory of trees or timber) are deductible from ordinary income when the expenses are incurred for management purposes, such as developing a management plan. Timber cruises for the purpose of establishing a timber sale volume are a cost of the sale and are deducted from sale proceeds when the sale occurs.

Costs for temporary logging roads that are used for one operation and then abandoned are depreciated over the period of use. Permanent roads have various costs that are treated separately. Costs of establishing the road, such as surveying, clearing the

Reforestation Tax Credit

The following example illustrates the procedure used to calculate the reforestation tax credit.

Assume a small landowner has $12,000 in eligible reforestation expenses, of which 75 percent is covered by cost-share programs. Under the current law, 10 percent of the amount, exclusive of the cost-shared amount, is eligible for the reforestation tax credit. The reforestation tax credit amount = $12,000 – (0.75 × $12,000) (the cost-share grant amount) = $12,000 – $9,000, or $3,000. The landowner can take a 10 percent tax credit on the $3,000 invested: $3,000 × 0.10 = $300. This is a tax credit that reduces your tax liability, not a deduction from income.

In addition, the full $3,000 can be amortized over a 7-year period. Because the investment is assumed to occur in mid-year, only one-fourteenth may be deducted in years 1 and 8. In years 2 to 7 the landowner deducts one-seventh of the investment. This deduction for the $3,000 investment is calculated as follows: Years 1 and 8: $3,000 ÷ 14 = $214.28; Years 2 through 7: $3,000 ÷ 7 = $428.57.

roadbed, or other nonrecurring costs, are capital investments used to adjust the basis. Costs for culvert repair, bridges, or other periodic events are depreciable as a capital expense. Annual maintenance costs, such as graveling, repairing water bars, and mowing roadsides, are deductible expenses from ordinary income.

Casualty losses resulting from sudden, unanticipated natural disasters may be deducted from ordinary income. Fire losses are the most common example. In contrast, losses due to insect attack usually must be capitalized. These types of losses are considered capital losses because they can be anticipated and lessened by planning and preemptive actions such as thinning and competition control. It helps to have a good inventory of your timber and other values when claiming these losses. It can be difficult and expensive to recreate conditions and values before the fire or disaster after the fact.

Active, Passive, and Portfolio Activities

Three types of income or loss are recognized: active, portfolio, and passive. Active income includes salary, bonuses, and other income derived from for-profit activities in which the taxpayer materially participates. Portfolio income is derived from investments and includes interest, dividends, and royalties, unless earned in the ordinary course of a trade or business. Passive income or loss is derived from limited partnerships and other business, trade, or investment activities in which the taxpayer does not materially participate.

Losses from passive activities can offset only passive income. They cannot be deducted from active or portfolio income. Passive losses can be carried over to future years and applied against future passive income. Tax credits from passive activities, such as the reforestation tax credit, can offset only the tax payable on passive income. The basis in property is reduced by depreciation even if the deductions are not usable because of passive loss rules.

Most taxpayer losses from real estate operations are considered passive, even if the taxpayer is materially participating. If the taxpayer has at least a 10 percent interest in the venture, up to $25,000 of losses may be considered nonpassive and, therefore, deductible.

The use of consultants should not make an activity passive if the consultant, such as a forester, acts at the request of the taxpayer rather than as a paid advisor directing the conduct of the taxpayer. This means that the taxpayer must make the actual decisions; however, the forester can make suggestions and recommendations.

Other Income Tax Laws Affecting Landowners

If an activity makes a profit in less than 3 out of the past 5 years, the IRS assumes that the activity is a hobby and not a profit-making activity, that is, not a business subject to business expense and tax treatment. All such assumptions by the IRS may be contested, usually successfully. A written management plan demonstrates the long-term nature of forestry investments and the landowner's objective of a profit-making activity.

Tax laws are complex and subject to interpretation by the taxpayer, courts, and the IRS. If your tax situation is complicated, consult with a professional tax consultant or certified public account who is familiar with tax treatment of timber. Many are not. Conversely, foresters who are technically proficient in their field may be unfamiliar with tax laws. Some foresters do specialize in tax preparation.

All professionals charge for their time, usually by the hour. Keeping your records clear and organized may save a significant amount of money in tax preparation costs. Current knowledge of tax legislation and regulations, including recent changes, may allow you to minimize tax liability within the law's constraints. Joining landowner associations is one means of keeping current.

PROPERTY TAXATION

The traditional means of revenue generation for local governments in California has been the collection of an annual ad valorem property tax, that is, an annual tax based on the current assessed value of property at its highest and best use. On forest property, where annual taxes must be paid out of infrequent income from timber sales, annual ad valorem taxes have been a disincentive to sustainable forest management for small landowners. The ad valorem tax has often been seen as an incentive for converting the land to its defined "highest and best use," which is usually the conversion of open space forest to subdivision and homes. Changes in California property tax laws were enacted in 1976 to alleviate these problems.

In 1976, the state Forest Taxation Reform Act established a timber yield tax and the timberland preserve zone, later renamed timberland production zone (TPZ), to emphasize the timber production and working forest intent of the legislation. The annual ad valorem property tax on standing timber value was changed to a yield tax on harvested timber.

Timberland Production Zone

A timberland production zone (TPZ) is a county zoning classification in which the primary allowed use is the production of timber. Annual property tax is paid, but the assessed value of TPZ land is based on its value for growing timber, not its development value for homes. This usually results in a lower tax assessment than customary "highest and best use" valuation. In return for the lower assessment, the property must be managed for timber and compatible uses for a minimum of 10 more years.

TPZ property valuation is determined in a joint process between the county assessor and the State Board of Equalization. TPZ land is put into five productivity classes by the county assessor corresponding to timber site class (Sites I to V) as determined from soil and vegetation surveys or other sources. The State Board of Equalization prepares timberland value tables based on these productivity classes. These tables show the bare land value for TPZ land. The assessor can add to these values for existing compatible uses such as grazing value per acre.

There are two ways to obtain TPZ zoning if it is not currently applied to a property. Under the first procedure, the landowner petitions the county to classify the land as TPZ. The land must be capable of growing and harvesting timber, and it must meet the following criteria.

- A forest management plan prepared or approved by a registered professional forester (RPF) must be submitted. Timber harvest must be provided for in a reasonable time.
- The parcel must meet stocking requirements set forth in the forest practice rules adopted by the State Board of Forestry for the district in which the parcel is located. Alternatively, the landowner can make an agreement with the county that stocking requirements will be met within 5 years.
- At the county's option, two additional requirements may have to be met. These are a minimum contiguous ownership of up to 160 acres (some counties elect to make this contiguous ownership smaller) and that the land must be Site III or better.

The second way is that timberland may be added to an existing TPZ parcel if the landowner already has TPZ land contiguous to the new property. Some counties require physical contiguity, while others require the addition to be managed jointly, without physical proximity.

You may be able to remove property from TPZ by either of two processes. The first is to petition the county board of supervisors for rezoning. This method faces some constraints. The county does not have to approve the rezoning. Also, rezoning is not effective until 10 years after the date of approval. Finally, property taxes increase immediately and continue to increase annually over the ensuing 10 years.

