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Research Article

Selection of Rest Structures and Microsites by Fishers in Oregon

KEITH B. AUBRY,[1] *USDA Forest Service, Pacific Northwest Research Station, 3625 93rd Avenue SW, Olympia, WA 98512, USA*
CATHERINE M. RALEY, *USDA Forest Service, Pacific Northwest Research Station, 3625 93rd Avenue SW, Olympia, WA 98512, USA*
PATRICK G. CUNNINGHAM, *USDA Forest Service, Pacific Northwest Research Station, 3200 Jefferson Way, Corvallis, OR 97331, USA*

ABSTRACT Most previous studies of resting habitat for fishers (*Pekania pennanti*) in the Pacific coastal region of the western United States and Canada were focused on habitat conditions within rest sites (typically $\leq$0.5 ha), which include the rest structure (e.g., live tree, snag, log) at its center. Studies of selection for rest structures were sparse and compared characteristics of rest structures to those occurring within rest sites; none investigated selection by sampling resource availability throughout the study area. In addition, limited data were available on the use of rest microsites (e.g., mistletoe brooms, platform branches, cavities) by fishers, and no studies have quantified their availability. To better inform forest management activities designed to improve resting habitat for fishers, we documented use of rest structures and microsites throughout the year by 12 female and 7 male fishers on the west slope of the Cascade Range in southern Oregon, USA from 1995 to 2001, systematically sampled the availability of rest structures and microsites, and used logistic regression modeling to investigate selection of rest structures. Fishers primarily used live trees (65%), snags (14%), and logs (16%) for resting; in all 3 resulting models, the characteristic that best distinguished used from available rest structures was the presence of a suitable rest microsite: mistletoe broom or cavity in live trees, cavity in snags, and hollow end in logs. Only the snag and log models included covariates associated with tree size, likely reflecting the need for enclosed rest microsites (cavities, hollow ends) to be large enough to contain an adult fisher. We then used our availability data to model the ecological characteristics associated with mistletoe brooms in live trees, cavities in snags, and hollow ends in logs. Whether a tree was a hemlock (*Tsuga* spp.) had the greatest effect on the presence of suitable mistletoe broom microsites, but the most important characteristics of snags with cavities and logs with hollow ends were being in moderate stages of decay and relatively large in diameter at breast height (snags) or diameter 3 m from the large end (logs). Forest structures containing suitable rest microsites for fishers were uncommon in our study and may represent a limited resource. Accordingly, we recommend that management of resting habitat for fishers be focused on retaining relatively large structures that already contain suitable rest microsites, rather than simply retaining the largest available structures. Published 2018. This article is a U.S. Government work and is in the public domain in the USA.

KEY WORDS fisher, habitat selection, Oregon, *Pekania pennanti*, rest microsite, rest site, rest structure.

Fisher (*Pekania pennanti*) populations in western North America experienced substantial reductions in distribution and abundance during the twentieth century, with human-caused habitat changes, overtrapping, and predator-poisoning campaigns implicated as primary contributing factors (Zielinski et al. 1995, Aubry and Lewis 2003, Lofroth et al. 2010, Lewis et al. 2012). In 1998, the fisher was listed as a state endangered species in Washington (Lewis and Stinson 1998). It is considered a sensitive species of particular conservation concern in Oregon (Oregon Department of Fish and Wildlife 2016), and the southernmost populations in California were designated threatened by the state of California in 2016 (California Department of Fish and Wildlife 2017). In response to long-standing concerns about the conservation status of fisher populations in all 3 Pacific states, the United States Fish and Wildlife Service (USFWS) proposed in 2014 that fisher populations on the west coast be listed under the United States Endangered Species Act (USFWS 2014). The proposed listing was withdrawn in 2016, however, because of a subsequent determination by the USFWS that stressors were of insufficient magnitude, scope, or imminence to indicate that western fishers were in danger of extinction, or likely to become so in the foreseeable future (USFWS 2016). That decision is currently being challenged in federal court, but regardless of the outcome, forest managers in this region will continue to be tasked with developing effective ways to improve the habitat quality of

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[1]*E-mail: kaubry@fs.fed.us*

low- to mid-elevation conifer and mixed conifer-hardwood forests for fishers.

When fishers are not actively hunting or traveling, they use protected sites for resting that help them conserve energy, avoid predation, gain thermoregulatory advantages, and consume prey safely (Lofroth et al. 2010, Raley et al. 2012). Resting habitat has been studied more than any other aspect of fisher habitat ecology in the Pacific coastal region of the western United States and Canada (Raley et al. 2012, Aubry et al. 2013), yet our understanding of the ecological characteristics of fisher resting habitat remains incomplete. Selection of resting habitat for fishers is hierarchical in nature. At the coarse end of the scale is the selection of a rest site, which represents the vegetative and physiographic attributes in the immediate vicinity of the rest location (typically $\leq$0.5 ha; Raley et al. 2012). Resource-selection studies that compared habitat conditions within fisher resting sites (use) to those within randomly located sites in the study area or in each individual's home range (availability) are relatively common (Weir and Harestad 2003, Zielinski et al. 2004, Yaeger 2005, Weir and Corbould 2008, Purcell et al. 2009). Meta-analyses of standardized data from 8 studies revealed that patterns of selection for vegetative and physiographic attributes within fisher rest sites were consistent throughout the Pacific coastal region (Aubry et al. 2013). In this portion of their range, fishers selected sites for resting that contained relatively steep slopes, cool microclimates, dense overhead cover, high log volumes, high basal areas, and large live trees and snags.

The next level in this hierarchy is selection of the individual forest structure that a fisher uses for resting, which is located at the center of the rest site. Many studies in this region have documented use of various structure types by fishers for resting, indicating that they typically rest in relatively large deformed or decaying live trees, snags, and logs (Seglund 1995, Mazzoni 2002, Weir and Harestad 2003, Zielinski et al. 2004, Purcell et al. 2009). As with rest sites, ecological attributes of the structures fishers used for resting were overwhelmingly consistent throughout the Pacific coastal region (Lofroth et al. 2010, Raley et al. 2012). Several studies have compared the characteristics of rest structures to the structures available within rest sites (Weir and Harestad 2003, Zielinski et al. 2004, Yaeger 2005, Davis 2009, Purcell et al. 2009). The average size of live trees, snags, and logs that fishers used for resting were 1.4–3.4 times larger in diameter than structures within rest sites (Raley et al. 2012), suggesting that fishers are also selective of the rest structures they use. However, meta-analyses of rest-site selection studies (Aubry et al. 2013) revealed that the sites fishers selected for resting contained a suite of environmental characteristics that differed significantly from those that were available in each study area, including characteristics associated with tree size and age. Thus, it remains unclear how selective fishers are of rest structures when availability is sampled at larger spatial scales. Such information would be particularly useful for guiding forest management activities aimed at improving habitat conditions for fishers at multiple spatial scales.

The third and finest level in this hierarchy is the selection of a rest microsite, which is the specific location within a forest structure where a fisher rests (e.g., mistletoe broom, platform branch, tree cavity, hollow end of log). Besides providing protection from predators and competitors (Lofroth et al. 2010), rest microsites may provide thermoregulatory benefits to fishers. Weir et al. (2004) investigated the effects of ambient temperature on the use of rest microsites by fishers in the northern portion of their Pacific coastal range in British Columbia, Canada, and reported that temperatures were significantly colder when fishers used rest microsites in coarse woody debris (inside, amongst, or under downed wood in the subnivean layer) than when they used arboreal rest microsites (rust brooms, platform branches, cavities). In addition, when temperatures dropped below -14.2°C, fishers used subnivean sites associated with coarse woody debris exclusively; they were not observed using either arboreal or ground (burrows, rock piles) microsites.

