Landscape-Scale Habitat Selection by Fishers Translocated to the Olympic Peninsula of Washington

JEFFREY C. LEWIS^{**}, *University of Washington, School of Environmental and Forest Sciences, Seattle, WA 98195 and Washington Department of Fish and Wildlife, 600 Capitol Way N, Olympia, WA 98501*

KURT J. JENKINS, *U.S. Geological Survey, Forest and Rangeland Ecosystem Science Center, 600 E. Park Ave., Port Angeles, WA 98362*

PATRICIA J. HAPPE, *Olympic National Park, 600 E. Park Ave., Port Angeles, WA 98362*

DAVID J. MANSON, *Olympic National Park, 600 E. Park Ave., Port Angeles, WA 98362*

MARC MCCALMON, *Washington Department of Fish and Wildlife, 600 Capitol Way N, Olympia, WA 98501*

**Corresponding Author: Jeffrey.Lewis@dfw.wa.gov; 360-902-2374

Abstract: The fisher was extirpated from much of the Pacific Northwestern United States during the mid- to late-1900s and is now proposed for federal listing as a threatened species in all or part of its west coast range. Following the translocation of 90 fishers from central British Columbia, Canada, to the Olympic Peninsula of Washington State from 2008 to 2010, we investigated the landscape-scale habitat selection of reintroduced fishers across a broad range of forest ages and disturbance histories, providing the first information on habitat relationships of newly reintroduced fishers in coastal coniferous forests in the Pacific Northwest. We developed *a priori* models to evaluate several habitat-selection hypotheses based on premises of habitat models used to forecast habitat suitability for the reintroduced population. Further, we hypothesized that female fishers, because of their smaller body size than males, greater vulnerability to predation, and specific reproductive requirements, would be more selective than males for mid- to late-seral forest communities, where complex forest structural elements provide secure foraging, resting, and denning sites. We assessed 11 forest structure and landscape characteristics within the home range core-areas used by 19 females and 12 males and within randomly placed pseudo core areas that represented available habitats. We used case-controlled logistic regression to compare the characteristics of used and pseudo core areas and to assess

selection by male and female fishers. Females were more selective of core area placement than males. Fifteen of 19 females (79%) and 5 of 12 males (42%) selected core areas within federal lands that encompassed primarily forests with an overstory of mid-sized or large trees. Male fishers exhibited only weak selection for core areas dominated by forests with an overstory of small trees, primarily on land managed for timber production or at high elevations. The amount of natural open area best distinguished the use of core areas between males and females, with females using substantially less natural open area than males. Although sex-specific selection has been suspected for fishers, we identified factors that distinguish the selection of core areas by females from those of males, information which will be valuable to managers planning reintroductions or providing suitable habitat to promote fisher recovery in the Pacific Northwest.

Keywords: fisher, *Pekania pennanti*, habitat selection, habitat suitability, translocation, forest management, Washington

1. Introduction

The fisher is a mid-sized forest carnivore that once occurred broadly throughout boreal and temperate forests of North America, but was extirpated from much of the northern United States and southern Canada during the mid to late 20th century as a result of over-trapping, incidental capture, poaching, incidental mortality through predator-control campaigns, and loss of habitat (Powell, 1993; Powell and Zielinski, 1994; Lewis and Zielinski, 1996; Lewis et al., 2012). These factors contributed to the extirpation of the fisher from Washington State by the mid-1900s (Aubry and Lewis, 2003; Hayes and Lewis, 2006), and its listing as an endangered species in Washington State in 1998. The fisher is also currently proposed for federal listing as a threatened species in all or part of its West Coast range in the United States (western Washington, western Oregon, and California; USFWS, 2014).