Immediate rezoning allows for a new land use upon approval. Immediate rezoning requires that a public meeting be held to show that rezoning is in the public interest. An environmental impact report (EIR) may be required at the landowner's expense. A conversion permit from the State Board of Forestry must be obtained. Immediate rezoning requires you to pay taxes on the full cash value of the property in its new use for the current year and for the number of years, up to 10, that the property has been in TPZ.

The purpose of the rezoning and immediate rezoning restrictions is to ensure that TPZ valuation is not used simply as a tax shelter. TPZ landowners wishing to convert their land to another use have a mechanism to do so, but that mechanism may be costly.

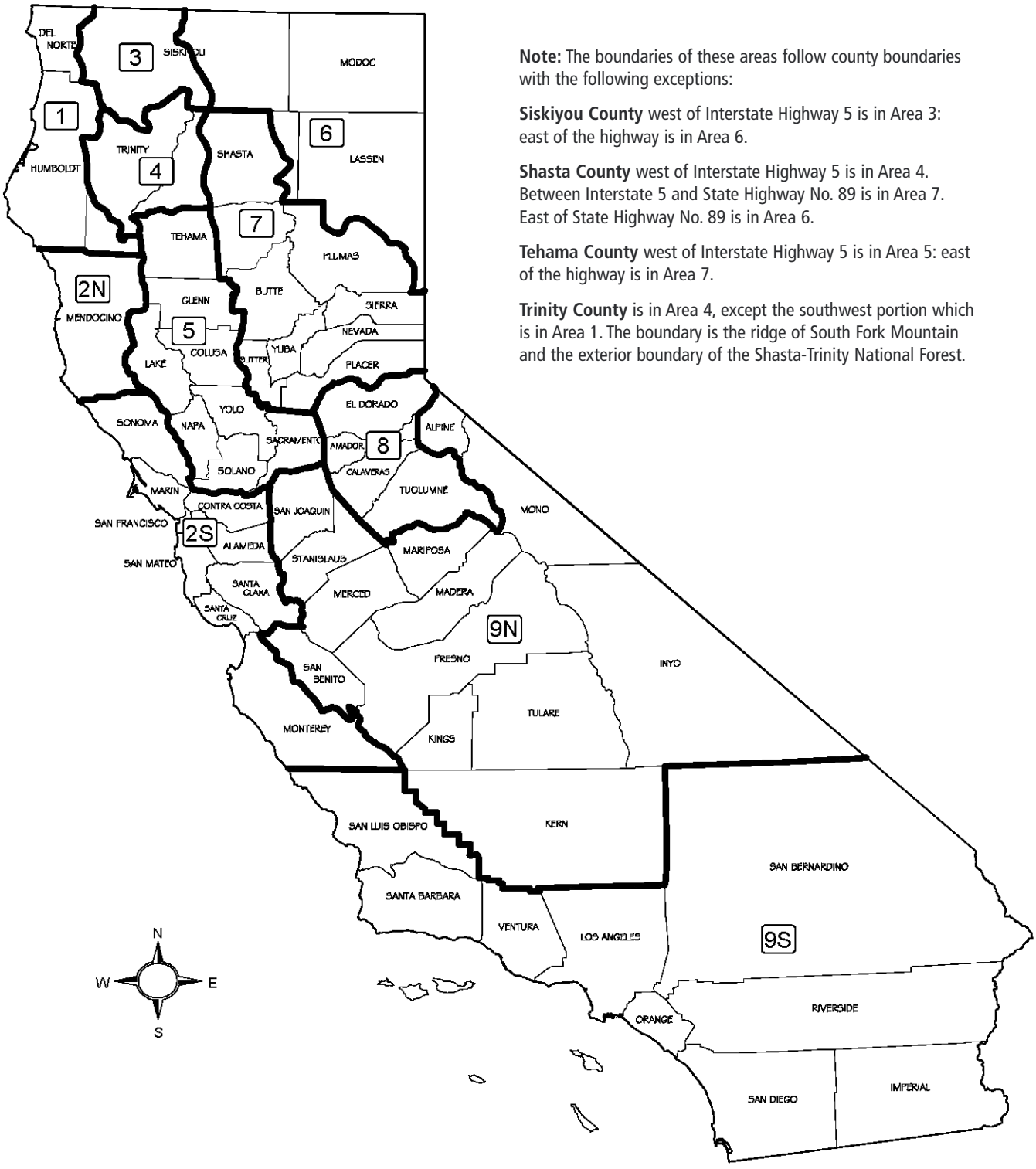
YIELD TAXATION

Under the current yield tax system, a tax is paid on the value of the timber just before it is harvested. This is the stumpage value, the value of the tree standing on the stump. The owner of the timber at the time it is cut is responsible for paying the tax. Often the Licensed Timber Operator (LTO, or logger) who harvests the timber arranges for this tax to be paid.

Taxpayers use the current Harvest Value Schedule to compute the yield tax. Every six months, the State Board of Equalization, Timber Tax Division, publishes the Harvest Value Schedules that show average timber prices for geographical areas called timber value areas (TVAs) (for a map showing the boundaries of the timber value areas, see figure 1. The map is also available at the BOE Web site, http://www.boe.ca.gov/proptaxes/pdf/20071HFinal.pdf). TVAs generally have uniform prices for timber throughout. The actual price you receive for your timber will probably vary from the schedule values, which are the previous six-months' average of many sales. However, the tax you pay is based on the schedule values, not your actual sales prices. Harvest value schedules are posted at the BOE Web site given above.

To calculate the tax, locate the TVA for your property and note the species, quantity and quality of the timber harvested along with the type of logging system used. At the bottom of the table are adjustments to harvest value that may apply to your situation. Multiply the volume you harvested by the value reported in the table, and then by the tax rate, which is 2.9 percent. This timber yield tax rate has been very stable at 2.9 percent for more than a decade.

For example, using the January 1 through June 30, 2007, Harvest Value Schedule, Table G, if your harvest is in El Dorado County, your TVA is 8 (TVA8). Assume you harvested 75 MBF of young-growth ponderosa pine using tractor logging. The Harvest Value Schedule lists young-growth ponderosa pine in TVA8 at $270 per MBF. However, there is a $100 adjustment for a small total volume of less than 100 MBF harvested in that quarter, making your harvest value $170 per MBF. Multiply the adjusted harvest value ($410 per MBF) by the volume harvested (75 MBF) to get the total harvest value ($12,750). Multiply this by the 2.9 percent tax rate to get a yield tax of $370. Note that the Harvest Value Schedule value, not the actual timber revenue, is the basis for determining yield tax payments.



Note: The boundaries of these areas follow county boundaries with the following exceptions:

Siskiyou County west of Interstate Highway 5 is in Area 3: east of the highway is in Area 6.

Shasta County west of Interstate Highway 5 is in Area 4. Between Interstate 5 and State Highway No. 89 is in Area 7. East of State Highway No. 89 is in Area 6.