Although several studies have described the use of different microsites by fishers for resting (Weir et al. 2004, Zielinski et al. 2004, Yaeger 2005, Davis 2009, Purcell et al. 2009), these efforts were largely opportunistic, and none attempted to quantify the availability of suitable rest microsites for fishers to investigate selection of these attributes. Thus, we also lack a clear understanding of the microsite types that are used by fishers for resting in the Pacific coastal region, the prevalence of suitable rest microsites within the landscapes fishers occupy, or the characteristics of forest structures that are most likely to contain suitable rest microsites for fishers. Without such information, forest managers cannot know whether prescriptions designed to maintain or create resting habitat for fishers are likely to provide substantial benefits to their populations.

Our objectives in this study were to document the use of rest structures and microsites by fishers in the Cascade Range of southern Oregon; investigate selection of live trees, snags, and logs as rest structures by fishers; quantify the prevalence of suitable rest microsites that were available to fishers; and identify the characteristics of forest structures that contain suitable rest microsites for fishers.

STUDY AREA

Our study was located primarily in the upper Rogue River drainage on the west slope of the Cascade Range in southern Oregon, USA (Fig. 1) from 1995 to 2001. The topography in our study area is rugged, with elevations ranging from 400 m to 2,892 m. The climate is maritime, and characterized by mild and wet winters (Dec to Feb) and relatively cool and dry summers (Jun to Aug), but precipitation and snowfall increase and temperatures decrease with increasing elevation (Franklin and Dyrness 1988). In our analysis area (Fig. 1), average annual temperatures range from 8.2°C to 11.2°C, and average annual precipitation varies from 106.5 cm to 167.6 cm. During winter and early spring, precipitation generally falls as snow, with accumulations on the ground ranging from 4 cm to 73 cm.

Our study occurred primarily in the mixed-conifer forest zone (Franklin and Dyrness 1988), and contained varying

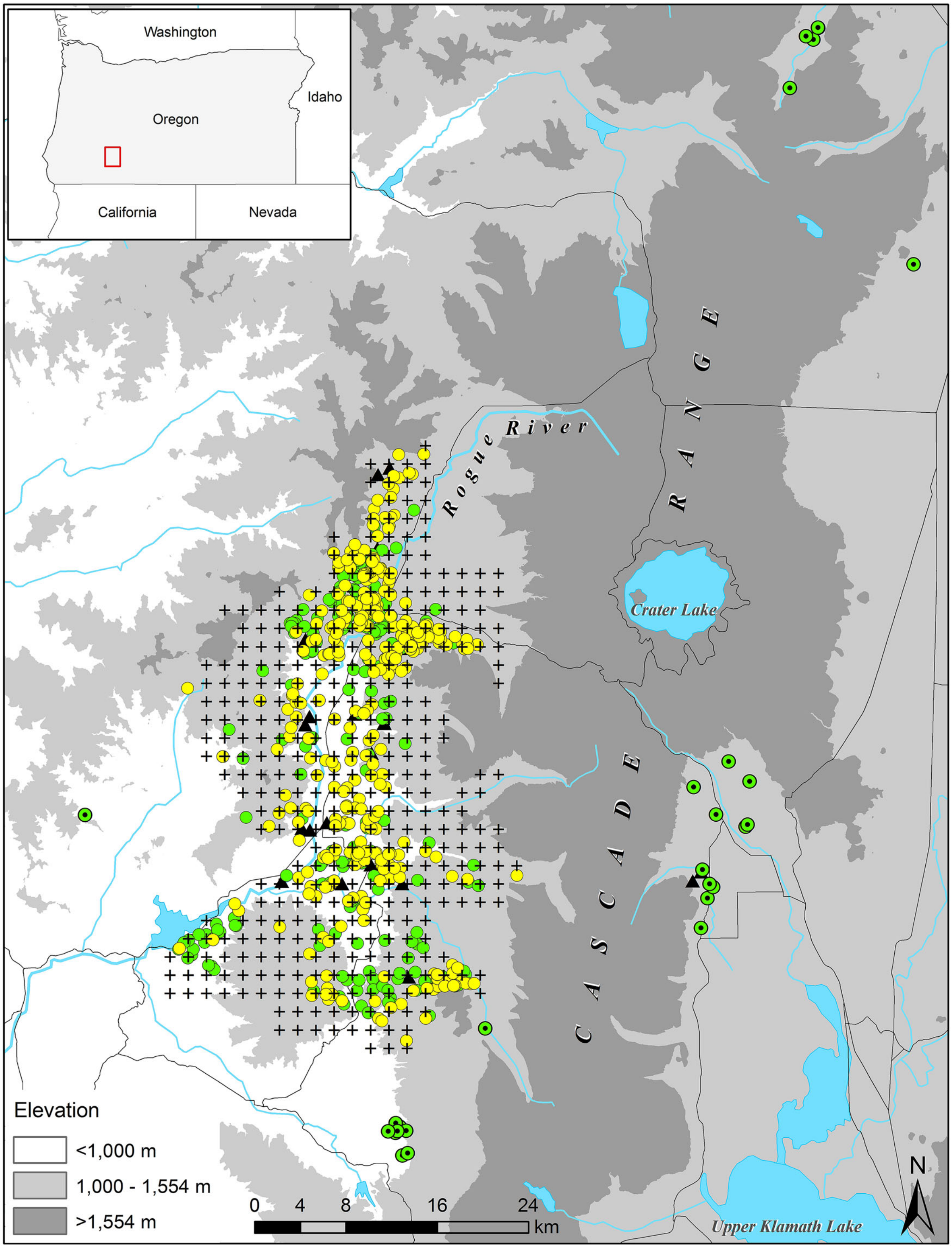

Figure 1. The geographic locations of structures used by fishers for resting on the west slope of the Cascade Range in southern Oregon, USA, 1995–2001. Colored circles indicate the locations of live trees, snags, and logs that were used by fishers for resting ($n = 607$), black triangles indicate the locations of other types of rest structures used by fishers (e.g., slash piles, rock outcrops; $n = 32$), and black crosses indicate the locations of our availability sampling points ($n = 373$). Yellow circles indicate the subsample of live trees, snags, and logs used in logistic regression modeling ($n = 353$), green circles indicate those that were not sampled in detail because of logistical constraints ($n = 227$), and green circles with black dots indicate those that were excluded from logistic regression modeling because they were >1.6 km from an availability sampling point ($n = 27$). Accordingly, the area depicted in the figure represents our radio-telemetry study area (about 8,500 km^2), whereas our analysis area (i.e., the area within which we collected data for logistic regression modeling) was delineated by the subsample of live trees, snags, and logs used as rest structures by fishers (yellow circles) and our availability sampling points (black crosses), and encompassed 1,137 km^2.

