Role of Oaks in Fisher Habitat Quality in the Sierra Nevada Mountains at Multiple Spatial Scales[1]

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Abstract

Fishers (*Pekania pennanti*) occur in ponderosa pine, mixed conifer, and mixed hardwood conifer habitats in the southern Sierra Nevada at elevations from approximately 1400 to 2300 m. They are a candidate species for listing under both the Federal and California Endangered Species Acts. Since 2007, the U.S. Department of Agriculture, Forest Service (USDA FS) Pacific Southwest Research Station has been investigating fisher habitat selection in the mixed hardwood conifer landscape of the Sierra National Forest. California black oaks (*Quercus kelloggii*) occur in the forest types fishers occupy and are important habitat elements at multiple spatial scales. In the Kings River Fisher Project study area, black oaks were the most common species used for denning and the second most common species used for resting (52 percent and 24 percent respectively). At larger spatial scales, occupancy models indicate that hardwoods, in association with structural characteristics, such as stem diameter diversity and the presence of large snags, are important components of fisher habitat. Although little is known of fisher foraging habitat, black oaks are also associated with many important prey species of fishers. Shade-intolerant California black oaks are less abundant than they were historically; the creation of small openings to promote recruitment of young trees would therefore aid in the long-term maintenance of Sierra Nevada fisher habitat.

Key words: cavity, California black oak, fisher, habitat use, Pekania pennanti

Introduction

Oaks are known to be a vital resource for numerous wildlife species throughout the United States. In 1940, W.R. Van Dersal wrote “few treatises on birds or mammals fail to mention acorns as the food of some animal or another, if any foods at all are listed. The records are widely scattered, but in accumulating data with respect to the utilization of woody plants by wildlife for another purpose (Van Dersal 1938b), those for oaks were found to surpass the records for most other genera of woody plants” (Van Dersal 1940). The author went on to list 186 different species known to use either acorns or oak leaves as a primary food source. Oaks provide other resources as well, readily forming cavities that are used as den or nest sites for numerous bird and mammal species (McDonald 1990).

The importance of oaks to ecological systems includes indirect effects as well. Ostfeld and others (1996) presented a conceptual model outlining the direct and indirect relationships between oak trees, birds and herbivorous mammals, carnivores, raptors, insects, and humans. They highlighted the positive relationships between mast production, small mammal densities, and predators. Changes in forest composition nationwide, particularly the loss of oaks due to altered disturbance

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regimes, has been identified as potential trophic cascade resulting in the loss of native biodiversity (Gillen and Hellgren 2013).

Fishers (*Pekani pennanti*) are a species of conservation concern in the western United States, currently proposed for listing under the Endangered Species Act. Once distributed widely across North America, their western range is now restricted to isolated populations in the Cascade, Klamath, and Sierra Nevada regions. Recently reintroduced populations in Olympic National Park and the central Sierra Nevada represent an effort to connect isolated populations and reestablish populations in historic habitat.

Fishers maintain large home ranges to meet their life functions. Rather than occupying a fixed den site, they move constantly and select new resting sites when necessary. This behavior necessitates the presence of numerous suitable resting sites scattered throughout the animal's home range. Fishers can use a variety of structures for resting, including tree cavities, stick nests, mistletoe brooms, large branches, hollow logs, rock piles, and underground burrows.

Female fishers typically give birth in late March to early April. At this point they cease the typical nomadic behavior of moving to a new rest site each day and localize to a single tree cavity. This cavity, referred to as the natal den, is where the female gives birth to one to three kits (fig. 1). The family remains in this cavity for a period of weeks, after which she begins moving the kits to new structures referred to as maternal dens. This behavior continues for several months during which the females use anywhere from zero to six maternal dens. While tree cavities are the predominant structure used, as the kits get older hollow logs and underground burrows may be used as well.