From 2008 to 2010 we translocated 90 fishers from British Columbia, Canada, to northwestern Washington State in an effort to restore fishers and enhance the species' conservation status throughout the Pacific Northwest coastal region (Lewis, 2014). Because fishers were extirpated from Washington and much of Oregon by the mid-1900s (Aubry and Lewis, 2003), there was little information beyond museum and trapping records and anecdotal observations as a basis for identifying the most suitable habitats for supporting a reintroduced fisher population in the

Pacific Northwest. Consequently, we assessed habitat suitability and identified optimum reintroduction sites in Washington based on resource selection studies from other regions, which suggested low to mid-elevation late-seral forest stands were the highest-quality habitats (Lewis and Hayes, 2004). However, forested environments in coastal Washington, and particularly the Olympic Peninsula, are unique compared to forests elsewhere in the Pacific Northwest due to the protection of large areas of late-seral temperate rainforests within Olympic National Park and Olympic National Forest, the extraordinary productivity and size of trees present in late-seral stands, and the diversity of forest management practices on the peninsula. We examined landscape scale selection patterns of fishers translocated to Washington's Olympic Peninsula as a basis for refining habitat models for future reintroductions and understanding fisher-habitat relationships in the Pacific Northwest coastal region.

Where their habitat associations have been studied in western North America, fishers commonly prefer low- and mid-elevation landscapes dominated by mid- to late-seral forests with moderate-to-high canopy cover (Buskirk and Powell, 1994; Powell and Zielinski, 1994; Lofroth et al., 2010; Raley et al., 2012; Weir et al., 2012; Aubry et al., 2013), where large woody structures such as large cavity trees, snags, and logs are relatively common features (Hansen et al., 1991; Spies and Franklin, 1991). Forests with moderate to high canopy closure are likely to provide: 1) overhead cover and escape cover for fishers (which are good climbers; Powell, 1993), 2) cover for fisher prey, 3) suitable microclimates for den and rest sites (Weir et al., 2004), and 4) a sufficient canopy to intercept snow that would otherwise accumulate in greater depths on the forest floor and potentially impede efficient travel (Krohn et al., 1995, 1997, 2004). Fishers will cross small forest openings to access forest stands within their home ranges, however they will typically avoid large open areas (*e.g.*, wetlands, meadows, agricultural fields, and clearcuts; Buskirk and Powell, 1994; Powell and Zielinski, 1994; Zielinski et al., 2004a). Recent studies suggest that female fishers may be more selective of habitats than males at the home range scale, and at finer scales, as a result of their dependence on woody structures for den sites and greater security requirements than males (Zielinski et al., 2004a, 2004b; Raley et al., 2012), although these relationships remain poorly understood.

Our objectives in this study were to identify forest-structure and landscape characteristics associated with home range establishment by translocated male and female fishers, and

determine if landscape-scale habitat selection differed by sex. First we examined the premise of the initial habitat suitability model (Lewis and Hayes 2004), which was based on the hypothesis that fishers would favor relatively dense, low to mid-elevation (<1300 m, i.e., average upper limit of the Pacific silver fir zone) conifer forests dominated by mid- to late-seral forest stages of development (>25cm quadratic mean diameter [QMDA]), and would avoid open areas (<40% canopy closure) and early-seral stands that lacked complex forest structures associated with denning and resting. Moreover, because developed areas, paved roads, and areas with an abundance of human activity (e.g., campgrounds, off-road vehicle recreation areas, timber harvest units, ski areas) may pose threats to fishers (Naney et al., 2012), we speculated that fishers would likely avoid areas with more paved roads (i.e., more vehicle traffic), where human disturbances were likely to be greatest.