amounts of Douglas-fir (*Pseudotsuga menziesii*), grand fir (*Abies grandis*), white fir (*A. concolor*), western hemlock (*Tsuga heterophylla*), incense cedar (*Calocedrus decurrens*), sugar pine (*Pinus lambertiana*), western white pine (*P. monticola*), ponderosa pine (*P. ponderosa*), and giant chinquapin (*Chrysolepis chrysophylla*). California red fir (*A. magnifica*), mountain hemlock (*T. mertensiana*), Engelmann spruce (*Picea engelmannii*), lodgepole pine (*P. contorta*), and subalpine fir (*A. lasiocarpa*) were more common at elevations >1,500 m. Potential predators or competitors of the fisher in our study area included the coyote (*Canis latrans*), common gray fox (*Urocyon cinereoargenteus*), Cascade red fox (*Vulpes vulpes cascadensis*), mountain lion (*Puma concolor*), bobcat (*Lynx rufus*), striped (*Mephitis mephitis*) and western spotted (*Spilogale gracilis*) skunks, northern river otter (*Lontra canadensis*), Pacific marten (*Martes caurina*), American mink (*Vison vison*), long-tailed weasel (*Mustela frenata*), ermine (*M. erminea*), northern raccoon (*Procyon lotor*), ringtail (*Bassariscus astutus*), American black bear (*Ursus americanus*), and an array of hawks and owls. Potential prey included hares (*Lepus* spp.), rabbits (*Sylvilagus* spp.), shrews (*Sorex* spp.), American shrew (*Neurotrichus gibbsii*) and coast moles (*Scapanus orarius*), black-tailed deer (*Odocoileus hemionus*), elk (*Cervus canadensis*), muskrat (*Ondatra zibethicus*), woodrats (*Neotoma* spp.), mice (*Peromyscus* spp. and *Zapus* spp.), voles (*Myodes* spp. and *Microtus* spp.), North American porcupine (*Erethizon dorsatum*), ground squirrels (*Callospermophilus* spp. and *Otospermophilus* spp.), Douglas' squirrel (*Tamiasciurus douglasii*), northern flying squirrel (*Glaucomys sabrinus*), western gray squirrel (*Sciurus griseus*), chipmunks (*Tamias* spp.), and an array of forest birds. Most of our analysis area was located on federal lands, including the Rogue River-Siskiyou National Forest, the Medford District of the Bureau of Land Management, and Crater Lake National Park. The remainder was privately owned and managed primarily for timber production; other uses included agriculture and rural residential development.

METHODS

Animal Capture and Radio-Telemetry

We used reinforced live-traps (Models 108 and 108.5; Tomahawk Live Trap, Hazelhurst, WI, USA) to capture fishers. To provide shelter for captured animals, we attached a plywood cubby to the back of the trap. We operated live traps primarily during winter and early spring, baited them with a whole, feathered chicken carcass, and checked them daily. When we captured a fisher, we attached a heavy canvas sleeve with a metal handling cone to the back of the trap, maneuvered the fisher into the handling cone, and sedated it with a mixture of ketamine hydrochloride and diazepam (5 mg diazepam/1,000 mg ketamine) at a dosage of 15–20 mg/kg of body mass. We then weighed it, collected standard body measurements, and evaluated its overall health based on tooth wear and the presence of injuries or ectoparasites.

We fitted each fisher with a very high frequency (VHF) radio-collar (Model MI-2, Holohil Systems, Carp, Ontario, Canada) that weighed 42 g and had a battery life of 18 months. The telemetry-collar was 1.5% of the average weight of adult females captured during our study (2.8 kg), and 0.7% of the average weight of adult males (5.9 kg). We tracked study animals throughout the year, using ground-based homing techniques (Thompson et al. 2012) to locate resting fishers. We attempted to locate each individual at least twice per week at intervals >48 hours between locations. Our study plan was approved by the Pacific Northwest Research Station of the United States Department of Agriculture (USDA) Forest Service, and the procedures we used to live-trap, handle, and radio-collar fishers complied with guidelines published by the American Society of Mammalogists for the use of wild mammals in research (Sikes et al. 2011).

Sampling Structures Used by Fishers for Resting

Each time we located an inactive fisher at a rest location, we identified the forest structure (e.g., live tree, snag, log, slash pile) it was using by circling around the suspected structure and checking the strength and direction of the telemetry signal to rule out adjacent structures. If we obtained a visual observation, we also recorded the type of microsite (e.g., mistletoe broom, platform branch, cavity, stick nest, hollow end of log) the fisher was using. Minimizing disturbance to resting fishers was a priority; thus, we used topographic maps and aerial photographs to plot the location of each rest structure found and revisited the structure at a later date to collect detailed habitat data. Because we lacked adequate resources to collect detailed data on all rest structures used by radio-collared fishers, our goal was to sample the first 2 rest structures used each month by each study animal to ensure that we sampled rest structures evenly throughout the year.

During revisits to rest structures, we recorded tree species, made standard measurements of size and condition, and documented the presence of potential rest microsites by examining each rest structure thoroughly, and using binoculars to search the upper bole and crown of live trees and snags (Table 1). We distinguished microsites that were suitable for a fisher to use for resting from those that were not by visually assessing whether they were large or sturdy enough to be used by a female fisher. Field technicians considered platform microsites that were sturdy enough to support a domestic cat and cavity openings created by pileated woodpeckers (*Dryocopus pileatus*) or northern flickers (*Colaptes auratus*), as the minimum sizes that were suitable for a female fisher to use for resting.

When examining live trees for the presence of mistletoe brooms (typically caused by dwarf mistletoes [*Arceuthobium* spp.]) or brooms caused by rust fungi (e.g., *Chrysomyxa* spp., *Melampsorella* spp.), we did not attempt to identify incipient infections; rather, we simply determined whether a broom was present that could support the size and weight of a resting fisher. When recording data on microsites, we distinguished between present but too small for a fisher to use and absent. For data analyses, however, we combined them into a single category that indicated the absence of a microsite that was suitable for a fisher to use for resting.

Table 1. Characteristics sampled on live trees (T), snags (S), and logs (L) used by fishers for resting, and on available structures in the Cascade Range of southern Oregon, USA, 1995–2001.

Attribute	Structure type
Tree species	T, S, L
Diameter at breast height (cm)	T, S
Diameter at small end (cm)	L
Diameter at large end (cm)	L
Height (m)	T, S
Length (m)	L
Growth form: 15 categories based on condition of tree bole and top (e.g., straight bole with intact top, swollen knot in bole with broken top)	T
Canopy position: super, upper, mid-, or lower	T
Decay class: 4 (snag) or 3 (log) decay classes ranging from hard and mostly intact to soft and deteriorating[a]	S, L
Presence of suitable rest microsites	
Cavity excavated by a woodpecker	T, S, L
Cavity created by natural processes (e.g., decay, frost, fire)	T, S, L
Broom caused by mistletoe infection	T, S
Broom caused by rust fungi infection	T, S
Platform branch not caused by mistletoe or rust fungi infection[b]	T, S
Stick nest (e.g., woodrat, squirrel, raptor)	T, S
Interstitial space between tree bole and separating bark	S
Hollow in at least 1 end of a log created by wood-decay processes	L

[a] Snag decay classes are from Cline et al. (1980), and log decay classes are from Maser et al. (1979).
[b] Platform branch microsites were primarily fan-shaped branches (multiple stems radiating from a small area on the tree bole) but also included other growth patterns that created a platform.

Lastly, because we thoroughly searched each rest structure used by fishers for the presence of suitable rest microsites, each structure could contain >1 microsite. Data collected on the rest structures we were unable to revisit were limited to the information we recorded during our initial visit, which included the type of structure the fisher was using and, if possible, the microsite it was using.

Sampling Available Live Trees, Snags, and Logs

To investigate selection of the structures fishers used for resting, we sampled the availability of live trees, snags, and logs systematically throughout our analysis area. We did not sample the availability of other types of rest structures (e.g., slash piles, rock outcrops) because our field observations (Aubry and Raley 2006) and the literature (Lofroth et al. 2010) indicated that fishers in this region rest primarily in standing and fallen trees. We randomly overlaid a grid of availability sampling points spaced at 1.6-km intervals and used a United States military precision lightweight global positioning system (GPS) receiver (PLGR) to navigate to each sample point. To ensure that the areas we sampled could support resident fishers, we used relocation data from the first 4 years of our telemetry study to inform our sampling design. Accordingly, we did not sample resource availability in areas where elevations exceeded 1,554 m because fishers in our study area primarily used lower elevation forests. We also excluded sampling points in non-forested conditions, such as agricultural and rural residential areas. The resulting 373 availability sampling points encompassed 93% of telemetry relocations obtained during our 6-year study (1,834/1,971) and delineated the area within which we collected data for logistic regression modeling (Fig. 1).