Throughout California, fisher habitat is frequently associated with the presence of hardwoods, particularly California black oaks (*Quercus kelloggii*). Oaks provide fishers a variety of resources, including resting and denning sites. Oaks also help to support rodent and sciurid populations, which are an important prey source for fishers. Our objective in this paper is to summarize fisher use of oaks as resting and denning sites, and to explore the ecological relationship between fishers and hardwoods at larger spatial scales.

Figure 1—Fisher natal den in a CA black oak cavity formed by heartrot penetrating where a dead branch was broken off. Left: female fisher coaxing a juvenile out of the den. Right: fisher kit curled in the bottom of an oak cavity.

Study area

The Kings River Fisher Project study area is located in the High Sierra District of the Sierra National Forest, approximately 50 km east-northeast of Fresno, California (fig. 2). Elevation ranges from 1100 m to 2282 m. Dominant forest types include montane hardwood-conifer, Sierran mixed conifer, and ponderosa pine (*Pinus ponderosa*; http://www.dfg.ca.gov/biogeodata/cwhr/). Dominant tree species at the lower elevations include ponderosa pine, incense cedar (*Libocedrus decurrens*), and California black oak. At higher elevations the vegetation is dominated by incense cedar, white fir (*Abies concolor*), and ponderosa pine with infrequent sugar pine (*Pinus lambertiana*) and giant sequoia (*Sequoiadendron giganteum*). The climate is Mediterranean, with the majority of precipitation falling in the winter months as rain and snow.

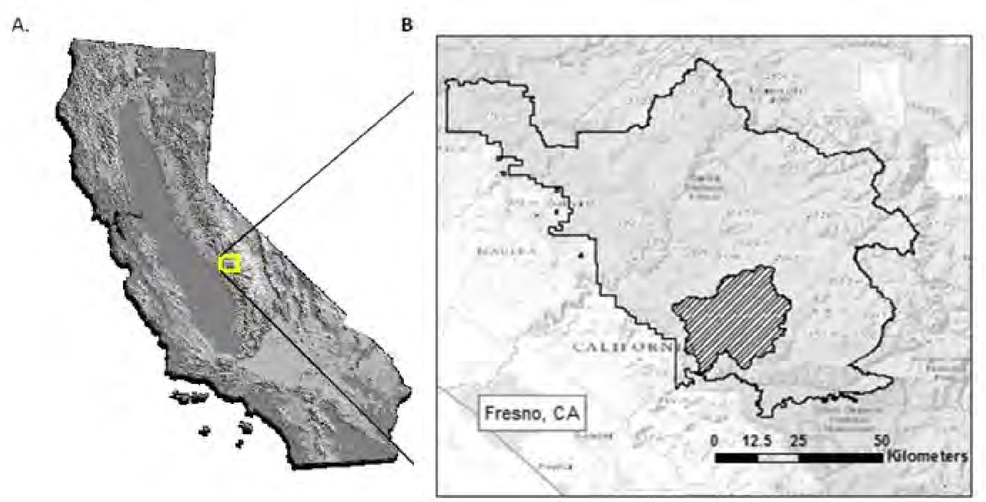

Figure 2—Location of the Kings River Fisher Project. The Kings River study area (crosshatch) is located in the SW portion of the Sierra National Forest, east-northeast of Fresno, California.

Methods

Microsite

We used radio telemetry to follow fishers to resting sites from 2007 through 2014 in the Sierra National Forest. Fishers were captured using Tomahawk box traps equipped with an attached cubby for the animal’s comfort and security. Traplines were laid out along secondary or tertiary roads, with traps spaced approximately 500 to 1000 m apart. Traps were placed in the most suitable habitat available: dense forest drainages, along large logs, or in areas of complex understory. Traps were checked daily; captured fishers were transferred into a metal handling cone and anesthetized using a combination of Ketamine hydrochloride and Diazepam (200 mg Ketamine /1 mg Diazepam). Animals were weighed, sexed, and aged using a combination of tooth wear and sagittal crest development. Body measurements recorded included body length, tail length, girth, zygomatic arch width, footpad dimensions, and canine length. Biological samples collected included up to 6 cc blood for epidemiological analysis, tissue and hair for genetic identification, and any ectoparasites observed.