Tehama County west of Interstate Highway 5 is in Area 5: east of the highway is in Area 7.

Trinity County is in Area 4, except the southwest portion which is in Area 1. The boundary is the ridge of South Fork Mountain and the exterior boundary of the Shasta-Trinity National Forest.

Figure 1. Timber value areas of California. *Source:* Courtesy California State Board of Equalization..

Questions To Ask When Choosing an Estate Planning Lawyer

Estate planning for forest landowners is unique. Your lawyer must be knowledgeable in this specialized field. The following questions are designed to help you assess the candidate's knowledge of estate planning as it relates to forestland.

Q. How is Form T, the Forest Industries Schedules, used to formulate adjusted basis and depletion of timber lands?

A. Schedule F of Form T provides a series of questions that establish depletion or adjusted basis (basis is essentially a calculation of "book value" for the land.)

Q. What is special use valuation and how does it apply to forest ownership?

A Special use valuation is a special provision within the federal tax code that allows an estate to be evaluated by its present use rather than the highest and best use, which is normally used. Under certain circumstances, forest estates can be appraised for timber growing rather than for potential development use, thus reducing the value of the estate and estate tax liability.

Q. Who is the consulting forester you have worked with in other estate planning endeavors?

A. Although the answer may include several foresters, you should expect the lawyer to have a working relationship with a capable and trustworthy forester.

Q. What is a conservation easement?

A. It is an agreement between a landowner and a conservation organization or public agency that restricts the use of the property in perpetuity, to keep the land in forest use.

Q. When a conservation easement is passed to a legal recipient, how many years does one have to use up (carry forward) the value in tax deduction?

A. Five years.

Q. What is a remainder interest?

A. The act of making a gift now to take effect at the time of death.

Q. Under the "general rule," how much may a taxpayer who makes a charitable contribution of property deduct from his or her income?

A. Thirty percent.

Q. Under the "special rule," what provisions apply?

A. Under this rule, a taxpayer who makes a charitable gift of appreciated property can choose to reduce the amount of the deduction to the cost or basis of the property.

Q. Who is Stephen J. Small?

A. He is the author of *Preserving Family Lands*, a book on estate planning, and the original author of the federal tax law that provides special tax treatment for donated conservation easements.

Other important questions:

Q. How many estate plans have you prepared for nonindustrial private forestland owners?

Q. What is your fee schedule?

Q. How will you determine what my interests and objectives are? (It is important that you choose a lawyer who has your interests and objectives in mind.)

Q. Can you provide three nonindustrial private forestland owner references who have received estate planning services from you? (You should contact the references for recommendations.)

Source: Michael Washburn and Lloyd Casey, *Forest Stewardship 13: Estate Planning* (University Park: The Pennsylvania State University and the Pennsylvania Forest Stewardship Program, 1997), reprinted with permission.

ESTATE PLANNING

Federal inheritance taxes apply only if your taxable estate is $1 million or more (2007). Inheritance tax laws will be changing in 2010, so visit the National Timber Tax Web site (http://www.timbertax.org/) for updates on this and other taxes.

Good estate planning can save your heirs thousands of dollars and may prevent the selling of parcels or heavy logging to pay estate taxes. This is particularly true in California, where land values are high and many forest landowners are "land-rich and cash-poor," which can lead to a crisis for your heirs. However, forest landowners should take a broad view of estate planning and wealth transfer, and not focus solely on minimizing estate taxes unless that is your sole estate goal and interest. Some of the more common estate planning strategies include

- gifting, or taking advantage of tax-free gifts of $10,000 per year per person to an unlimited number of recipients
- living trusts, which avoid probate and help reduce taxes
- life insurance and life insurance trusts, which can provide the cash needed to pay the estate tax
- charitable gifts you make to reduce the tax liability of the estate
- family partnerships to remove property from the taxable estate
- conservation easements to help reduce the taxable basis of the estate

The tax laws are changing, and proposals exist to eliminate estate taxes altogether at some point in the future. Bear in mind, however, that it is wise to plan your estate around the possibility that the tax may not be completely eliminated. The new laws sunset in 2010 and, if not extended by Congress, the current laws would remain in effect.

Estate planning is even more complex than timber taxation. Knowledge of and experience with the estate tax laws is necessary to ensure that your estate is taxed at the minimum legal rate. It is critical to have the assistance of a good estate planning lawyer. To find a good lawyer, ask your forester, other landowners, or members of organizations such as the Forest Landowners of California (www.forestlandowners.org).

The services of a good estate tax lawyer, trust officer, and estate planner may be necessary if your efforts for producing a valuable timber crop on your land are to be continued by your heirs.

Remember that the professionals you employ charge by the hour, and an expert's time is costly. Those charges, though, are frequently money well spent in terms of the amount of taxes assessed. The following questions will assist you in determining your estate and wealth transfer goals, whether or not you hire professional help.

- Who will receive your assets? You must supply the name of your beneficiary and any special considerations, such as if the beneficiary is under age of majority.
- Why are you making your estate plan? What are your objectives?
- When do you want to implement the transfer—during life, at death, or after death?
- What property rights do you wish to transfer and to whom? You should have a reasonable inventory of the assets on your property.
- How, given your objectives, is the property to be transferred? Tax savings are important at this point but only to the extent they do not interfere with your objectives.

Due to the great complexity of estate planning, you are strongly advised to consult a professional in order to ensure that the land that is such an important part of your life continues to benefit your family.

CONSERVATION EASEMENTS

A conservation easement is a tool for forest landowners to preserve or conserve certain aspects of their property. The easement places restrictions on the use of the property, for example, prohibiting tree clearing for intensive agricultural development or for subdivision. These restrictions can reduce the assessed value of the property and the annual and estate taxes due.

For example, a property worth $500,000 before restrictions might be worth only $100,000 after an easement is in place that, for example, restricts subdivision and development rights. A very restrictive easement can reduce the assessed value of the land by as much as 90 percent. The $400,000 "loss" can be taken as a charitable contribution by the landowner over a 5-year period to reduce taxable income. It also reduces the value of the taxable estate and can therefore be a useful estate planning tool. In some cases, the landowner may receive payment for the conservation easement. The controls on land use that are imposed in perpetuity are as important as the tax implications of an easement. In this case, the property can never be subdivided and developed and will continue to function as a forest.

A Landowner's Experience with a Conservation Easement

Chris Hayes has nothing but positive things to say about conservation easements. It worked for him.

Hayes owns 952 acres of mixed range and forestland that spans the Sonoma-Mendocino county border. He bought the property 12 years ago to use for hunting. It had been logged in the past but his interest was in stewardship activities, including a nonindustrial timber management plan (NTMP) to do forest thinning.

In 1997, Hayes was looking for a tax break and decided to investigate conservation easements. He did a lot of homework, got good professional help, and was able to accomplish his objectives with a conservation easement. He feels that everyone benefited from the transaction. "It's one of those situations where it's beneficial to the landowner and the land both."