Our field observations (Aubry and Raley 2006) also indicated that fishers rarely rested in live trees, snags, or logs <25 cm in diameter at breast height (DBH) or average diameter (based on the first 3 m from the large end). Thus, at each availability sampling point, we located the nearest live tree, snag, and log within a 50-m radius in each of 3 size-classes: 25–50 cm DBH or average diameter, 51–100 cm DBH or average diameter, and >100 cm DBH or average diameter. We only sampled snags in decay classes 1–4 (Cline et al. 1980) and logs in decay classes 1–3 (Maser et al. 1979) because our field observations indicated that fishers did not use the most advanced stages of decay for resting (decay class 5 snags and decay class 4 and 5 logs). Although snags in decay class 4 still retain some height and structural integrity, logs in this stage of decay have completely collapsed and provide few, if any, microsites for a resting fisher. We also reasoned that snags needed to be ≥1 m high, and logs needed to be ≥3 m long to serve as rest structures for fishers. We collected the same measurements on forest structures at availability sampling points that we took on the structures fishers used for resting, including the presence of suitable rest microsites (Table 1). If we did not find a structure or size-class combination within our search radius, we recorded a zero.

Data Analyses

Selection of rest structures by fishers.—To determine if fishers selected specific characteristics of live trees, snags, or logs for resting, we fitted logistic regression models using data from forest structures used by fishers versus data from available structures. We used the generalized linear mixed models (GLIMMIX) procedure in SAS 9.4 (SAS Institute 2013) to generate separate models for live trees, snags, and logs with a binary response variable representing structures used by fishers for resting (response = 1) and available structures (response = 0). We used random effects in GLIMMIX to model the clustered nature of our 2 data sets. The used data set was clustered in accordance with individual fishers, whereas the available data set was clustered in accordance with the 373 availability sampling points at which we collected data on multiple structures.

For each modeling exercise, we included a suite of ecological covariates that would affect a fisher's choice of live trees, snags, or logs for resting (Table 2). Although we recorded the presence of all suitable rest microsites when sampling used and available structures (Table 1), some microsite types were rarely used by fishers (e.g., interstitial space between bole and separating bark) or were uncommon in our analysis area (e.g., brooms caused by rust fungi). Consequently, we excluded some microsite types as covariates in our analyses because of inadequate sample sizes. In addition, we combined some microsite types into a single covariate because they were functionally similar (e.g., woodpecker cavities and natural cavities).

Ecological characteristics of structures containing suitable rest microsites for fishers.—To describe the ecological characteristics of forest structures in our analysis area that contained suitable rest microsites for fishers, we fitted logistic regression models using data on available live trees, snags, or logs that contained suitable fisher microsites (response = 1) versus data on available structures that lacked them (response = 0; Table 3). As with previous analyses, we used random effects in GLIMMIX to model the clustered nature of our availability data set. With this novel approach, we sought to generate new insights about the availability of suitable rest microsites for fishers within our analysis area and identify the characteristics of forest structures that could be targeted by resource managers to improve resting habitat for fishers in this region.

To generate a logistic regression model that differentiated between available live trees containing mistletoe microsites and those without them, we included only tree species that are susceptible to dwarf mistletoe infections, grouped by genus: *Tsuga* (western hemlock and mountain hemlock), *Pseudotsuga* (Douglas-fir), and *Abies* (grand fir, white fir, and California red fir; Table 3). Although most of the pine species in our study area are susceptible to dwarf mistletoe infections, we did not include them in our analyses because pine trees containing brooms were rare (only 1 pine in our availability data set had brooms, and they were too small to support a fisher). Incense cedar is a common tree species in our study area, and we often observed cedars that contained dense clumps produced by incense cedar mistletoe (*Phoradendron libocedri*); however, these growths are pendant and do not provide structural support for a resting fisher.

Prior to model development, we examined continuous covariates for correlations (Spearman rank correlation, 2-tailed test of significance; IBM SPSS Statistics version 24; SPSS, Chicago, IL, USA). Measurements of DBH and height in live trees were correlated ($r > 0.70$); thus, we did not include these variables together in any single model. To generate the most parsimonious final model for each structure type (live tree, snag, and log), we built the full model and then removed non-significant ($P > 0.05$) covariates iteratively until the model contained only covariates that remained significant when in combination with each other. Our modeling efforts were designed to provide new insights about fisher habitat relations at the scale of rest structures and rest microsites; thus, they should be considered exploratory, not predictive, in nature. Because so little research had been conducted on the selection of rest

Table 2. Covariates included in logistic regression modeling to investigate selection of live trees, snags, and logs as resting structures by fishers in the Cascade Range of southern Oregon, USA, 1995–2001.

Model	Variable	Description
Live tree rest structure	DBH	Diameter at breast height (cm)
	Height	Height (m)
	Genus	Generated from tree species: *Abies*, *Pseudotsuga*, *Tsuga*, all other genera
	Top	Top condition generated from live-tree growth form: dead or damaged top, green and intact top
	Canopy	Based on live-tree canopy position: overstory[a], understory[b]
	Mistletoe	At least 1 broom created by mistletoe infection: present and large enough for a fisher to use, absent[c]
	Platform	At least 1 platform branch: present and large enough for a fisher to use, absent[c]
	Cavity	At least 1 cavity opening: present and large enough for a fisher to use, absent[c]
Snag rest structure	DBH	Diameter at breast height (cm)
	Height	Height (m)
	Decay	Snag decay class (1–4)[d]
	Cavity	At least 1 cavity opening: present and large enough for a fisher to use, absent[c]
Log rest structure	Diameter	Diameter at large end of the log (cm)
	Length	Length (m)
	Decay	Log decay class (1–3)[e]
	Hollow end	At least 1 hollow end that extends into the length of the log for at least 1 m: present and large enough for a fisher to use, absent[c]
	Cavity	At least 1 cavity opening that is not associated with a hollow end: present and large enough for a fisher to use, absent[c]

[a] Includes super and upper canopy trees.
[b] Includes mid- and lower canopy trees.
[c] The category absent includes microsites that were present but too small for a fisher to use.
[d] From Cline et al. (1980).
[e] From Maser et al. (1979).

Table 3. Covariates included in logistic regression modeling to investigate whether the characteristics of available live trees, snags, and logs containing microsites suitable for a fisher to use for resting differed from those of available live trees, snags, and logs that lacked suitable rest microsites for fishers in the Cascade Range of southern Oregon, USA, 1995–2001.

Model	Variable	Description
Live tree with at least 1 mistletoe broom	DBH	Diameter at breast height (cm)
	Height	Height (m)
	Genus	Generated from tree species: *Abies, Pseudotsuga, Tsuga*
	Top	Top condition generated from live-tree growth form: dead or damaged top, green and intact top
	Canopy	Based on live-tree canopy position: overstory[a], understory[b]
Snag with at least 1 cavity opening	DBH	Diameter at breast height (cm)
	Height	Height (m)
	Decay	Snag decay class (1–4)[c]
Log with at least 1 hollow end	Diameter	Diameter at large end of the log (cm)
	Length	Length (m)
	Decay	Log decay class (1–3)[d]

[a] Includes super and upper canopy trees.
[b] Includes mid- and lower canopy trees.
[c] From Cline et al. (1980).
[d] From Maser et al. (1979).

structures or rest microsites by fishers, we lacked a set of plausible research hypotheses that we could evaluate with our data using an information-theoretic approach (Burnham and Anderson 2002); accordingly, we used a stepwise approach to model selection.

