Committee Report: Hardwood Retention for North Coast California Timberlands
Northern Sonoma, Mendocino, Southwest Trinity, and Southern Humboldt Counties

Contributions made by the Regional Committee on Hardwood Retention, North Coast 1996

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Chapter 1

Introduction and Background

Existing California Department of Fish and Game (CDFG) Interim Hardwood Retention Guidelines focus on true oaks (*Quercus spp.*) that dominate open range land and not coastal forests. The hardwoods that generally are found throughout the northcoast have a large Tanoak (*Lithocarpus spp.*) component and are primarily classified as timberlands. To date, there have been no guidelines, in terms of tree size, age, basal area, canopy cover, or dispersion, upon which to base retention of non-true oak hardwoods in coastal forests. Because active removal of these coastal hardwoods is intensifying on the north coast, management guidelines are increasingly necessary to assure coastal hardwood removal proceeds in an ecologically sound manner.

California's North Coast hardwoods provide ecological benefits ranging from provision of structural diversity and fog drip to fixing nitrogen and supplying abundant mast (fruit). The high ecological value of hardwoods coupled with their lower economic value can lead to conflicts between landowners' goals to improve economic returns and the State's interests in protecting public trust resources. The purpose of these guidelines is to provide a conceptual basis for evaluating these management tradeoffs. This evaluation of management options is important because habitat recovery may be slow or reversed once a harvest plan is executed.

The Integrated Hardwood Range Management Program assembled a Regional Hardwood Retention Guidelines Committee in 1996. The purpose was to develop these interim hardwood retention guidelines for North Coast forest types including the redwood, tanoak, and Doug-fir/tanoak series. The committee represented a diversity of professionals, (see title page list) and this report reflects the points on which the committee reached agreement. Available scientific and management literature on the role of hardwoods in North Coast forests was assembled and used to compile these guidelines. Because little research and monitoring has been done on hardwoods in this region, these guidelines discuss topics that should be addressed through additional research before quantitative retention guidelines are developed.

The committee specifically addressed:

1) the primary habitat types that would most benefit from retention guidelines;
2) the widespread conversion from conifer dominated habitat to a dominance of hardwoods as a result of historical timber removal practices;
3) additional information that is needed to better understand the structure, composition, and function of the forests that exist along the North Coast today;
4) the criteria that should be considered when selecting hardwood retention objectives; and
5) guidelines to help landowners determine appropriate hardwood retention.

These guidelines were developed for resource managers and forest landowners for California's coastal forests where current forest management practices and harvesting pressure have the greatest impact on hardwoods. To focus the committee's efforts and allow participation of local interested parties, the committee restricted the region of applicability to northern Sonoma, Mendocino, southern Humboldt and southwestern Trinity Counties. (see Map, Figure 1-1). The committee's knowledge of this region, and physiographic similarities, and associated habitat types were the basis for this delineation. Northern Humboldt County is not included because the prevalence of Oregon white oak (*Quercus garryana*) and red alder (*Alnus rubra*) communities, would increase the number of habitat types to be addressed. A regional committee based in northern Humboldt and Del Norte Counties should be convened to address these additional habitat types and the region in its entirety. Hopefully, the process developed in this document will assist other regions in developing similar guidelines that can include specific information and relevant support documents for the region in question.

HISTORY

Native people who lived along the coast historically used hardwood tree species for various purposes, practices that continue in many areas today. In the region delineated for these guidelines, hardwoods used by native people include bigleaf maple, California bay, golden chinkapin, madrone, mountain dogwood, Oregon ash, red alder, tanoak, wax myrtle, willow, and California buckeye (see Appendix A for descriptions of use). Extraction of natural resources today where Native Americans continue traditional resource use, such as on public lands, should be considerate of the traditions and current practices of indigenous people.

Upon settlement of California by European descendents, thousands of acres of forest were converted to range or agricultural uses. Many of these early conversion attempts ultimately failed, particularly in the coastal redwood area, although conversions in the inland Douglas-fir areas persist. Natural regeneration of these cut-over forests resulted in wide variations of hardwood-conifer densities. In addition to land clearing, some resource extraction occurred. One of the first products extracted from California's coastal forests was tanoak bark for the tanning industry.

Tractor logging and selective logging of old-growth forests became widespread during the 1940s. During a stand entry, conifers above a specified minimum diameter were harvested, while most hardwoods were retained because of the high removal cost and low relative value of hardwoods. Consequently, total hardwood volume and proportion of hardwood volume relative to conifer increased. In 1953, hardwoods accounted for approximately 10 percent of all standing volume within the redwood/Douglas-fir region of California. Selective diameter limit cutting of conifers was common through the 1980s with an incremental reduction in the minimum diameter in successive stand entries. During this period, hardwood volume increased dramatically because hardwood logging and mortality were largely incidental (amounting to no more than 1 percent of recorded annual harvest). By 1968, hardwoods accounted for 15 percent of all standing volume in Sonoma and Mendocino counties. This increased to 33 percent by 1994. Standing hardwood volume doubled over this 26-year period, and tripled since 1953.

In managed, north coast conifer stands today, rotation ages generally vary between 50 and 100 years. Barring a concerted effort to eliminate tanoak from the stand through mechanical or chemical treatment, tanoak in the small to mid size range (i.e. 1 to 20 inches diameter breast height or dbh) can be expected to remain well represented into the foreseeable future. Due to this fact, it is probably not necessary to recommend retention of small to moderately sized trees within areas managed on an even-aged basis, assuming that landscape cutting patterns will not create extremely large areas of young habitat within a short period of time. This type of cutting pattern has occurred in the past, but is not as likely to occur in the future due to existing acreage restrictions on individual cutting units, and due to existing patterns of land ownership.

ECONOMICS

Most privately owned forests are managed to achieve an economic return for the timberland owners. Short-term and long-term economic objectives should be considered. However, long term economic planning is uncertain given the dramatic shifts in demand for various natural resources over time. For example, 100 years ago, tanoaks were highly valued by the tanning industry, and conifer dominated sites were converted to open rangeland for livestock grazing. History has demonstrated that to assume a particular wood product will be highly valued in another century is risky.

Today softwoods still have higher economic value than hardwoods. In 1996 the value of Douglas-fir was approximately $75 per ton, while hardwood logs were valued at just $9 per ton; because a market has not been developed for California hardwoods due to low value and high mill costs, comparison of Douglas-fir and hardwoods in board-foot volume is difficult. These economic realities parallel management goals in some locales that are focused on increasing conifer production. Low prices for hardwood log make it difficult for landowners to cover transportation costs for hardwood removal, so some remote areas of the North Coast have almost no hardwood harvesting. Extensive hardwood removal by harvest, chemical treatment, or slashing is common in other areas to reduce competition with conifers for light, water, and space. Because of these differences across the region, it is difficult to propose generalized recommendations for hardwood management.

Beyond regulations that mandate retention or maintenance of specific forest elements, economics will be the primary determinant of habitat quantity and quality across the landscape. For example, timber retention is regulated in watercourse and lake protection zones for water quality and habitat protection. This shifts more intensive timber management activities to upland sites. Increasing conifer values, combined with periodic spikes in hardwood value, are expected to result in slow declines in the standing volume of hardwoods. In the absence of other constraints, the highest quality conifer sites will have the greatest hardwood reduction. Over time, this may shift hardwood volume towards the less productive conifer sites.

Today, the U.S. hardwood market looks more positive than it has in the past, but product development, processing technology, and marketing will dictate the future utilization of western U.S. hardwoods. The majority of hardwoods are converted into pulp chips for domestic and international use. The economic value of hardwood chips is tied to global market conditions. The current driving force behind North Coast chip log prices is the Japanese market, which sets its price through semi-annual negotiations. In recent years, the price per green ton have varied widely as the paper market has fluctuated.

Logging and trucking costs need to be compared with delivered log prices to determine the economic feasibility of harvesting hardwoods. The deciding factor is generally the haul distance to chipping sites. Since most chipping facilities are located in the Eureka area, landowners in southern Mendocino often harvest hardwood at a loss, while harvests in northern Mendocino break-even at best. The added value of future conifer growth may justify this economic investment in harvesting hardwoods at a loss.

In Mendocino County, though newly emerging operations are addressing tanoak manufacturing, only a very small percentage of harvested hardwoods are currently sawn for secondary manufacture such as for furniture or paneling. Tanoak and madrone have relatively poor form when compared to hardwood from other regions; tanoak and madrone often grow with curved stems, and have other common defects such as rot and excessive knot size, resulting in high manufacturing costs and low net lumber returns. In addition, drying hardwood lumber is challenging and further losses occur due to warping and splitting. The prices that mills have offered for sawlog quality hardwood has varied tremendously depending on market forces and quality. Green tons are the most common method of sale although some buyers will buy on scale and grade.

FOREST TYPE CLASSIFICATION

The committee identified 13 hardwood tree species of concern in North Coast forest types. Some of these species are most commonly found in timberland forest types (tanoak, Pacific madrone, California bay, giant chinkapin, red alder, bigleaf maple). Others are found almost exclusively in non-commercial woodlands (coast live oak, blue oak, interior live oak, valley oak). The remaining species are found in both forest and woodlands of the North Coast (Oregon white oak, California black oak, and canyon live oak). The habitat, life history, competition, and uses of each of these species are described in Appendix B.

These hardwoods are found in a variety of forest types, as classified by existing classification systems (see Appendix C for examples). Classifying forest vegetation is important for managing forest stands on a landscape scale. The broadest level of vegetation classification in these references is known as the “series.” Until better research information is developed, interim hardwood retention guidelines should be based on this broadest classification level. In the future, classification at the sub-series and plant association levels will allow better management recommendations because they distinguish differences in both physical (i.e., parent materials, soils, physiography) and biological conditions.

The extent and composition of hardwoods typically varies between forest series depending on how the stand was initiated, its age, disturbance, and fire history. Absence of hardwoods from a site does not necessarily mean that they cannot naturally occur there, indeed hardwoods are frequently a component in natural stand succession towards the climax species. Conversely, absence of conifers from a site does not necessarily mean that they cannot be a natural component of the area. Where there are indications that conifers previously occurred at a site, such as the presence of conifer stumps, this does not necessarily imply that the location should be managed exclusively as a "conifer site." However, indications that conifers once occurred at a site where they are currently absent can help the landowner decide which species can potentially be managed at the site.

Although it is widely believed that hardwoods only *dominate* young forests, hardwood species can also be a significant part of more advanced stages of forest succession. For example, in Six Rivers and Klamath National Forests, the tanoak series had a mean stand age of 263 years, with the greatest number of trees in the 226-275-year range.

Many habitat types exist within the focus region. In particular, coastal tanoak dominated forests are facing future management scenarios that involve extensive hardwood removal. Therefore, these guidelines are focused on three vegetation series as defined in “A Manual of California Vegetation” that would most benefit from a review of hardwood retention strategies. These are the redwood, tanoak, and Douglas-fir/tanoak series because these represent habitat types that are most likely to undergo extensive hardwood removal to enhance conifer production. Table 1-1 lists tree species commonly found in these three series.

Table 1-1. North coast vegetation series and associated tree species found on these series (Sawyer and Keeler-Wolf 1995).

Redwood Series	**Tanoak Series**	**Douglas-fir/Tanoak Series**
Redwood	Tanoak	Douglas-fir
Sequoia sempervirens	*Lithocarpus densiflorus*	*Pseudotsuga menziessi*
Bigleaf maple	California bay	California bay
Acer macrophyllum	*U. californica*	*U. californica*
CA bay	Pacific madrone	Giant chinkapin
Umbellularia californica	*A. menziesii*	*Castanopsis chrysophylla*
Pacific madrone	Black oak	Pacific madrone
Arbutus menziesii	*Quercus kelloggii*	*A. menziesii*
Tanoak	Canyon live oak	Black oak
Lithocarpus densiflorus	*Quercus chrysolepis*	*Quercus kelloggii*
Douglas-fir	Coast live oak	Canyon live oak
Pseudotsuga menziesii	*Quercus agrifolia*	*Q. chrysolepis*
Grand fir	Douglas-fir	Tanoak
Abies grandis	*P. menziesii*	*L. densiflorus*
W. hemlock	Sugar pine	Vine maple
Tsuga heterophylla	*Pinus lambertiana*	*Acer circinatum*
		Sugar pine
		P. lambertiana
		Pacific yew
		Taxus brevifolia

REGULATORY STANDARDS THAT APPLY

All commercial timber harvesting on non-federal lands in California is regulated by the Z'berg-Nejedly California Forest Practice Act. The Act addresses silvicultural systems and yarding methods as well as a variety of other issues. While the Forest Practice Rules emphasize the growth and harvest of conifer tree species, a number of Rules provide a basis for hardwood retention: Title 14, California Code of Regulations Sections 897, 898, 912.9, 916, 919, 919.4, and PRC 4513. Note that these guidelines refer to the Coast Forest District Rule sections and pertain to portions of the Coast and Northern Forest Practice Districts.

Retention of Trees of Each Native Commercial Species

Forest Practice Rules require retention of trees of each native commercial species, in order *"to maintain and improve tree species diversity, genetic material and seed production"* (Title 14 CCR 913.2(d)). Furthermore, *"these leave trees shall be representative of the best phenotypes available in the pre-harvest stand."* Commercial tree retention standards do not apply to California hardwoods. In fact, hardwood retention may not be required at a specific harvest site if a Sustained Yield Plan (SYP) has been approved, or when the registered professional forester (RPF) has proposed a specific plan that protects existing regeneration or provides for regeneration. Hardwood retention is evaluated in these long-term plans on an ownership or watershed scale.

Consideration of Wildlife Habitats

The Forest Practice Rules do require consideration of wildlife habitats when developing timber harvest plans (THP) and SYPs. This includes the provision of sufficient functional wildlife habitat to maintain the existing wildlife community within the planning watershed. Specifically, retention or recruitment of late and diverse seral stage wildlife habitat concentrated in the watercourse and lake protection zones can improve functional connectivity between habitats. Maintenance of biological diversity, watershed integrity, and the protection of sensitive species must also be considered (14 CCR 897).

Consideration of the Cumulative Impacts

The Forest Practice Rules require an assessment of the cumulative impacts that may result from proposed timber operations within a geographical area (Title 14 CCR 912.9 Cumulative Impacts Assessment, Board of Forestry Technical Addendum No. 2). Hardwoods are an important habitat component in cumulative impact analysis, because they often provide snags, den trees, downed large woody debris, multistory canopy, cover, mast, late seral stage forest characteristics, and connectivity between habitats.

Resource Conservation Standards

Rule section 14 CCR 912.7(c) describes resource conservation standards that may be met with conifers or hardwoods. This rule requires that conifer stocking levels be maintained at the same or higher relative levels, on a percentage basis, as before logging. In addition, the set of rules under 14 CCR 913.11 (c), Maximum Sustained Production of High Quality Timber Products, requires that stocking be met exclusively with “Group A” species (conifers). For example, if a stand is 75% conifer by basal area per acre before timber operations, it must be at least 75% conifer basal area per acre post harvest within the required stocking time frame. Exceptions to the conifer standard are allowed, but require extensive support documentation. There are special provisions to consider if additional hardwood stocking is proposed, or if reductions in hardwood stocking are necessary to help conifers become re-established.

Watercourse and Lake Protection Zone Rules

Under the watercourse and lake protection zone rules (14CCR 916.3), non-commercial vegetation species within and bordering wetlands and wet meadows shall be retained and protected during timber operations. Exceptions to this rule may be made if explained and justified in the THP and approved by the director. Therefore, hardwood trees in close proximity to water courses are usually retained. In many cases, hardwood retention along stream courses is beneficial to those riparian obligate species who may use the various structures provided by hardwoods i.e. perching sites, roosting sites, etc.

ADDITIONAL CONSIDERATIONS IN CONDUCTING TIMBER OPERATIONS

Though the retention of hardwoods must be weighed against landowner goals, operational requirements of timber harvesting, and other land management activities and considerations the fact remains that hardwoods serve ecological functions in north coast timberlands and there retention can not be ignore soley for economic considerations. The following operational factors should be considered when planning hardwood removal and retention.

Even-Aged Methods

With even-aged management, which includes clearcutting, shelterwood, and seed tree harvest methods, hardwoods may be designated for retention. Survival of retained hardwoods depends upon the amount of conifer timber being cut (potentially causing falling damage), the method by which the area is harvested (tractor or cable), and other causes of mortality after logging is completed (e.g. windthrow). Post-harvest survival chances are improved by leaving groups of trees, or individual trees in sheltered areas. The chances of windthrow increase as post- harvest canopy cover declines. Current regulations and logging practices favor timber falling in a direction away from watercourses. This provides protection for hardwood trees located near the channel. Additionally, most harvest operations are selective near watercourses and this provides an opportunity to retain older and larger hardwoods.