Further, we examined whether translocated fishers exhibited different levels of selectivity that may reflect sex-specific differences in reproductive requirements and body size (Powell, 1993). Because females give birth and raise young in large snags, cavity trees, and down logs, we hypothesized that females would be more selective than males of landscapes dominated by contiguous mid- or late-seral forests, where these structural components of forests are most abundant (Raley et al., 2012). Females are also smaller than males (2-3 kg versus 4-6 kg; Powell, 1993; Lewis et al., 2011), which results in greater vulnerability to predation by other mid-sized carnivores (e.g., bobcats [*Felis rufus*] and coyotes [*Canis latrans*]; Wengert et al., 2013). We therefore hypothesized that this would reinforce their selection for continuous mid- to late-seral forests and avoidance of highly fragmented forest landscapes (e.g., industrial timberlands), where bobcat and coyote densities were likely greatest (Voigt and Berg, 1987; Anderson and Lovallo, 2003). In recognition that resource selection following translocations may reflect social and behavioral factors as well as habitat cues that signal requisite prey and security values (Stamps, 1988; Smith and Peacock, 1990; Stamps and Swaisgood, 2007), we conclude by discussing the potential roles of non-habitat related factors affecting home range establishment of translocated fishers.

2. Material and methods

2.1. Study area

The study area (14,412 km²) included most of the Olympic Peninsula in western Washington, which is bordered by the Pacific Ocean to the west, the Strait of Juan de Fuca to the north, and Hood Canal to the east (Figure 1). The center of the peninsula is dominated by the Olympic Mountains and Mt. Olympus (at a height of 2,215 m) within Olympic National Park. Eleven major watersheds radiate outwards from the mountainous core of the peninsula, sloping down to a pronounced coastal plain near sea level to the west and to smaller plains to the north and east.

The Olympic Peninsula has a temperate maritime climate characterized by warm summers and cool winters (Peel et al., 2007). There is a pronounced orographic influence of the Olympic Mountains on precipitation across the peninsula, which ranges generally from 300 to 500 cm on the west slope of the mountains to 40 cm in the northeastern corner of the peninsula on the leeward side of the Olympic Mountains (Gavin and Brubaker, 2015). Eighty percent of annual precipitation on the Olympic Peninsula falls from October through March, primarily as rain at elevations below 305 m and as snow above 760 m.

Conifer forests dominate the peninsula from sea level to the subalpine and alpine zones, which generally prevail above about 1500 m, depending on temperature and precipitation (Houston and Schreiner, 1994). Forest zones ordered along elevational gradients range from the Sitka spruce (*Picea sitchensis*) zone (<~250m in coastal areas and west-side floodplains), to the western hemlock (*Tsuga heterophylla*) zone at low to mid-elevations (<~1100 m), the Pacific silver fir (*Abies amabilis*) at mid-elevations (<~1300 m), and mountain hemlock (*Tsuga mertensiana*) and subalpine fir (*Abies lasiocarpa*) zones that extend to timberline (Franklin and Dyrness, 1988; Houston and Schreiner, 1994). Forests in the Sitka spruce zone on the west side of the Olympic Mountains are often referred to as temperate rainforests, and are characterized by large-diameter trees (>1 m diameter at breast height), epiphytic plants, and dense understory vegetation (Franklin and Dyrness, 1988). Hardwoods including red alder (*Alnus rubra*), bigleaf maple (*Acer macrophyllum*) and black cottonwood (*Populus trichocarpa*) are common in riparian forests along major rivers (Fonda, 1974; Houston and Schreiner, 1994). Sixteen meadow communities have been identified in subalpine parklands and alpine zones of the park, generally above 1500m,

comprising diverse assemblages of herbaceous forbs, grasses, sedges, and low ericaceous shrubs (Schreiner, 1994).