RESULTS

Use of Rest Structures and Microsites by Fishers

We radio-tracked 19 individual fishers (12 females, 7 males) throughout the year from 1995 to 2001 and located 650 rest locations. We isolated the telemetry signal to an individual rest structure at 98% (639/650) of these locations. Fishers rested primarily in live trees ($n = 416$; 65%) but also used logs ($n = 101$; 16%), and snags ($n = 90$; 14%). Fishers rested infrequently in other structure types, including slash piles ($n = 16$; 2%), rock outcrops ($n = 7$; 1%), log piles created by wind- or snow-downed trees ($n = 3$; <1%), and others ($n = 6$; 1%). Thirteen percent (83/639) of the rest structures we located were reused by the same fisher ($\bar{x}$ number of reuses = 1.5; range = 1–7), and most of the reuses occurred during a different month (42/83) or in a different year (29/83). Eighteen rest structures were used on separate occasions by 2 or 3 different study animals and, although most instances involved members of the opposite sex, a few rest structures were used by 2 different females or 2 different males. Female fishers used snags for resting 3.5 times more often than males (21% and 6%, respectively), whereas live trees (63% and 77% for females and males, respectively) and logs (16% and 17%) were used at similar rates by both sexes.

We observed fishers using a rest microsite at 38% (244/639) of the rest structures we located (Table 4). When resting in live trees, fishers used mistletoe brooms (including mistletoe broom and stick-nest complexes) more frequently than any other microsite (55%). Platform branches (including platform branch and stick-nest complexes) were the second most frequently used microsite (21%), followed by stick nests (14%). Many of the stick nests appeared to be those of the dusky-footed woodrat (*Neotoma fuscipes*), but fishers also used squirrel and raptor nests. We observed a fisher using a

Table 4. Visual and auditory observations of fishers using microsites in 244 rest structures in the Cascade Range of southern Oregon, USA, 1995–2001.

	Type of rest structure			
Microsite used	Live tree	Snag	Log	Other
Mistletoe broom	97	1		
Mistletoe broom and stick-nest complex	6	1		
Platform branch	36			
Platform branch and stick-nest complex	4			
Stick nest	26			
Cavity	1	15[a]	3	
Hollow end			22[b]	
Depression at the top of a broken tree or snag	1	6		
Interstitial space between tree bole and separating bark		2		
Other	17[c]	1[d]		5[e]
Totals	188	26	25	5

[a] For 3 of these detections, the fisher was heard moving inside the snag.
[b] For 3 of these detections, the fisher was heard moving or vocalizing inside the log.
[c] Includes use of a branch ($n = 11$), a platform created by intertwining branches from multiple trees ($n = 3$), and unknowns when the fisher was seen after it had moved in the tree in response to the tracker's presence ($n = 3$).
[d] The fisher rested against the bole of the snag on a limb.
[e] Fishers rested in a below-ground cavity associated with a cut stump ($n = 1$), in a slash pile ($n = 2$), on the ground in dense brush ($n = 1$), or under a suspended log ($n = 1$).

cavity microsite in a live tree on only 1 occasion (<1%), yet cavities were the most frequently used microsites in snags (58%). When resting in logs, fishers typically used hollow ends as microsites (88%), but occasionally (12%) accessed openings in the bole of the log created by natural processes (decay, impact from falling, knothole; Table 4).

Among the 607 live tree, snag, and log rest structures used by radio-collared fishers, 27 were >1.6 km from any of the points at which we sampled available forest structures (Fig. 1). Most (19/27) of these rest structures were used by 3 males: 2 adults that frequented our analysis area during the breeding season but whose non-breeding home ranges were located >15 km east of that area, and 1 subadult that dispersed >50 km to the northeast (Aubry et al. 2004; Fig. 1). Among the 580 live trees, snags, and logs fishers used for resting in our analysis area, we collected detailed measurements on a subsample of 353 (61%) for inclusion in logistic regression modeling. The composition of our subsample in terms of sex, rest structure type, and season corresponded closely to that of the full data set (Table 5), indicating that it was representative of the structures used by fishers during our study. Both samples favored females (61%) because most (12/19) of the individuals we monitored were females. We believe that our sample included most of the resident fishers in our analysis area because we conducted extensive livetrapping and telemetry efforts each year, and no large portions of our analysis area were unoccupied by radio-collared fishers.

The mean DBH of live trees used by fishers for resting was 75.5 ± 39.9 (SD) cm ($n = 230$; range = 18–201 cm). We excluded 2 live-tree rest structures from logistic regression modeling because they were smaller than the minimum size of trees included in our availability sample (25 cm DBH). The mean DBH and height of snags used by fishers for resting was 112.7 ± 38.2 cm ($n = 50$; range = 29–196 cm) and 16 ± 11.6 m ($n = 50$; range = 5–60 m), and all were larger than the minimum size of snags included in our availability sample (≥25 cm DBH and ≥1 m high). Logs used by fishers also exceeded the minimum size we established for sampling available logs (≥25 cm average diameter within 3 m of the large end, and ≥3 m in length); the mean large-end diameter of logs used by fishers for resting was 105.4 ± 29.4 cm ($n = 73$; range = 48–182 cm) and the mean length was 20.8 ± 12.2 m ($n = 73$; range = 4.1–52.1 m).

Table 5. Characteristics of the subsample ($n = 353$) of structures used by fishers for resting (live trees, snags, and logs only) that were included in logistic regression modeling, compared to the full sample ($n = 580$) of fisher rest structures that we located in the Cascade Range of southern Oregon, USA, 1995–2001.

	Subsample		**Full sample**	
Characteristic	***n***	**%**	***n***	**%**
Sex				
Female	217	61	351	61
Male	136	39	229	39
Type of rest structure				
Live tree	230	65	393	68
Snag	50	14	88	15
Log	73	21	99	17
Season				
Winter (Dec–Feb)	88	25	137	24
Spring (Mar–May)	80	23	135	23
Summer (Jun–Aug)	99	28	152	26
Fall (Sep–Nov)	86	24	156	27

Selection of Live Trees, Snags, and Logs by Fishers for Resting

At 373 availability sampling points, we measured 875 live trees (362 medium, 330 large, and 183 very large), 649 snags (298 medium, 242 large, and 109 very large), and 824 logs (354 medium, 328 large, and 142 very large). Medium-sized (25–50 cm DBH or average diameter) forest structures were present at most (80–97%) of our availability sampling points. Large (51–100 cm DBH or average diameter) live trees and logs were present at 88% of the points, but large snags occurred at only 65%. Very large forest structures (>100 cm DBH or average diameter) were less common in our analysis area; live trees, snags, and logs in this size class were present at 49%, 29%, and 38% of our availability points, respectively.

Logistic regression modeling showed that fishers primarily selected live trees for resting that contained mistletoe brooms or cavities or were part of the overstory. Holding all other terms in the model constant, live trees containing a suitable mistletoe broom or cavity microsite (i.e., ≥1 mistletoe broom or cavity opening large enough for a fisher to use), were 21.8 and 13.2 times more likely, respectively, to be used by fishers for resting than live trees that lacked these microsites (Table 6). In addition, live trees were almost twice as likely to be used for resting if they were in the overstory, rather than the understory. Neither tree size nor the presence of platform branches was included in the final model. However, 34% of the live trees used by fishers for resting that contained platform branches also contained mistletoe brooms. When resting in snags, fishers selected those that contained ≥1 suitable cavity microsite or were relatively large in diameter. The probability that a snag would be used for resting increased by a factor of 13 for snags with ≥1 cavity opening compared to snags without cavity openings, and increased by a factor of 2 with a 25-cm increase in DBH (i.e., from the mean of 65.6 cm for both used and available snags to 90.6 cm; Table 6). The logs that fishers selected for resting had ≥1 hollow end and were relatively large in length or diameter. The likelihood that a fisher would use a log for resting increased by a factor of almost 33 when a hollow end was present (Table 6). The size of the log was also influential, but to a lesser extent. A 25-cm increase in diameter at the large end increased the probability that a log would be used for resting by a factor of 1.9, whereas a 5-m increase in length increased the probability of use by a factor of 1.5 (Table 6).