Uneven-Aged Methods

Hardwoods can be retained with uneven-aged methods such as single tree or group selection, or with commercial thinning of even-aged stands. The amount of light penetrating the conifer canopy will determine hardwood growth rate. Many coastal hardwoods are capable of initially out-competing conifers for available light within a partially cut stand. In general, there is less post-harvest mortality of retained hardwoods in selectively logged stands; however, hardwood growth may be slower than would occur in clearcut areas due to lower light levels. Hardwoods retained in selection areas may require thinning of surrounding trees over time to retain sufficient growing space for survival and growth.

Hardwood Removal

If hardwoods are slashed or logged, the stumps are sometimes treated with chemicals to suppress sprouting. Although this treatment does not always kill hardwood stumps, it retards their rate of sprouting, allowing conifers to grow above the hardwoods. Chemical treatment of hardwood sprouts by basal or foliar spray is an effective means of killing or retarding hardwood growth. This treatment is most effective between one and five years after initial sprouting. Standing trees may be killed or retarded by chemical stem injection, often referred to as "frill" treatment. This is generally effective in killing or retarding the standing portion of the tree, but is often followed by vigorous sprouting from the root crown. Hand grubbing of hardwood sprouts is another control option, but very costly and largely ineffective.

Timber Felling

The broad crowns and multiple tops of hardwoods make them more difficult to fall, de-limb, and buck into log lengths than conifers. Retention of specific hardwood trees can create obstacles to directional timber falling away from watercourses and towards a yarding corridor. This can be minimized during timber marking and yarding design layout. These considerations are also particularly important to ensure worker safety. Additionally, residue from hardwood harvesting (slash and debris) is greater than that from conifer harvesting. Therefore, fire hazard reduction is a critical issue and requires mitigation.

Yarding Method

Working around retained hardwood trees depends on the yarding method and the volume moving past a control point. Stationary yarder and cable yarding methods require an unobstructed corridor to move logs. Corridors can not always be narrow enough to avoid damaging retained trees. Convergence areas near cable landings require more space to accommodate overlapping corridors and logging decks. Tractor logging using an established skid trail system, is a method to reduce damage to residual trees. Trees immediately adjacent to skid trails may be damaged occasionally intentionally to facilitate turning the logs down the skid trails – these are call vab trees and are frequently marked by the RPF.

Site Preparation

Various site preparation methods have different impacts on retained hardwood trees. Brush raking with piles or windrows of slash can avoid retention trees if sufficient room to pile and burn slash and to maneuver equipment is provided. Lopping slash has minimal impacts on retained trees but is costly. Ground applications of chemical treatments can avoid damaging retention trees, although it is virtually impossible during aerial herbicide application. Broadcast burning, even under “cool” prescriptions may impact a significant proportion of retained hardwood trees. Clearing around tree root crowns and boles may mitigate fire impacts. Spot burning can be configured to avoid areas with hardwoods.

Fire Protection

Hardwood retention along planned fire control lines such as major roads and ridge tops can create operational problems for controlling both wild and prescribed fire. Broad crowned or leaning hardwoods can become control and safety problems if partially or totally burned. Tall trees along ridge tops may pose problems during electrical storms. Decayed portions of trees can catch burning embers thus starting or carrying aerial fires. Ground cavities can lead to chimney fires in the tree bole and create a control or safety problem. Trees retained near critical fire control lines should be healthy with little defect.

Exposure of Retained Trees

Residual trees in exposed areas have a greater chance of wind throw. Sudden exposure to solar radiation, wind desiccation, frost, and snow load may speed tree decline and may reduce their value as wildlife habitat.

Roads

Developing roads and landings for hardwood harvesting may result in greater impacts to soil and water resources than conifer harvesting. Logging roads may need to be designed for chip vans such that grades do not exceed 10%, turn radii may need to be increased, and landings may need to be larger.

Site Specific Considerations

Hardwood retention can be concentrated along visual corridors to mitigate visual impacts from timber operations. Trees retained near structures, roads and building sites should be specifically evaluated to ensure they are not, and will not become, hazards. Tree retention around unstable areas should be evaluated for both positive and negative impacts on slope stability. Wet areas may require specific tree retention standards to protect aquatic habitat.

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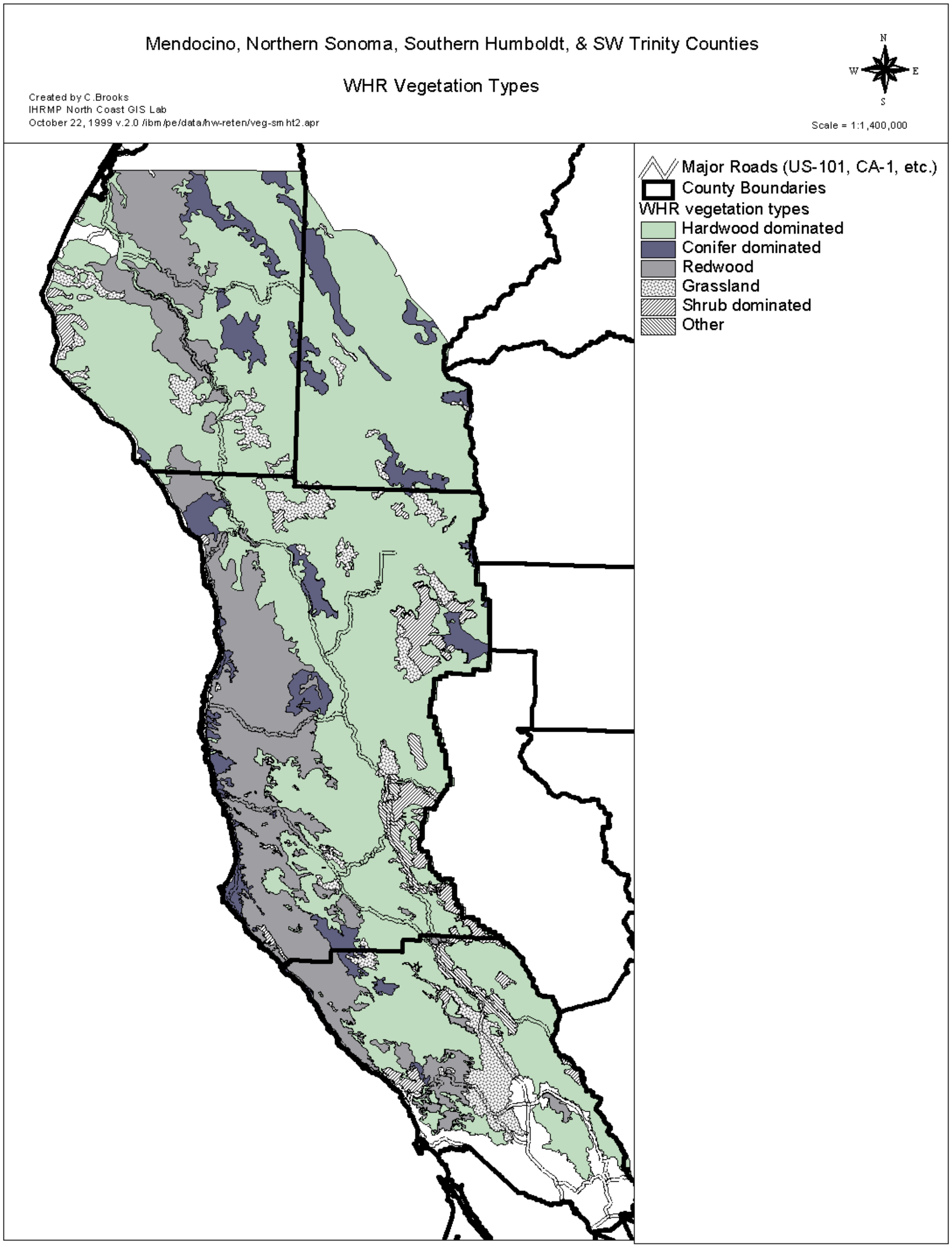
Figure 1-1. Map of focus area for this report.



Chapter 2

Criteria for Determining Hardwood Retention Plan

There are many criteria that influence decisions about appropriate hardwood retention in a particular stand. It is common practice to describe the *existing* condition of a stand so that appropriate management actions can be implemented to achieve a *desired* condition. The existing condition of an area can be defined as a description of the biotic and abiotic characteristics that currently exist in the stand or landscape of interest, and is the baseline from which any change in the past or future, anthropogenic or natural, can be measured. The existing condition is described within a relatively short time frame, where the existing attributes are unlikely to change to any significant degree. Existing condition should not to be confused with satellite vegetation classifications where existing stands are classified according to potential natural communities. The desired condition is defined as the land or resource conditions that are expected to result if management goals and objectives are achieved.

The time frame to achieve desired condition should be appropriate for the land management practices employed. For example, a time frame of 35-100 years might be appropriate for high yield plantation forest management, but more than 250 years might be required to achieve an old-growth forest condition goal. Desired condition reflects the management goals of the land owner or manager given the area's potential to provide the desired conditions (i.e. commercial timber, wildlife, water, etc.). If the existing condition and the site potential have been accurately described, debates over land management practices will generally focus on the desired condition and differing opinions about what it should be.

The USDA Forest Service Ecosystem Management Guide Book provides a detailed summary of the components of describing existing condition in the context of ecosystem management. For these retention guidelines, the committee identified several criteria of existing condition that should be considered before determining appropriate hardwood retention. These include: 1) site history and potential, 2) wildlife, 3) landscape patterns, and 4) ecosystem function. These criteria are described in detail below.

SITE HISTORY, CURRENT STRUCTURE, AND SITE POTENTIAL

Hardwood retention standards should consider what the site once supported, the current structure, the post harvest stand structure, and desired stand performance during the next management cycle. Outside information such as photo histories and survey descriptions can be used to provide a complete management history of the assessment area. Actual site occupation is dependent on site-specific environmental, biological, and management history. Data on current strand structure should be collected in the field:

- ***Species***: When collecting stand data, it is preferable to collect data concerning all hardwood and conifer tree species within the stand. Data for each species should be calculated and displayed separately, to avoid grouping of species. It is important to note that the wildlife value of different hardwood species and hardwood species distribution will vary throughout the site.

- ***Diameter***: The distribution of trees by dbh class is an important consideration in the determination of canopy cover, potential wildlife use, and future growth considerations.

- ***Basal Area per unit area***:Basal area is a measure of tree stocking, usually expressed in square feet per acre, and is the sum of tree cross-sectional areas at dbh per site. For wildlife purposes, it may be more useful to consider dbh distribution data rather than basal area square footage.

- ***Trees per unit area***: The number of trees in each diameter class is an important indicator of stand density, and can be utilized to obtain an estimate of basal area. Moderately large trees, 18-24" dbh should be evaluated for specific habitat elements (e.g. acorn production, nesting cavities, loose bark).

- ***Tree height***: If tree or stand volume is an important consideration, it would be wise to measure some individual tree heights, and record the heights for individual trees along with their corresponding diameter. This allows tree and stand volume to be estimated. Volume can be related to future growth estimation and economic considerations.

- ***Habitat elements***: There are many tree-associated habitat elements of value to both wildlife and non-wildlife species including snags, fallen trees, live trees with broken and/or dead tops, live trees with visible cavities, mast-producing potential, loose bark, etc. In planning to create, maintain, or predict habitat attributes, an inventory of these habitat elements is very useful. In many instances these attributes will remain on the site for a number of years (snags, downed logs) and will need to be inventoried only once.

- ***Forest type or habitat type***: When assessing stand structure, document forest or habitat types with aerial photographs or by mapping in the forest. Forest type mapping can distinguish smaller habitat patches not discernible from a stand table that covers a broad area.

- ***Tree age***: Tree and stand-age are important factors, along with stand treatment history, to predict the future condition of the stand. Age is an important ecological consideration since it can be the basis of many aspects of decadence that can only occur over time. Tree ages can be determined from a small sample of recently cut stumps or with an increment borer, although hardwoods are difficult to bore.

- ***Evidence of historical events or causes of damage***: Recording evidence of past impacts or events such as logging, fire, or grazing, can help explain current conditions and predict future conditions. These data can be recorded for stands or for individual trees. Often, individual tree data such as fire scars, logging damage, and animal damage correspond with valuable habitat elements, such as snags and trees with cavities.

By identifying past trends in relation to current conditions, forest management goals can be adapted to better achieve site goals. Historical and current structure information helps determine site potential (productivity) and the probable climax plant community. Future growth is a function of site productivity, stocking and future management. The general trend of species dominance as a function of site potential is shown for the immediate coast range and the interior coast range in figure 3-1.

Questions to Answer

Questions to help determine if a site has high potential for conifer growth:

- Do historical photos, survey information, or remaining stumps indicate that conifers once dominated the site?
- Do the soil, aspect, and climate match that needed to grow conifers?
- Does the current cover type match those would be expected in an early seral conifer dominated site?
- What is the management history of the site and does this support a history of early conifer logging?

SITE POTENTIAL

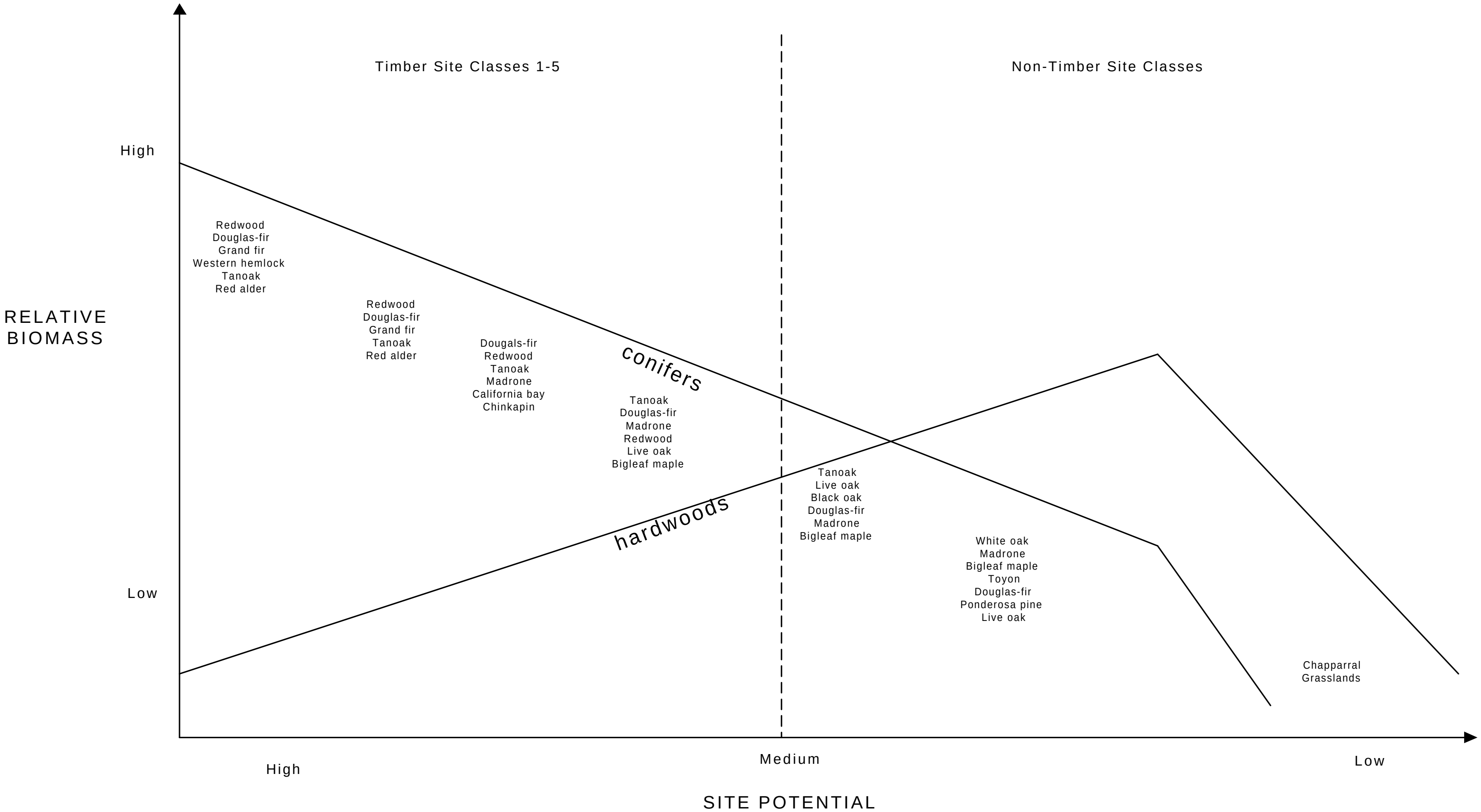


Figure 3-1 Schematic diagram of site potential and the dominant tree type.

Habitat types containing hardwoods provide some of the most suitable and important conditions for wildlife. The highest number of species and abundance of birds, rodents, deer, and elk are generally found in mature oaks with scattered conifers and a moderately heavy understory of shrubs and grasses. Other oak habitats also have high diversity and abundance relative to other habitat types.