A wide variety of land ownerships and management uses comprise the Olympic Peninsula. Olympic National Park and Olympic National Forest make up the Olympic Recovery Area as defined in the Washington State Fisher Recovery Plan on the basis of the extent and quality of protected, late-seral forested ecosystems (Hayes and Lewis, 2006). Olympic National Park preserves about 284,955 ha (704,139 ac) of forested habitat that is off-limits to commercial timber production and other extractive uses, almost all (96%) of which is designated as wilderness. Much of the park's circumference is bounded by Olympic National Forest (Figure 1), which encompasses mountainous terrain in the middle portions of many of the drainages that originate in the park. Olympic National Forest also contains 35,719 ha of designated wilderness where resource extraction is prohibited. The remainder of Olympic National Forest (218,465 ha) was managed for timber and other values from the 1950s to the 1990s, but is now managed under the Northwest Forest Plan (USDA Forest Service and USDI Bureau of Land Management, 1994) to protect late-seral forests and accelerate the development of late-seral forest characteristics in regenerating forests resulting from past logging. Lower elevation lands outside the Olympic National Forest boundary are owned and managed by Washington Department of Natural Resources (WDNR), Native American tribes, private timber companies and other private landowners, counties, and local municipalities. Washington Department of Natural Resources' lands are managed under the guidance of a Habitat Conservation Plan (Washington Department of Natural Resources, 1997), which targets the retention of older forests for northern spotted owls (*Strix occidentalis caurina*) and marbled murrelets (*Brachyramphus marmoratus*) in portions of the western Olympic Peninsula. Private and tribal lands are dominated by second-growth forests as a result of past timber management practices.

Because of the drier climate in the eastern and northeastern Olympic Mountains, wildfires in this area have had a more pronounced role in forest succession than in other areas of the Olympic Peninsula (Henderson et al., 1989). Extensive stand-replacing wildfires (*i.e.*, >1 million ha) burned a broad swath along the northern and eastern perimeter of the Olympic Mountains at approximately 200 year intervals in the early 1300's, 1500's, and 1700's (Gavin and Brubaker, 2015). Considerable areas burned again on the northern Olympic Peninsula and along Hood

Canal during the human settlement period from 1860-1900, mostly due to fires that escaped from land-clearing activities (Gavin and Brubaker, 2015). Fire history in the northern and eastern Olympic Mountains has left large landscapes dominated by mid- to late-seral stands at mid-elevations. Although much of this region of the peninsula is dominated by mid-sized trees, a notable characteristic of these aging burns is the high frequency of patches of large trees and individual legacy trees that survived fire, leaving a fine-grained mosaic of diverse forest ages and structures (Henderson et al., 1989).

2.2. Fisher release

We released 90 fishers (50 F, 40 M) at 10 sites in Olympic National Park from 27 January 2008 to 20 February 2010 with the goal of reestablishing a self-sustaining population of fishers on the Olympic Peninsula (Figure 1; Lewis et al., 2011; Lewis, 2014). Release sites were distributed widely in the park to facilitate fisher occupancy of landscapes dominated by late-seral conifer forests. All fishers were released immediately upon arrival at a release site; there was no acclimation period prior to release, as has been the case for some fisher reintroductions (*i.e.*, soft releases; Roy, 1991; Heinemeyer, 1993; Weir, 1995). Of the 90 fishers released, 82 (50 F, 32 M) were equipped with a 40-g VHF radio-collar (model MI-2 with mortality sensor, Holohil Systems Ltd., Carp, Ontario, Canada; <http://www.holohil.com>; accessed 15.02.16). Among the remaining eight fishers, five males (each weighing >4.5 kg) were equipped with a 120-g Argos satellite collar (Kiwisat 202, Sirtrack Ltd, Havelock North, New Zealand; <http://www.sirtrack.com>; accessed 15.02.16) and three males were equipped with a 41-g VHF transmitter surgically implanted in the abdominal cavity (model IMP/310/L with mortality sensor, Telonics Inc., Mesa, AZ, USA; <http://www.telonics.com>; accessed 15.02.16). Animal-handling procedures met or exceeded the guidelines of the American Society of Mammalogists for the use of wild mammals for research (Sikes and Gannon et al., 2011) and were approved by Washington Department of Fish and Wildlife's Animal Care and Use Committee.

