Habitat Relations

Meta-Analyses of Habitat Selection by Fishers at Resting Sites in the Pacific Coastal Region

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ABSTRACT The fisher (*Pekania pennanti*) is a species of conservation concern throughout the Pacific coastal region in North America. A number of radiotelemetry studies of habitat selection by fishers at resting sites have been conducted in this region, but the applicability of observed patterns beyond the boundaries of each study area is unknown. Broadly applicable information on habitat selection by fishers in this region would be useful for conservation planning and for informing forest management decisions in areas where intensive field studies have not been conducted. To provide such information, we conducted formal meta-analyses of habitat selection by fishers at resting sites in 8 study areas located from central British Columbia to the southern Sierra Nevada in California, including all areas that currently contain established fisher populations. Each study included in the meta-analyses measured environmental attributes at sites used by fishers for resting (i.e., the immediate vicinity of resting structures; typically $\leq$0.5 ha) and at random or systematically located sites representing resource availability in each study area. We selected 9 environmental attributes that we expected to be associated with fisher resting sites: slope, heat load index, percent cover of vegetation $\geq$2 m above the ground, volume of moderately decayed logs $\geq$26 cm in mean diameter, basal area of live conifers 51–100 cm in diameter at breast height (dbh), basal area of live hardwoods 51–100 cm in dbh, basal area of moderately decayed snags 51–100 cm in dbh, mean dbh of live conifers $\geq$10 cm in dbh, and mean dbh of live hardwoods $\geq$10 cm in dbh. Despite substantial variation in environmental conditions among study locations, our analyses revealed statistically significant summary effect sizes for each of the 9 environmental attributes we analyzed. Fishers selected sites for resting that had steeper slopes, cooler microclimates, denser overhead cover, a greater volume of logs, and a greater prevalence of large trees and snags than were generally available. Thus, in areas within the Pacific coastal region where fishers have not been studied and data on selection of resting sites are lacking, our findings provide empirical support for management or conservation actions for fishers that promote the retention or development of these environmental attributes. © 2013 The Wildlife Society.

KEY WORDS fisher, habitat selection, meta-analysis, Pacific coastal region, *Pekania pennanti*, resting site.

Fisher (*Pekania pennanti*; formerly *Martes pennanti* [see Sato et al. 2012]) populations in western North America have experienced substantial reductions in distribution and abundance, with human-caused habitat changes implicated as a contributing factor (Zielinski et al. 1995, Aubry and Lewis 2003, Lofroth et al. 2010, Lewis et al. 2012). In 2004, growing concerns about the conservation status of these populations resulted in the United States Fish and Wildlife Service (2004) designating the fisher in the Pacific coastal states as a candidate for listing under the Endangered Species Act (i.e., listing was deemed warranted but precluded by higher priority actions), and in 2005 the British Columbia Ministry of Environment designated the fisher as a species of special concern throughout the province ("vulnerable to extirpation or extinction;" British Columbia Conservation Data Centre 2012). In response to these decisions, a team of state, federal, and provincial biologists was formed in 2005 to develop a conservation assessment for the fisher in the Pacific coastal states (Washington, Oregon, and California) and British Columbia (Lofroth et al. 2010, 2011; Naney et al. 2012). Lofroth et al. (2011) noted that comparing findings among studies of fisher habitat selection was difficult because investigators evaluated different attributes

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and used a variety of sampling designs and field methods to assess resource use and availability.

Resource managers are often required to include information in regulatory and environmental documents about the potential effects of land management activities on a species of conservation concern, even in areas where that species has not been studied. A number of studies of habitat use and selection by fishers have been conducted in their Pacific coastal range (e.g., Weir and Harestad 2003; Zielinski et al. 2004*a*, *b*; Aubry and Raley 2006; Weir and Corbould 2008; Purcell et al. 2009), but the applicability of research findings beyond the boundaries of each study area is unknown. Developing new information that would be useful for managing fisher habitat throughout the Pacific coastal region would represent an important contribution to fisher conservation.

Selection of resting sites has been studied more than any other aspect of fisher habitat ecology in the Pacific coastal region (Lofroth et al. 2010, Raley et al. 2012). Resting sites used by fishers include the individual forest structure (e.g., live tree, snag, and log) that was used for resting, as well as the physiographic and vegetative (hereafter, environmental) attributes in the immediate vicinity of the resting structure (typically $\leq$0.5 ha; Raley et al. 2012). Resting sites are hypothesized to integrate key components of fisher habitat that provide thermoregulatory benefits, protection from predators, proximity to prey, and secure locations for consuming prey (Kilpatrick and Rego 1994, Zielinski et al. 2004*a*, Aubry and Raley 2006, Purcell et al. 2009, Raley et al. 2012). Several researchers have developed study area-specific models of habitat selection by fishers at resting sites in British Columbia (Weir 1995, Weir and Harestad 2003, Weir and Corbould 2008) and California (Seglund 1995, Mazzoni 2002, Zielinski et al. 2004*a*, Yaeger 2005, Purcell et al. 2009). Similar environmental attributes were included in many of these models, but none were included in all of them, and substantial variation existed among the attributes included in these models. In addition, although many of the attributes in these models appear to represent analogous environmental conditions, they may not be directly comparable. For example, attributes in these models that appear to reflect selection for relatively large trees at fisher resting sites included density of trees $>$40 cm in diameter at breast height (dbh; Weir 1995), mean dbh of the 4 largest trees (Seglund 1995, Yaeger 2005), dbh of the largest tree (Zielinski et al. 2004*a*), and basal area of live trees $>$76 cm dbh (Mazzoni 2002). Consequently, it would not be appropriate to extract a list of environmental attributes from these models to guide forest management activities throughout the fisher's Pacific coastal range, nor to direct resource managers to apply a model in geographic locations other than the one in which it was created (see Zielinski et al. 2004*a*).