This was a learning experience that took a bit of effort. First, Hayes had to find a land trust to take his easement. He also hired an attorney who was knowledgeable about conservation easements to go over the agreement. Since timber was a great deal of the value of the property, he worked with a forester to evaluate the forest resources and give advice on long-term management. And an independent appraiser was needed to calculate the property's total worth.

The costs of securing the conservation easement included payments to all the professionals plus a gift to the land trust for management purposes constitutes a charitable donation. But all those costs are tax deductible, and Hayes feels he got "a good deal."

"It's time consuming. You have to go through a few steps," Hayes acknowledges. The number of steps depends on how big the property is and how complicated the easement is. Hayes was under a time constraint because he wanted the tax break at the end of the year. His easement took 6 months to complete.

A conservation easement devalues the property by restricting certain rights. In this case, the development rights that were ceded were rights Hayes had no intention of exercising anyway. Twenty acres around the house were excluded from the conservation easement in case he wants to "do things" with that area in the future.

"The conservation easement is pretty specific. The land trust maps the whole property and then goes over it on the ground. They have the right to come by to check that the easement terms are being followed, but usually they will notify and let us know they are coming by to check. It hasn't been invasive at all. They've only been up there once in three years. It all depends on the land trust, the nature of the easement, and how easy it is to come by."

Forest management plans are built into a conservation easement. Each one is different, depending on the needs and objectives of the landowner, the land trust, and the property characteristics. Hayes retained the right to log within the NTMP.

"You can give away as much or as little as you want," he notes. "It all depends on how you write up the easement. Basically it's a negotiation—as long as you have something the land trust values, you have leverage."

His experience has inspired others. Since Hayes got his conservation easement, his neighbors are following suit.

His advice for others? The most important thing is to make sure you know what you're willing to give up. Get an attorney to look out for your interests.

"For me it was a perfect match. I don't have designs to change the property any more than it's been changed. It hasn't really changed my life or how I use my property."

An easement is held by a conservation organization, such as a land trust, that helps in the planning and writing of the easement. Have a forester look over the easement to make sure you are giving up only those rights you want to give up. Land trusts vary in the types of easements they prefer to handle. Some focus on strict preservation while others support working landscapes where agriculture, cattle grazing, or timber production are permitted with some restrictions.

Because conservation easements are tied to the title of the land and are usually valid in perpetuity, be careful about what rights you give up and pay close attention to the wording. Think about what could possibly happen, not what usually happens, because the easement will apply to all situations. Be sure you understand the fine print, and have your forester or lawyer explain anything you do not understand.

The easement can be tailored to suit your needs and objectives. Below are some examples of rights that you can choose to give up or specifically retain.

- Subdivision, which includes the right to divide parcels or sell off individual parcels from a large holding.
- Development, which might include development for housing, vineyards, or other purposes.
- Timber harvesting. You may choose to prohibit or restrict timber operations. You may agree to or decline restrictions related to harvest timing or frequency, silvicultural systems, and environmental constraints.

Conservation easements are expensive, but if you have an income high enough to take advantage of the charitable contribution tax deduction, they can reduce your income taxes. Costs associated with developing the easement include planning, writing, filing fees, and a donation to

Conservation Easement Frequently Asked Questions

Q. What is a conservation easement?

A. A conservation easement is a voluntary agreement with a nonprofit land trust or government agency that allows a landowner to limit the type or amount of development on their property while retaining private ownership of the land. When completed, the conservation easement becomes part of the property deed. A way to visualize this is to think of owning land as a bundle of property rights: —the right to build a house, extract minerals, harvest timber, allow hunting, graze cattle, subdivide the property, and so on. A landowner may give up certain rights through the conservation easement.

Q. How does it work?

A. Conservation easements are tailored to the needs of the landowner and the recipient organization (which must be a qualified nonprofit organization or government agency). The easement holder agrees to hold, but not use, the transferred rights. A landowner may either donate the conservation easement or sell it for partial or full appraised value. The terms of each conservation easement are negotiated by the landowner and the recipient organization.

Q. Who owns and manages easement protected land?

A. The landowner retains full rights to control and manage the property within the terms of the easement. The landowner continues to bear all costs and liabilities related to ownership and maintenance of the property. The organization that owns the easement will monitor the property to ensure compliance with the easement's terms, but it has no other management responsibilities and exercises no direct control over other activities on the land.

Q. Why do people grant conservation easements?

A. People grant conservation easements because they want to protect their property from future unwanted development or land uses while retaining ownership of their land. By granting a conservation easement, a landowner can assure that the property will be protected forever, regardless of who owns it in the future. An additional benefit is that the donation of an easement may provide significant financial advantages.

Q. What kind of financial advantages result from donating an easement?

A. Many landowners receive a federal income tax deduction for the gift of a conservation easement, as a charitable donation. The IRS allows a deduction if the easement is perpetual, is donated "exclusively for conservation purposes," and meets certain criteria for those conservation purposes. The amount of the tax deduction is determined by the value of the easement. In addition, the landowner may realize estate and property tax relief because the value of the property is reduced.

Q. What activities are allowed on land protected by an easement?

A. These depend on the landowner's wishes and the terms of the easement. In some cases, no further development is allowed. In others, some additional development is allowed, but the amount and type is restricted. Conservation easements may cover all or a portion of a property, and specific restrictions can vary for different parts.

the conservation organization to enforce the easement. The conservation organization is charged with ensuring that the conditions of the easement are followed in perpetuity by the landowners, and the donation is designed to cover the costs of doing so.

SUMMARY

Tax laws are complex, and most forest landowners will require the assistance of qualified tax professionals if they have relatively active management programs involving timber production. A few general principles can help you and your family.

- Keep accurate, well-organized, detailed records. If you are engaged in timber production, keep subaccounts for land, timber, buildings and improvements, and Christmas trees. In many cases you'll also want to keep separate subaccounts for plantation documents (site preparation, planting, etc.), submerchantable timber, and merchantable timber, including volume data for older stands.
- Reporting your timber sale income as capital gain rather than as ordinary income can reduce taxes by avoiding the 15 percent self-employment tax. Capital gain income also has a lower marginal tax rate than ordinary income. Spread income over tax years if possible.
- Many costs of managing and maintaining your forest land are tax deductible.
- Tax credits (a direct reduction in income tax) for reforestation expenses are available for 10 percent of allowable costs. These credits, up to $10,000 per year, are available for seedlings, planting, and other expenses including brush removal up to 2 years after planting.
- Tax deductions (reducing taxable income) for reforestation expenses are available in addition to the tax credits. These deductions are spread over 7 years.

Conservation Easement FAQ, cont.

Q. Can the landowner still sell or give the property away?

A. The landowner continues to own the property after executing an easement. Therefore, the owner can sell, give, or lease the property as before. However, all future owners are subject to the conditions of the easement.

Q. Does the public have a right of access to easement-protected property?

A. Not unless the landowner who grants the easement specifically allows it. Most easement donors do not want, and therefore do not allow, public access to their property.