2.3. Telemetry Monitoring

We tracked the movements of transmitter-equipped fishers for up to 2 years following their release using standard aerial telemetry methods from a single-engine, fixed-wing airplane. We attempted to locate each fisher at least once per week, but inclement weather prevented flights

during some weeks. Furthermore, the extensive and rugged nature of the study area, the relatively short transmission distance of VHF radio-collars, and the long-distance movements of many fishers made it impossible to locate each fisher every week. Occasionally, we determined locations using standard ground-tracking techniques, generally to supplement aerial locations of fishers in areas where ground telemetry was feasible, to locate den sites, or retrieve dead fishers. Once we determined a fisher's specific location, either by ground or air, we recorded Universal Transverse Mercator grid coordinates with a global positioning system (GPS) and rated accuracy based on subjective judgments of signal strength, altitude of the aircraft, and terrain. An accuracy rating of 1.5 was given to locations with an estimated error <500 m, a rating of 2 for locations with an estimated error 500 m - 1 km, a rating of 3 for locations with an estimated error 1 - 5 km, and a rating of 4 for locations with an estimated error >5 km. A location-accuracy rating of 1 was given to ground locations where the location was known (*e.g.*, carcass found, visual observation, fisher occupying a known den) or considered accurate within 100 m.

We evaluated the accuracy of aerial-telemetry locations by placing test collars at 31 known locations within the study area that were representative of the range of topographic and vegetation conditions occupied by fishers, and unknown to the tracking pilot. Locations given an accuracy rating of 1.5 had a mean location error of 281 ± 47 m ($\pm$ SE) and locations given an accuracy rating of 2 had a mean location error of 420 ± 117 m. Thus, the accuracy of test-collar locations was generally greater than the accuracy rating we assigned to those locations during the test flights.

For analyses of home range and core area estimation, we only used locations with an accuracy rating ≤ 3 ; however, <5% of the locations used in our analyses had an accuracy rating of 3. To avoid temporal autocorrelation, we used locations collected ≥ 24 h apart. We limited the number of ground locations that were mixed with aerial locations to no more than 1 ground location during each 7-day period to minimize any bias associated with a greater number of ground locations obtained for fishers that occupied more accessible areas. An exception to this rule was made for male M011 because the area M011 inhabited was entirely accessible by vehicle and its movements were consistently monitored from the ground by the staff of the Makah Tribal Forestry Department.

2.4. Home Range and Core Area Estimation

Reintroduced fishers generally explored their new environment prior to establishing a home range (Heinemeyer, 1993; Proulx et al., 1994; Weir, 1995; Lewis, 2014). The nature of this exploration varied considerably among individuals, but once a translocated fisher found a suitable location, its movements become localized and the distances between subsequent locations become smaller as it established a home range (Weir, 1995; Lewis, 2014).

We defined home ranges and home range core-areas of established fishers after each settled into a consistent space-use pattern. We distinguished post-release exploratory movements from movements associated with home range establishment following methods of Weir (1995) and Weir et al. (2009) by plotting the mean-squared distance (MSD) between consecutive sets of 6 successive locations for each fisher (generally obtained over 6-12 weeks), and subjectively determining when movements became localized within a consistently used home range.

Following home range establishment, we estimated home range and core area boundaries using the fixed-kernel method (Worton, 1989) to create 95% and 50% utilization distributions, respectively. We used Animal Space Use to calculate smoothing parameters (Horne and Garton, 2009) and Home Range Tools for Arc GIS to delineate home range and core range boundaries (Rodgers et al., 2007). All home ranges and core areas were based on >20 locations collected over >6 months from the time the home range was established and until it died or its radio-transmitter failed. Animals failing to meet that minimum sampling requirement were not considered further for analysis. Occasionally a fisher left its home range, often during the breeding season, and returned 12-130 days later (Lewis, 2014), but locations associated with such forays were not included in location tallies or home range calculations.