A meta-analysis is a statistical approach for evaluating the strength and consistency of results obtained from multiple studies and, because it is quantitative and replicable, has many advantages over other approaches for synthesizing research findings (e.g., narrative reviews, vote-counting; Gurevitch et al. 2001). In a meta-analysis, the individual study is the analytical unit, rather than the number of study animals or observations (Arnqvist and Wooster 1995:236). The statistical metric compared across studies is the effect size, which indicates the magnitude of the effect being studied, such as responses to an experimental treatment or differences between used and available resources. Meta-analyses of ecological data are relatively common (Gurevitch et al. 2001), but those that evaluate multiple studies of habitat selection by mammals or birds are extremely rare (Kalcounis-Rüppell et al. 2005, Hagen et al. 2007). For species at risk, such analyses may be particularly useful to resource managers and conservationists because they can provide insights about the broader applicability of research findings from habitat selection studies, and the potential influence of geographic variation in environmental conditions and other covariates on patterns of habitat selection.

Our objective was to conduct meta-analyses of standardized data from multiple fisher studies in the Pacific coastal region to rigorously evaluate previously published assessments of the influence of various environmental attributes on fishers at resting sites (Buskirk and Powell 1994, Powell and Zielinski 1994, Lofroth et al. 2010, Raley et al. 2012). Characteristics of the individual forest structures that fishers use for resting in this region have been well described by researchers, but only a few studies collected data on the availability of individual forest structures or microsites (e.g., rust or mistletoe brooms, cavities, hollows, broken tops, and platform branches) within the study area (Aubry and Raley 2006, Weir and Corbould 2008). Thus, conducting meta-analyses of selection for either the resting structure itself or the microsites used by fishers for resting was not appropriate. In addition, few data are available that could be used to conduct meta-analyses of habitat selection by fishers for denning, foraging, or establishing home ranges (Raley et al. 2012). In contrast, a number of studies in the Pacific coastal region have investigated habitat selection at fisher resting sites by collecting data on both resource use and availability. Consequently, our meta-analyses are focused on the selection of environmental attributes by fishers at resting sites. Ours is the first study to investigate the broader applicability of habitat selection patterns for fishers derived from multiple independent radiotelemetry studies conducted over a broad geographic area.

STUDY AREA

Our sample included at least 1 study from all geographic areas in the Pacific coastal region that currently contain established fisher populations (Fig. 1). Selected study areas encompassed a latitudinal gradient of 20°, within which forest types available to fishers ranged from the spruce-dominated boreal forests of central British Columbia (latitude 56°N), through the mixed-conifer forests of southwestern Oregon and northwestern California, to the mixed conifer-hardwood forests of the southern Sierra Nevada (latitude 36°N). In addition, our sample included studies that were conducted in the core of the fisher's historical range in North America (Williston and Beaver

Figure 1. Locations of radiotelemetry studies included in meta-analyses of habitat selection at resting sites by fishers in the Pacific coastal region. The current distribution of the fisher in this region is indicated with hatching (modified from Lofroth et al. 2010).

Valley), some that occurred to the south in the mid-portion of their peninsular range along the Pacific coast (Cascade Range, Hoopa Valley, Shasta-Trinity, Pilot Creek), and some that were located at the southernmost edge of their distribution, where suitable fisher habitat reaches its narrowest extent (Kings River, Tule River; see range map in Lewis et al. 2012).

METHODS

We identified 10 independent field studies conducted in the Pacific coastal region that had used radiotelemetry to investigate selection of resting sites by fishers as candidates for inclusion in our meta-analyses. Several criteria had to be met for a study to be included: 1) use of resting sites was quantified by measuring environmental conditions in the immediate vicinity of resting structures, and availability was quantified by measuring environmental conditions at random or systematically located sites within each study area; 2) data collection at availability sites was conducted using the same sampling protocol as for resting sites; 3) estimates of various environmental attributes at resting sites included the individual forest structure used by fishers for resting (e.g., log resting structures were included in estimates of log volume at resting sites); 4) data collection had been completed and resulting data had been checked for errors and summarized by the principal investigator; and 5) the data set included $\geq$20 resting sites from $\geq$3 individual fishers.

We selected 8 of the 10 candidate studies for inclusion in the meta-analyses (Fig. 1, Table 1). We eliminated 2 studies from consideration because one had collected environmental data only at fisher resting sites, and the other had used sampling methodologies that did not meet our criteria. The principal investigator for each of the 8 selected studies agreed to collaborate in conducting the meta-analyses, and was asked to generate new data sets from their raw data in a form that was suitable for inclusion in the analyses. Thus, unlike most meta-analyses, the data sets we analyzed were not limited to those published in the primary literature. This eliminated the potential problem of publication bias, which is the tendency of researchers and journal editors to limit published results to those that are statistically significant, which can misrepresent the frequency of non-significant findings.