Q. How long does an easement last, and who upholds it in the future?

A. To be eligible for a federal income tax deduction the easement must be "perpetual," that is, it must last forever. The property is monitored by the land trust or government agency—the easement grantee—to assure that the terms of the easement are not being violated. If the easement has been breached, steps must be taken to uphold its terms. Land trusts typically require the landowner to make a financial contribution (tax deductible) to cover the long-term management costs of enforcing the easement.

Q. Does the easement have to cover all of the landowner's property?

A. No, some easements cover only a portion of the property; it depends on the landowner's wishes. For example, if someone owns 80 acres, of which 35 acres are wetlands, the landowner may decide to restrict development only on these 35 acres. The remaining 45 acres would not be affected by the easement.

Q. What kind of land can be protected by conservation easements?

A. IRS regulations require that the property have "significant" conservation values. This includes forests, wetlands, endangered species habitat, scenic areas, and so on.

- Generally, you'll want to expense costs (deduct them in the year they occur), depreciate what cannot be expensed, and add to the basis what cannot be expensed or depreciated, to reduce the capital gain.
- Losses from disasters such as fires or windstorms are deductible as a casualty loss.
- Cost-share payments must be reported as income, though you may be able to ultimately exclude some or all of those payments.
- Remain an active participant in your business.
- Demonstrate a profit motive in your forest property ownership by having a written long-term management plan. This helps demonstrate your profit motive so that the IRS will not consider your activity a hobby.
- Whether you manage for timber production or not it is extremely important to protect your estate. You may also want to consider the benefits of entering into conservation easements as a way of reducing tax burdens and ensuring that your management style is carried forward.

RESOURCES

General Information on Taxation

Haney, H. L. Jr, W. L. Hoover, W. C. Siegel, and J. L. Greene. 2001. Forest landowner's guide to the federal income tax. Agriculture Handbook 718. Washington, DC: Government Printing Office. USDA Forest Service Web site, http://www.srs.fs.usda.gov/pubs/misc/ah_718.pdf.

National Timber Tax Web site, http://www.timbertax.org/, an excellent source of current tax law and information.

Tax Tips for Forest Landowners, a two-page summary produced each year by the Forest Service. A free copy of the most recent summary is available from the Forest Stewardship Helpline at 1-800-738-8733. For the 2006 summary, see the Forest Service Web site, http://www.na.fs.fed.us/pubs/taxtips/taxtips.pdf.

Property Taxes

Contact your county assessor.

Yield Taxes

California State Board of Equalization, Timber Tax Division, 450 N Street, MIC: 60, P.O. Box 942879, Sacramento, CA 94279-0060. Phone 916-445-6964 or 1-800-400-7115, Web site http://www.boe.ca.gov/.

California Timber Yield Tax. 2007. Publication 86. Sacramento: California State Board of Equalization. BOE Web site, http://www.boe.ca.gov/proptaxes/pdf/pub86.pdf.

Guide to the California Timber Yield Tax. 2007. Publication 87. Sacramento: California State Board of Equalization. BOE Web site, http://www.boe.ca.gov/proptaxes/pdf/pub87.pdf.

Forestry-related Taxes and Estate Planning

Haney, H. L. Jr., and W. C. Siegel. 1993. Estate planning for forest landowners: What will become of your timberland? USDA Forest Service General Technical Report SO-97. Forest Service Web site, http://soforext.net/pdfs/estate.pdf.

Hoover, W. L. Timber tax management for tree farmers. Annually updated loose-leaf binder. West Lafayette, IN: Purdue University Department of Forestry and Natural Resources. For information on ordering, telephone 1-888-398-4636.

ENGLISH–METRIC CONVERSIONS

English	Conversion factor for English to Metric	Conversion factor for Metric to English	Metric
foot (ft)	0.3048	3.28	meter (m)
yard (yd)	0.914	1.09	meter (m)
mile (mi)	1.61	0.62	kilometer (km)
acre (ac)	0.4047	2.47	hectare (ha)

FOR FURTHER INFORMATION

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FOREST STEWARDSHIP SERIES 23

Technical and Financial Assistance

YANA VALACHOVIC, UCCE Forest Advisor, Humboldt and Del Norte Counties

UNIVERSITY OF CALIFORNIA
Division of Agriculture and Natural Resources
http://anrcatalog.ucdavis.edu

UC PEER REVIEWED

Objective

Identify and understand the technical assistance and cost-share programs available to help you in your forest stewardship.

Competencies

- *Understand that University of California Cooperative Extension forestry and general natural resource specialists are located in several forested counties. They are available to help with many of your management questions and can help you understand many of the resources presented in this leaflet.*
- *Become aware that additional resources can be found through the Forest Stewardship Helpline (1-800-738-TREE) and CAL-FIRE's forestry assistance specialists.*
- *Understand that cost-share programs can offer financial assistance for accomplishing management goals, such as thinning, forest stand improvement, tree planting, and wildlife habitat improvement.*

Related Forest Stewardship Series Publications

- *Professional Assistance, ANR Publication 8254*
- *Stewardship Objectives and Planning, ANR Publication 8248*

GENERAL ASSISTANCE ON FORESTRY QUESTIONS

University of California Cooperative Extension (UCCE)

http://www.ucanr.org

UCCE staffs 64 county-based offices to bring the University's research-based information to all California residents. More than 400 campus-based specialists and county-based farm, forestry, natural resources, home, and youth advisors work as teams to develop and deliver practical solutions for local problems. Their efforts range from technical forestry and farm assistance and water conservation research to nutrition education for low-income families and advances in veterinary medicine.

UCCE is a partnership of federal, state, county, and private agencies and organizations. UCCE's teaching tools include Web-based publications (like this one), meetings, conferences, workshops, demonstrations, field days, video programs, newsletters, and manuals. Visit the UC Agriculture and Natural Resources Web site (above) for contact information, subject matter information, publication lists for all UCCE academics, and links to further information.

The Forest Stewardship Helpline

1-800-738-TREE
http://ceres.ca.gov/foreststeward

The Forest Stewardship Helpline provides a free service for California forest landowners and the public. The helpline is staffed by a registered professional forester (RPF) who can answer questions or provide referrals on any California forestry-related topic.

Forestland Steward Newsletter

http://ceres.ca.gov/foreststeward

This quarterly publication for forest landowners is available by a free subscription through the Forest Stewardship Helpline. Archived newsletters are available at the California Forest Stewardship Program Web site.

Forestry Assistance Specialists—California Department of Forestry and Fire Protection (CAL FIRE)

http://www.fire.ca.gov/

For a list of forestry assistance specialists, contact the Forest Stewardship Helpline or visit the CAL FIRE Web site, http://www.fire.ca.gov/ResourceManagement/PDF/ForestAdvisorList6-5-01.pdf.