Animals were permanently marked using passive integrated transponder (PIT) tags inserted subcutaneously at the nape of the neck and equipped with radio collars weighing no more than 3 percent of the animals total body weight. Animals were placed back in the trap cubby, then released at the trap site when fully recovered.

Ground telemetry was used to locate the animals as frequently as possible (typically every 3 to 5 days). Once an animal's telemetry signal was detected, technicians attempted to estimate the animal's location using triangulation. If the animal appeared stationary, the technician attempted to follow the radio signal and locate the exact structure in which the animal was resting. Once located, the structure was tagged, UTM coordinates were collected, and basic data were recorded (e.g., structure type, tree species, forest conditions). More detailed data such as tree diameter at breast height (DBH), tree height, and slope position were recorded on subsequent visits after the animal had left the area.

Adult female fishers were carefully monitored during late winter and spring to document reproduction and den site selection. Once an adult female was located in the same location for 3 consecutive days, the structure was labelled a natal den and motion-sensitive cameras were placed around the structure to verify use and document litter size. When the female moved the kits to a new maternal den, the process was repeated. By mid-June, when the family was again moving on a near-daily basis, structures were considered rest sites, not dens.

Mid-scale

To quantify fisher use of different forest types within the study area, we conducted semi-annual scat detector dog surveys between 2007 and 2012. Detector dogs, provided by the University of Washington's Center for Conservation Biology, are trained to locate the scat of a focal species. Surveys were conducted in May and October of each year, and scats collected were genetically verified by the U.S. Department of Agriculture, Forest Service (USDA FS) Rocky Mountain Research Station's Wildlife Genetics Laboratory. Surveys consisted of two dogs alternating visits to a 14 km^2 sampling unit. Each unit was surveyed three times during each semi-annual survey. Confirmed fisher scat locations were overlaid on a 1-km-square grid of the study area. Because detector dog surveys are an unstructured survey method, each dog had a GPS logger attached to its collar to document the survey path. The survey route for a particular day would cover a number of grid cells, and we developed an effort covariate for each cell based on the amount of time spent surveying that grid cell. This process resulted in a binary detection matrix with 234 sampled 1 km^2 cells and 12 sampling occasions (Spring 2007 – Fall 2012).

We quantified forest type and structure within each grid cell using global nearest neighbor (GNN) data developed by the Landscape Ecology, Modeling, Mapping, and Analysis (LEMMA) team at Oregon State University (http://lemma.forestry.oregonstate.edu/data/structure-maps). GNN data are 30 m resolution ArcGIS grids created by extrapolating plot-level data to remote imagery. We used 2012 imagery, the most recent data available. While LEMMA GNN data provide a variety of structural attributes, to better understand the importance of oak habitat to fishers, we focused on 15 variables known to be important to fishers (table 1).

Table 1—Forest structure variables selected for use in evaluating fisher use of hardwood habitat with the Sierra National Forest, California; data generated by the Landscape Ecology, Modeling, Mapping, and Analysis group at Oregon State University

Variable Name	Description
BA	Basal area of live trees >=2.5 cm dbh
BA_con	Basal area of live conifers >=2.5 cm dbh
BA_hdwd	Basal area of live hardwoods >=2.5 cm dbh
CANCOV	Canopy cover of all live trees
CC_con	Canopy cover of all conifers
CC_hdwd	Canopy cover of all hardwoods
OGSI	Regionalized old-growth structure index for plots within NWFP. Calculated from abundance of large live trees, snags and down wood, and diversity of tree sizes
DDI	Diameter diversity index. DDI is a measure of the structural diversity of a forest stand, based on tree densities in different DBH classes
COVCL	Categorical cover class: 1 = sparse (CANCOV < 10), 2 = open (CANCOV >=10 and < 40), 3 = moderate (CANCOV >=40 and <70), and 4 = closed (CANCOV >=70)
SIZECL	Categorical size class, based on dominant quadratic mean diameter and canopy cover. 1 = shrub/seedling (QMD < 2.5 or CANCOV < 10), 2 = sapling (QMD >= 2.5 and < 25), 3 = small tree (QMD >=25 and <37.5), 4 = medium tree (QMD >=37.5 and <50), 5 = large tree (QMD >+50 and <75), 6 = giant tree (QMD > 75)
SNAGDEN	Density of snags >=25 cm dbh and >=2 m tall
DWbio	Biomass of down wood >=25 cm diameter at large end and >=3m long