Characteristics of Structures Containing Suitable Rest Microsites for Fishers

The likelihood that a live tree contained a mistletoe broom large enough for a fisher to use for resting increased by a factor of 13.4 if the tree was a hemlock, rather than a true fir (Table 7). Trees with a dead or damaged top, or trees in the overstory, were more than twice as likely to contain a suitable

Table 6. Final logistic regression models investigating selection of live trees, snags, and logs as rest structures by fishers in the Cascade Range of southern Oregon, USA, 1995–2001.

Model	*n* Used	*n* Available	Coefficient	SE	*F*-test	Probability of *F*	Odds ratio[a]
Live tree	227[b]	875					
Mistletoe			3.08	0.188	268.4	<0.001	21.8
Cavity			2.58	0.438	34.7	<0.001	13.2
Canopy (overstory)			0.67	0.237	7.9	0.005	1.9
Snag	50	649					
Cavity			2.57	0.349	54.2	<0.001	13.0
DBH			0.03	0.004	45.8	<0.001	2.0[c]
Log	73	824					
Hollow end			3.49	0.306	129.7	<0.001	32.8
Length			0.08	0.011	55.8	<0.001	1.5[d]
Diameter			0.03	0.004	47.7	<0.001	1.9[e]

[a] Odds ratios for coefficient estimates are based on holding all other terms in the model constant.
[b] We measured 230 live trees but excluded 3 from analyses: 2 trees were <25 cm DBH, and a third had missing canopy data.
[c] For a 25-cm increase from the mean DBH of 65.6 cm (used and available snags combined) to 90.6 cm.
[d] For a 5-m increase from the mean length of 12.2 m (used and available logs combined) to 17.2 m.
[e] For a 25-cm increase from the mean large-end diameter of 65.9 cm (used and available logs combined) to 90.9 cm.

mistletoe microsite than trees with a green and intact top, or those in the understory; tree diameter also contributed to the final model, but less so. Snags were most likely to contain a cavity large enough for a fisher to use for resting if they were in moderate stages of decay (decay classes 2–4) or relatively large in diameter (Table 7). Similarly, logs were most likely to contain a hollow end large enough for a fisher to use for resting if they were in moderate stages of decay (decay classes 2 and 3) or greater than average in diameter at the large end.

DISCUSSION

In coniferous forests on the west slope of the Cascade Range in southern Oregon, fishers rested primarily in live trees (65%), and less frequently in snags (14%) and logs (16%); other structure types (slash piles, rock outcrops, log piles) were rarely used (5%). Our results fell within the ranges reported in a review of 11 fisher studies from the Pacific coastal region (live trees [64–83%], snags [7–26%], logs

Table 7. Final logistic regression models investigating whether the characteristics of available live trees, snags, and logs containing microsites large enough for a fisher to use differed from those of available live trees, snags, and logs that lacked suitable rest microsites for fishers in the Cascade Range of southern Oregon, USA, 1995–2001.

Model	Microsite present (*n*) Yes	Microsite present (*n*) No	Coefficient	SE	*F*-test	Probability of *F*	Odds ratio[a]
Live tree with at least 1 mistletoe broom	71	616					
Genus					29.7	<0.001	
Tsuga			2.59	0.396			13.4[b]
Pseudotsuga			0.01	0.340			1.0[b]
Top (dead or damaged)			0.89	0.304	8.6	0.005	2.4
Canopy (overstory)			0.85	0.352	5.8	0.017	2.3
DBH			0.01	0.003	8.1	0.005	1.3[c]
Snag with at least 1 cavity opening	110	539					
DBH			0.02	0.003	25.7	<0.001	1.5[d]
Decay					12.0	<0.001	
Class 2			0.94	0.389			2.6[e]
Class 3			1.95	0.361			7.0[e]
Class 4			1.77	0.375			5.9[e]
Log with at least 1 hollow end	113[f]	709[f]					
Diameter			0.02	0.003	47.9	<0.001	1.7[g]
Decay					7.0	0.001	
Class 2			0.80	0.530			2.2[h]
Class 3			1.43	0.519			4.2[h]

[a] Odds ratios for coefficient estimates are based on holding all other terms in the model constant.
[b] Odds of having at least 1 mistletoe broom compared to *Abies*.
[c] For a 25-cm increase from mean DBH of 66.5 cm (live trees with and without mistletoe brooms combined) to 91.5 cm.
[d] For a 25-cm increase from mean DBH of 62 cm (snags with and without cavities combined) to 87 cm.
[e] Odds of having at least 1 cavity opening compared to a decay class 1 snag.
[f] Sample size after 1 log excluded because of missing decay data.
[g] For a 25-cm increase from mean large-end diameter of 62.4 cm (logs with and without hollow ends combined) to 87.4 cm.
[h] Odds of having at least 1 hollow end compared to a decay class 1 log.

[2–20%], other [0–9%]; Lofroth et al. 2010), supporting previous assertions that the types of structures fishers use for resting are strikingly consistent throughout this region (Raley et al. 2012). Previous researchers reported that the forest structures fishers used for resting were relatively large, leading to speculations that fishers selected the largest trees, snags, and logs available for rest structures (Weir and Harestad 2003, Zielinski et al. 2004, Yaeger 2005, Davis 2009, Purcell et al. 2009). However, the extent to which large size is an essential characteristic of suitable fisher rest structures remains unclear because a structure can only be used by a fisher for resting if it contains a suitable rest microsite, and the presence of such microsites may or may not be strongly associated with the size or age of the structure (Manion 1991, Bull et al. 1997, Conklin 2009).

Our results indicated that females used snags for resting >3 times more often than males, whereas males and females used live trees and logs at similar rates. Based on our observations of fishers using microsites (Table 4), snag microsites were typically enclosed (i.e., cavities), whereas live tree microsites were typically open (i.e., mistletoe brooms, platform branches, stick nests). Our observations agree with previous findings and appear to provide support for speculations that females are more likely than males to use cavity microsites because of their greater need for security from predators or competitors, or protection from inclement weather (Zielinski et al. 2004). However, we examined our data on microsite use by fishers according to sex, season, ambient temperature, and whether rest microsites were enclosed or open, and found no clear patterns. Thus, our study provided little support for the hypotheses that fishers select rest microsites to meet either security or thermoregulatory needs. Additional studies designed to investigate these hypotheses will be needed to understand the ecological basis for the selection of rest microsites by fishers.

Our study provides additional evidence that reuse of rest structures by individual fishers is rare in the Pacific coastal region (3–14%; Seglund 1995, Zielinski et al. 2004, Purcell et al. 2009). Previous researchers speculated that the low reuse of rest structures by fishers may indicate that they require multiple resting locations distributed throughout their home ranges to minimize the time spent traveling between kill sites and a resting location (Zielinski et al. 2004). However, alternative hypotheses, such as the avoidance of predators or competitors, social interactions, and home range defense, cannot be ruled out. Thus, additional research will be needed to understand the ecological basis for these observations.