2.4. Resource Selection

We assessed landscape selection patterns by comparing characteristics of habitats within core areas (i.e., 50% utilization contour) used by fishers to characteristics within a randomly placed sample of ‘pseudo’ core areas that represented habitats available to the translocated fishers. This method has been used to study landscape selection patterns of fisher home ranges (Weir and Corbould, 2010; Sauder and Rachlow, 2014), although we made one primary modification by applying this methodology to core areas rather than home ranges. Prior to making this decision, we examined patterns produced from both analyses and found remarkably consistent results (Lewis, 2014), although patterns were more pronounced based on 50% core areas. We reasoned

that selection should be more meaningful if the analysis is based on the most frequently used and highly selected portion of each animal's utilization distribution.

For each fisher with >20 locations, we defined the landscape available for core area establishment as all land area within 66 km (for females) and 108 km (for males) of each fisher's release site. These distances were equal to the greatest distance observed between a release site and the center of a used core area for female and male fishers. We inscribed the area available for core area establishment based on the maximum distances between release sites and core areas because most fishers traversed a greater distance away from the release site before returning closer to the release site to establish a home range.

To assess the characteristics of available areas, we generated a sample of 50 pseudo core areas for each fisher, and each pseudo core area was identical in shape and configuration to the used core area. Pseudo core areas were placed in random locations within the available landscape but were rotated in random directions (0-360 degrees) (Katnik and Weilgus, 2005). The random placement of pseudo core areas for each individual was constrained to prevent overlap; however, overlap was allowed among different individuals. Pseudo core areas that were located at the periphery of the study area (*i.e.*, the core area centroid was within the boundary) were clipped to exclude areas beyond the study area boundary, including the Pacific Ocean, Strait of Juan de Fuca, and Hood Canal.

2.5. Environmental Variables and Models

We examined support for the influence of 11 environmental variables on the selection of core areas by radio-collared fishers (Table 1). We obtained 30 x 30-m pixel data from the Landscape Ecology, Modeling, Mapping and Analysis (LEMMA) project of the U.S. Forest Service and Oregon State University (<http://www.fsl.orst.edu/lemma/>; accessed 15.02.16). Ohmann and Gregory, 2002) to characterize forest structure within used core areas and pseudo core areas. LEMMA data were derived from 2006 satellite imagery of all lands within the analysis area of the Northwest Forest Plan (western Washington, western Oregon, and northwestern California); thus, these data are most appropriate for analyses conducted at large spatial scales (*i.e.*, the landscape scale; Ohmann and Gregory, 2002). We used only LEMMA data with accuracy assessments that indicated >70% agreement between observed (plot) and predicted (model) data

(i.e., agreement was 0.75 for canopy cover and 0.72 for QMDA of dominant/co-dominant trees).

We developed a series of 17 *a priori* models of factors influencing core area selection to evaluate our primary hypotheses (Table 2) that forest structure, landscape composition, and human disturbance were expected to influence core area establishment by translocated fishers. To examine the hypothesis that females were more selective than males, we evaluated each model separately for male and female fishers. In addition to examining resource selection patterns of male and female fishers relative to habitat availability, we also contrasted selection patterns of male and female fishers directly by comparing the composition of male and female core areas (Table 2).

2.6. Statistical Analyses

We used the one-to-many case-controlled logistic regression outlined by Hosmer and Lemeshow (2000) to compare used and pseudo core areas for male and female fishers. Landscape characteristics of each used core area (i.e., one) were compared to characteristics of 50 pseudo core areas (i.e., many) that were available to that individual. We used PROC LOGISTIC with the STRATA command in program SAS (SAS Institute, Cary, NC) to run the case-controlled logistic regressions, which enabled us to control for the influence of unique shapes and sizes of core areas on the measurement of environmental variables (Table 2). Because the case-controlled logistic regression does not produce a single intercept value, the modelled probabilities represent relative probability of use ranging from 0 to 1. We also used PROC LOGISTIC to compare landscape characteristics of the used core areas of females to those of males. For all analyses, we limited candidate models to two variables to maintain a >5 to 1 ratio in the number of independent sampling units (i.e., 12 male fishers) to variables, as recommended by Vittinghoff and McCulloch (2007). To avoid issues of multicollinearity, we limited our use of multivariate models to those with variables that had Pearson correlation coefficients <0.65.