To evaluate fisher use of each grid cell, we created an occupancy model using Program PRESENCE (Hines 2006). We assumed constant probability of cell colonization and extinction across the study period, in part due to the small size of a grid cell compared to a fisher home range. Colonization and extinction rates refer to the probability that a grid cell will go from unoccupied to occupied, or occupied to unoccupied, respectively, between survey efforts. We assumed that detection rates varied according to both the season of the survey and the amount time spent surveying a particular cell.

We examined the influence of habitat variables on fisher occupancy using two approaches. First, we evaluated the influence of hardwood and conifer structure by comparing univariate models of canopy cover and basal area. Differences in performance among models were assessed using log-likelihood ratio tests. Second, we used an all model approach, retained models with non-zero AIC weights, and calculated evidence ratios for individual variables (Arnold 2010).

Statewide

Statewide, we collected information on den use from three other large-scale fisher monitoring projects. The Sierra Nevada Adaptive Management Project (SNAMP) was a large-scale investigation, led by the University of California at Berkeley, into the ecological impacts of fuel reduction and forest restoration in the Sierra National Forest. Between 2007 and 2014, SNAMP captured and monitored fishers in an area between Oakhurst, California and the south entrance of Yosemite National Park.

SNAMP researchers identified 125 fisher dens over 7 seasons. In northwestern California, the Hoopa Valley Tribe and the Wildlife Conservation Society has monitored fisher density and reproduction on the Hoopa Valley Reservation since the mid-1990s. The study began collecting detailed information on den structures in 2005, and over 4 seasons, provided descriptions of 111 dens. Finally, on industrial timberland in north-central California, Sierra Pacific Industries (SPI) has been monitoring fisher reproduction on two study areas since 2006. In Sacramento Canyon outside Weaverville, SPI recorded 55 denning structures used by fishers in 2006 and 2007. Then from 2010 through 2013, SPI monitored reproductive activity of reintroduced fishers on their Stirling Tract, northeast of Chico, and identified 63 dens.

Results

Microsite scale

We located 260 fisher den sites between 2007 and 2014. California black oaks accounted for 52 percent of den sites (n = 135), followed by white fir (25 percent, n = 64) and incense cedar (13 percent, n = 34) (fig. 3). The dens located in oaks were exclusively in cavities, with the overwhelming majority occurring in live trees (95 percent, n = 248). Oaks used for denning were generally large, averaging 75.9 cm DBH and 17.6 m tall. However, a variety of sizes of trees were used, ranging from 15.8 to 134.5 cm DBH (fig. 4).