Wildlife Habitat Relationships

A landowner's management objectives should include maintaining and enhancing forest stand structure and composition to benefit one to several wildlife species. To accomplish this, landowners would need to know which wildlife species potentially occur in the landscape, the habitat types preferred, and the management steps needed to recruit and maintain such habitat. Alternatively, a landowner may want to better understand the positive and negative effects on wildlife species of managing a forest for selected economic objectives.

The California Wildlife Habitat Relationship (CWHR) system is a tool that can help landowners decide what habitat types benefit selected wildlife species. The system includes computer-supported models that associate species with habitat types and seral stages. For example, the landowner can use the CWHR system to predict what species could potentially occur in a forest based on observed vegetation composition and structure. Alternatively, the landowner could use CWHR to predict what species might be affected by the application of silvicultural prescriptions that change forest vegetation species composition and structure. The user of CWHR should be cautioned that these models have not been validated, so a wildlife biologist should review any output.

The CWHR system is based on broad categories of habitats associated with vegetation types similar to those described in the vegetation classification systems described earlier. Figure 1-1 shows a map of CWHR habitat types for the area of these guidelines. The three most common CWHR habitat types found in the four county region of focus are Montane Hardwood/Conifer (34%), Montane Hardwood (21.4%), and Redwood (18.8%). A CWHR habitat type may correspond to more than one vegetation type of another classification system and vice versa. Table 2-1 gives a suggested "cross-walk" between selected CWHR system forest habitat classifications and three vegetation series from " A Manual of California" on which these guidelines focus (Appendix C is a more detailed comparison of these vegetation classifications).

Table 2-1. The CWHR habitat classifications that correspond to the three vegetation series that are most important to these guidelines

Vegetation Classification Series (Jimerson et al.1996, Sawyer and Keeler-Wolf 1995)	**CWHR Habitat Classifications** (CDFG, 1997)
Redwood Series	Redwood
Tanoak Series	Montane Hardwood and Montane Hardwood-Conifer
Douglas-fir - Tanoak	Douglas-fir, Klamath Mixed-Conifer, Montane Hardwood-Conifer*

* only if the tanoak canopy cover is greater than Douglas-fir.

Appendix B contains information from the CWHR, including habitat value, model confidence, legal status, life history, and habitat element information for roughly 250 species of amphibians, birds, mammals, and reptiles predicted to occur in the region of focus. Some of these species will be more sensitive than others to changes in the hardwood composition of forest stands. Site-specific wildlife surveys are essential to document species presence. Further research in California's North Coast forests will be necessary to improve our understanding of the wildlife community supported within the various habitat types.

Some vertebrates are legally protected and necessitate protection of habitat elements on which these species depend. The legal status of vertebrates continually changes and, thus, up-to-date information on protected species must be obtained directly from the United States Fish and Wildlife Service or the California Department of Fish and Game. Although attention to specific taxa is often required, it may be more efficient for managers to consider the needs of multiple taxa when developing management plans for commercial harvest and hardwood retention.

Habitat Elements

Habitats must provide the necessary attributes to ensure viable populations over time. Many species possess rather generalized habitat preferences and have adapted themselves, over time, to a variety of habitat types, elements and stand ages. Most resource managers recognize the basic habitat criteria associated with deciduous and coniferous forests. Recently, it has become more evident that fine-scale structural features, such as branch architecture, bark texture, percentage of vegetation cover, snag characteristics and the density and geometry of the foliage, can be quite important components of species' habitat preferences. For example, some perch gleaning birds must expend more energy while foraging in deciduous trees because of the leave structure and distribution on the branches. Leaf structure can also influence birds foraging ability in mixed-conifer sites.

The wildlife literature identifies some key habitat elements that are provided by both conifers and hardwoods, including snags, cavities, downed logs, food production (foliage, berries, nuts, and insect production on leaves and leaf litter), and cover. Specific habitat elements are essential for certain species such as cavities for nesting birds, and tree hollows for bat roosts. A study in old-growth redwood hollows in the north coast found that bats use trees closer to water and that have greater hollow volumes and diameters. Clearly forests lacking trees large enough to contain hollows will provide fewer roosting opportunities, negatively affecting the abundance and diversity of bats. Because branching patterns of hardwoods often lead to breakage, hardwoods tend to develop larger and more complex cavities than similar size conifers. Likewise, features related to bark architecture and texture are important if habitat is to meet the spatial requirements for resident bark-gleaning birds.

Acorns are an important, though seasonal, habitat element that influences abundance of some wildlife species. This is demonstrated by the fact that large California black oaks with well developed crowns are consistently part of the habitats in which the largest number and the most species of wildlife are observed. Research shows that acorn production between individual trees displays a high degree of variance. By visually classifying annual acorn production on individual trees, preferably over several years, landowners can remove selected poor acorn-producing oaks and still provide acorns for wildlife in specific areas; leaving small trees in the stand is important for continual recruitment of acorn-producing trees over time. Maintaining acorn producing trees in sufficient numbers may also facilitate post-harvest Douglas-fir regeneration by providing an alternative food source to Douglas-fir seeds for granivores.

The land manager must take into account these broad-scale and fine-scale habitat attributes when selecting individual trees to meet hardwood retention levels in forest stands. Some trees in smaller size classes should be retained in order to recruit larger trees over time. Natural stand growth can provide various habitat elements over time, unless older age class trees are continually removed. Effective wildlife habitat management should also consider both the temporal and spatial needs of species when deciding the extent and distribution of retention. For example, seasonal considerations must be addressed if retention is to provide both hard and soft mast.

Canopy openings or gaps are an example of an important spatial criteria. Generally, canopy openings are conspicuous characteristics of late seral stage stands. The higher incidence of light provided to the forest floor by gaps often increases the abundance of mast producing shrubs and trees. Heightened avian richness and abundance typically characterize these areas. Some aerial insectivores (e.g. flycatchers, tanagers) are positively associated with gaps, and use these areas for foraging.

Figure 2-2 provides an example of specificity in use of some habitat elements by terrestrial vertebrate taxa in a hardwood conifer site. The schematic is intended to demonstrate the intricacies of habitat element use for a variety of commonly found species. Managing for these habitat elements across the landscape requires recognition by resource managers of the importance of temporal and spatial importance of habitat elements. Given the broad array of vertebrate species that utilize hardwoods and the associated habitat elements, a resource manager should consider habitat element retention as a pragmatic approach to meeting the wildlife needs at both the stand and landscape levels.

Birds

The important role that oaks play for California's avifauna is well documented by the fact that oak woodlands support almost 160 species of birds. Despite the fact that California birds are well studied, relatively little is known about the birds in California's north coast forests. The following information is a review of bird studies that may shed some light on how coastal hardwoods should be managed to support bird populations.

Birds and mammals were censused in tanoak and mixed tanoak-conifer communities in southwest Oregon. The tanoak forest receives considerable bird use. During the spring and summer, tanoak stands are utilized primarily by insect gleaning canopy feeders, while during the early winter months, birds feeding on acorns and madrone seeds are more prevalent.

Management of oak habitats for birds should emphasize the maintenance of mixed-species and uneven-aged stands that will provide a continuous, abundant supply of acorns. Large, old trees are particularly important for birds because they provide a wider array of foraging sites, produce many acorns, and are best suited for excavation by cavity nesting birds. Where present, a shrub layer should be maintained.

Tree cutting can alter bird presence and abundance. For example, reduction of old-growth Douglas-fir/tanoak forests in northwestern California would likely lead to significantly lower densities of breeding Hammond's flycatchers (*Empidonax hammondii*); the Pacific-slope flycatcher (*Empidonax difficilis*) would probably be less affected by conversion of old-growth forests to younger-aged classes because of different nesting habitat needs. Changes in diversity and relative abundance of avifauna due to logging are most evident within 3 years of cutting. Surveys on heavily managed areas in the Douglas-fir region of northwestern California found that generalist species such as woodpeckers, juncos, quail, and jays increased, while forest-dependent species such as chestnut-backed chickadee (*Parus rufescens*) and red-breasted nuthatch (*Sitta canadensis*) populations were reduced.

Many birds utilize hardwoods and older trees. For example, several birds are dependent on Pacific madrone for berry crops, and madrone is a preferred nest tree species; 89 percent of the nests found were in trees over 12 inches dbh. The abundance of olive-sided flycatcher (*Contopus borealis*), western flycatcher (*Empidonax difficilis*), hermit thrush (*Catharus guttatus*), varied thrush (*Ixoreus naevius*), warbling vireo (*Vireo gilvus*), and Wilson's warbler (*Wilsonia pusilla*) were also found to be significantly correlated with canopy volume of tanoak.

Mammals

Over 80 terrestrial mammal species use oak woodlands for food or cover. For example, dusky-footed woodrats (*Neotoma fuscipes*) utilize hardwoods for nesting, fishers (*Martes pennanti*) forage in hardwood stands, and deer mice (*Peromyscus maniculatus*) and chipmunks (*Tamias spp.*) use the cover provided by the hardwood canopy. Oaks are particularly important sources of forage for deer (*Odocoileus hemionus*) and black bear (*Ursus americanus*). Deer are dependent on acorns during fall and winter while they browse the foliage of many hardwood species during spring and summer. Tanoak, madrone, and other hardwoods are important winter-spring forage sources for deer, black bear, northern flying squirrels (*Glaucomys sabrinus*), and dusky-footed woodrats.

The tanoak acorn crop has been estimated at 1,000 pounds a year per 30 inch dbh tree. However, acorn production of tanoaks can be extremely variable. Large, mature trees (over 30 years old) produce the largest acorn crops. Mast production from tanoaks 18-24 inches dbh ranged from 3,900-4,600 acorns, while a 30" dbh tanoak produced almost 110,000 acorns. Elk, deer, bear, turkey and pig most likely consume these acorns. The importance of oaks for deer is well documented. It is evident that hardwood cutting losses due to timber operations can impose negative effects on deer populations.

In addition to acorn crops, forest structure is also important to mammals. For example, the dusky-footed woodrat, an important prey species of northern spotted owls, require hardwood brush clumps between 5-10 yards wide that are typically part of tanoak stands in early successional stages. Mammals whose abundance is correlated with tanoak canopy cover include the Fisher and Northern flying squirrel.

Amphibians

Amphibians may be useful indicators of forest health because, in general, they are sensitive to changes in soil temperature, moisture, and shifts in forest community composition. Additionally, Amphibians use hardwood logs and snags for resting, hiding and perhaps nesting. Abundance of Del Norte salamander (*Plethodon elongatus*), ensatina (*Ensatina eschscholtzii*), black salamander (*Aneides flavipunctatus*), and clouded salamander (*Aneides ferreus*) were found to be correlated with tanoak canopy cover.

Research Needed

Gaps remain in our knowledge about the importance of coastal hardwoods for wildlife. Following are some of the more important questions for current research to investigate:

1) How does hardwood composition and age class distribution influence wildlife populations?
2) Is adequate mast production correlated with the unique structural components needed by wildlife?
3) Are there certain wildlife species that should be the primary target for conservation or can serve as indicator taxa?
4) What habitat patch size is critical to support various target species?
5) How do large landscape habitat mosaic patterns influence species abundance and distribution?

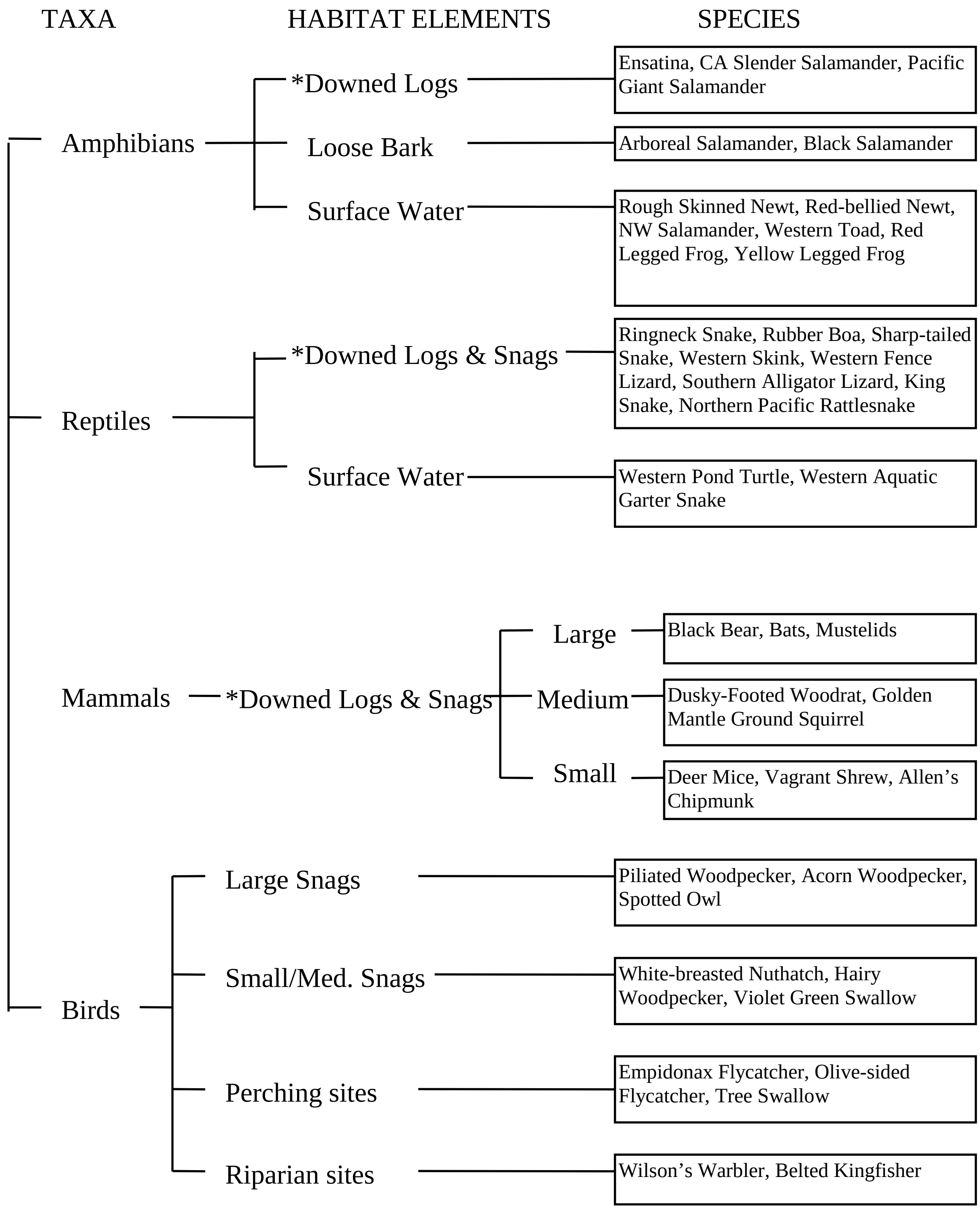
Demographic studies of species before and after removal of various hardwoods will be necessary to establish causal links between wildlife populations and the ratio of hardwood to conifer trees. Until such studies are completed, the available evidence is sufficient to recommend retaining mature hardwoods of all species in forest stands and maintaining some proportion of cutover forest in tanoak dominated brushy condition. Hardwoods are an important resource for wildlife and even brushy clearcuts dominated by tanoak provide nesting sites, mast, and hiding cover for small mammals and birds.

Questions to Answer

The following questions were designed to help determine if there are wildlife species that may be negatively impacted by hardwood removal.

- Are any of the species listed in Appendix B found at the site?
- Will a sufficient number of madrone trees be retained or recruited to provide berries for resident and migratory birds?
- Are large hardwoods (greater than 18” dbh) being retained for acorn production and wildlife structure?
- Are trees in smaller size classes being maintained to provide mature trees over a longer time frame?
- Are trees with cavities being retained?
- Are snags and downed woody material being retained for cover and habitat?
- Are clumps of smaller hardwoods being retained around larger trees for small mammal habitat?

Figure 2-2. An example of selective resource use based on a few habitat elements of some common wildlife species found in mixed hardwood/conifer stands throughout northwestern California.



*Large woody debris (LWD)

LANDSCAPE PATTERNS

The landscape may be composed of a mixture of stands of different habitats and patch sizes. There are areas that may naturally support hardwoods and areas that may naturally support conifers. Therefore, management of hardwoods and decisions, particularly on large industrial ownership's, regarding hardwood retention must also take place at the landscape scale. For example, areas may be designated for hardwood removal while other areas may be designated for hardwood retention. This criterion focuses on landscape level decision making to ensure adjacency and connectivity of hardwood habitat types in areas subject to forest management activities.

Landscape-scale analysis provides flexibility when planning hardwood retention areas. A landowner may decide to remove hardwoods in certain patches, while retaining them in others. Historic harvest practices in coastal forests have favored hardwood retention and resulted in extensive hardwood dominated stands. Recently, some landowners have concentrated on hardwood removal and establishment of nearly pure sapling conifer stands. The harvest history in the assessment area will significantly influence landscape-scale retention decisions.