Resource Conservation Districts (RCDs)

There are currently over 100 RCDs in the state working to create opportunities for private landowners to identify and accomplish stewardship goals on an individual or watershed basis. RCDs are

independent local government organizations that coordinate between local landowners and the federal government, primarily with the Natural Resources Conservation Service, to promote voluntary conservation of land, water, forests, wildlife, and other resources. As a local government entity with no regulatory power, RCDs can work with any local, state, or federal agency through simple cooperative agreements. This allows them to receive and spend conservation grant funding. To find the RCD in your area, contact the California Association of Resource Conservation Districts (CARCD) at http://www.carcd.org.

GOVERNMENT AGENCIES

California Department of Fish and Game (DFG)

http://www.dfg.ca.gov

A state agency that manages California's wetlands, wildlife habitats, and ecosystems.

California Department of Forestry and Fire Protection (CAL FIRE)

http://www.fire.ca.gov

A state agency that provides fire protection and oversees enforcement of California's forest practice regulations that guide timber harvesting on private lands. Additionally, they provide a financial assistance program to small landowners (see the State Forestry Assistance section of this publication) and have a conifer nursery that sells seedlings for your planting projects. Local units can be reached under the "State Government" listings in a telephone directory or at the CAL FIRE Web site given above. Information about the nursery program can be found at http://www.fire.ca.gov/rsrc-mgt_statenurseries.php.

USDA Natural Resources Conservation Service (NRCS)

http://www.nrcs.usda.gov/

A federal agency with experts in soil science. NRCS administers federal cost-share programs such as the Environmental Quality Incentives Program (EQIP). The NRCS also creates and distributes soil maps; for information from soil surveys, see http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx.

USDI Fish and Wildlife Service (FWS)

http://www.fws.gov

This federal agency may be helpful when seeking information about wildlife habitats and endangered species environments.

USDA Forest Service (FS)

http://www.fs.fed.us

This federal agency manages 18 National Forests in California comprising 20 million acres. Local forest supervisor offices and district offices have information about national forests adjacent to private landowners. The Forest Service often has fire protection responsibilities in forested rural areas. The Forest Service also has a research branch, the Pacific Southwest Research Station, in Albany, California, that conducts forest management, wildlife, fire, soils, and watershed research. For more information, see their Web site, http://www.fs.fed.us/psw/.

USDI National Marine Fisheries Service (NMFS)

http://www.nmfs.noaa.gov/

This federal agency is responsible for marine fishes, including those that live part-time in freshwater such as salmon and steelhead.

COST-SHARE PROGRAMS AND TECHNICAL ASSISTANCE

Many state and the federal forestry assistance programs are available to landowners. Assistance is available in the form of cost-share opportunities; local, state, and federal agency programs; and free or low-cost publications on many subjects, from forest and habitat improvement to fuel reduction projects. Funding for these programs changes annually.

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, 1-800-738-TREE. This guide was last updated in 2003 and some of the information is out of date, but it does provide a good summary of how to determine your eligibility to various cost share programs.

Contact local offices and staff of the CAL FIRE, RCD, and NRCS for more cost-share information.

STATE FORESTRY FINANCIAL ASSISTANCE PROGRAMS

California Forest Improvement Program (CFIP)

www.fire.ca.gov/php/rsrc-mgt_forestryassistance_cfip.php

CFIP is administered by CAL FIRE and is designed for private nonindustrial landowners to improve their forest productivity, including timber, fish and wildlife habitat, and soil resources. Activities covered under this program include management planning, reforestation, site preparation, thinning, land conservation (erosion control, forest road rehabilitation, revegetation) and fish and wildlife habitat improvement. Landowners who own between 20 to 5,000 acres of forestland with at least 10 percent forest cover are eligible. Tribal trust lands are not eligible. The cost-share rate is generally 75 percent, with a higher rate of 90 percent going to those properties affected by a natural disaster such as a fire, flood, disease, or insect outbreak. The maximum allowable contract is $50,000.

Forest Legacy Program (FLP)

www.fire.ca.gov/php/rsrc-mgt_forestryassistance_legacy.php

The goal of the FLP is to identify and protect environmentally important forestlands threatened by present or future conversion to nonforest uses. Through the program, conservation easements are accepted from willing private landowners to control conversion to nonforest uses. Forest management activities, including timber harvesting, and recreational activities such as hunting, fishing, and hiking may be permitted as long as they are consistent with the program's purposes.

CAL FIRE, the USDA Forest Service and the California Forest Stewardship Coordinating Council administer the program. The FLP cost-share may not exceed 75 percent of any costs associated with the donation. There are no parcel size limitations. Contact the Forest Legacy Coordinator at 916-653-8286 or visit their Web site for more information.

Vegetation Management Program (VMP)

www.fire.ca.gov/php/rsrc-mgt_vegetationmanagement.php

The Vegetation Management Program, administered by CAL FIRE, provides incentives for using fire as a tool to control unwanted brush and other vegetation that create wildfire hazards. Through VMP, the planning, implementation, and liability for projects

using prescribed fire are covered. As a part of the project, participants develop a management plan for the property with consideration of follow-up treatments to enhance and maintain the effects of the burn.

Depending on land management objectives, the landowner will pay at least 10 percent of the estimated costs. Costs depend on the size and complexity of the area and time of year. A burn with greater public benefits will improve the cost share ratio. For further information, contact the VMP program manager at 916-653-2380 or visit their Web site.

Private Lands Wildlife Habitat Enhancement and Management Program (PLM)

http://www.dfg.ca.gov

The PLM seeks to enhance and safeguard habitat for California's wildlife and, at the same time, improve profits for ranchers and farmers, forestland owners, and managers. To be eligible, private landowners must complete a habitat assessment, prepare a statement of objectives, maintain records of progress in improving wildlife habitat, develop and receive approval for a management plan, pay the license fee, and make a 3-year commitment to the program. The DFG sponsors this program. Contact the Deer Program coordinator at 916-653-4673 for more information.

CALFED Bay-Delta Program

http://www.calwater.ca.gov

The mission of the CALFED Bay-Delta program is to restore ecosystem health and improve water management for beneficial uses of the San Francisco Bay/Sacramento–San Joaquin Delta, including flood control, irrigation, and domestic water for the southern Central Valley and southern California, as well as protection of Delta endangered species and anadromous fish runs. The Bay-Delta system is the intricate web of waterways at the junction of the San Francisco Bay and the Sacramento and San Joaquin Rivers and the watershed that feeds them. Focused grants are available for ecosystem restoration in areas that have been identified as priorities by stakeholders. Grants will be awarded for many areas of interest to forestland owners, including watershed planning, education, fish screens, flood plain acquisition, habitat restoration, and research and monitoring projects. Any landowner in the Bay-Delta and tributary watersheds is eligible. For more information, contact the CALFED program coordinator at (916) 654-1334 or visit their Web site.

Fisheries Restoration Grant Program

http://www.dfg.ca.gov

This program is designed to improve or restore salmon and steelhead populations in coastal California through watershed planning, watershed restoration, fish habitat improvement projects, cooperative fish-rearing programs, watershed organization support, private-sector technical training, and public education. Public agencies, nonprofit organizations, Indian tribes, and private entities are eligible. Cost share is recommended. For more information contact DFG at (916)-327-8842 or visit the DFG Web site.