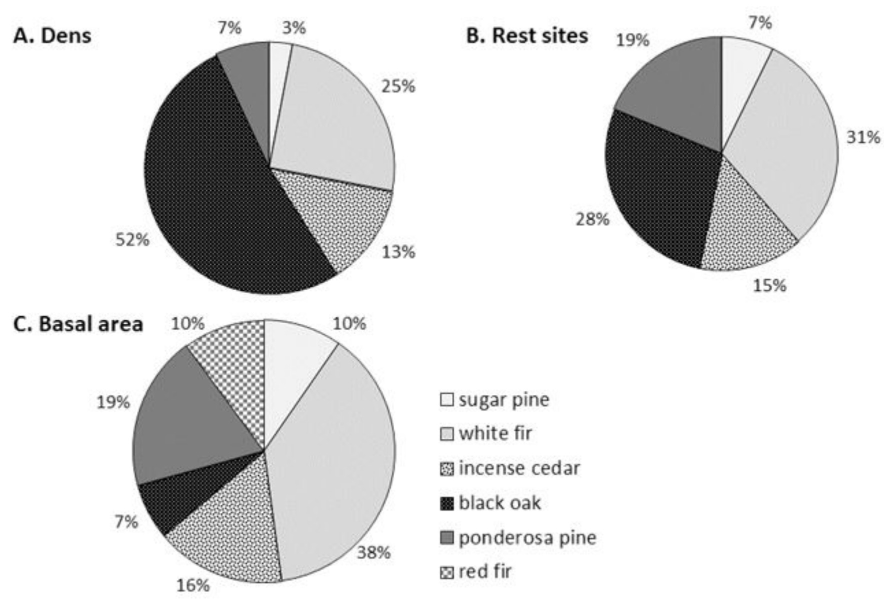

Figure 3—Use of different tree species by fishers for (A) den sites, and (B) rest sites in the Kings River Fisher Project study area of the Sierra National Forest, 2007-2014. (C) Distribution of basal area by species across the study area for comparison.

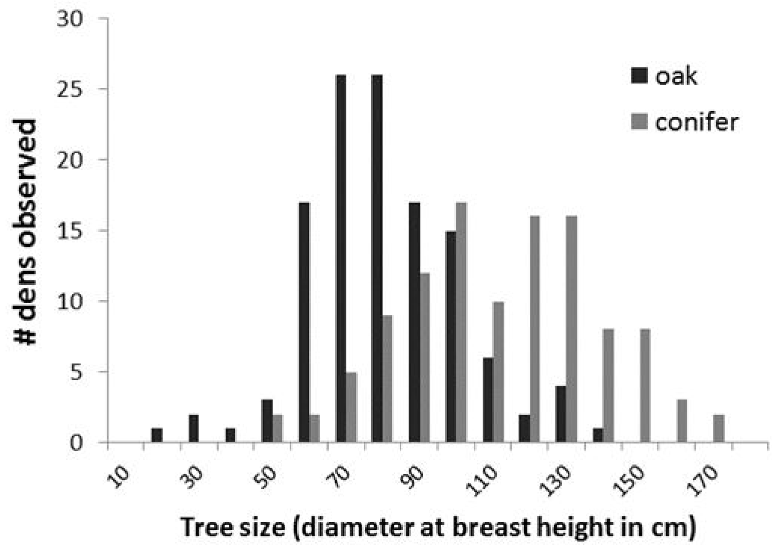

Figure 4—Size of conifer and hardwood trees used by fishers for denning in the Sierra National Forest, 2007-2014.

During the same period, we located 853 rest sites, with California black oaks accounting for 28 percent (n = 234) (fig. 3). Other dominant species used included white fir (31 percent, n = 259), sugar pine (7 percent, n = 59), ponderosa pine (19 percent, n = 148), and incense cedar (15 percent, n = 117) (fig. 3). Oaks used as rest sites tended to be large, averaging 78.4 cm DBH (SD = 22.4 cm) and 18.2 m tall (SD = 8 m). Comparatively, conifers used as rest sites averaged 101.9 cm DBH (SD = 36.1 cm) and 28.3 m tall (SD = 16.0 m). Of the rest sites located in black oaks, 196 (84 percent) were located in cavities typically formed by heartrot and accessed through a branch scar. The remaining 16 percent were platforms created by either a large limb or a broken top.

Mid-scale

Over the 12 sampling periods, we located 877 genetically-verified fisher scats. We calculated univariate occupancy models for six hardwood or conifer canopy cover and basal area variables, and a null model. Influence of season on detection rate of scats was dropped as a covariate because in all cases it reduced model performance. Log Likelihood ratio tests indicated that while overall canopy cover was the best fitting model (table 2), it was not significantly different than the second best fit, basal area of hardwoods ($P = 0.09$). Basal area of hardwoods was a significantly better fitting model than either total basal area ($P < 0.0001$) and basal area of conifers ($P < 0.0001$) (table 2).