The appropriate scale for evaluating hardwood retention is an important consideration. This should reflect what is possible, meaningful, and measurable. Starting at a smaller scale allows information to be accumulated up to larger scales, permitting flexibility in the scale of discussion. However, starting with too large a scale does not allow assessment of smaller landscape scales.

In order to evaluate hardwood habitat adjacency and connectivity beyond the stand level, a two-tiered ecosystem management perspective can be adopted.

- The first tier of analysis is a scale relevant to the acreage proposed for harvest, typically 100 to 1000 acres.
- The second tier allows for an enhanced ecosystem perspective and evaluates a 3,000 to 10,000 acre drainage, or a circle with a radius of 1.2 to 2.2 miles, a spotted owl bulls eye.

The characterization of hardwoods in the assessment area includes species, age classes, associated tree species, species distribution and acres occupied. Field verification of the landscape is required to detect specific habitat components or species that would trigger additional concern. Habitat components thought to be rare, excessive, or important for specific reasons should receive special attention.

The landscape assessment does not preclude specific decisions based on other criteria. A particular pocket of mature hardwoods may provide excellent cavity habitat. If cavity dweller that is a protected species is known in the vicinity, it may be desirable to retain these hardwoods, even if they are otherwise in overabundance in the general landscape. The landscape approach sets the stage for the rest of the evaluation. It is not appropriate to assess only on the landscape level or only on the stand level. A multi-tiered approach needs to be utilized.

Research Needed

- Develop landscape analyses methods to enable impact forecasts of various hardwood management scenarios based on current forest cover.

  Use landscape spatial analysis to assess relative impacts of desired silvicultural practices on a site by site basis. This will allow flexible regulation rather than the current single standard policy.

- Analyze the results of past land conversion to calculate future forest composition.

Use historical satellite imagery to detect changes in forest composition and cover over time. The result of past changes could be used to extrapolate future density, composition, and crown closure given different management scenarios.

Questions to Answer

Questions to help verify adjacency and connectivity for hardwood forests surrounding a timber harvest site include:

- What is the distribution and abundance of hardwoods in both the timber harvest project area and the surrounding planning watershed?
- Are these surrounding areas with hardwoods connected through water course set asides or other cover corridors?

ECOSYSTEM FUNCTION

Preserving forest ecosystem function is essential in forest management. A functioning ecosystem maintains its ability to recover from disturbance with speed and completeness (resilience), and lacks risks or threats of human-induced changes in the ecosystem composition, structure, and function. Under some circumstances, full ecosystem function can be maintained with reduced numbers of species. Different species may become important for ecosystem stability when conditions change in a fluctuating environment. Therefore, species may not be entirely redundant to ecosystem function when considering a longer time frame. There is little information about the mechanisms by which species diversity influences stability, which limits a quantitative assessment of species removal on ecosystem function.

Due to the complexity of these criterion, *strict hardwood retention guidelines* for maintaining ecosystem function are difficult to develop. To maintain proper ecological function and processes, it has been suggested that a representative distribution of seral stages, with the corresponding diversity of species and structure, and of the appropriate patch size, be preserved. This is because species in a forest landscape have adapted to a natural range of environmental variation that has historically prevailed in the landscape. Physical features and environmental processes influence plant species composition, age-class distribution, and patch size. Therefore, ecosystem function is scale dependent and should be considered across diverse landscapes.

Physical factors such as soil stability and hydrologic cycle contribute greatly to the functionality of an ecosystem. The most common reason that ecosystems fail to provide valuable goods and services to humans is major land use conversion leading to physical instability and/or changes in water flow and quality. In forestry, this is most often observed when tree removal followed by heavy rainfall results in large amounts of soil transport. Landslides and soil slippage can change the direction of watercourses, which can lead to flooding. Damage from water runoff and soil movement should be avoided by maintaining tree root structure, minimizing road impacts, and reducing tree removal and equipment operations on steep slopes.

Root Strength and Slope Stability

The removal or cutting of forest trees can increase the risk of shallow landslides where slopes are very steep and soils are relatively non-cohesive. The degree of risk increases as live root bio-mass (the mass of live roots in the soil) decreases. This decrease occurs as roots die and decay. Three key vegetative factors play a role in slope stability relative to root strength: 1) the magnitude of vegetative reduction (e.g. selection cutting vs. clear-cutting); 2) the rate of revegetation and new root growth; and 3) the presence of sprouting tree species.

Partial cutting may be advisable where slopes are very steep and relatively unstable. This maintains some root strength as the forest continues to grow. Rapid revegetation of harvested sites by both trees and brush rebuilds the root mass, replacing the root systems of harvested trees. Generally, the soil-holding capacity of a harvested site reaches a low point between 7 to 10 years after harvest, followed by a net increase and total root strength replacement in 20 to 60 years (depending upon forest type and conditions). When a large percentage of the harvested trees are sprouting species, root loss following harvest is somewhat reduced, since a portion of the roots remain alive to support new sprouts. An example of this is the redwood forest, where significant portions of tree roots remain alive after tree harvest.

The degree to which various levels of hardwood removal affect root strength and slope stability is largely unknown. Given current uncertainty, it would be wise to retain most if not all forest cover in inner gorges, in the very steep upper reaches of small draws or tributary drainages, and in or near areas of known instability.

Nutrient and Hydrologic Cycles

Hardwoods can improve growing conditions for conifer seedlings by providing high levels of ectomycorrhizal inoculum. Seedlings that form ectomycorrhizae quickly capture resources and are more likely to survive in harsh environments. Individual trees are linked spatially and temporally by hyphae (fungi roots) of ectomycorrhizal fungi that allow carbon and nutrients to pass among them and promote forest establishment following disturbance. These linkages can reduce plant competition for resources, promote forest recovery, and influence the pattern of plant succession. Management practices that retain living trees, shrubs, and input of organic matter provide the energy source and substrate necessary for ectomycorrhizal fungi.

Arboreal vegetation in most coastal forests use varying degrees of moisture generated by fog drip. Fog capture rates are proportional to tree height, canopy cover, and leaf area index. The micro-environments beneath rapidly growing hardwood sprout clumps are not well understood. Beneath these clumps, soil moisture was higher and soil temperature lower than outside them during a cool moist summer. Soil temperature remained lower beneath the clumps during a warm dry summer, but moisture conditions were similar beneath and outside the clumps after a prolonged drought.

Research Needed

- sites with varying hardwood retention levels should be monitored for both biotic composition and abiotic function.
- select and monitor a suite of indicator taxa
- measure soil condition and water quality under a range of hardwood retention levels
- assess effects of vegetation removal on watershed function such as soil erosion and hydrologic flow based on paired watershed studies, with emphasis on the relative role of hardwood species

Questions to Answer

The following questions can help determine if a given level of tree removal will significantly alter ecosystem function.

- Will removal of hardwoods lead to increased soil erosion at the site?

- Will increased particulate matter be transported into the watercourse?
- Will a long term nutrient deficiency result from hardwood removal?
- Is there sufficient surrounding vegetation to maintain a moist microclimate through fog drip? (for regions with coastal fog influence)
- Will the resulting environment promote revegetation?

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Chapter 3

HARDWOOD MANAGEMENT GUIDELINES

There are several possible approaches to developing hardwood retention standards.

• Historically, regulatory agencies have focused on tree retention based at the stand level. Considering economic, aesthetic and ecological values, and conforming with forest practice regulations, prescriptions could be made that maintained minimum hardwood basal area for each stand where hardwoods occur. Hardwoods could be maintained within size class frequency distributions that provide for the life-requisite needs of selected wildlife species that utilize hardwoods. Target objectives can be expressed in terms of basal area distribution within diameter size classes, tree frequency distribution per diameter size class and/or percent of stand tree canopy closure comprised of hardwoods (see Appendix C for examples on how to calculate these parameters). To the extent that hardwood species provide various benefits to wildlife, specific target objectives could be provided for each hardwood species.

• Another method for evaluating stand level hardwood retention is to focus on special features within the stand. For example, guidelines may recommend the retention of individual hardwood trees:

a) that provide habitat elements necessary for wildlife; and
b) that are situated such that their retention does not conflict with other management objectives.

This would include those trees that are known to be used by wildlife species for nesting, roosting, cover, perching or other behaviors. In general, larger hardwoods are more valuable to a greater diversity of wildlife than smaller trees. Retained trees can also include individuals or stands that have high aesthetic value.

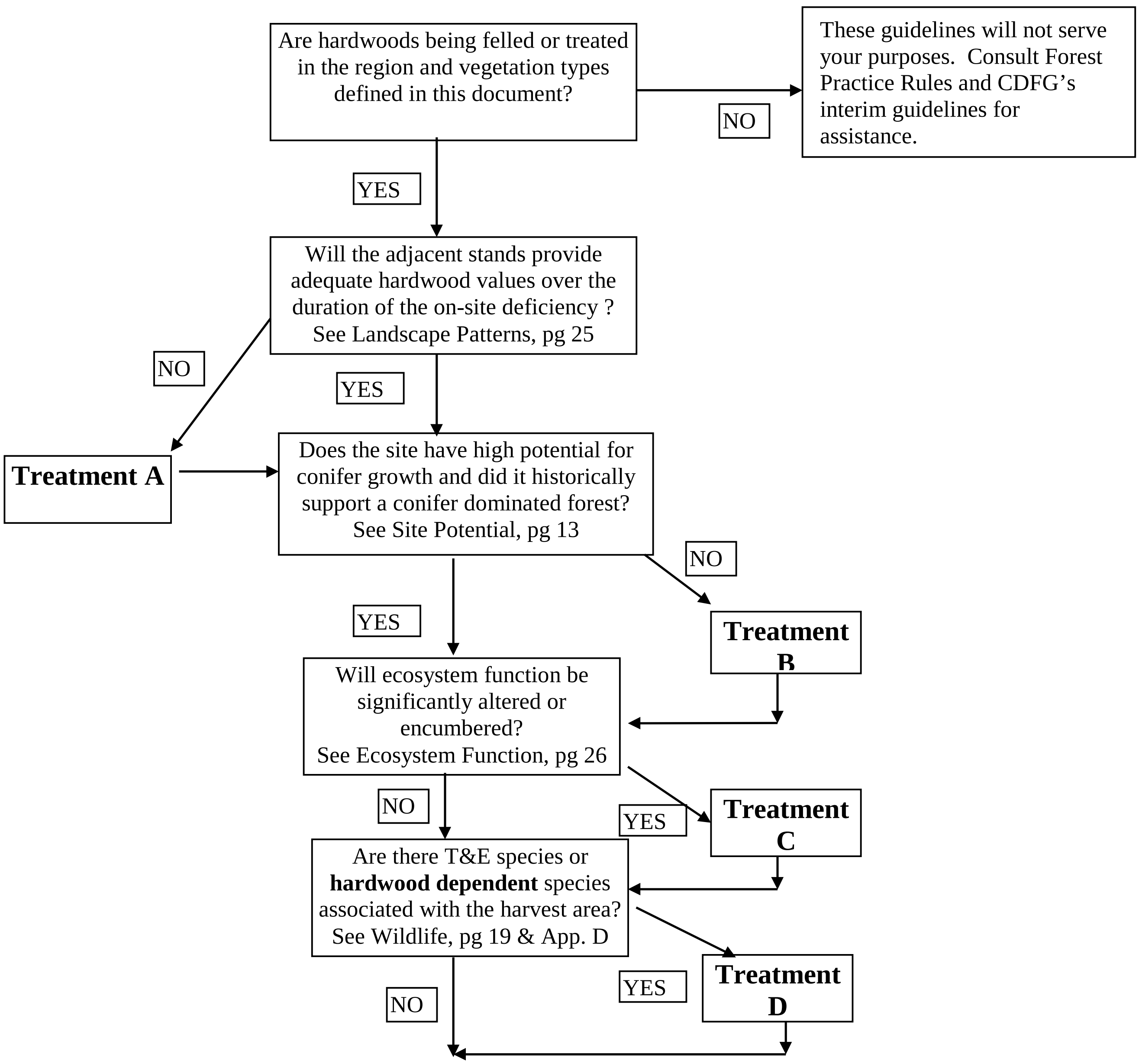
• As presented earlier, comprehensive forest management must include evaluation at scales greater than stand-level. Therefore, a landscape approach can supplement stand-level analysis to establish hardwood retention guidelines. Stands currently dominated by hardwoods can be set aside as "hardwood emphasis" areas. These may include locations where management for conifers is not economical, practicable, is constrained by regulation (e.g., wetlands, watercourse and lake protection zones, special treatment areas), or where hardwoods are better adapted than conifers to the site. Arranging hardwood retention at a landscape scale requires that the areas designated to preserve hardwood habitat values are permanently protected as hardwood set asides.

Integrating stand and landscape scales can effectively capture the benefits of both approaches. In this case, a retention minimum would apply at the stand level and other stand features such as wildlife habitat elements (e.g. large cavity trees) would be protected. To preserve habitat heterogeneity across the landscape, areas of “hardwood emphasis” could also be established.

Ensuring the viability of wildlife populations in managed ecosystems is the most common regulatory approach to forest management. This is because the State has a responsibility to maintain public trust resources such as wildlife. Therefore, information on habitat needs can be used to guide hardwood retention.

There are pros and cons to any set of retention guidelines, including those based on stand structure, landscape pattern, and habitat needs of specific wildlife species. Unfortunately, there are insufficient data to support quantitative recommendations for any of these approaches. Until more research is completed on stand dynamics, landscape pattern and process, and wildlife habitat relations in the North Coast, the recommendation is to take all of the criteria discussed into account when determining hardwood retention. Through continued research and adaptive management these guidelines can be updated and refined.

The following flow diagram was designed to assist land managers in considering stand dynamics, landscape pattern and process, and wildlife requirements. This flow diagram, similar to these guidelines, should be used if one is evaluating the treatment or felling of hardwoods at sites that are; 1) in northern Sonoma, Mendocino, southern Humboldt, and southwestern Trinity Counties and 2) in Redwood, tanoak, or Douglas-fir/Tanoak Series. To help answer the questions posed in the following flow diagram, a detailed list of questions can be found for each criterion in Chapter 3. If any true oaks (*Quercus spp.*) are going to be felled or treated, the California Department of Fish and Game's Interim Guidelines for hardwood retention should be followed. Clearly, considering the date of the CDFG Interim Guidelines, there should be an effort to review and possibly revise the statewide guidelines given the extent of work that has been done on the relationship between wildlife and California's oak woodlands in the last 10 years.



The following suggested retention treatments are based on the criteria described in Chapter 3 and listed in the above flow diagram. If it is not clear whether or not the following treatments apply to a particular harvest plan go back and answer the questions posed for each criteria in Chapter 3.

Treatment A (See Landscape Perspective, Chapter 3)
Often adjacent stands and habitat connectivity within the landscape can support wildlife values, thereby reducing the importance of the hardwood composition in a particular timber stand. If habitat adjacency and connectivity are not sufficient then implement the following.

- ☐ retain hardwoods in WLPZ
- ☐ retain large (>28” dbh) hardwoods within the treatment clumped with hardwoods of all size and age classes
- ☐ preserve habitat corridors between valley and ridge lines

Treatment B (See Site History and Potential, Chapter 3)
If the site is historically (pre-European) a hardwood dominated site then maintain high relative hardwood site occupancy at both stand and landscape level. Retaining large trees and clustered hardwoods will provide additional stand structure and species diversity, however, these patches may be highly influenced by edge effects.

- ☐ maintain tree species presence in relation preharvest ratios
- ☐ retain large amounts of all hardwood size, age and species classes
- ☐ retain clusters of hardwoods around prominent wildlife trees
- ☐ retain all prominent large hardwoods (>28”)
- ☐ maximize contiguous habitat area (large hardwood patch size)
- ☐ use these areas for habitat refuges and corridors to increase connectivity

Treatment C (See Ecosystem Function, Chapter 3)
Environmental attributes, such as clean water and stable hillsides, are important considerations. An effectively functioning ecosystem ensures the preservation of such basic needs. The loss of top soil, water quality, and depleted nutrients must be avoided. Therefore, if extensive removal of hardwood cover will significantly damage a watershed area, then follow these guidelines.

- ☐ retain hardwoods with deep and broad root structure to provide soil stabilization
- ☐ retain standing and downed hardwoods to mitigate down slope runoff
- ☐ retain hardwoods along the edge of all watercourses
- ☐ retain a significant number of trees on steep slopes (> 50%) to provide root mass

Treatment D (See Wildlife, Chapter 3)
Maintaining public trust values such as wildlife is a primary concern. In particular, species that are declining in numbers to the point where their survival is in question place all landowners in a position of responsibility for their survival. If federal or state protected species are present on a harvest site that use hardwoods, the particular habitat requirements for those species should be met. This will require going to the primary literature written on the species in question, some of which is cited in this document and consulting with the CDFG and USFWS. In certain situations, due to a lack of information, follow the general retention guidelines that have been suggested in this document to help support wildlife including the following.