We used the small sample variant of Akaike's Information Criterion (AIC_c; Burnham and Anderson, 2002) to assess the support for candidate models. We considered models with $\Delta AIC_c < 2$ to be highly supported, those with ΔAIC_c from 2 to 4 to be moderately supported, and those with $\Delta AIC_c > 4$ and <8 to have limited support. To incorporate the effects of model uncertainty on core area selection, we averaged the predicted probabilities of use based on models that

accounted for the top 95% of the cumulative model weights (i.e., a 95% confidence set). We model-averaged the predicted responses of models in the candidate set, rather than deriving predictions from model-averaged parameters, as required for non-linear models (Cade, 2015). We calculated odds ratios (and 95% confidence limits) to assess the direction and magnitude of individual covariate effects in the highly supported models on core area selection. We considered model variables influential in predicting core area selection if the estimated odds ratios and associated 95% confidence intervals did not overlap 1. To illustrate the effect of key variables in the highly supported models of core area use, we calculated the relative probabilities of use (Hosmer and Lemeshow, 2000) and plotted these against the predictor variables based on the range of values for predictor variables found within pseudo core areas.

3. Results

We estimated home ranges and core areas for 19 females and 12 males (Figure 2). Home ranges of male and female fishers averaged $128.3 \pm 21.2 \text{ km}^2$ and $63.5 \pm 9.0 \text{ km}^2$, respectively, whereas core area sizes averaged $32.8 \pm 5.5 \text{ km}^2$ and $15.3 \pm 2.3 \text{ km}^2$, respectively. Core areas of 15 (79%) of the 19 females occurred within the boundaries of Olympic National Park or Olympic National Forest (i.e., the Olympic Recovery Area; Figure 2), whereas the remaining four females (21%) used core areas on primarily non-federal lands (see ownerships in Figure 1). By contrast, only five of the 12 males (42%) used core areas primarily on federal lands; the remaining seven males (58%) used core areas that were primarily on non-federal lands (Figure 2).

Core areas of males tended to encompass larger areas of small trees and natural open areas than those of females, whereas core areas of females tended to comprise larger proportions of area in mid-sized and large trees (Table 3). Pseudo core areas, which reflected landscapes available based on the extent of post-release movements of males and females, also tended to differ between males and females, with greater proportions of small trees and low elevations available to males, and greater proportions of mid-sized to large tree classes available to females (Table 3).

3.1. Core Area Selection by Females

Core area selection by females was most closely associated with forests comprised of mid-sized trees at higher elevations ($w_i = 0.960$; Table 4). This top model had 25 times more support than the second-ranking model, which included only the percentage of forests in the mid-sized tree

class. Thus, the inclusion of mean elevation resulted in much greater support from the data. Five (26%) of the 19 females established core areas in low-elevation forest landscapes ($\bar{x} = 169$ m, range: 22-299), whereas 14 females (74%) established core areas in mid-elevation forest landscapes ($\bar{x} = 1041$ m; range: 657-1471).

Estimated odds ratios indicated that use of core areas by females was influenced positively by the percentage of forest in the mid-sized tree class and mean elevation (Table 4). Within core areas, an increase in the relative probability of use was greatest as the percentage of forest in the mid-sized class increased from 0 to 40% and as elevation increased from 25 to 800 m (Figure 3).