To create new standardized data sets for meta-analyses, we identified environmental attributes that were determined to be influential in previous studies of habitat selection at fisher resting sites, or that we believed may influence selection of resting sites. Most studies of habitat selection by fishers at resting sites did not measure live trees <10 cm in dbh, snags <26 cm in dbh, or logs <26 cm in mean diameter, because smaller structures were not believed to represent influential components of resting site suitability. Accordingly, we used these minimum values for the environmental attributes we compiled. For basal area measurements, we grouped available data into 3 size classes: small-medium (10–50 cm dbh for live trees, 26–50 cm dbh for snags), large (51–100 cm dbh), and very large (>100 cm dbh).

We selected 9 environmental attributes to include in our meta-analyses: slope, heat load index (the combined effects of aspect, slope, and latitude on temperature accumulation [McCune and Keon 2002]), percent cover of vegetation $\geq$2 m above the ground (hereafter, overhead cover), volume of moderately decayed logs $\geq$26 cm in mean diameter (hereafter, log volume), basal area of live conifers 51–100 cm in dbh, basal area of live hardwoods 51–100 cm in dbh, basal area of moderately decayed snags 51–100 cm in dbh, mean dbh of live conifers $\geq$10 cm in dbh, and mean dbh of live hardwoods $\geq$10 cm in dbh (Table 2). We only considered trees and snags 51–100 cm in dbh for the 3 basal area attributes we analyzed (hereafter, basal area of large conifers, hardwoods, and snags), because we were primarily interested in evaluating the influence of relatively large structures at fisher resting sites, and because very large trees and snags (>100 cm dbh) were extremely rare or absent in several study areas.

Table 1. Descriptive information on the 8 radiotelemetry studies of fishers in the Pacific coastal region that were included in meta-analyses of habitat selection at resting sites.

Study area	Principal investigators	Sample size[a] F fishers	F resting sites	M fishers	M resting sites	Age class of fishers	Seasonality of data on resting sites
Williston, central British Columbia	R. D. Weir and F. B. Corbould	8	23–53	3	7–10	Mostly adults (1F, 1M juvenile)	All months except Sep and Oct
Beaver Valley, central British Columbia	R. D. Weir	8	20–31	1	1	Mostly adults (2F, 1M juveniles)	All months except May and Jul
Cascade Range, southern Oregon	K. B. Aubry and C. M. Raley	4–12	39–229	3–5	38–152	Mostly adults (3F, 1M juveniles)	All months; approx. 33% in winter and 67% in other seasons
Hoopa Valley Indian Reservation, northwestern California	J. S. Yaeger and J. M. Higley	7–9	102–167	3–7	15–34	Mostly adults (1F, 1M juvenile)	All months except Jul
Shasta-Trinity National Forest, northwestern California	R. T. Golightly	7–11	42–204	7–12	87–254	Mostly adults	All months
Pilot Creek, Six Rivers National Forest, northwestern California	W. J. Zielinski	13	120–121	7	52–74	Mostly adults (1M juvenile)	All months; most (approx. 90%) in non-winter months
Kings River, Sierra National Forest, south-central California	K. L. Purcell and A. K. Mazzoni	6	43–57	5	18–21	All adults	Oct to May
Tule River, Sequoia National Forest, south-central California	W. J. Zielinski	11–13	171–219	9	63–81	Mostly adults (2F juveniles)	All months; approx. 33% in winter and 67% in other seasons

[a] In all studies, sample sizes for study animals, resting sites, and availability sites varied among environmental attributes (see Appendix); consequently, the numbers shown here reflect the range of variation in sample sizes among data sets.

In contrast to the other 8 environmental attributes included in our meta-analyses, heat load index had not been evaluated in previous fisher studies, nor had any other measure of microclimatic conditions. However, several studies of resting habitat selection conducted in the southern Sierra Nevada in California, where habitat conditions for fishers are generally hotter and drier than those in the north, have demonstrated selection for resting sites that were on steeper slopes and closer to water than availability sites (Zielinski et al. 2004*a*, Purcell et al. 2009). These researchers hypothesized that observed patterns may reflect selection of resting sites in the relatively cool and moist conditions that occur in riparian areas as a strategy for ameliorating thermal stress in hot and dry climatic conditions. Data on proximity to water or other attributes linked directly to riparian areas were not available from most study areas. However, if fishers are only selective of relatively cool and moist sites for resting in areas with particularly hot and dry environmental conditions, we would expect such patterns to be reflected in the results of our meta-analysis for heat loading.

All but 1 of the environmental attributes we selected were measured in at least 7 of the 8 studies. The only log attribute suitable for inclusion in our meta-analyses (volume of moderately decayed logs ≥26 cm in mean diameter) was measured in only 4 of the more northern study areas (Hoopa Valley in California, Cascade Range in Oregon, and Beaver Valley, and Williston in British Columbia; Fig. 1, Table 2). Nonetheless, we included log volume in our analyses because logs are believed to represent influential components of fisher resting habitat that are particularly well-suited to manipulation by resource managers (Lofroth et al. 2010, Raley et al. 2012). We caution, however, that applying results

Table 2. Environmental attributes included in meta-analyses of habitat selection by fishers at resting sites in the Pacific coastal region, and the number of studies that collected data on each attribute at both resting and availability sites.