FEDERAL FORESTRY FINANCIAL ASSISTANCE PROGRAMS

Environmental Quality Incentives Program (EQIP)

http://www.nrcs.usda.gov/

EQIP, a Farm Bill program, provides a single, voluntary conservation program for farmers, ranchers, and nonindustrial forest landowners to address significant natural resource needs and objectives. The program provides technical, financial, and educa-

tional assistance. The Natural Resources Conservation Service (NRCS) has leadership for EQIP, working with the Farm Service Agency (FSA). A variety of conservation programs are supported by EQIP and are eligible for a maximum of 75 percent cost share. For further information on the program, contact your local NRCS office.

Wildlife Habitat Improvement Program (WHIP)

http://www.nrcs.usda.gov/

WHIP, a Farm Bill program, provides a voluntary program for private landowners in partnership with neighbors or agencies who want to develop and improve wildlife habitat, by offering technical assistance and cost-share to help establish and improve fish and wildlife habitat. The NRCS has leadership for the program, which can support a maximum of 75 percent cost share. Landowners must agree to prepare and implement a wildlife habitat development plan. For further information, contact your local NRCS office or their Web site.

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PUBLICATION 8254

FOREST STEWARDSHIP SERIES 24

Professional Assistance

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HIRING PROFESSIONALS

We all have to hire professional assistance at one time or another for particular tasks. How do you go about finding the best professionals? The following simple steps will help you select the best professional for your particular project:

- identify potential professionals
- check qualifications and credentials
- check references
- check insurance—general liability and workers compensation (if necessary)

Begin your search for a professional by creating a list of professionals you think can help. The type of professional depends upon your situation. A forester (registered professional forester, RPF), logger (licensed timber operator, LTO), surveyor, wildlife biologist, botanist, hydrologist, archaeologist, or engineer are some of the many natural resource management professionals you may need.

Professional organizations such as the California Licensed Foresters Association, Society of American Foresters, and the Wildlife Society can supply a list of members that offer consulting services. Word of mouth, the telephone book, or an Internet search might also provide you with a list of available professionals. Personal recommendations are often the best method of finding a professional that will meet your needs.

REGISTERED PROFESSIONAL FORESTERS

If you are considering a project on your property and you are not sure whether you need an RPF, contact CAL FIRE. To harvest timber on your property, an RPF must prepare a timber harvest plan and an LTO must do the on-the-ground operations, including logging road construction. You may also want to consult with an RPF to help with decisions regarding tree planting, rehabilitation work after a fire, or other activities. Choose an RPF as you would any professional—with great care. You want one who will look out for your financial and environmental interests and who can explain the complex rules and regulations to you. Figure 1 provides a sample timeline for harvest planning and operations.

Objective

Understand which resource management professionals may be able to assist you with forest stewardship and where to find them.

Competencies

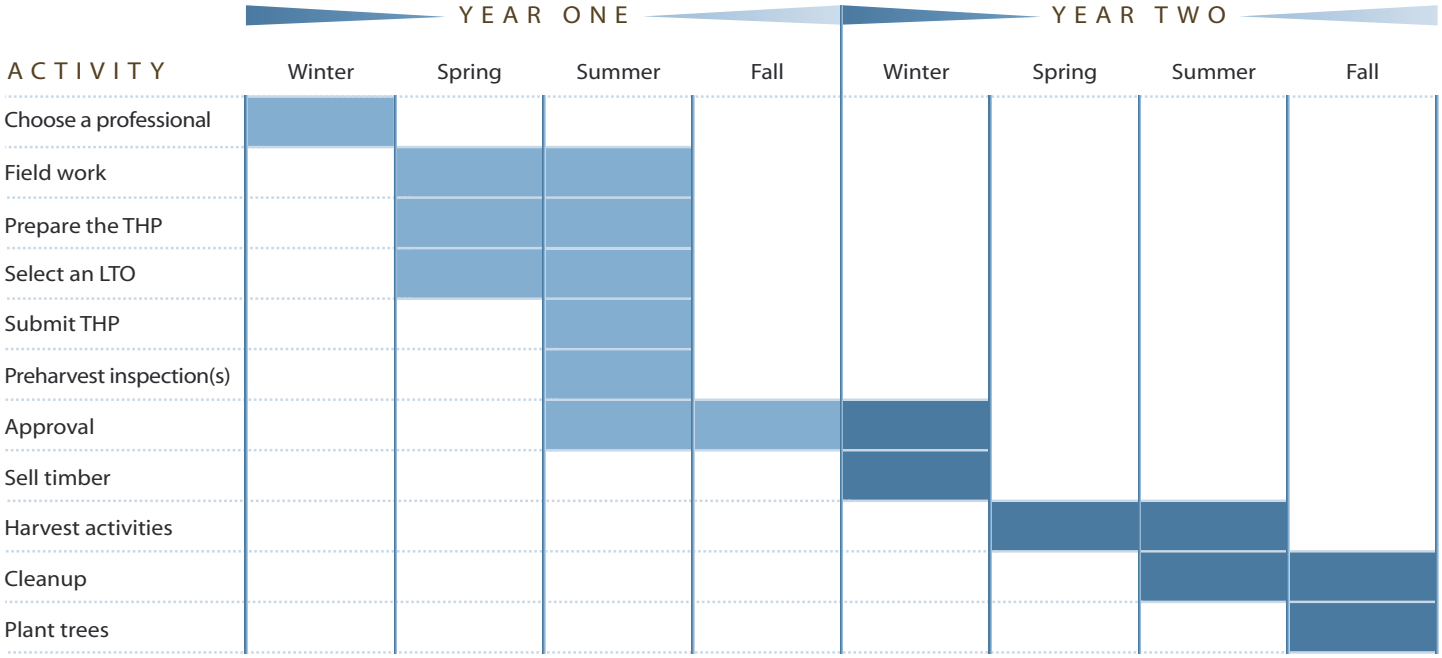
- *Understand that if you plan to harvest timber, you will need to hire a registered professional forester (RPF) to prepare the permit for you and that the person who harvests the trees must be a licensed timber operator (LTO).*
- *Learn how to select and interview the best professional for your situation.*
- *Become familiar with the by professional organizations that can help you find qualified professionals.*

Related Forest Stewardship Series Publications

- *Laws and Regulations Affecting Forests, Part I: Timber Harvesting, ANR Publication 8249*
- *Laws and Regulations Affecting Forests, Part II: Activities Other Than Timber Harvesting, ANR Publication 8250*
- *Stewardship Objectives and Planning, ANR Publication 8248*
- *Technical and Financial Assistance, ANR Publication 8253*

UC PEER REVIEWED

Figure 1. Sample timeline for timber harvest planning and operations.



Call several foresters before you decide on one. Request references for recent jobs and follow up on them. Find out if the RPF's clients were satisfied with the work and if they would hire that person again. You might also want to check with the State Board of Forestry to see if the RPF has had any disciplinary actions.