- ☐ retain all hardwoods in Class I, II, III and WLPZ
- ☐ retain large individual hardwood trees over the landscape
- ☐ retain large prominent wildlife trees with special habitat features such as cavities and superior mast production
- ☐ retain standing hardwood snags and provide for snag recruitment
- ☐ maintain habitat corridors by retaining hardwoods for conductivity with minimal edge
- ☐ retain clumps of smaller hardwoods around larger trees as habitat islands
- ☐ California Fish and Game recommends that hardwood basal area should be maintained between 35 and 25 ft^2/acre for some inland hardwood types

Adequate Site Occupancy- The range of stocking levels that provides a balance between the largest number of trees per acres capable of maximum individual tree growth on future cop tree and maximum overall stand growth.

Cavities- Cavities are caused by injury to the tree as a result of fire, wind, lightning, age, or other mechanical or natural factors. Cavities are utilized for nesting, roosting, and other purposes. Some salamanders need this moist habitat to survive. Some species are closely associated with older forests because older forests contain more trees with these types of features.

Connected habitats- Most species will only move between the habitats they require if they can do so without fear of attack, or without venturing out into areas which are not conducive to their survival. For this reason, it is sometimes necessary to retain pathways between habitat patches. The pathways, or connections, must be capable of use by the species under consideration. The connections need not always be ideal habitat, but must be of sufficient quality to allow short-term movement between preferred habitats. Many studies have recommended that habitat areas be connected by retaining forest cover along watercourses and along or over ridges.

Cover- Cover needs vary markedly by species. Some require dense, brushy habitats, while others require a continuous overstory canopy with an open understory. Knowledge of individual wildlife species or associated groups of species is necessary to recommend various levels or types of cover.

Diameter breast height (DBH)- Diameter breast height (dbh) is the diameter of the tree measured at 4.5 feet on the high side of the topography.

Good mast producers- These trees are of high value to many species of wildlife. Oaks, which produce acorns, are of value to deer, birds, and many other species. Trees that produce fruits such as madrone are also of value to many species. Some trees are capable of much higher mast production than others, and trees can be periodically examined for evidence of this production.

Grouped- The way in which hardwood trees are grouped can affect their value. For example, retaining a group of mixed species may be of higher value than retaining a group consisting of a single species.

Habitat diversity- Diversity between and within habitats is considered to be valuable to wildlife. Forest stands with multiple species, densities, sizes, and ages are of greater value.

Landscape- A heterogeneous land area composed of a cluster of interacting ecosystems that is repeated in similar form throughout (Noss and Cooperrider 1994).

Large trees- Large trees are widely recognized for their potential wildlife value. These trees are capable of high mast production levels, and have potential to form large nesting cavities and nesting and roosting platforms. These trees also provide cavities used by salamanders and other creatures. Highest priority should be given to retention of those large trees which have some of the attributes listed below.

Litter production (terrestrial and aquatic)- Hardwoods of all sizes produce leaf and branch litter fall. The amount of this material produced is probably related more to canopy density than to tree size. Disturbances in the forest can have an effect upon the amount of litter on the forest floor. Leaf litter delivers nutrients and food to vertebrates and invertebrates living at the forest floor, and living in streams.

Nesting platforms, heavy branching- Large, older trees often have characteristic large branches, which provide good nesting and roosting sites for wildlife.

Patch size- Larger patches of trees are generally regarded as being of greater value than smaller ones. This is related to the concept of "edge". Small patches of forest are subject to intrusion by more open-forest species moving in from the edge. If the patch is not of sufficient size, there is no internal area within which to take refuge. Larger patches are generally capable of supporting a greater number of animals of any given species.

Recruitment Trees- In order to maintain a constant supply of larger trees, some consideration must be given to the rate at which those large trees will die or be lost, so that a sufficient number of smaller replacement trees can be retained to grow into the larger sizes. This can be accomplished by retaining small numbers of scattered replacement trees, or by allowing young stands to age and replace stands that are cut or removed.

Residual Trees- Trees left in a stand from previous entries, generally because they were not of sufficient form or merchantability to warrant harvesting. These trees are often predominant in a stand and are highly valuable as a wildlife habitat element because of their advanced age, stage of decadence and structural attributes, which contribute to increased wildlife habitat diversity within a stand.

Site Potential- Site potential is the aggregate of all environmental condition affecting the growth of future crop trees.

Spacing- The spacing of trees or stands can be an important consideration. This concept is closely related to cover and connectivity. For some species, widely spaced trees within otherwise open areas cannot be utilized. Spacing also affects the rate at which individual trees grow.

Stand- Vegetation occupying a specific area and sufficiently uniform in species composition, age arrangement, structure and condition as to be distinguished from the vegetation on adjoining areas (Smith 1994).

Large Woody Debris (LWD)- Large trees eventually fall and decay. Once on the ground, they provide nutrients to the soil, and provide a home for many species of wildlife, including salamanders, snakes, and rodents. Large trees not only provide more of this living space due to their size, but they persist longer due to their size.

Appendix A: Hardwoods utilized by indigenous people and a description of their uses.

Hardwood species	Uses
Big-Leaf Maple	Inner bark used for making baskets. [1]
California Bay-Laurel	The nut is used for camphor and is eaten as food. The leaves and bark are used to purify the ground and fires. Leaves make a strong insecticide for cleaning house and the bark can be boiled and used as a scalp cleaner. [2]
Golden Chinquapin	The nut called "California Chestnut" is collected for food. [1]
Madrone	Used for making ceremonial clappers of a chief or high presiding person. Also a slow burning firewood or cooking wood. [2]
Oregon Ash	Used for firewood and carved tobacco smoking pipes (Yuki). [1]
Red Alder/White Alder	Wood used for smoking fish and meat. [2] Arrows sometimes made of shoots and dry rot from wood was mixed with the powdered bark of *Salix lasiolepis* as a poultice for burns. Bark an astringent and dye, also used as a cure for TB hemorrhages. [1] A dye used on grasses woven into baskets. [3]
Tanoak and True Oaks	A staple food for north coast tribes and for the game species upon which they depend. Wood used for ceremonial and dance clappers for medicine woman , shaman and designated singers, and for the tanning of skins. [2]
Willow	Used for burden, baby and supply baskets, fish traps and caches. Weather can be predicted by the bark. [2] The inner bark of willow is used for rope. [3]
California Buckeye	Leaves and nuts used to stupify fish in the process of harvesting them from streams. Nuts were eaten following roasting, grinding and leaching. [3]
Mountain Dogwood	Used in the making of baby and burden baskets. Inner bark has quinine properties, taken as a tea.

1. V.K. Chestnut, "Plants Used by Indians of Mendocino Co., California".
2. Florence Silva, Pomo
3. Edith Van Allen Murphey, "Indian Uses of Native Plants

Appendix B: Characteristics of North Coast hardwood tree species (Standiford and Tinnin 1996, Burns and Honkala 1990, Pavlik et al. 1991; Sudworth 1967).

Species	Habitat	Life History	Competition	Wood Uses
Tanoak *Lithocarpus densiflorus* (also tanbark oak)	Common along California coast. Populations also found in Southern Oregon and the Sierra Nevada. Bulk of precipitation in winter, mostly as rain. Humid, with mild temperature. Grows best on deep, well-drained soils with texture between loamy and gravely, including sandy. Favors similar soils to redwood. Shrub form found on less moist soils. Found on shallow stony soils less suited for conifers, though does less well here than other hardwoods.	Reproduce from acorn-like seeds. Animal predation and desiccation interferes with germination. Seedlings emerge in spring, with good survival rate, particularly under conifer overstories. Excellent sprouter. Has one main trunk without side branches in dense stands. Large, horizontal limbs and short main trunk in open stands. Flowers in late spring to early summer. Acorns ripen in fall of the second year. Good seed crops after 30-40 years. Leaves are evergreen.	Classified as shade tolerant, though best growth with direct light from above. Quickly dominates disturbed or logged areas, competes with redwood and Douglas-fir. Chief cause of damage to mature trees is fire. Pathogens can enter wounds and hollow out tree. Other than fire, tanoak experiences few insect and fungi problems. Weather also does not damage many trees, except those already damaged by fire.	Hard, fine-grained wood. Strongest wood of any western oak species. Used for firewood and pulp. Potential for furniture, flooring, specialty products and better commercial quality of any oak species in its range. Historically used for tannin for leather industry and as astringent. Acorns used by Native Americans.
Pacific madrone *Arbutus menziesii*	Grows along coast from British Columbia to Big Sur. Grows best in coastal region with mild winters and year round moisture, often as fog, and does not prefer dry sites. Wide range of soils, but does best on rich soils and in valleys and canyons near water sources.	Seeds have high germination. Fungi kill large number of seedlings. Most successful establishment on bare soils in disturbed areas. Slow early growth. Sprouts well. Straight trunk, but can be brushy on poor sites. Seed production begins at 3-5 years and varies from year to year. Berries mature in fall. Leaves are evergreen.	Thin bark makes susceptible to fire. Resprout after fire. Minimal animal and insect damage. Madrone canker causes dieback. Cavities develop in heartwood due to heart rot.	Hard, strong wood, similar to black cherry in color and grain. Attractive veneer, paneling, and specialty items. Used for firewood, and historically for charcoal.
Giant chinkapin *Castanopsis chrysophylla* (also western chinkapin)	Largest population in Oregon and California along Coast Range. Mild, wet, winters and dry, but not hot summers. Shrub form more common in drier areas. Maximum size occurs on deep soils, but does not require highly fertile sites. North slopes and valley bottoms have best growth.	Low germination rate; best in partial shade with light leaf litter and no dense understory. Very slow seedling growth of only several inches a year. Can live a long time in understory and sprout following cutting or injury. Seed production of large, hard-shelled nuts is a 2-year cycle. Leaves are evergreen.	Out-performs other species on poorer sites; slow growth on better sites. Remains in brushy form in understory unless openings in canopy occur. No significant insect or disease problems.	Small specialty market for furniture and veneer. Generally poor form limits widespread use.

Species	Habitat	Life History	Competition	Uses
Red alder *Alnus rubra* (also Oregon alder, western alder, Pacific coast alder)	Lowland species along Pacific Coast from SE Alaska to So. California. Grows in humid areas with mild winters and cool summers. Found in areas with >25 inches rain or with root access to ground water. Grows best on deep, well-drained soils, but can survive poorly drained areas and areas subject to flooding. Usually limited to streamside areas in California.	Reaches sexual maturity at 4 to 8 years. Flower in later winter to early spring. Prolific and consistent seed producer on conelike strobili. Seeds can be dispersed great distance by wind. Germinates and grows well on moist mineral soil with full sunlight. Rapid early height growth (up to 3 feet first year and 10 feet per year possible after 2 to 5 years). Vigorous sprouter. Nitrogen-fixing nodules on roots. Deciduous leaves.	Extremely rapid juvenile height growth. Short-lived species that matures in 60-70 years, seldom living beyond 100. Require full sunlight, and will die if in shade for more than few years. Must stay in upper canopy to persist in stand. Fairly free of insects and disease, except heart rot in older trees.	Moderately dense. Uniform texture. Well-established hardwood industry in Pacific NW for furniture, cabinets, pallets, firewood and pulp, and use and value is increasing. Potential for biomass. Enhances soil nitrogen.
California bay *Umbellularia californica* (also California laurel, Oregon myrtle, Pacific myrtle, Pepperwood)	Coastal region of southern Oregon to south of Big Sur, with isolated populations into southern California. Found on diverse sites, but does best with constant moisture. Slightly acidic soils. Best growth on downslope, alluvial fans and gravely outwash.	Germinate in fall or late winter. Best germination with light litter layer. Seedling growth only several inches in first year. After taproot development, branching occurs in third year. Sapling growth on best sites can be up to 2 feet per year. Mature trees produce abundant crops of nutlike fruit in the fall of most years. Leaves are evergreen.	Classed as shade tolerant, although growth is slow in the understory. Litter has allelopathic effect on other species. Few natural enemies, with wind and snow causing most damage. Excellent sprouter.	Excellent wood quality and possible uses for trim, paneling, veneer, and specialty uses. Leaves used as food seasoning.
Bigleaf maple *Acer macrophyllum* (also Oregon maple, broadleaf maple)	>From British Columbia to Mexican border. Found over wide range of temperatures and moisture, but usually associated with permanent water sources. Found on deep, gravely soils with abundant moisture. Considered “soil builder”, high concentrations of potassium, calcium, and other nutrients.	Seeds germinate in early winter; best on mineral soil. Seedlings do best in shaded conditions. Can grow 6 feet per year in optimal conditions. Produce seeds at 10 years of age, with seed crop produced annually. Good stump sprouter. Leaves are deciduous.	Best establishment under canopy rather than direct sunlight. Best growth in open stands (either thinned or naturally open). Fungi can invade wounds and deteriorate wood. Verticillium wilt can cause mortality. Fungi and boring insects can damage trees and degrade lumber value.	Popular ornamental shade tree. Can be used for furniture, veneer. Often used for firewood. Some potential for use of sap for syrup.

Species	Habitat	Life History	Competition	Uses
Oregon white oak *Quercus garryana* (also Garry oak, Brewer oak)	Similar distribution to madrone and California bay, but in more inland location. Grows in variety of climates. Usually out-competed on better sites. Tends to dominate on poorer, drier sites (rocky ridges and south slopes). Also common on wet sites, including flood plains and clay soils. Nor common on very steep slopes. Favored soils tend to be acidic.	Germination occurs in fall or spring following dispersal. Very slow shoot growth, with seedling energy directed to growing a taproot. Slow growth, although tree can become quite large. Seed production is highly variable from year to year. Important mast source for wildlife. Leaves are deciduous.	Will die under closed canopy, but survive under partial light. Fire required to keep dominance in the community. If overtopped by conifers, will die out. Heartwood fairly resistant to rot. Impact from insects not severe. Rodents may damage roots or branches.	Dense wood, but doesn't withstand shock –brittle wood. Used for pallets, fenceposts, firewood and furniture. Some potential for cooperage. Acorns, parasitic mistletoe, and mushrooms have some potential specialty uses.
California black oak *Quercus kelloggii*	Most common oak in California. Found throughout the Coast Range and the Sierra Nevada. Sites characterized by hot, dry summers and cool, moist winters. Grows on variety of soils but prefers soils with good drainage.	Seeds require conditioning for germination. Dormancy broken by overwintering on forest floor. Spring germination as weather warms. Grow slowly first year, with most energy directed to growing a taproot. Seedling mortality to drought and herbivory. Vigorous sprouter, with up to 2 feet of height growth per year in openings. Often grow in clumps. Deciduous oak. Viable acorns produced at age 30, mass production not beginning until 80-100 years.	Likes light and grows best in full sunlight. Older trees become suppressed and die if they can't remain in sun. Sensitive to fire because of thin bark. Heart rot fungi common in wounds. Attacked by carpenter worms.	Attractive grain, good hardness and strength. Source of paneling, furniture, flooring. Used for firewood. Native Americans use acorns.
Coast live oak *Quercus agrifolia* (also California live oak, encina)	Found along coastal areas from Southern California to Mendocino County. Proximity to ocean provides milder climate, and moister winters. Usually on hardwood rangeland sites. Often found in pure stands. Common on valley floors or fairly moist, fertile slopes. Sites well-drained.	Acorns mature in one year. Germinate well in shady conditions. Regeneration relatively good throughout the state. A very vigorous sprouter, especially after fire. Leaves are evergreen.	Tolerant of shade. Very tolerant of fires due to thick bark. Due to ability to sprout, more resistant to grazing than blue oaks , such that dominance may be shifting from blue to coast live oak in some areas. No major insect or disease problems.	Used for firewood. Historically used for charcoal, and for acorns by Native Americans.