Environmental attribute	No. of studies
Slope (%)	8
Heat load index (combined effects of aspect, slope, and latitude on temperature accumulation[a])	8
Cover of vegetation ≥2 m above the ground (%)	8
Volume of moderately decayed[b] logs ≥26 cm in mean diameter (m^3/ha)	4[c]
Basal area of live conifers 51–100 cm in dbh (m^2/ha)	8
Basal area of live hardwoods 51–100 cm in dbh (m^2/ha)	8
Basal area of moderately decayed[d] snags 51–100 cm in dbh (m^2/ha)	7[e]
Mean dbh of live conifers ≥10 cm in dbh (cm)	8
Mean dbh of live hardwoods ≥10 cm in dbh (cm)	8

[a] Calculated using equation 3 in McCune and Keon (2002) multiplied by 100.
[b] Log decay classes 1–4 (Maser et al. 1979); we excluded completely decayed logs (class 5).
[c] No data were available from the Shasta-Trinity, Pilot Creek, Kings River, or Tule River study areas in California.
[d] Snag decay classes 3–7 (Maser et al. 1979); we excluded live trees (classes 1–2) and completely decayed snags (classes 8–9).
[e] No data were available from the Shasta-Trinity study area in California.

of the meta-analysis for log volume in the southernmost study areas (Kings River and Tule River) would not be appropriate.

For most of these studies, the number of study animals monitored was too small to enable the disaggregation of sexes or age classes. Although results presented here include both sexes and all age-classes, they are biased toward females (males comprised 10–50% of samples, depending on study) and age ratios that favored adults (juveniles comprised 0–30% of samples, some unknown; Table 1). However, because fishers are polygynous, exhibit intrasexual territoriality, and males do not contribute to the raising of young (Powell 1993), patterns of habitat selection by adult females are expected to be particularly important from a management or conservation perspective (Lofroth et al. 2010).

We used the rmeta package (Lumley 2009) in R (R Development Core Team 2009) to conduct the meta-analyses. To improve the independence of our data, we included each fisher resting site only once in a data set, even if it was used by more than 1 individual or multiple times by the same individual. In addition, although we conducted our analyses at the population level (i.e., in each study area, all fisher resting sites were combined into a single data set), to calculate the standard error of the effect size for each study area, we used the number of fishers monitored in each study area as the sample size, rather than the total number of rest sites (see Appendix). Because rest sites used by the same individual may not be independent, we reasoned that taking a conservative approach to determining our sample sizes would improve the reliability of our results. Among all 8 study areas, resulting sample sizes ranged from 7 to 23 fishers for the 9 environmental attributes included in our meta-analyses (see Appendix).

We estimated effect sizes by calculating the raw difference in mean values between environmental attributes measured at fisher resting sites and those measured at availability sites (see Appendix). Because we generated new data sets for each of the studies included in the meta-analyses, we did not need to use a standardized effect size metric such as the log response ratio (*lr*) or Hedges' *d* (see Gurevitch et al. 2001). This enabled us to plot our results graphically against the measurement units for each attribute, which greatly improved the interpretability of our results. We used a random-effects model to conduct our meta-analyses because we assumed that selection could vary both within and among studies. To generate summary effect sizes, we combined results from all studies with data for each environmental attribute using weights that were inversely proportional to the variance (Borenstein et al. 2009). We represented the variance in effect sizes graphically as 90% confidence intervals, which we used to evaluate statistical significance. We chose the 90% confidence level because ecological data tend to be noisy, especially when data sets collected by multiple investigators are combined into a single analysis. Thus, we believe this confidence level provided an appropriate indication of statistical significance for the effect sizes we estimated.

RESULTS

Summary effect sizes were statistically significant for all 9 of the environmental attributes we analyzed (i.e., 90% CIs did not include 0; Fig. 2a–i). Thus, throughout their Pacific coastal range, fishers exhibited clear and remarkably consistent selection for resting sites that had steeper slopes; cooler microclimates; denser overhead cover; greater volume of logs; greater basal area of large conifers, hardwoods, and snags; and larger diameter conifers and hardwoods than were generally available. We found a few local exceptions to these patterns; for example, Hoopa Valley showed negative selection for overhead cover (Fig. 2c) and Kings River was negative for mean dbh of conifers (Fig. 2h). Nonetheless, we found consistently strong patterns of selection for all 9 attributes throughout the Pacific coastal region.

Summary effect sizes (i.e., the mean differences between use and availability) were as follows: slope = 5%; heat load index = −1.53; overhead cover = 10%; volume of moderately decayed logs ≥26 cm in mean diameter = 131 m^3/ha; basal area of conifers 51–100 cm in dbh = 2.1 m^2/ha; basal area of hardwoods 51–100 cm in dbh = 2.3 m^2/ha; basal area of moderately decayed snags 51–100 cm in dbh = 0.6 m^2/ha; mean dbh of live conifers ≥10 cm in dbh = 9 cm; and mean dbh of live hardwoods ≥10 cm in dbh = 12 cm. Although we lack a strong empirical basis for evaluating the biological significance of these summary effect sizes to fishers, we concluded that observed differences in used versus available resources were large and consistent enough to influence the selection of resting sites by fishers.