Table 2—Univariate fisher occupancy models for forest structural variables in the Sierra National Forest, CA. Symbols indicate occupancy (ψ), colonization (ɥ), extinction (ε), and detection probability (p). In all models, colonization and extinction rates were assumed to be constant, detection probability varied by survey effort, and occupancy was related to structural variables. Variable descriptions are listed in Table 1.

Model	AIC	ΔAIC	AIC wgt	-2*LogLike
ψ (CANCOV), ɥ , ε, p (effort)	1170.71	0	0.742	1158.71
ψ (BA_hdwd), ɥ , ε, p (effort)	1173.62	2.91	0.173	1161.62
ψ (CC_hdwd), ɥ , ε, p (effort)	1175.05	4.34	0.084	1163.05
ψ (BA), ɥ , ε, p (effort)	1190.47	19.76	0	1178.47
ψ (CC_con), ɥ , ε, p (effort)	1197.56	26.85	0	1185.56
ψ (BA_con), ɥ , ε, p (effort)	1199.49	28.78	0	1187.49
ψ, ɥ , ε, p (effort)	1201.86	31.15	0	1191.86

The all model approach, utilizing multivariate models to quantify evidence ratios for each variable, resulted in 34 models with non-zero AIC model weights. No one model dominated, the highest ranked model, [ψ (BA_con, DDI, SNAGDEN)] received an AIC weight of only 0.215. Instead, the top 10 models all included various combinations of hardwood and conifer canopy cover or basal area, stem diversity, and snag density (table 3). Biomass of downed wood, old-growth structure index, cover class, and size class were dropped from consideration because they failed to appear in any of the top 25 models. Evidence ratios indicated that the strongest contributing variables were stem diameter diversity and snag density, which appeared in nearly all the top 10 models (table 4). However it should be noted that neither of these variables, when considered singly, was among the top models. In fact, a univariate snag density model received an AIC value of 1200.96 (ΔAIC = 50.86) and was not significantly different than a null model (P = 0.09). A univariate stem diameter diversity model performed slightly better, with an AIC = 1181.73, ΔAIC = 31.63. Therefore while these variables are important to fishers, evidence indicates that they must be present in combination with other variables to be useful.

Table 3—Top 10 multivariate models relating forest structure to fisher occupancy in the Sierra National Forest, CA. Symbols indicate occupancy (ψ), colonization (ɥ), extinction (ε), and detection probability (p). In all models, colonization and extinction rates were assumed to be constant, detection probability varied by survey effort, and occupancy was related to structural variables. Variable descriptions are listed in Table 1.

Model	AIC	ΔAIC	AIC weight
ψ (BA_con + DDI + SNAGDEN), ɥ , ε, p (effort)	1150.1	0	0.2155
ψ CC_hdwd+ba_hdwd + DDI + SNAGDEN), ɥ , ε, p (effort)	1150.86	0.76	0.1474
ψ (cancover+BA_con + DDI + SNAGDEN), ɥ , ε, p (effort)	1151.83	1.73	0.0907
ψ (CC_hdwd+BA_con + DDI + SNAGDEN), ɥ , ε, p (effort))	1151.88	1.78	0.0885
ψ (CC_con+BA_con + DDI + SNAGDEN), ɥ , ε, p (effort)	1152.1	2	0.0793
ψ (BA_hdwd + DDI + SNAGDEN),ɥ , ε, p (effort)	1152.19	2.09	0.0758
ψ (cancover + BA_hdwd + DDI + SNAGDEN), ɥ , ε, p (effort)	1152.99	2.89	0.0508
ψ (BA_con + DDI), ɥ , ε, p (effort)	1153.6	3.5	0.0374
ψ (CC_hdwd+BA + DDI + SNAGDEN), ɥ , ε, p (effort)	1153.62	3.52	0.0371