Remember that since you may be interacting with your forester extensively, his or her personality can be just as important to you as technical expertise. Choose someone whose style and approach to forest management is compatible with yours. Finally, you might ask the forester to visit you on your property for an initial consultation. Such visits can be free.

The following are several ways you can find an RPF:

- World of mouth—ask your neighbors, friends, family, or members of landowner organizations such as the Forest Landowners of California for a referral.
- Call your local CAL FIRE office. Ask for resource management, and ask them to send you a listing of local consulting foresters.
- Contact the office of a forestry professional society such as the Northern California Society of American Foresters (1-800-738-8733, e-mail ncsaf@mcn.org) or the California Licensed Foresters Association (e-mail clfa@volcano.net).
- Look under "Foresters—Consulting" in the yellow pages of your local phone book.
- The official list of all the California registered professional foresters can be found on State Board of Forestry and Fire Protection's Web site, http://www.bof.fire.ca.gov/licensing/licensing_current_docs.aspx.

Remember to avoid having an LTO provide forestry services. Some loggers work with or have an RPF on staff and will prepare a timber harvest plan (THP) as part of a logging contract. However, an RPF is legally and ethically bound to serve the financial interests of the person who is paying for his or her services, so you want to be the one writing the check.

LICENSED TIMBER OPERATORS

Licensed timber operators (LTOs) do the actual logging on a harvest plan. Hiring the right LTO is important in making sure that the harvesting plan is implemented as written. Oversight of the logging by the RPF who prepared the harvest plan is often advisable.

LTOs are licensed by the state and are required to take a course in timber harvest laws, document at least 3,000 hours of timber harvesting experience, and present a certificate of timber harvesting insurance that includes one million dollars in commercial general liability and logger's third-party damage liability.

If you do not have a particular logger with whom you want to work, your RPF can prepare a proposal that specifies the quantity and quality of the timber that is to be sold, roadwork that needs to be done, any limitations, and other pertinent information, and sends this "bid package" out to LTOs for competitive bids on the logging.

Choose an LTO not just on their ability to harvest your trees, but also on their ability to process the logging slash and maintain your roads. Your forest can be left in quite a wide range of conditions following a timber harvest. Cleanup and removal of nonmerchantable material and logging slash, including tree tops, limbs, and branches, is a major consideration. To dispose of this material, your LTO can clean it up for a fee, or you might be able to get it chipped and sold as fuel, or you could pile and burn it yourself after obtaining burn and air quality permits. Additionally, the LTO can often do road maintenance work not associated with the timber harvest, because they have the equipment on site and this would be less expensive than bringing in a separate contractor.

When choosing an LTO, ask for references and locations of recent jobs, and ask to visit a recent job site. You might also ask if the LTO has had any legal situations arise and, if so, to explain them. Ask your RPF about any experience he or she has had with the LTO you are considering hiring. Always check qualifications and references.

CHECKING REFERENCES

It is essential to check references. Prepare questions ahead of time and be ready to take notes. If you are nervous about calling a stranger, you might want to prepare a list of questions to help you get started. A suggested script and list of questions to ask follows. Add specific questions for the type of professional that you are checking on and any other questions specific to your property:

Hello, my name is _____. I am considering hiring _____ (the professional) who provided you as a reference. Do you have a few minutes to answer some questions? (If not, ask for a more convenient time to call).

- Were you satisfied with the services this professional performed? Why or why not?
- Did this professional respond to your questions in a timely and professional manner?
- Would you hire this professional again? Why or why not?
- What would you have done differently?
- Are there any questions you should have asked but didn't?
- Were there any surprises I should avoid?
- If I have any more questions, would it be okay to call again?
- If so, when is the best time to reach you?

INTERVIEW

Once you find a recommended professional, it is important to determine if they are right for you. Ask the candidate to visit your property. Some of the types of questions you might want to ask candidate RPFs and LTOs include the following:

- How long have you worked in this forest type?
- Have the results of your work met your expectations and the expectations of your clients?
- Have you ever made what you think might be a mistake?
- Given our family's goals and objectives, how would you recommend that we proceed? What are our management options?
- Can you show me a place where you have been working to demonstrate the results of your work?

OTHER PROFESSIONALS

In California, many professions have specific licensing requirements. Professions such as forestry, surveying, and pest control require licenses in order to practice in that field. Check with the appropriate agency to see if the professional's license is in good standing. Licensing agencies usually provide information on disciplinary actions taken against individuals. Table 1 provides a summary of some of the professionals you may need, licensing requirements, and the responsible licensing agency.

Boards, agencies, and professional organizations can offer certificates to document completion of training or specialization. For example, CAL FIRE offers a training course in archaeology for RPFs. Foresters who complete this course are then qualified to conduct preliminary archaeological surveys on private property. You may want to confirm that your candidate professional has a certificate of specialization before they conduct the archeological survey required for a timber harvest permit.

Many professions have an organization that represents their members and often offers continuing education or some type of certification (see table 1). These organizations will usually confirm whether an individual is a member and has met their requirements. The California Registered Environmental Assessor Program serves the public by identifying and registering qualified environmental professionals who perform many different environmental activities. It is important to note that not all activities are covered. For more information visit the California Department of Toxic Substances Control Web site, http://www.dtsc.ca.gov/REA/index.cfm.

Table 1. Professionals involved in forest stewardship

Professional	Required license or certificate	Regulatory board	Professional organizations
forester	Registered Professional Forester	California Board of Forestry	California Licensed Foresters Association, Association of Consulting Foresters
	certification available by Society of American Foresters	Certified Forester certification board	Society of American Foresters
wildlife biologist	none required; certification available from Wildlife Society	—	Wildlife Society
fisheries biologist	certification required for fish sampling or relocation	—	American Fisheries Society
archaeologist	none required; certification available from Society of California Archaeology	—	Society of California Archaeology
logger	Licensed Timber Operator	California Board of Forestry	Association of California Loggers
surveyor	Licensed Surveyor	California Board of Professional Engineers and Land Surveyors	California Land Surveyors Association
pest control adviser – weed control	Pest Control Adviser (by category)	California Dept. of Pesticide Regulation	Western Society of Weed Science
pesticide application – supervision	Qualified Applicators Certificate	California Dept. of Pesticide Regulation	—
pesticide application – commercial	Qualified Applicators License	California Dept. of Pesticide Regulation	—
botanist	none required	—	California Native Plant Society Botanical Society of America
hydrologist or civil engineer	Registered Civil Engineer	California Board of Professional Engineers and Land Surveyors	American Institute of Hydrology
	certification available by the American Institute of Hydrology	—	—
hydrogeologist	Certified Hydrogeologist	California Board of Geologists and Geophysicists	—
geologist	Registered Geologist Certified Engineering Geologist	California Board of Geologists and Geophysicists	American Institute of Professional Geologists Association of Engineering Geologists
	certification available by the American Institute of Practicing Geologists	—	National Association of State Boards of Geology
soil engineer	Licensed Civil Engineer	California Board of Professional Engineers and Land Surveyors	

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