DISCUSSION

Ours is the first study to provide resource managers with a clear and reliable basis for implementing management actions designed to maintain or improve resting habitat for fishers in portions of the Pacific coastal region where resource selection models have not been developed. Despite substantial variation in latitude, physiographic and maritime influences on weather patterns, topography, and vegetation (e.g., tree sizes, species composition, and conifer/hardwood ratios) among our study areas (Lofroth et al. 2010), we demonstrated that both physiographic (steeper slopes and cooler microclimates) and vegetative attributes (denser overhead cover, greater amounts of coarse woody debris, and larger forest structures) provide habitat value to fishers at resting sites throughout their Pacific coastal range. However, other aspects of fisher habitat ecology are also likely to influence their population persistence, including selection of individual denning and resting structures and their associated microsites, foraging habitat, and habitat conditions within home ranges or landscapes.

Throughout the Pacific coastal region, fishers selected sites for resting with significantly steeper slopes and lesser heat load indices (i.e., cooler microclimatic conditions) than availability sites. Thus, contrary to previous speculations, these patterns of resting site selection by fishers are not limited to areas with particularly hot and dry climatic conditions; rather, they represent influences on resting site

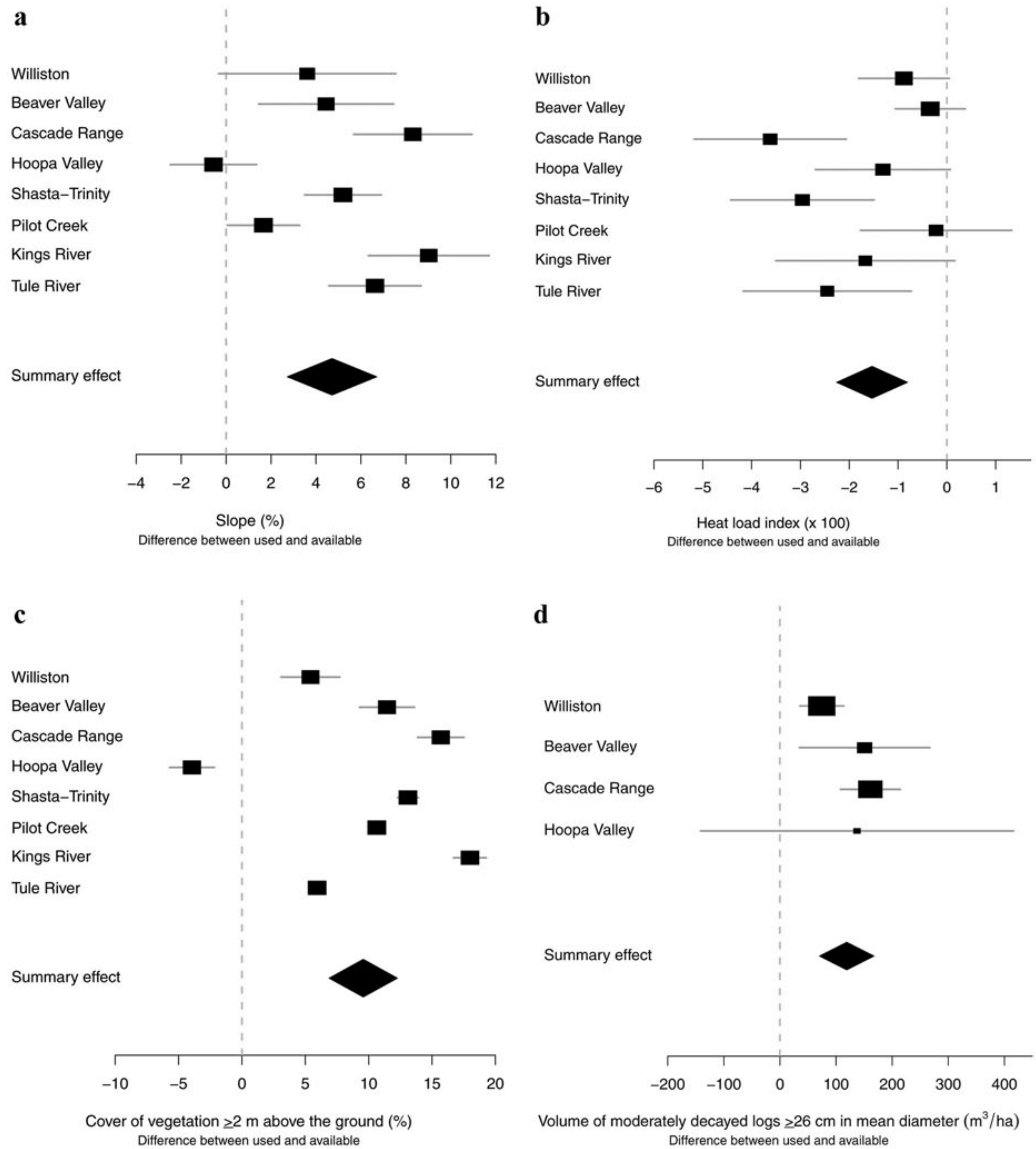

Figure 2. Effect sizes for selection of 9 environmental attributes at resting sites by fishers in 8 study areas in the Pacific coastal region. In each graph, results are presented from north (top) to south (bottom) in accordance with the latitudinal gradient among our study areas. In each graph, the area of the boxes represent the weighting factors used to generate summary effect sizes. Weighting factors are inversely proportional to that study's variance of the raw mean difference (i.e., smaller variances have larger weighting factors); the whiskers indicate the 90% confidence interval around each effect size. The summary effect size is shown with a diamond at the bottom of each plot; the center of the diamond indicates the mean value and the width of the diamond indicates the 90% confidence interval around the mean. Areas to the left of the dashed lines indicate negative selection (avoidance) for that attribute, whereas areas to the right indicate positive selection (preference).