ψ (CC_con+BA_hdwd + DDI + SNAGDEN), γ , ε, p (effort)	1154.19	4.09	0.0279

Table 4—Weight of evidence ratios supporting the importance of individual forest characteristics in fisher occupancy models. Values range from -1 (low importance) to 1 (high importance)

Variable	Summed model weight	Evidence ratio
DDI	0.979	0.957
STPH	0.818	0.635
BA_con	0.571	0.141
BA_hdwd	0.361	-0.278
CC_hdwd	0.316	-0.368
Cancover	0.184	-0.631
CC_con	0.154	-0.692
BA	0.058	-0.884

Statewide

Statewide we collected information on a total of 614 dens used by fishers between 2006 and 2014 (table 5). Overall, use of hardwoods versus conifers was fairly evenly divided; 53 percent hardwood versus 47 percent conifer. However the dominant species used was California black oak, accounting for 39 percent of all den sites. In three of the four studies providing data, an oak species was the most common den site.

Table 5—Documented den use of tree/snag species by female fishers at four research projects throughout California

	Kings River Project, USFS	UC Berkeley, Sierra Nevada Adaptive Management Project	Hoopa Monitoring Program	Sierra Pacific Industries
# dens located	**260**	**125**	**111**	**118**
time period	**2007-2014**	**2008-2014**	**2005-2008**	**2006-2013**
CA black oak	52%	27%	13%	46%
White oak	-	-	2%	-
Tanoak	-	-	48%	3%
Chinquipin oak	-	-	6%	-
Live oak	< 1%	-	-	7%
White fir	25%	26%	-	6%
Ponderosa pine	7%	3%	-	3%
Incense cedar	13%	35%	1%	6%
Douglas-fir	-	-	25%	19%
Sugar pine	3%	7%	3%	3%
other	-	2%	2%	8%

Discussion

Oaks provide essential resources and habitat elements for fishers and related species worldwide. In Portugal, hardwood cavities accounted for 65 percent of the rest sites used by genets (*Genetta genetta*), with the majority of these located in cork oak (*Quercus suber*) and holm oak (*Q. ilex*) (Carvalho and others 2014). In Poland, cavities accounted for 60 percent of the rest sites selected by pine marten (*Martes martes*), with 20 percent of those located in oaks (Zaleweski 1997). In the United States, hardwoods comprised 40 percent of maternal dens in the northeast United States (Powell and others 1997), 94 percent of natal dens in Maine (Paragi and others 1996) and 90 percent of rest sites in Wisconsin (Kohn and others 1993). In California, Zielinski and others (2006) identified mean DBH of hardwoods as a significant predictor of fisher rest site suitability and Yaeger (2005) identified California black oak as the only tree species used more than expected by fishers for resting on two study sites in Northern California; the Hoopa Valley Reservation and the Shasta-Trinity National Forest.

Den site selection

In California, large oaks appear to be the dominant source of den structures for fishers. In a comprehensive review of fisher denning habitat in the western United States, Raley and others (2012) reported that the cavities used for natal and maternal were most often created by heartwood decay, and that the presence of heartrot is greater in older trees than younger (Manion 1991). It has also been shown that the number of dead limbs in California black oak, potential avenues for heartrot entry, increases exponentially with age (Garrison and others 2002). Another potential benefit to the use of cavities in live hardwood trees for denning is security. During the spring breeding season, males wait outside the natal den for the opportunity to breed when the female leaves the cavity. Females often select cavities with an opening too small for the larger male to enter, thereby protecting her newborn kits from potential harm. When formed via heartrot, cavities in oaks form scar tissue around the entrance. This woody tissue is extremely dense, and neither aggressive male fishers nor potential predators are capable of expanding the entrance to gain access. Conifers and snags do not form this scar tissue, and cavities are therefore more vulnerable to aggressive intrusion.