Species	Habitat	Life History	Competition	Uses
Canyon live oak *Quercus chrysolepis* (also gold cup oak, maul oak)	Found in Coast Range and the Sierra Nevada. Most common on sheltered north slopes and steep canyons. Found with mixed conifer, chaparral, and woodland species. Dominates on steep, shallow, infertile sites. On deeper soils, secondary to Douglas-fir.	Acorns mature in one year. Production is highly variable. Produce flowers in 15-20 years. Acorns drop in fall, and germinate in spring after stratification. Best seedling development in understory on seedbed with leaf litter. High survival. Leaves are evergreen.	Tolerant of shade and drought, although less than tanoak, chinkapin, and Douglas-fir. Variable growth form, with both shrubby and tree form. Wide distribution of tree ages when free of disturbance. Early successional species on poor sites. Damage by deer browsing significant. Vulnerable to fire. Little insect damage. Heart rots common.	Good wood properties, although usually has poor form. Most commonly used for firewood, although some possibility for custom furniture and flooring exists.
Interior live oak *Quercus wislizenii* (also highland live oak, Sierra live oak)	Common in more interior Coast Range locations and throughout the Sierra Nevada. Found in pure stands, and mixed with blue, coast live, and valley oaks, as well as in mixed evergreen forests. Usually found on moister areas than blue oak woodlands. Hot, dry summers, and wet winters.	Acorns mature in two years. Seedlings germinate well in shade. Very vigorous sprouter after fire or harvest. Leaves are evergreen.	Seedlings are tolerant of shade. Older trees are less tolerant. Usually occurs in fairly dense canopy cover. Over long-term, would require canopy openings to allow recruitment of saplings. No major insect or disease problems.	Good wood properties, although poor form. Typical use is firewood. Possibility for custom furniture and flooring.
Valley oak *Quercus lobata* (also California white oak, mush oak, water oak, roble)	Found in interior valleys throughout the state. Prefers fertile, well-drained bottomland soils, streambeds, and lower foothill location. Many areas historically supporting have been converted to agricultural uses. Can grow well in areas of summer drought if roots tap into ground water. Usually removed from fog belt area on coast. Important component of riparian forests.	Very large acorn matures in first year. Early growth goes into development of taproot. Acorns require one year to mature. No stratification required, and germination occurs in the fall. Early energy goes into taproot development. Leaves are deciduous.	Seedlings are somewhat tolerant of shade. As trees mature, however, they will die out unless exposed to full sunlight. Capable of very rapid early growth. Trees can grow rapidly throughout life, and reach very large sizes.	Good machinability, grain. Some potential for cooperage, and possibility for grade lumber, furniture, and flooring.
Blue oak *Quercus douglasii* (also white oak, mountain oak, iron oak, post oak)	Widely distributed throughout the state. Found in pure stands on dry hardwood rangelands. Most common on hot, dry sites with rocky soils. Grade into valley oak stands at low elevations, and into live oak stands at higher elevations.	Annual acorn production varies greatly. Seedlings germinate in shaded or open conditions. Dry environment causes large losses due to moisture competition. Leaves are deciduous.	Seedlings germinate in shade, but die without direct sunlight. Growth not as rapid as live oak species. Losses to rodents, grasshoppers, grazing, and browsing are common. Lack of saplings common, due to moisture competition, competition for light, and herbivory.	Very poor form makes use for anything except firewood and specialty items unlikely.

Appendix C: North Coast vegetation and associated tree species described by three different forest type classifications.

CWHR TYPE	Sawyer and Keeler-Wolf 1995 SERIES Sole, Dominant, or Important (S) (D) (I)	Other Trees Commonly Present *broadleaf*	 *needleleaf*	Jimerson and others 1996 SUBSERIES
Douglas-fir	Douglas-fir Series (S,D)	Big-leaf maple chinquapin Pacific madrone Oaks: Black Canyon live Oregon white Tanoak Vine maple	Incense cedar Redwood Sugar pine Western hemlock	Douglas-fir-California Bay Douglas-fir-Red alder Douglas-fir-Black oak Douglas-fir-Incense cedar Douglas-fir-Oregon white oak Douglas-fir-Canyon live oak Douglas-fir-Jeffrey pine Douglas-fir-Tanoak Douglas-fir-Maple Douglas-fir-Huckleberry oak Douglas-fir-Chinquapin Douglas-fir-Moist shrub
Douglas-fir	Douglas-fir - Tanoak Series (I)	California bay Chinquapin Pacific madrone Oaks: Black Canyon live Tanoak Vine maple White alder	Sugar pine Pacific yew	Douglas-fir-tanoak
Douglas-fir	Western Hemlock Series (S, D)	California bay Pacific madrone Tanoak	Douglas-fir Redwood Sitka spruce	
Douglas-fir	Sitka Spruce Series (S, D)	Cascara Red alder	Grand fir Redwood Western hemlock	

CWHR TYPE	**Sawyer and Keeler-Wolf 1995** SERIES Sole, Dominant, or Important (S) (D) (I)	Other Trees Commonly Present *broadleaf*	*needleleaf*	**Jimerson and others 1996** SUBSERIES
Douglas-fir	Grand fir Series (S, D)	Red alder Tanoak	Bishop pine Douglas-fir Redwood Sitka spruce Western hemlock	
Redwood	Redwood Series (S, D, I)	Bigleaf maple California bay Pacific madrone Tanoak	Douglas-fir Grand fir Western hemlock	
Coastal oak woodland	California Bay Series (S,D)	Coast silktassle Pacific madrone Oaks: Canyon live Interior live	Redwood	Douglas-fir-California Bay Tanoak-California Bay
Coastal oak woodland	Mixed Oak Series	California bay Pacific madrone Oaks: Black Blue Coast live Interior live Oregon white Valley	Foothill (gray) pine	
Montane hardwood	Black oak Series (S, D, I)	Bigleaf maple Pacific madrone Oaks: Canyon live Coast live Oregon white Valley	Incense cedar Knobcone pine	Tanoak-Black oak Douglas-fir -Black oak

CWHR TYPE	Sawyer and Keeler-Wolf 1995 SERIES: Sole, Dominant, or Important (S) (D) (I)	Other Trees Commonly Present: *broadleaf*	*needleleaf*	Jimerson and others 1996 SUBSERIES
Montane hardwood	Tanoak Series (S, D)	California bay Pacific madrone Oaks: Black Canyon live Coast live	Douglas-fir Sugar pine	Tanoak/Evergreen huckleberry Tanoak-California Bay Tanoak/Moist shrub Tanoak-Port-Orford cedar Tanoak-Black oak Tanoak-Canyon live oak Tanoak-Maple Tanoak/Dry shrub Tanoak/Salal Tanoak/Huckleberry oak Tanoak-Chinquapin
Montane hardwood	Oregon White Oak Series (S, D)	Pacific madrone Oaks: Black white oak Canyon live	Douglas-fir Incense cedar	Douglas-fir-Oregon
Montane riparian (S, D)	Red Alder Series	Black cottonwood Vine maple Willows: Arroyo Hooker	Douglas-fir Grand fir Redwood Sitka spruce Western hemlock	Douglas-fir-Red alder
Closed pine-cypress (S, D)	Bishop pine Series	Pacific madrone	Douglas-fir Grand fir Incense cedar Knobcone pine	

Appendix D: CWHR habitat values, model confidence, legal status, life history, and habitat element information for around 250 species of amphibians, birds, mammals, and reptiles predicted to occur in the region of focus. This information was developed from the California Wildlife Habitat Relationships Program (CWHR) version 6.0, produced in 1997. New versions should be consulted as information is subject to change.

The variables listed in the table include the following. The habitat values are averaged across all stages and life requisites, therefore, they are scaled within an individual species from 0-1; a higher value for a particular species means that the habitat with the higher score has a higher level of habitat suitability for the species. Low scores may mean that only a few life requisites were rated as suitable for a few stages, yet the stages rated may be very high (e.g., marbled murrelet), or many stages were rated with low suitability for several life requisites. Only species preferring or making great use of the elements are listed as requiring a particular element. For example, all species probably use riparian or wetland habitats to some degree, but those that do not prefer it or make extensive use of the habitats and elements were not placed on the list

MHW - CWHR predicted average habitat suitability value for all 16 tree size/canopy cover classes for montane hardwood habitat

MHC - CWHR predicted average habitat suitability value for all 17 tree size/canopy cover classes for montane hardwood-conifer habitat

KMC - CWHR predicted average habitat suitability value for all 17 tree size/canopy cover classes for klamath mixed-conifer habitat

DFR - CWHR predicted average habitat suitability value for all 17 tree size/canopy cover classes for Douglas-fir habitat

RDW - CWHR predicted average habitat suitability value for all 17 tree size/canopy cover classes for redwood habitat

TA - the animal is primarily terrestrial (1) or aquatic (0)

NA - the animal is native (1) or exotic (0)

BR- the animal breeds in the region (1) or doesn't breed in the region (0)

MC - a subjective rating based on the confidence that CDFG has in the raw data (3= highest, 2=moderate, 1=lowest)

Common Name - accepted common name

Scientific Name - accepted scientific name

FE - Federally listed as endangered

FT - Federally listed as threatened

CE - California listed as endangered

CT - California listed as threatened

CS - California species of special concern by CDFG

FC - candidate or proposed for listing by federal government

HA - a regulated harvest species by CDFG

AC - prefers or makes great use of acorns as a habitat element

FR - prefers or makes great use of fruit as a habitat element

HT- prefers or makes great use of hardwood trees (>11" dbh) as a habitat element

RH - prefers or makes great use of riparian habitats

DW - prefers or makes great use of downed logs, slash, or brush piles as a habitat element

SS - prefers or makes great use of snags or stumps as a habitat element

RC - prefers or makes great use of rocks, cliffs, caves, talus, or lithic scatters as a habitat element

VP - prefers or makes great use of vernal pools, wetlands, emergent or submergent aquatic vegetation as a habitat element

Common Name	Genus species	MHW	MHC	KMC	DFR	RDW	TA	NA	BR	MC	FE	FT	CE	CT	CS	FC	HA	AC	FR	HT	RH	DW	SS	RC	VP
ACORN WOODPECKER	*Melanerpes formicivorus*	0.67	0.67	0.18	0.27	0.27	1	1	1	2								X		X	X		X		
ALLEN'S CHIPMUNK	*Tamias senex*	0.39	0.39	0.69	0.45	0.48	1	1	1	1											X	X	X	X	
ALLEN'S HUMMINGBIRD	*Selasphorus sasin*	0.34	0.34	0.00	0.23	0.34	1	1	1	2										X	X				X
AMERICAN BEAVER	*Castor canadensis*	0.33	0.33	0.33	0.33	0.22	0	1	1	2							X			X	X				X
AMERICAN CROW	*Corvus brachyrhynchos*	0.24	0.09	0.09	0.22	0.04	1	1	1	2							X			X	X				
AMERICAN GOLDFINCH	*Carduelis tristis*	0.23	0.12	0.00	0.12	0.12	1	1	1	2										X	X				
AMERICAN KESTREL	*Falco sparverius*	0.59	0.60	0.60	0.34	0.37	1	1	1	2										X	X		X	X	
AMERICAN MARTEN	*Martes americana*	0.00	0.44	0.32	0.45	0.11	1	1	1	2					X						X	X	X		
AMERICAN ROBIN	*Turdus migratorius*	0.68	0.60	0.62	0.58	0.58	1	1	1	2									X	X	X				
ANNA'S HUMMINGBIRD	*Calypte anna*	0.45	0.35	0.34	0.26	0.19	1	1	1	2										X	X				
ARBOREAL SALAMANDER	*Aneides lugubris*	0.33	0.00	0.31	0.26	0.26	1	1	1	1										X	X	X	X	X	X
ASH-THROATED FLYCATCHER	*Myiarchus cinerascens*	0.72	0.52	0.32	0.32	0.23	1	1	1	2										X	X		X		
BALD EAGLE	*Haliaeetus leucocephalu*	0.32	0.31	0.68	0.19	0.16	1	1	1	2		X	X								X		X	X	X
BAND-TAILED PIGEON	*Columba fasciata*	0.60	0.62	0.60	0.52	0.20	1	1	1	2							X	X	X	X	X		X		
BARN OWL	*Tyto alba*	0.71	0.67	0.22	0.17	0.22	1	1	1	2										X	X		X	X	
BARN SWALLOW	*Hirundo rustica*	0.62	0.60	0.61	0.61	0.68	1	1	1	2											X			X	X
BELTED KINGFISHER	*Ceryle alcyon*	0.11	0.11	0.11	0.11	0.11	1	1	1	2											X		X	X	
BEWICK'S WREN	*Thryomanes bewickii*	0.27	0.15	0.15	0.15	0.22	1	1	1	2											X	X		X	
BIG BROWN BAT	*Eptesicus fuscus*	1.00	0.94	0.94	0.62	0.33	1	1	1	1											X		X	X	
BLACK-CROWNED NIGHT HERON	*Nycticorax nycticorax*	0.17	0.17	0.17	0.17	0.17	1	1	1	2										X	X				X
BLACK-HEADED GROSBEAK	*Pheucticus melanocephal*	0.71	0.67	0.38	0.23	0.23	1	1	1	2										X	X				
BLACK-TAILED HARE	*Lepus californicus*	0.46	0.36	0.28	0.26	0.26	1	1	1	2							X								
BLACK-THROATED GRAY WARBLER	*Dendroica nigrescens*	0.83	0.67	0.52	0.21	0.21	1	1	1	2										X	X				
BLACK BEAR	*Ursus americanus*	0.60	0.61	0.59	0.59	0.51	1	1	1	2							X	X	X	X	X	X	X	X	X
BLACK PHOEBE	*Sayornis nigricans*	0.33	0.33	0.23	0.23	0.23	1	1	1	2										X	X		X	X	X
BLACK SALAMANDER	*Aneides flavipunctatus*	0.49	0.51	0.61	0.56	0.72	1	1	1	1											X	X		X	
BLUE-GRAY GNATCATCHER	*Polioptila caerulea*	0.47	0.00	0.00	0.00	0.00	1	1	1	2											X				
BLUE GROUSE	*Dendragapus obscurus*	0.17	0.55	0.67	0.82	0.04	1	1	1	3							X		X		X	X			
BOBCAT	*Felis rufus*	0.68	0.68	0.68	0.68	0.63	1	1	1	2							X				X	X		X	
BOTTA'S POCKET GOPHER	*Thomomys bottae*	0.25	0.26	0.29	0.26	0.20	1	1	1	1											X				X
BRAZILIAN FREE-TAILED BAT	*Tadarida brasiliensis*	0.33	0.22	0.22	0.22	0.22	1	1	1	1											X		X	X	
BROAD-FOOTED MOLE	*Scapanus latimanus*	0.21	0.18	0.18	0.18	0.15	1	1	1	1											X				X
BROWN-HEADED COWBIRD	*Molothrus ater*	0.38	0.37	0.37	0.37	0.37	1	1	1	2											X				
BROWN CREEPER	*Certhia americana*	0.18	0.43	0.51	0.46	0.50	1	1	1	2										X	X		X		
BRUSH MOUSE	*Peromyscus boylii*	0.54	0.74	0.40	0.48	0.11	1	1	1	1								X	X	X	X	X		X	
BRUSH RABBIT	*Sylvilagus bachmani*	0.25	0.31	0.31	0.31	0.30	1	1	1	2							X				X				X
BULLFROG	*Rana catesbeiana*	0.66	0.66	0.62	0.62	0.66	0	0	1	2							X				X				X
BULLOCK'S ORIOLE	*Icterus bullockii*	0.41	0.26	0.00	0.00	0.00	1	1	1	2										X	X				