suitability throughout this region. We caution, however, that the extent to which observed patterns reflect selection of riparian areas by fishers for resting remains unknown. As Purcell et al. (2009) noted, the environmental influences in riparian areas (e.g., proximity to water, topographic position, steepness, aspect, density of vegetation, and management history) are intricately interrelated. Consequently, new studies are needed to identify the causal factors involved in observed patterns of association with relatively steep slopes and cool microclimatic conditions.

Because of the ecological processes involved in tree senescence and death and the heterogeneous stand conditions that are created by disturbance events (e.g., wildfire, wind, and disease), large damaged or deteriorating trees, snags, and logs tend to be patchily distributed within forests (e.g., Bull et al. 1997, Agee 1999, Ohmann and

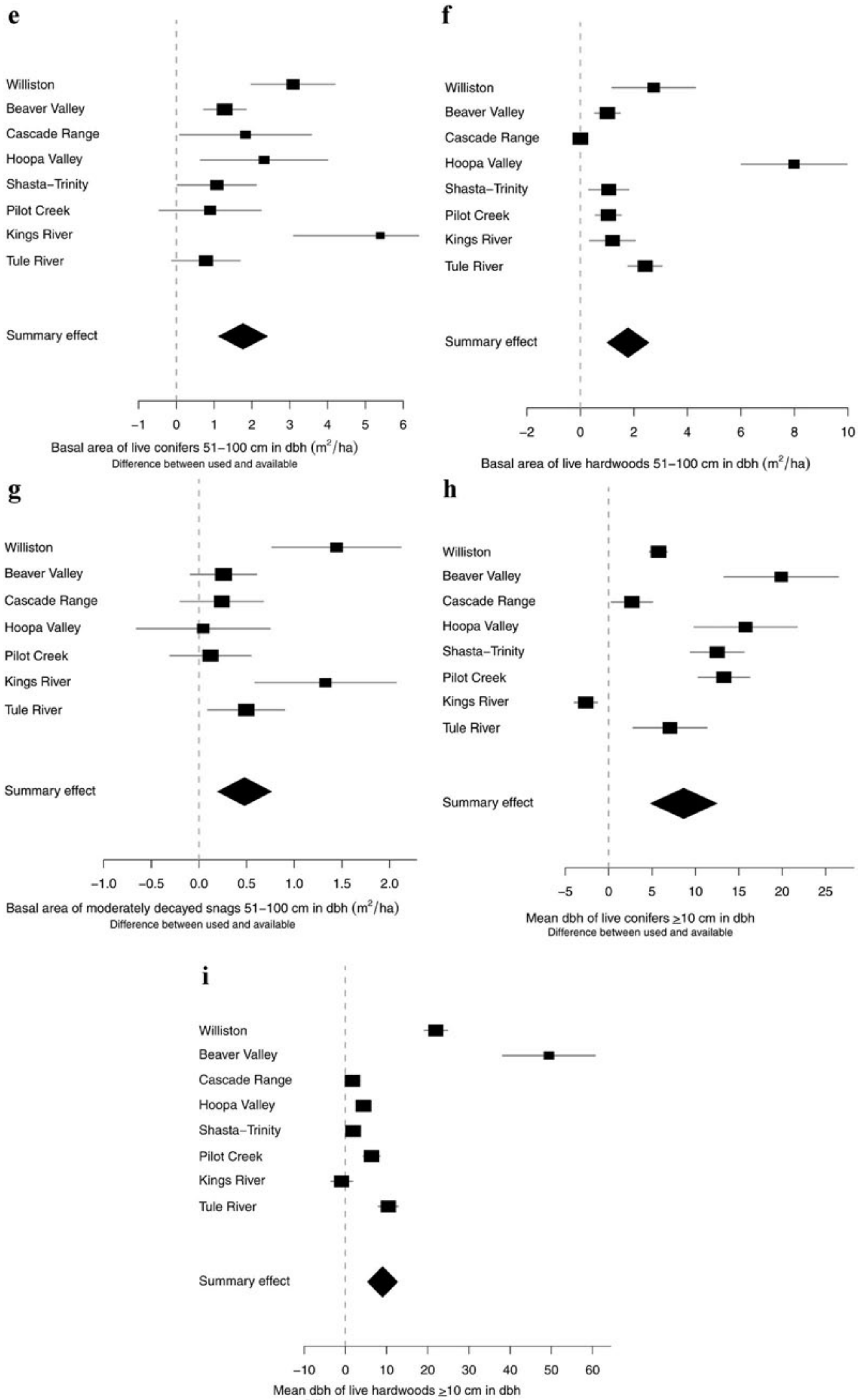

Figure 2. (*Continued*)

Waddell 1999). Consequently, the selection of vegetative attributes at resting sites that we have demonstrated could reflect the clumped distribution of such features within these forests. That is, fishers appear to be selective of relatively dense overhead cover and large forest structures at resting sites simply because they use relatively large trees, snags, and logs for resting, and the forest conditions around such structures differ from those that occur randomly in the forest. In addition, the resting structure itself could influence some resting site attributes, such as overhead cover. To evaluate this potential source of bias, Zielinski et al. (2004*a*) centered their availability plots on a large forest structure similar to those that were used by fishers for resting. Even with this sampling design, however, they were able to demonstrate selection of denser canopy cover and larger trees and snags at resting sites than were generally available, indicating that fishers are actively selecting specific environmental conditions around resting structures.