Thermoregulation

Fishers' selection of resting and denning structures is influenced by a variety of factors, including thermoregulatory properties. Tree size is clearly important. Large trees modulate temperature better than smaller trees and cool less at night (Coombs and others 2010, Wiebe 2001). Entrance size also influences temperatures in cavities (Rhodes and others 2009). In British Columbia, fishers shifted from platforms to cavities to subterranean rest sites as the ambient temperature dropped (Weir and others 2005). In the Sierra Nevada, at the southern extent of the fishers' range, the relationship appears inverted; fishers use cavities more often for resting when minimum temperatures are colder (Purcell and Thompson, unpublished data). Similar behavior and consequences have been observed in other species as well; pine marten in Poland select resting sites in relation to ambient temperature (Zaleweski 1997) and black bears (*Ursus americanus*) in the eastern United States suffered 15 percent greater heat loss during winter hibernation in subterranean dens as opposed to tree cavities (Pelton 1996).

Oak cavities also appear to be more stable thermal environments than conifer cavities. In a study examining the interior conditions of tree cavities during prescribed fire, internal temperatures in cavities in live California black oak trees were more stable than within either snags or conifer trees (C. Thompson, unpublished data). While this observation needs to be explored in greater detail, it may help explain the frequent use of oak cavities as dens. Fisher kits are born with limited thermoregulatory capacity, and temperature stability may therefore be a critical consideration in den selection and thermoregulation (Raley and others 2012).

Association with prey

Numerous small mammal and sciurid species are known to rely on oak mast as a primary food source. For example, Innes and others (2007) found that dusky-footed woodrat (*Neotoma fuscipes*) density was positively associated with the presence of large oaks and Steinecker and Browning (1970) highlighted the importance of acorn availability to overwintering by western gray squirrels (*Sciurus griseus*). The population density of these species often fluctuates strongly in relation to mast production (Wolff 1996), and both fishers and martens respond numerically to these fluctuations (Jensen and others 2012). Therefore, the role of black oaks in supporting healthy prey populations for fishers in the state appears well established.

Our results also indicate that oaks play an important role in the suitability of California fisher habitat at larger spatial scales. Both hardwood basal area and hardwood canopy cover univariate occupancy models performed better than their conifer counterparts. The better performance of the hardwood basal area model compared to hardwood canopy cover may be associated with the value of having large oaks distributed throughout a fisher's territory, as opposed to denser stands of smaller trees. Given the tendency of larger, older oaks to produce greater mast crops (McDonald 1990), the larger oaks would support a more stable and diversified prey base for fishers.

Furthermore, Purcell and others (2009) reported that while structures selected for resting were large, they were often surrounded by smaller trees, making the standard diversity of tree DBH an important predictor of rest site habitat. The authors concluded that this pattern may reflect the fact that historical logging and management has transformed the Sierra Nevada mixed conifer forest from a forest dominated by large trees and snags to one having fewer large trees surrounded by a matrix of smaller trees (Goforth and Minnich 2008,Vankat and Major 1978). Our finding that the diameter diversity index, in association with closed forest conditions, is strongly associated with occupancy at the home range scale may indicate a resource benefit from a complex forest structure as well.

Management implications

California black oaks provide a wealth of resources to fishers and help to maintain a stable prey base. Altered disturbance regimes have resulted in the loss of oaks throughout California. In the Sierra Nevada, decades of fire suppression have resulted in the shade-intolerant oaks being outcompeted by shade-tolerant species such as incense-cedar and white fir. While fishers do use these shade-intolerant species for resting and denning, they clearly select hardwood species when available. Furthermore, the shade-tolerant conifer species do not support the diverse prey assemblage associated with oak mast. Therefore to promote fisher habitat throughout the state, land managers should not only promote the retention of large oaks wherever they occur, but also promote the recruitment and growth of young oaks through the creation of small gaps within the forest and the reduction of shade-tolerant conifers.

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