Common Name	Genus species	MHW	MHC	KMC	DFR	RDW	TA	NA	BR	MC	FE	FT	CE	CT	CS	FC	HA	AC	FR	HT	RH	DW	SS	RC	VP
BUSHTIT	*Psaltriparus minimus*	0.48	0.49	0.11	0.11	0.11	1	1	1	2										X	X				
BUSHY-TAILED WOODRAT	*Neotoma cinerea*	0.62	0.40	0.57	0.57	0.51	1	1	1	1									X		X	X		X	
CALIFORNIA GROUND SQUIRREL	*Spermophilus beecheyi*	0.56	0.56	0.51	0.33	0.28	1	1	1	2								X	X	X	X	X			
CALIFORNIA KANGAROO RAT	*Dipodomys californicus*	0.19	0.00	0.00	0.00	0.00	1	1	1	1									X						
CALIFORNIA MOUNTAIN KINGSNAKE	*Lampropeltis zonata*	0.52	0.53	0.53	0.53	0.53	1	1	1	1											X	X		X	
CALIFORNIA MYOTIS	*Myotis californicus*	0.63	0.60	0.63	0.33	0.33	1	1	1	1											X		X	X	X
CALIFORNIA NEWT	*Taricha torosa*	0.33	0.33	0.33	0.33	0.33	1	1	1	1											X			X	X
CALIFORNIA QUAIL	*Callipepla californica*	0.63	0.62	0.62	0.62	0.62	1	1	1	3							X	X	X	X	X	X			
CALIFORNIA RED TREE VOLE	*Phenacomys longicaudus*	0.00	0.24	0.33	0.46	0.39	1	1	1	1					X										
CALIFORNIA SLENDER SALAMANDER	*Batrachoseps attenuatus*	0.33	0.33	0.33	0.96	1.00	1	1	1	1											X	X		X	
CALIFORNIA THRASHER	*Toxostoma redivivum*	0.10	0.07	0.00	0.00	0.00	1	1	1	2											X				
CALIFORNIA TOWHEE	*Pipilo crissalis*	0.52	0.18	0.00	0.00	0.00	1	1	1	2											X				
CALIFORNIA VOLE	*Microtus californicus*	0.08	0.28	0.15	0.35	0.29	1	1	1	1											X				X
CALIFORNIA WHIPSNAKE	*Masticophis lateralis*	0.33	0.33	0.33	0.33	0.00	1	1	1	1											X	X		X	
CALLIOPE HUMMINGBIRD	*Stellula calliope*	0.44	0.51	0.51	0.35	0.00	1	1	1	2										X	X				
CASSIN'S FINCH	*Carpodacus cassinii*	0.00	0.00	0.45	0.16	0.00	1	1	1	2									X		X				X
CEDAR WAXWING	*Bombycilla cedrorum*	0.21	0.21	0.21	0.43	0.43	1	1	1	2									X	X	X				
CHESTNUT-BACKED CHICKADEE	*Parus rufescens*	0.38	0.38	0.18	0.74	0.74	1	1	1	2										X	X		X		
CHIPPING SPARROW	*Spizella passerina*	0.68	0.55	0.55	0.42	0.40	1	1	1	2										X	X				
CLIFF SWALLOW	*Hirundo pyrrhonota*	0.11	0.05	0.00	0.11	0.11	1	1	1	2											X			X	X
CLOUDED SALAMANDER	*Aneides ferreus*	0.28	0.63	0.28	0.64	0.63	1	1	1	1											X	X	X	X	
COAST MOLE	*Scapanus orarius*	0.17	0.17	0.17	0.17	0.17	1	1	1	1											X				
COMMON GARTER SNAKE	*Thamnophis sirtalis*	0.58	0.33	0.56	0.66	0.55	1	1	1	1											X	X		X	X
COMMON KINGSNAKE	*Lampropeltis getulus*	0.33	0.33	0.33	0.26	0.24	1	1	1	2											X	X		X	
COMMON NIGHTHAWK	*Chordeiles minor*	0.00	0.64	0.64	0.42	0.00	1	1	1	2											X			X	X
COMMON POORWILL	*Phalaenoptilus nuttalli*	0.50	0.49	0.22	0.22	0.00	1	1	1	2											X	X		X	X
COMMON PORCUPINE	*Erethizon dorsatum*	0.30	0.55	0.63	0.57	0.22	1	1	1	2										X	X	X	X		
COMMON RAVEN	*Corvus corax*	0.84	0.85	0.85	0.85	0.83	1	1	1	2											X			X	
COOPER'S HAWK	*Accipiter cooperii*	0.55	0.67	0.48	0.31	0.31	1	1	1	2					X					X	X		X		
COYOTE	*Canis latrans*	0.66	0.64	0.64	0.64	0.61	1	1	1	2							X		X		X	X		X	
CREEPING VOLE	*Microtus oregoni*	0.00	0.28	0.42	0.41	0.37	1	1	1	1											X				X
DARK-EYED JUNCO	*Junco hyemalis*	0.79	0.74	0.76	0.79	0.71	1	1	1	2											X				
DEER MOUSE	*Peromyscus maniculatus*	0.56	0.83	0.74	0.61	0.64	1	1	1	1								X	X	X	X	X			
DOUGLAS' SQUIRREL	*Tamiasciurus douglasii*	0.23	0.38	0.38	0.38	0.23	1	1	1	3							X	X	X	X	X	X	X	X	
DOWNY WOODPECKER	*Picoides pubescens*	0.45	0.47	0.38	0.38	0.39	1	1	1	2								X	X	X	X		X		
DUSKY-FOOTED WOODRAT	*Neotoma fuscipes*	0.72	0.57	0.63	0.68	0.57	1	1	1	1								X	X	X	X	X			
DUSKY FLYCATCHER	*Empidonax oberholseri*	0.15	0.75	0.75	0.75	0.15	1	1	1	2										X	X				
ELK	*Cervus elaphus*	0.36	0.56	0.56	0.57	0.55	1	1	1	3							X				X				X

Common Name	Genus species	MHW	MHC	KMC	DFR	RDW	TA	NA	BR	MC	FE	FT	CE	CT	CS	FC	HA	AC	FR	HT	RH	DW	SS	RC	VP
ENSATINA	*Ensatina eschscholtzii*	0.49	0.50	0.50	0.66	0.83	1	1	1	1										X	X	X		X	
ERMINE	*Mustela erminea*	0.53	0.54	0.58	0.58	0.11	1	1	1	2							X				X	X	X	X	X
EUROPEAN STARLING	*Sturnus vulgaris*	0.47	0.48	0.24	0.24	0.50	1	0	1	2									X	X	X		X		
EVENING GROSBEAK	*Coccothraustes vesperti*	0.26	0.27	0.50	0.28	0.21	1	1	1	2									X		X				
FISHER	*Martes pennanti*	0.00	0.32	0.32	0.32	0.32	1	1	1	2					X					X	X	X	X	X	
FLAMMULATED OWL	*Otus flammeolus*	0.70	0.72	0.72	0.72	0.00	1	1	1	2										X	X		X		
FOOTHILL YELLOW-LEGGED FROG	*Rana boylii*	0.33	0.31	0.33	0.33	0.33	0	1	1	1					X						X			X	X
FOX SPARROW	*Passerella iliaca*	0.40	0.47	0.61	0.24	0.41	1	1	1	2									X		X				
FRINGED MYOTIS	*Myotis thysanodes*	0.22	0.22	0.33	0.11	0.11	1	1	1	1											X			X	X
GIANT SALAMANDER	*Dicamptodon sp.*	0.42	0.43	0.60	0.61	0.66	1	1	1	1											X	X		X	X
GOLDEN-CROWNED KINGLET	*Regulus satrapa*	0.08	0.33	0.70	0.70	0.71	1	1	1	2											X				
GOLDEN-CROWNED SPARROW	*Zonotrichia atricapilla*	0.22	0.11	0.11	0.26	0.26	1	1	1	2											X				
GOLDEN-MANTLED GR. SQUIRREL	*Spermophilus lateralis*	0.73	0.73	0.73	0.68	0.11	1	1	1	2									X		X	X		X	
GOLDEN EAGLE	*Aquila chrysaetos*	0.92	0.93	0.93	0.52	0.47	1	1	1	2					X					X	X		X	X	
GOPHER SNAKE	*Pituophis melanoleucus*	0.43	0.44	0.48	0.40	0.18	1	1	1	2											X	X		X	
GRAY FOX	*Urocyon cinereoargenteu*	0.59	0.59	0.52	0.50	0.51	1	1	1	2							X		X		X	X	X	X	
GRAY JAY	*Perisoreus canadensis*	0.00	0.00	0.63	0.63	0.63	1	1	1	2									X		X				
GREAT BLUE HERON	*Ardea herodias*	0.16	0.17	0.34	0.34	0.34	1	1	1	2										X	X				X
GREAT EGRET	*Ardea alba*	0.10	0.10	0.10	0.10	0.10	1	1	1	2										X	X				X
GREAT HORNED OWL	*Bubo virginianus*	0.73	0.72	0.69	0.49	0.61	1	1	1	2										X	X		X	X	
GREEN-TAILED TOWHEE	*Pipilo chlorurus*	0.31	0.30	0.30	0.11	0.00	1	1	1	2											X				
GREEN HERON	*Butorides virescens*	0.17	0.17	0.22	0.22	0.22	1	1	1	2										X	X				X
HAIRY WOODPECKER	*Picoides villosus*	0.60	0.62	0.69	0.53	0.50	1	1	1	2								X	X	X	X	X	X		
HAMMOND'S FLYCATCHER	*Empidonax hammondii*	0.31	0.31	0.31	0.31	0.16	1	1	1	2										X	X				
HERMIT THRUSH	*Catharus guttatus*	0.66	0.68	0.68	0.49	0.52	1	1	1	2									X		X				
HERMIT WARBLER	*Dendroica occidentalis*	0.34	0.56	0.65	0.65	0.64	1	1	1	2										X	X				
HOARY BAT	*Lasiurus cinereus*	0.58	0.58	0.58	0.58	0.27	1	1	1	1											X		X		
HOUSE FINCH	*Carpodacus mexicanus*	0.32	0.16	0.11	0.11	0.23	1	1	1	2									X		X			X	
HOUSE MOUSE	*Mus musculus*	0.22	0.11	0.11	0.11	0.22	1	0	1	2									X		X	X		X	
HOUSE WREN	*Troglodytes aedon*	0.60	0.56	0.25	0.25	0.25	1	1	1	2										X	X	X	X		
HUTTON'S VIREO	*Vireo huttoni*	0.61	0.62	0.00	0.29	0.31	1	1	1	2										X	X				
LARK SPARROW	*Chondestes grammacus*	0.39	0.13	0.00	0.00	0.00	1	1	1	2										X	X				
LAWRENCE'S GOLDFINCH	*Carduelis lawrencei*	0.51	0.22	0.00	0.00	0.00	1	1	1	2										X	X				
LAZULI BUNTING	*Passerina amoena*	0.31	0.17	0.12	0.12	0.12	1	1	1	2											X				
LESSER GOLDFINCH	*Carduelis psaltria*	0.53	0.23	0.15	0.15	0.15	1	1	1	2									X	X	X				
LEWIS' WOODPECKER	*Melanerpes lewis*	0.59	0.61	0.61	0.26	0.26	1	1	1	2								X	X	X	X		X		
LINCOLN'S SPARROW	*Melospiza lincolnii*	0.06	0.06	0.09	0.06	0.06	1	1	1	2											X				X
LITTLE BROWN MYOTIS	*Myotis lucifugus*	0.27	0.27	0.27	0.27	0.19	1	1	1	1											X		X	X	X

Common Name	Genus species	MHW	MHC	KMC	DFR	RDW	TA	NA	BR	MC	FE	FT	CE	CT	CS	FC	HA	AC	FR	HT	RH	DW	SS	RC	VP
LOGGERHEAD SHRIKE	*Lanius ludovicianus*	0.12	0.12	0.00	0.00	0.12	1	1	1	2					X					X	X				
LONG-EARED MYOTIS	*Myotis evotis*	0.66	0.74	0.79	0.78	0.66	1	1	1	1										X	X		X	X	X
LONG-EARED OWL	*Asio otus*	0.39	0.43	0.43	0.00	0.00	1	1	1	2					X					X	X				
LONG-LEGGED MYOTIS	*Myotis volans*	0.84	0.84	0.84	0.33	0.33	1	1	1	1											X		X	X	X
LONG-TAILED VOLE	*Microtus longicaudus*	0.00	0.26	0.26	0.26	0.26	1	1	1	1											X				X
LONG-TAILED WEASEL	*Mustela frenata*	0.65	0.65	0.65	0.66	0.59	1	1	1	2							X				X	X		X	X
MACGILLIVRAY'S WARBLER	*Oporornis tolmiei*	0.07	0.26	0.29	0.29	0.46	1	1	1	2											X				
MARBLED MURRELET	*Brachyramphus marmoratu*	0.00	0.00	0.00	0.18	0.18	1	1	1	3		X	X								X				
MARSH SHREW	*Sorex bendirii*	0.00	0.07	0.12	0.12	0.07	1	1	1	1											X	X			X
MERLIN	*Falco columbarius*	0.17	0.17	0.23	0.23	0.23	1	1	0	2					X					X	X				X
MOUNTAIN BEAVER	*Aplodontia rufa*	0.30	0.59	0.59	0.79	0.76	1	1	1	2	X										X			X	X
MOUNTAIN BLUEBIRD	*Sialia currucoides*	0.00	0.00	0.11	0.00	0.00	1	1	1	2									X		X	X	X		
MOUNTAIN CHICKADEE	*Parus gambeli*	0.21	0.52	0.70	0.47	0.00	1	1	1	2										X	X		X		
MOUNTAIN LION	*Felis concolor*	0.66	0.73	0.76	0.64	0.48	1	1	1	2										X	X			X	
MOUNTAIN QUAIL	*Oreortyx pictus*	0.88	0.87	0.87	0.54	0.54	1	1	1	3							X	X	X	X	X	X		X	
MOURNING DOVE	*Zenaida macroura*	0.75	0.66	0.44	0.43	0.31	1	1	1	2							X			X	X				
MULE DEER	*Odocoileus hemionus*	0.66	0.65	0.65	0.66	0.66	1	1	1	3							X	X		X	X				
NASHVILLE WARBLER	*Vermivora ruficapilla*	0.65	0.65	0.65	0.32	0.04	1	1	1	2										X	X				
NORTHERN ALLIGATOR LIZARD	*Elgaria coerulea*	0.86	0.83	0.83	0.92	0.74	1	1	1	2											X	X		X	
NORTHERN FLICKER	*Colaptes auratus*	0.67	0.69	0.65	0.37	0.38	1	1	1	2								X	X	X	X	X	X		
NORTHERN FLYING SQUIRREL	*Glaucomys sabrinus*	0.23	0.28	0.46	0.41	0.37	1	1	1	2								X	X	X	X	X	X		
NORTHERN GOSHAWK	*Accipiter gentilis*	0.51	0.54	0.55	0.40	0.08	1	1	1	2					X					X	X		X		
NORTHERN HARRIER	*Circus cyaneus*	0.03	0.02	0.02	0.02	0.01	1	1	1	2					X										X
NORTHERN PYGMY OWL	*Glaucidium gnoma*	0.66	0.68	0.68	0.68	0.46	1	1	1	2										X	X		X		
NORTHERN ROUGH-WINGED SWALLOW	*Stelgidopteryx serripen*	0.92	0.87	0.00	0.11	0.11	1	1	1	2											X			X	X
NORTHERN SAW-WHET OWL	*Aegolius acadicus*	0.65	0.67	0.67	0.67	0.65	1	1	1	2										X	X		X		
NORTHERN SHRIKE	*Lanius excubitor*	0.06	0.06	0.00	0.00	0.06	1	1	0	1															
NORTHWESTERN SALAMANDER	*Ambystoma gracile*	0.33	0.37	0.51	0.33	0.37	1	1	1	1											X	X			X
NORWAY RAT	*Rattus norvegicus*	0.00	0.00	0.00	0.11	0.11	1	0	1	2											X			X	
NUTTALL'S WOODPECKER	*Picoides nuttallii*	0.54	0.55	0.39	0.00	0.00	1	1	1	2									X	X	X		X		
OLIVE-SIDED FLYCATCHER	*Contopus borealis*	0.30	0.64	0.64	0.58	0.60	1	1	1	2										X	X		X		
ORANGE-CROWNED WARBLER	*Vermivora celata*	0.53	0.53	0.32	0.14	0.48	1	1	1	2										X	X				
ORNATE SHREW	*Sorex ornatus*	0.40	0.40	0.00	0.00	0.00	1	1	1	1											X	X			X
OSPREY	*Pandion haliaetus*	0.36	0.48	0.62	0.50	0.60	1	1	1	2					X					X	X		X		X
PACIFIC-SLOPE FLYCATCHER	*Empidonax difficilis*	0.61	0.63	0.63	0.63	0.67	1	1	1	2										X	X			X	
PACIFIC JUMPING MOUSE	*Zapus trinotatus*	0.53	0.48	0.00	0.53	0.53	1	1	1	1									X		X	X		X	
PACIFIC SHREW	*Sorex pacificus*	0.63	0.63	0.00	0.63	0.63	1	1	1	1											X	X			X
PACIFIC TREEFROG	*Hyla regilla*	0.66	0.66	0.65	0.66	0.74	1	1	1	1											X			X	X