All of the physiographic and vegetative attributes (or ones that appear to measure similar environmental conditions) that we analyzed have either been included in published models for selection of resting sites by fishers (e.g., Weir and Harestad 2003, Zielinski et al. 2004*a*, Purcell et al. 2009), or have been hypothesized to represent key habitat components for fishers (e.g., Buskirk and Powell 1994, Powell and Zielinski 1994). The selection of resting sites by fishers with relatively large amounts of overhead cover, coarse woody debris, and large live trees and snags may benefit fishers by providing relief from thermal stress, protection from predators, improved access to prey, or secure sites for consuming prey (Raley et al. 2012). In addition, because resting sites often contain additional forest structures that are large enough to be suitable for use as a resting structure, the presence of these attributes within the site could provide fishers with alternative structures to use for future resting bouts. Although our findings confirm that these forest attributes are influential components of resting site habitat quality for fishers throughout their Pacific coastal range, new types of studies designed to test these hypotheses will be needed to better understand the role of resting sites in the life history of fishers. Such studies could include comparing microclimatic conditions and prey populations in resting versus availability sites, investigating the relation between predation risk and resting site habitat quality, and determining the extent to which different structures at resting sites are later used for resting.

MANAGEMENT IMPLICATIONS

Our findings provide new information to resource managers charged with maintaining or improving habitat conditions for fishers in the Pacific coastal region. In portions of this region where information on habitat selection by fishers is lacking, our findings provide empirical support for management or conservation actions for fishers that promote the retention or development of the environmental attributes included in our meta-analyses. For example, if regeneration timber harvests are being planned, adverse effects on fisher habitat quality would be reduced by locating harvests in areas where slopes are relatively flat, microclimates are warm, or overhead cover is sparse, and designing them in ways that minimize adverse effects on logs and large-diameter trees and snags. Because all of the meta-analyses were statistically significant, however, our findings do not indicate which attributes are more influential; also, other key attributes may not have been included in our analyses. In addition, several of the environmental attributes we analyzed may be correlated to some degree. Thus, in geographic locations where resource selection functions for environmental conditions at fisher resting sites have been derived (i.e., where additional environmental attributes have been evaluated, and appropriate techniques have been applied to ensure the independence of attributes included in resulting models), our results should be used to augment information contained in existing models. Note that because we standardized both use and availability data for each environmental attribute prior to conducting the meta-analyses, the means and standard errors presented in the Appendix can be compared directly among study areas. These summary statistics are unique and can provide additional guidance for designing forest management prescriptions in ways that benefit fishers. Resting sites occur at a relatively small spatial scale, but each fisher uses a large number of different resting sites within its home range (Lofroth et al. 2010). Thus, until more reliable information is available on other aspects of fisher habitat ecology, data on habitat selection at resting sites may represent the best source of information that resource managers can use to maintain or improve habitat conditions for fishers in their area of interest.

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Appendix. Data used in meta-analyses of resting site selection by fishers obtained from 8 radiotelemetry studies in the Pacific coastal region. Sample sizes presented for fisher resting sites are the number of fishers monitored, with the number of resting sites sampled shown in parentheses; sample sizes for availability sites are the number of sites sampled. Dashed lines indicate no data.

	Study area											
	Williston						Beaver Valley					
	Fisher resting sites			Availability sites			Fisher resting sites			Availability sites		
Environmental attribute	**Mean**	**SD**	***n***	**Mean**	**SD**	***n***	**Mean**	**SD**	***n***	**Mean**	**SD**	***n***
Slope (%)	11.2	26.9	11 (60)	7.5	14.8	120	10.7	17.7	9 (27)	6.3	6.4	72
Heat load index (×100)	76.60	7.26	11 (60)	77.48	6.71	120	81.70	5.15	9 (32)	82.04	4.21	71
Overhead cover (%)	39.8	18.3	11 (63)	34.4	18.5	121	61.4	18.6	9 (22)	49.9	23.9	72
Log volume (m^3/ha)	109.3	175.8	11 (63)	34.7	65.4	121	191.5	445.0	9 (21)	40.4	66.9	72
Basal area of large conifers (m^2/ha)	4.9	8.4	11 (63)	1.8	7.2	121	3.3	4.4	9 (25)	2.0	4.4	72
Basal area of large hardwoods (m^2/ha)	3.4	9.8	11 (63)	0.7	3.2	121	1.7	3.4	9 (25)	0.7	3.0	72
Basal area of large snags (m^2/ha)	1.9	4.2	11 (63)	0.4	1.9	121	0.5	2.0	9 (25)	0.2	1.0	72
Mean dbh of conifers (cm)	38.0	9.2	11 (47)	32.3	11.5	72	51.6	37.8	9 (21)	31.7	10.8	51
Mean dbh of hardwoods (cm)	66.1	31.1	9 (23)	44.1	31.7	22	99.6	67.6	9 (14)	50.2	20.9	34