Our logistic regression models indicated that the most important characteristic of live trees, snags, and logs selected by fishers for resting was the presence of a suitable rest microsite (mistletoe broom, cavity, and hollow end, respectively; Table 6). The second most influential covariate in live trees was the presence of a suitable cavity microsite. Both of these microsite types were uncommon in live trees within our analysis area. Among the live trees that fishers used for resting, 64% (146/227) had $\geq$1 mistletoe broom large enough for a fisher to use, compared to only 8% (73/875) in our availability sample. Similarly, 6% (14/227) of live-tree rest structures contained a cavity opening large enough for a fisher to access, compared to 1% (10/875) of available trees. The only non-microsite covariate included in the live-tree model was being in the overstory; neither of the covariates for tree size (DBH, height) were included in the final model (Table 6). These results were not unexpected because mistletoe broom microsites need only to be large enough to support a resting fisher, and such brooms can form in a wide range of tree sizes and ages (Conklin 2009). Although overstory trees are relatively tall by definition, height was not included in the final model, indicating that fishers may not be selecting live trees in the overstory for resting simply because they are large. Rather, live trees in the overstory may provide better resting habitat for fishers because the microsites they contain offer better cover from potential predators and competitors than those in the understory, or because they are more likely to contain suitable mistletoe broom microsites. Dwarf mistletoes are parasitic organisms that persist only in live trees and do poorly in well-shaded conditions; the most robust shoots and best complement of seeds are produced in full sunlight (Shaw et al. 2009). Thus, trees in the overstory may be more likely to contain suitable mistletoe broom microsites for fishers because they receive greater amounts of sunlight than those in the understory.

In contrast, size covariates were included in the snag (DBH) and log (length and diameter) selection models (Table 6). To serve as rest microsites, cavities in snags and hollow ends in logs must be large enough to contain an adult fisher; smaller snags and logs cannot provide suitable rest microsites. Both of these enclosed microsite types are created by ecological processes (e.g., infection of live trees by heart-rot fungi, advanced wood decay, excavation by woodpeckers) that require a long time to develop but whose presence cannot be predicted solely on the basis of tree size or age (Manion 1991, Bull et al. 1997, Aubry and Raley 2002). Thus, our models indicated that large size had a greater effect on the selection of snags and logs as rest structures by fishers than on the selection of live trees. As with live trees containing mistletoe brooms or cavities, snags with suitable cavity microsites and logs with suitable hollow-end microsites were also uncommon. Among the snags fishers used for resting, 80% (40/50) had $\geq$1 cavity opening compared to only 17% (110/649) of available snags, and 72% (36/50) of resting snags had $\geq$1 cavity opening and were larger than average in DBH (65.6 cm), compared to just 9% (59/649) of available snags. Among the logs fishers used for resting, 84% (61/73) had >1 hollow end compared to 14% (114/824) of available logs, and 52% (38/73) had $\geq$1 hollow end and were greater than average in diameter at the large end and length (65.9 cm and 12.2 m, respectively), whereas only 3% (23/824) of available logs met those criteria.

Visual observations of fishers using cavities as rest microsites differed strongly between live trees and snags (<1% and 58%, respectively; Table 4), yet the presence of a suitable tree cavity was an important covariate in the live tree and snag selection models (odds ratios of 13.2 and 13.0, respectively; Table 6). Of the 14 live trees used as rest structures by fishers that contained suitable cavity microsites, we only obtained 1 visual observation of a fisher in a cavity. However, at 9 of the remaining 13 trees, the telemetry signal indicated that the fisher was most likely resting in a cavity and, in all cases, the cavity was the only suitable microsite present in the tree. Thus, it is likely that fishers used cavities in live trees as rest microsites more frequently than our visual observations indicated.

To better understand the characteristics of forest structures that are most likely to provide resting habitat for fishers, we modeled the presence of suitable mistletoe brooms in live trees, cavities in snags, and hollow ends in logs, based on the presence or absence of such microsites in our availability sample (Table 7). In live trees, tree species had a greater effect on the presence of suitable mistletoe broom microsites than size or condition. However, the likelihood that a live tree had $\geq$1 mistletoe broom that a fisher could use for resting was 2.3 times greater if the tree was in the overstory, providing additional support for our finding that suitable mistletoe brooms are more prevalent in overstory trees than in understory trees. Other factors, including the presence of a dead or damaged top and whether the tree was larger than average in DBH, were also included in the final model, indicating that tree size and age also play a role in the formation of suitable mistletoe broom rest microsites. Mistletoe infections are long-lived and persistent but spread slowly (0.3–0.6 m/year), and it takes 6–10 years for new mistletoe plants to produce seed (Conklin 2009); thus, it may take many years for suitable mistletoe broom rest microsites to form. Moreover, because live trees with larger than average DBH or dead and damaged tops often belong to the oldest and tallest cohort (i.e., dominant trees), the inclusion of these covariates may also be related to the greater amounts of sunlight received by dominant trees compared to co-dominant trees (Bechtold 2003).

The likelihood that a snag or log contained a suitable cavity or hollow-end microsite, respectively, was greatest for relatively large structures in moderate stages of decay (decay class 2–4 snags and decay class 2–3 logs). Thus, for snags and logs, the wood must be decayed enough for suitable microsites to form while retaining the structural integrity needed to support a relatively large cavity or hollow end. Although fishers need to rest in relatively large forest structures simply because of their body size, especially when using cavities or hollow ends, their use of such structures is likely also related to the long periods of time that are required for suitable rest microsites to develop (Raley et al. 2012).

Fishers give birth exclusively in cavities in live trees and snags (natal dens), and such cavities are also used for maternal dens (Raley et al. 2012). During our study, we located 13 natal dens (7 in live trees and 6 in snags) and 18 maternal dens (10 in tree cavities, 5 in logs, 2 in mistletoe brooms, and 1 in a rodent nest; Aubry and Raley 2006). Thus, the tree cavities that are required by fishers for natal dens and often used for maternal dens are critical components of fisher habitat and, as our availability data indicate, may represent a limited resource in our analysis area. Moreover, most (8/13) of the natal dens we found were excavated by pileated woodpeckers, suggesting that they may be particularly important for creating den microsites for fishers.

MANAGEMENT IMPLICATIONS

Forest management activities designed to retain or recruit large forest structures will not improve the quality of fisher resting habitat in the short-term if those structures lack suitable rest microsites. To maximize benefits to fishers, we recommend that forest managers retain relatively large live trees, snags, and logs that already contain suitable rest microsites for fishers, many of which are associated with disease or decay processes. We recognize that retaining live trees with mistletoe brooms may conflict with timber management objectives, but the value of mistletoe brooms to fishers and other wildlife species may outweigh the potential negative effects of mistletoe infections on wood production. Retaining live trees as recommended would also improve the recruitment of future snags and logs containing suitable rest microsites. Although an array of suitable rest microsites can form in live trees as they age (e.g., mistletoe brooms, cavities, platform branches), that is not the case for suitable cavity microsites in snags and hollow-end microsites in logs, which require decay from heart-rot fungi that only infect live trees; such microsites do not form after the tree dies. Thus, retaining snags and logs to improve resting habitat for fishers can only provide intended benefits if they already contain suitable rest microsites. Importantly, retaining relatively large live trees and snags with cavities or live trees with heart-rot decay will also increase the availability of reproductive denning habitat for fishers.

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LITERATURE CITED

Aubry, K. B., and J. C. Lewis. 2003. Extirpation and reintroduction of fishers (*Martes pennanti*) in Oregon: implications for their conservation in the Pacific states. Biological Conservation 114:79–90.

Aubry, K. B., and C. M. Raley. 2002. Selection of nest and roost trees by pileated woodpeckers in coastal forests of Washington. Journal of Wildlife Management 66:392–406.

Aubry, K. B., and C. M. Raley. 2006. Ecological characteristics of fishers (*Martes pennanti*) in the southern Oregon Cascade Range. USDA Forest Service, Pacific Northwest Research Station, Olympia, Washington, USA.