Common Name	Genus species	MHW	MHC	KMC	DFR	RDW	TA	NA	BR	MC	FE	FT	CE	CT	CS	FC	HA	AC	FR	HT	RH	DW	SS	RC	VP
PALLID BAT	*Antrozous pallidus*	0.11	0.11	0.11	0.11	0.11	1	1	1	1					X						X		X	X	
PEREGRINE FALCON	*Falco peregrinus*	0.89	0.89	0.89	0.89	0.22	1	1	1	2	X		X							X	X			X	X
PILEATED WOODPECKER	*Dryocopus pileatus*	0.20	0.38	0.38	0.37	0.38	1	1	1	2								X	X	X	X	X	X		
PINE SISKIN	*Carduelis pinus*	0.26	0.22	0.29	0.60	0.60	1	1	1	2											X				
PINYON MOUSE	*Peromyscus truei*	0.66	0.66	0.55	0.37	0.37	1	1	1	1								X	X	X	X	X		X	
PLAIN TITMOUSE	*Parus inornatus*	0.72	0.73	0.11	0.11	0.11	1	1	1	2								X	X	X	X		X		
PRAIRIE FALCON	*Falco mexicanus*	0.87	0.87	0.87	0.87	0.21	1	1	1	2					X									X	
PURPLE FINCH	*Carpodacus purpureus*	0.44	0.44	0.45	0.46	0.34	1	1	1	2									X	X	X				
PURPLE MARTIN	*Progne subis*	0.33	0.31	0.16	0.26	0.26	1	1	1	2					X					X	X		X		X
PYGMY NUTHATCH	*Sitta pygmaea*	0.00	0.28	0.57	0.00	0.00	1	1	1	2													X		
RACCOON	*Procyon lotor*	0.58	0.61	0.61	0.59	0.59	1	1	1	2							X				X	X	X	X	X
RACER	*Coluber constrictor*	0.37	0.42	0.42	0.48	0.35	1	1	1	1											X	X		X	
RED-BELLIED NEWT	*Taricha rivularis*	0.84	0.85	0.61	0.55	0.85	1	1	1	1											X	X		X	X
RED-BREASTED NUTHATCH	*Sitta canadensis*	0.16	0.28	0.52	0.52	0.28	1	1	1	2											X		X		
RED-BREASTED SAPSUCKER	*Sphyrapicus ruber*	0.60	0.65	0.65	0.65	0.62	1	1	1	2										X	X		X		
RED-LEGGED FROG	*Rana aurora*	0.33	0.33	0.66	0.64	0.66	0	1	1	1		X			X						X				X
RED-SHOULDERED HAWK	*Buteo lineatus*	0.41	0.39	0.00	0.00	0.09	1	1	1	2										X	X		X		X
RED-TAILED HAWK	*Buteo jamaicensis*	0.72	0.73	0.73	0.68	0.69	1	1	1	2										X	X		X	X	
RED CROSSBILL	*Loxia curvirostra*	0.00	0.11	0.33	0.37	0.00	1	1	1	2											X				
RED FOX	*Vulpes vulpes*	0.11	0.11	0.22	0.22	0.11	1	1	1	2							X				X	X	X	X	
RINGNECK SNAKE	*Diadophis punctatus*	0.33	0.33	0.24	0.33	0.33	1	1	1	1											X	X		X	
RINGTAIL	*Bassariscus astutus*	0.33	0.55	0.37	0.57	0.41	1	1	1	2									X		X	X	X	X	
ROCK WREN	*Salpinctes obsoletus*	0.25	0.13	0.00	0.00	0.00	1	1	1	2														X	
ROUGH-SKINNED NEWT	*Taricha granulosa*	0.37	0.59	0.59	0.47	0.55	1	1	1	1											X	X		X	X
RUBBER BOA	*Charina bottae*	0.80	0.81	0.81	0.81	0.53	1	1	1	2											X	X		X	X
RUBY-CROWNED KINGLET	*Regulus calendula*	0.57	0.70	0.90	0.51	0.43	1	1	1	2											X				
RUFFED GROUSE	*Bonasa umbellus*	0.58	0.60	0.60	0.60	0.48	1	1	1	3					X		X	X	X	X	X	X			
RUFOUS HUMMINGBIRD	*Selasphorus rufus*	0.48	0.46	0.46	0.46	0.46	1	1	1	2										X	X				
SAGEBRUSH LIZARD	*Sceloporus graciosus*	0.39	0.37	0.33	0.33	0.11	1	1	1	1												X		X	
SHARP-SHINNED HAWK	*Accipiter striatus*	0.74	0.75	0.75	0.54	0.75	1	1	1	2					X					X	X		X		
SHARP-TAILED SNAKE	*Contia tenuis*	0.50	0.44	0.31	0.40	0.42	1	1	1	1											X	X		X	
SHORT-EARED OWL	*Asio flammeus*	0.11	0.11	0.11	0.11	0.11	1	1	0	2					X										X
SHREW-MOLE	*Neurotrichus gibbsii*	0.20	0.20	0.25	0.29	0.27	1	1	1	1											X	X	X		
SILVER-HAIRED BAT	*Lasionycteris noctivaga*	0.40	0.51	0.65	0.58	0.48	1	1	1	1											X		X	X	
SOLITARY VIREO	*Vireo solitarius*	0.73	0.75	0.56	0.43	0.44	1	1	1	2										X	X				
SONG SPARROW	*Melospiza melodia*	0.25	0.25	0.17	0.25	0.25	1	1	1	2											X				X
SONOMA CHIPMUNK	*Tamias sonomae*	0.53	0.66	0.50	0.29	0.51	1	1	1	1								X	X	X	X	X	X	X	
SOUTHERN ALLIGATOR LIZARD	*Elgaria multicarinata*	0.51	0.51	0.51	0.51	0.51	1	1	1	2											X	X		X	

Common Name	Genus species	MHW	MHC	KMC	DFR	RDW	TA	NA	BR	MC	FE	FT	CE	CT	CS	FC	HA	AC	FR	HT	RH	DW	SS	RC	VP
SOUTHERN SEEP SALAMANDER	*Rhyacotriton variegatus*	0.35	0.55	0.55	0.55	0.55	1	1	1	1					X						X			X	X
SPOTTED OWL	*Strix occidentalis*	0.21	0.31	0.37	0.37	0.44	1	1	1	3		X								X	X				
SPOTTED TOWHEE	*Pipilo maculatus*	0.47	0.33	0.35	0.37	0.31	1	1	1	2								X	X	X	X				
STELLER'S JAY	*Cyanocitta stelleri*	0.32	0.79	0.77	0.77	0.77	1	1	1	2								X		X	X				
STRIPED SKUNK	*Mephitis mephitis*	0.58	0.56	0.56	0.53	0.39	1	1	1	2							X				X	X	X	X	
SWAINSON'S THRUSH	*Catharus ustulatus*	0.25	0.26	0.28	0.28	0.34	1	1	1	2									X		X				
TAILED FROG	*Ascaphus truei*	0.23	0.23	0.46	0.46	0.46	1	1	1	2					X						X	X		X	
TOWNSEND'S BIG-EARED BAT	*Plecotus townsendii*	0.22	0.22	0.35	0.22	0.22	1	1	1	1					X						X			X	
TOWNSEND'S SOLITAIRE	*Myadestes townsendi*	0.41	0.61	0.61	0.41	0.00	1	1	1	2									X		X	X		X	
TOWNSEND'S WARBLER	*Dendroica townsendi*	0.31	0.32	0.32	0.48	0.48	1	1	1	2										X	X				
TREE SWALLOW	*Tachycineta bicolor*	0.48	0.45	0.00	0.26	0.26	1	1	1	2										X	X		X		X
TROWBRIDGE'S SHREW	*Sorex trowbridgii*	0.33	0.63	0.63	0.63	0.63	1	1	1	1											X	X			
TURKEY VULTURE	*Cathartes aura*	0.87	0.86	0.92	0.92	0.92	1	1	1	2										X	X	X	X	X	
VAGRANT SHREW	*Sorex vagrans*	0.23	0.18	0.18	0.18	0.17	1	1	1	1											X	X			X
VARIED THRUSH	*Ixoreus naevius*	0.29	0.31	0.31	0.71	0.78	1	1	1	2									X	X	X				
VAUX'S SWIFT	*Chaetura vauxi*	0.27	0.28	0.44	0.52	0.67	1	1	1	2					X						X		X		X
VIOLET-GREEN SWALLOW	*Tachycineta thalassina*	0.67	0.68	0.68	0.35	0.35	1	1	1	2										X	X		X	X	X
VIRGINIA OPOSSUM	*Didelphis virginiana*	0.51	0.50	0.33	0.50	0.50	1	0	1	2							X		X		X				
W. AQUATIC GARTER SNAKE	*Thamnophis auratus*	0.56	0.57	0.57	0.57	0.57	1	1	1	1											X	X		X	X
W. TERR. GARTER SNAKE	*Thamnophis elegans*	0.58	0.57	0.57	0.76	0.74	1	1	1	1											X	X		X	X
WARBLING VIREO	*Vireo gilvus*	0.70	0.71	0.41	0.46	0.20	1	1	1	2										X	X				
WATER SHREW	*Sorex palustris*	0.00	0.09	0.18	0.18	0.00	1	1	1	1											X	X		X	X
WESTERN BLUEBIRD	*Sialia mexicana*	0.47	0.34	0.27	0.27	0.27	1	1	1	2									X	X	X		X		
WESTERN FENCE LIZARD	*Sceloporus occidentalis*	0.92	0.92	0.72	0.68	0.51	1	1	1	2										X	X	X	X	X	
WESTERN GRAY SQUIRREL	*Sciurus griseus*	0.56	0.58	0.36	0.32	0.29	1	1	1	3							X	X	X	X	X		X		
WESTERN HARVEST MOUSE	*Reithrodontomys megalot*	0.35	0.35	0.15	0.24	0.24	1	1	1	1									X		X				X
WESTERN KINGBIRD	*Tyrannus verticalis*	0.46	0.38	0.00	0.00	0.00	1	1	1	2											X				
WESTERN MEADOWLARK	*Sturnella neglecta*	0.22	0.15	0.09	0.15	0.15	1	1	1	2															
WESTERN PIPISTRELLE	*Pipistrellus hesperus*	0.11	0.11	0.11	0.11	0.11	1	1	1	1											X		X	X	
WESTERN POND TURTLE	*Clemmys marmorata*	0.47	0.46	0.15	0.15	0.15	0	1	1	2					X						X	X			X
WESTERN RATTLESNAKE	*Crotalis viridis*	0.58	0.57	0.57	0.55	0.24	1	1	1	1											X	X		X	
WESTERN RED-BACKED VOLE	*Clethrionomys californi*	0.29	0.29	0.46	0.40	0.29	1	1	1	1											X	X	X		
WESTERN RED BAT	*Lasiurus blossevillii*	0.50	0.51	0.51	0.51	0.25	1	1	1	1										X	X		X	X	
WESTERN SCREECH OWL	*Otus kennicottii*	0.78	0.79	0.33	0.24	0.82	1	1	1	2										X	X		X		
WESTERN SCRUB-JAY	*Aphelocoma californica*	0.47	0.48	0.00	0.00	0.00	1	1	1	2								X		X	X				
WESTERN SKINK	*Eumeces skiltonianus*	0.58	0.57	0.44	0.51	0.24	1	1	1	1											X	X		X	
WESTERN SPOTTED SKUNK	*Spilogale gracilis*	0.54	0.51	0.51	0.47	0.47	1	1	1	2							X				X	X	X	X	
WESTERN TANAGER	*Piranga ludoviciana*	0.45	0.64	0.64	0.42	0.26	1	1	1	2										X	X				

Common Name	Genus species	MHW	MHC	KMC	DFR	RDW	TA	NA	BR	MC	FE	FT	CE	CT	CS	FC	HA	AC	FR	HT	RH	DW	SS	RC	VP
WESTERN TOAD	*Bufo boreas*	0.56	0.58	0.48	0.33	0.33	1	1	1	1											X	X		X	X
WESTERN WOOD-PEWEE	*Contopus sordidulus*	0.76	0.79	0.79	0.58	0.47	1	1	1	2										X	X				
WHITE-BREASTED NUTHATCH	*Sitta carolinensis*	0.72	0.73	0.73	0.49	0.00	1	1	1	2								X		X	X		X		
WHITE-CROWNED SPARROW	*Zonotrichia leucophrys*	0.25	0.13	0.07	0.20	0.31	1	1	1	2											X				
WHITE-HEADED WOODPECKER	*Picoides albolarvatus*	0.22	0.42	0.64	0.23	0.00	1	1	1	2											X		X		
WHITE-TAILED KITE	*Elanus leucurus*	0.14	0.00	0.00	0.00	0.14	1	1	1	2										X			X		
WHITE-THROATED SWIFT	*Aeronautes saxatalis*	1.00	1.00	1.00	0.22	0.11	1	1	1	2											X			X	X
WILD PIG	*Sus scrofa*	0.59	0.38	0.28	0.13	0.15	1	0	1	3							X	X		X	X				X
WILD TURKEY	*Meleagris gallopavo*	0.96	0.96	0.55	0.00	0.00	1	1	1	3							X	X	X	X	X				
WILSON'S WARBLER	*Wilsonia pusilla*	0.43	0.49	0.45	0.48	0.65	1	1	1	2											X				
WINTER WREN	*Troglodytes troglodytes*	0.11	0.49	0.39	0.41	0.55	1	1	1	2											X	X			
WOLVERINE	*Gulo gulo*	0.00	0.33	0.33	0.33	0.00	1	1	1	1				X							X	X		X	X
WOOD DUCK	*Aix sponsa*	0.14	0.17	0.11	0.11	0.13	0	1	1	2							X	X		X	X		X		X
WRENTIT	*Chamaea fasciata*	0.23	0.37	0.13	0.23	0.50	1	1	1	2															
YELLOW-CHEEKED CHIPMUNK	*Tamias ochrogenys*	0.52	0.76	0.76	0.76	0.76	1	1	1	1								X	X	X	X	X		X	
YELLOW-PINE CHIPMUNK	*Tamias amoenus*	0.68	0.68	0.76	0.66	0.00	1	1	1	1											X	X		X	
YELLOW-RUMPED WARBLER	*Dendroica coronata*	0.60	0.85	0.86	0.86	0.29	1	1	1	2										X	X				
YELLOW WARBLER	*Dendroica petechia*	0.28	0.24	0.16	0.16	0.10	1	1	1	2					X					X	X				
YUMA MYOTIS	*Myotis yumanensis*	0.22	0.22	0.11	0.11	0.11	1	1	1	1										X	X			X	X

Appendix E: Calculating Retention at the Stand Level

Table A-1 below illustrates the number of trees needed in order to retain a given level of basal area. Since most forested areas contain a mixture of tree sizes, the table should be used only as an indication of the number of trees that would actually be needed to retain the desired basal area, the sum of the tree cross-sectional area at dbh per unit area.

Table A-2 illustrates the potential canopy closure, defined as the area that would be covered by tree canopy for a given level of basal area retention. Since the values in the table are based upon predictive models of tree crown sizes for limited species and assume that trees are of full crown and without crown overlap, the figures should be seen as maximum possible area of crown coverage by well spaced trees. The tables are for illustrative purposes only, and the reader should expect actual field results to vary considerably.

Retention Calculation Examples

Assume that a land owner wished to maintain 25 square feet of hardwood trees which average 20 inches in diameter (at breast height). By reading across from 20 and down from 25, Table A-1 produces an estimate of 11 trees per acre which must be retained to achieve the 25 square foot basal area target. For this same tree size and basal area target, Table A-2 produces an estimate of 33%, which means that given well spaced trees, the 11 trees which are retained would occupy about one-third (33%) of an acre. The reader should keep in mind that actual tree crown widths may vary considerably, and there may be crown overlap between adjacent trees**. (Use the tables as guides only.)**

If the landowner determines that one large tree of each hardwood species were desired on a per- acre basis, then the landowner of a 40 acre harvest unit would have the opportunity to concentrate these trees into a group. If there are two hardwood species present, then the owner could retain a group of 80 trees somewhere within the 40 acre harvest unit. If designated for retention with the understanding that they should not be cut in future intermediate harvests, these trees could be expected to achieve a substantially higher stem diameter over the course of the next rotation. The potential for trees to grow large depends upon inter-tree competition. If too many trees are concentrated in too small of an area, few, if any will achieve much rapid diameter growth. For this reason, it is recommended that retention guidance include some target for crown space available to the trees that are retained. If, for example, two 30 inch future diameter hardwoods per acre equivalent were considered desirable, then an area of about .11 acre would be required to allow for crown expansion and high rates of diameter growth (0.055 acres per tree X 2 trees). If concentrated within a single area of a 40 acre harvest unit, approximately 4.4 acres of space would be required to produce 80 large trees (2 per acre X 40 acres X .055 acres/tree). Converted to lineal spacing, this equates to about 50 feet between retention trees.

Table A-1: DBH is diameter breast height or 4.5 feet on the high side of the topography, and basal area is the sum of tree cross-sectional areas at DBH per site. Number of trees per acre needed to achieve a specified basal area retention level is found by reading down DBH to the average DBH for the site and across the basal area to the desired target number. Values in the table are rounded (Paine and Hahn 1982).

Ave.		**Basal Area Target**					
DBH (inches)	**10**	**15**	**20**	**25**	**30**	**35**	**(ft^2/acre)**
4	115	171	229	286	344	401	
8	29	43	57	72	86	100	
12	13	19	25	32	38	45	
16	7	11	14	18	21	25	
20	5	7	9	11	14	16	
24	3	5	6	8	10	11	
28	2	4	5	6	7	8	
32	2	3	4	4	5	6	
36	1	2	3	4	4	5	

Table A-2. The percentage of each acre that the retained tree crowns would cover can be estimated using this chart by selecting the average DBH of the trees in the site and the desired basal area. Values in the table are rounded (Paine and Hahn 1982).

Ave.			**Basal Area Target**			
DBH (inches)	**10**	**15**	**20**	**25**	**30**	**35 (ft^2/acre)**
4	25%	37%	50%	62%	75%	87%
8	16%	25%	33%	41%	50%	58%
12	14%	21%	28%	35%	43%	50%
16	13%	19%	26%	33%	39%	46%
20	13%	19%	26%	33%	39%	46%
24	12%	18%	24%	30%	36%	42%
28	11%	17%	23%	29%	35%	41%
32	11%	17%	23%	29%	34%	40%
36	11%	16%	22%	27%	33%	38%