	Study area											
	Cascade Range						Hoopa Valley					
	Fisher resting sites			Availability sites			Fisher resting sites			Availability sites		
Environmental attribute	**Mean**	**SD**	***n***	**Mean**	**SD**	***n***	**Mean**	**SD**	***n***	**Mean**	**SD**	***n***
Slope (%)	29.2	22.8	17 (371)	20.8	19.9	372	48.2	19.8	16 (194)	48.8	19.3	129
Heat load index (×100)	85.09	13.13	17 (371)	88.71	10.00	372	87.90	14.04	16 (194)	89.21	13.32	129
Overhead cover (%)	83.1	18.1	17 (368)	67.4	26.7	373	78.5	17.7	16 (187)	82.4	17.9	129
Log volume (m^3/ha)	282.2	201.6	7 (73)	121.1	115.8	79	253.8	1157.5	10 (116)	116.4	336.9	129
Basal area of large conifers (m^2/ha)	14.2	11.8	7 (74)	12.4	13.9	79	6.6	11.6	10 (116)	4.3	9.2	129
Basal area of large hardwoods (m^2/ha)	0.0	0.4	7 (74)	0.0	0.3	79	14.0	13.0	10 (116)	6.0	8.5	129
Basal area of large snags (m^2/ha)	2.1	2.8	7 (74)	1.9	4.6	79	1.7	4.7	10 (116)	1.7	5.1	129
Mean dbh of conifers (cm)	36.5	15.5	7 (74)	33.8	19.2	76	51.1	39.9	10 (108)	35.3	29.6	106
Mean dbh of hardwoods (cm)	23.1	7.3	7 (49)	21.4	4.9	34	28.4	8.0	10 (115)	24.1	6.1	125

	Study area											
	Shasta-Trinity						Pilot Creek					
	Fisher resting sites			Availability sites			Fisher resting sites			Availability sites		
Environmental attribute	**Mean**	**SD**	***n***	**Mean**	**SD**	***n***	**Mean**	**SD**	***n***	**Mean**	**SD**	***n***
Slope (%)	45.9	19.2	23 (392)	40.7	17.2	243	45.8	18.4	20 (193)	44.1	19.0	191
Heat load index (×100)	83.13	16.42	23 (391)	86.09	14.42	241	89.32	16.45	20 (188)	89.54	14.47	191
Overhead cover (%)	89.6	13.0	23 (444)	76.5	23.4	243	94.6	6.5	20 (172)	84.0	22.1	191
Log volume (m^3/ha)	—	—	—	—	—	—	—	—	—	—	—	—
Basal area of large conifers (m^2/ha)	7.8	10.9	14 (129)	6.8	10.8	81	14.8	15.2	20 (195)	13.9	15.8	191
Basal area of large hardwoods (m^2/ha)	1.3	5.3	14 (129)	0.2	1.3	81	2.9	4.9	20 (195)	1.9	4.0	191
Basal area of large snags (m^2/ha)	—	—	—	—	—	—	2.3	4.1	20 (195)	2.2	4.2	191
Mean dbh of conifers (cm)	46.0	23.5	14 (128)	33.5	10.1	76	79.7	30.2	20 (177)	66.4	26.2	165
Mean dbh of hardwoods (cm)	29.3	11.0	12 (95)	27.5	4.8	46	46.5	24.8	19 (120)	40.1	27.9	115

	Study area											
	Kings River						Tule River					
	Fisher resting sites			Availability sites			Fisher resting sites			Availability sites		
Environmental attribute	**Mean**	**SD**	***n***	**Mean**	**SD**	***n***	**Mean**	**SD**	***n***	**Mean**	**SD**	***n***
Slope (%)	37.3	19.1	11 (78)	28.3	14.8	160	52.2	23.4	22 (272)	45.5	20.7	194
Heat load index (×100)	94.19	12.84	11 (78)	95.86	9.34	160	89.08	18.94	22 (265)	91.53	15.44	193
Overhead cover (%)	73.7	12.5	11 (61)	55.7	22.5	160	92.6	8.7	20 (228)	86.6	15.0	194
Log volume (m^3/ha)	—	—	—	—	—	—	—	—	—	—	—	—
Basal area of large conifers (m^2/ha)	21.2	16.6	11 (61)	15.8	14.0	160	11.2	10.5	20 (228)	10.4	11.9	194
Basal area of large hardwoods (m^2/ha)	2.6	5.8	11 (61)	1.4	3.9	160	2.9	5.4	20 (228)	0.5	1.9	194
Basal area of large snags (m^2/ha)	2.5	4.8	11 (61)	1.2	3.3	160	2.8	3.9	20 (228)	2.3	4.2	194
Mean dbh of conifers (cm)	31.4	10.1	11 (61)	34.0	11.9	159	58.5	39.1	20 (223)	51.5	22.7	167
Mean dbh of hardwoods (cm)	30.3	19.3	9 (43)	31.2	20.1	83	40.3	23.8	20 (166)	29.9	14.8	101