Aubry, K. B., C. M. Raley, S. W. Buskirk, W. J. Zielinski, M. K. Schwartz, R. T. Golightly, K. L. Purcell, R. D. Weir, and J. S. Yaeger. 2013. Meta-analyses of habitat selection by fishers at resting sites in the Pacific coastal region. Journal of Wildlife Management 77:965–974.

Aubry, K., S. Wisely, C. Raley, and S. Buskirk. 2004. Zoogeography, spacing patterns, and dispersal in fishers: insights gained from combining field and genetic data. Pages 201–220 *in* D. J. Harrison, A. K. Fuller, and G. Proulx, editors. Martens and fishers (*Martes*) in human-altered environments: an international perspective. Springer Science+Business Media, New York, New York, USA.

Bechtold, W. A. 2003. Crown position and light exposure classification—an alternative to field-assigned crown class. Northern Journal of Applied Forestry 20:154–160.

Bull, E. L., C. G. Parks, and T. R. Torgersen. 1997. Trees and logs important to wildlife in the Interior Columbia River Basin. USDA Forest Service, Pacific Northwest Research Station, General Technical Report PNW–GTR–391, Portland, Oregon, USA.

Burnham, K. P., and D. R. Anderson. 2002. Model selection and multimodel inference: a practical information-theoretic approach. Second edition. Springer-Verlag, New York, New York, USA.

California Department of Fish and Wildlife. 2017. State and federally listed endangered and threatened animals of California. https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=109405&inline. Accessed 5 Sep 2017.

Cline, S. P., A. B. Berg, and H. M. Wight. 1980. Snag characteristics and dynamics in Douglas-fir forests, western Oregon. Journal of Wildlife Management 44:773–786.

Conklin, D. 2009. Dwarf mistletoes. Pages 44–46 *in* G. Man, editor. Major forest insect and disease conditions in the United States 2007. USDA Forest Service, Forest Health Protection, Report FS–919, Washington, D.C., USA.

Davis, L. R. 2009. Denning ecology and habitat use by fisher (*Martes pennanti*) in pine dominated ecosystems of the Chilcotin Plateau. Thesis, Simon Fraser University, Burnaby, British Columbia, Canada.

Franklin, J. F., and C. T. Dyrness. 1988. Natural vegetation of Oregon and Washington. Oregon State University Press, Corvallis, USA.

Lewis, J. C., R. A. Powell, and W. J. Zielinski. 2012. Carnivore translocations and conservation: insights from population models and field data for fishers (*Martes pennanti*). PLOS ONE 7:e32726.

Lewis, J. C., and D. W. Stinson. 1998. Washington State status report for the fisher. Washington Department of Fish and Wildlife, Olympia, USA.

Lofroth, E. C., C. M. Raley, J. M. Higley, R. L. Truex, J. S. Yaeger, J. C. Lewis, P. J. Happe, L. L. Finley, R. H. Naney, L. J. Hale, A. L. Krause, S. A. Livingston, A. M. Myers, and R. N. Brown. 2010. Conservation of fishers (*Martes pennanti*) in south-central British Columbia, western Washington, western Oregon, and California—volume I: conservation assessment. USDI Bureau of Land Management, Denver, Colorado, USA.

Manion, P. D. 1991. Tree disease concepts. Second edition. Prentice-Hall, Englewood Cliffs, New Jersey, USA.

Maser, C., R. G. Anderson, K. Cromack, Jr., J. T. Williams, and R. E. Martin. 1979. Dead and down woody material. Pages 78–95 *in* J. W. Thomas, editor. Wildlife habitats in managed forests: the Blue Mountains of Oregon and Washington. USDA Forest Service, Agricultural Handbook 553, Washington, D.C., USA.

Mazzoni, A. K. 2002. Habitat use by fishers (*Martes pennanti*) in the southern Sierra Nevada, California. Thesis, California State University, Fresno, USA.

Oregon Department of Fish and Wildlife. 2016. Sensitive species list. http://www.dfw.state.or.us/wildlife/diversity/species/docs/2017_Sensitive_Species_List.pdf. Accessed 5 Sep 2017.

Purcell, K. L., A. K. Mazzoni, S. R. Mori, and B. B. Boroski. 2009. Resting structures and resting habitat of fishers in the southern Sierra Nevada, California. Forest Ecology and Management 258:2696–2706.

Raley, C. M., E. C. Lofroth, R. L. Truex, J. S. Yaeger, and J. M. Higley. 2012. Habitat ecology of fishers in western North America: a new synthesis. Pages 231–254 *in* K. B. Aubry, W. J. Zielinski, M. G. Raphael, G. Proulx, and S. W. Buskirk, editors. Biology and conservation of martens, sables, and fishers: a new synthesis. Cornell University Press, Ithaca, New York, USA.

SAS Institute. 2013. SAS/STAT® 13.1 user's guide. SAS Institute Inc., Cary, North Carolina, USA.

Seglund, A. E. 1995. The use of resting sites by the Pacific fisher. Thesis, Humboldt State University, Arcata, California, USA.

Shaw, D. C., P. T. Oester, and G. M. Filip. 2009. Managing insects and diseases of Oregon conifers. Oregon State University Extension Service Press, Extension Manual 8980, Corvallis, USA.

Sikes, R. S., W. L. Gannon, and the Animal Care and Use Committee of the American Society of Mammalogists. 2011. Guidelines of the American Society of Mammalogists for the use of wild mammals in research. Journal of Mammalogy 92:235–253.

Thompson, C. M., R. A. Green, J. Sauder, K. L. Purcell, R. A. Sweitzer, and J. M. Arnemo. 2012. The use of radiotelemetry in research of *Martes* species: techniques and technologies. Pages 284–319 *in* K. B. Aubry, W. J. Zielinski, M. G. Raphael, G. Proulx, and S. W. Buskirk, editors. Biology and conservation of martens, sables, and fishers: a new synthesis. Cornell University Press, Ithaca, New York, USA.

U. S. Fish and Wildlife Service [USFWS]. 2014. Threatened species status for West Coast distinct population segment of fisher. Federal Register 79:60419–60443.

U. S. Fish and Wildlife Service [USFWS]. 2016. Withdrawal of the proposed rule to list the West Coast distinct population segment of fisher. Federal Register 81:22710–22808.

Weir, R. D., and F. B. Corbould. 2008. Ecology of fishers in the sub-boreal forests of northcentral British Columbia: final report. Peace/Williston Fish and Wildlife Compensation Program, Report No. 315, Prince George, British Columbia, Canada.

Weir, R., F. Corbould, and A. Harestad. 2004. Effect of ambient temperature on the selection of rest structures by fishers. Pages 187–197 *in* D. J. Harrison, A. K. Fuller, and G. Proulx, editors. Martens and fishers (*Martes*) in human-altered environments: an international perspective. Springer Science+Business Media, New York, New York, USA.

Weir, R. D., and A. S. Harestad. 2003. Scale-dependent habitat selectivity by fishers in south-central British Columbia. Journal of Wildlife Management 67:73–82.

Yaeger, J. S. 2005. Habitat at fisher resting sites in the Klamath Province of northern California. Thesis, Humboldt State University, Arcata, California, USA.

Zielinski, W. J., T. E. Kucera, and R. H. Barrett. 1995. Current distribution of the fisher, *Martes pennanti*, in California. California Fish and Game 81:104–112.

Zielinski, W. J., R. L. Truex, G. A. Schmidt, F. V. Schlexer, K. N. Schmidt, and R. H. Barrett. 2004. Resting habitat selection by fishers in California. Journal of Wildlife Management 68:475–492.

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