3.2. Core Area Selection by Males

The highest-ranked model for explaining male selection of core areas included mean QMDA (-) and mean elevation (+) ($w_i = 0.200$); however, there were six models that were highly supported (*i.e.*, $\Delta AIC_c < 2.0$), all 17 models had at least limited support (*i.e.*, $\Delta AIC_c \leq 6.1$; Table 4), and notably, the null model of no selection was moderately supported ($\Delta AIC_c = 2.3$). Collectively, these indicators suggested that males were not highly selective of the core area attributes included in the models we evaluated. The three top-ranked models, however, had 2-3 times as much support as the null model based on ratios of model weights, suggesting there was a weak tendency for males to use core areas with a greater abundance of small trees, higher elevations, a greater percentage of forest in the small tree class, and greater patch density. Of these, the odds ratios indicated support only for selection of core areas with smaller overstory trees and a greater percentage of forest in the small tree class (Table 4). Graphical presentation of model-averaged results substantiated that gradients of tree size and elevation had minor influence on relative probabilities of selection (Figure 4).

3.3. Comparing Female and Male Use of Core Areas

The best model for distinguishing female and male core areas contained only the percentage of natural open area ($w_i = 0.465$; Table 5); all other models had less support from the data (ΔAIC_c values > 2.0). Estimated odds ratios indicated that, compared to males, females used core areas with less natural open area (Table 5). The predicted probability that a used core area belonged to a female versus a male declined from > 0.60 to negligible as the percentage of natural open area increased from 0 to 60%, and the probability also increased with the percentage of medium and

large trees (Figure 5).

4. Discussion

Our findings partially supported the premise that translocated fishers would choose landscapes dominated by late- and mid-seral forests at low to mid-elevations for core area selection (Lewis and Hayes, 2004). Female fishers selected core areas in protected landscapes (i.e., National Parks and National Forests) dominated by naturally regenerated stands of mid-sized trees over those dominated by the largest trees available in the study area and at middle rather than the lowest elevations. Females clustered primarily in two landscapes; one defined largely by historical wildfires that burned extensively throughout the northern and eastern Olympic Mountains in the early 1700s and late 1800s (Gavin and Brubaker, 2015), and the second found at the interface of managed forestlands and Olympic National Park on the west side of the peninsula (Figure 2). Although both locations are dominated by mid-seral forests, core areas selected by females encompassed diverse mosaics of tree size and age classes (e.g. 25, 43, and 20% of stands dominated by large, mid-sized, and small trees, respectively, Table 3), including remnant old-growth patches and legacy old-growth trees that survived historical fires. The second cluster of females was located on the margins of the logged and protected forest landscapes, where older forests were available nearby within Olympic National Park (Figure 2). Our observations were similar to those reported previously in northern Idaho, where fishers selected many seral stages, including young stands initiated by wildfires that retained scattered large trees and structures important for denning, security or thermoregulation (Jones and Garton, 1994). Our findings also support observations from northwestern California, where female fisher home ranges comprised an average of 28, 50, and 23% late-, mid-, and early-seral stands, respectively (Zielinski et al., 2004a). Collectively, our observations corroborate the growing consensus that fishers are not as closely linked to late-seral forests as once believed (Buskirk and Powell, 1994), but rather select mosaics of multiple stand ages that include relatively high proportions of mid- to late-seral forests (Lofroth et al., 2010; Raley et al., 2012).

Males were less selective in choosing core areas than were females, settling in forests with a wider range of tree sizes and age classes than females, including landscapes of younger forests not previously identified as suitable habitat (Lewis and Hayes, 2004). Core areas selected by male fishers contained a greater prevalence of small trees, higher patch density, and lower

canopy cover than was widely available throughout the study area. Male core areas corresponded largely with private, State, and Tribal lands where commercial timber production was a dominant land use, or high elevation forests in Olympic National Park where small tree classes were interspersed with natural meadows (Figure 2). Although there was weak support (relative to the null model of no selection) for male fishers selecting landscapes dominated by the small tree class, males selected core areas defined by high diversity of tree size classes similar to females (18, 32, and 32% of stands dominated by large, mid-sized, and small trees, respectively, Table 3), although the distribution for males was skewed towards the smaller size class of trees. This composition of core areas selected by males on the Olympic Peninsula is reasonably representative of forest age classes used by male fishers in northwestern California (Zielinski et al., 2004a; 25, 45, 25% of stands dominated by large, mid-sized, and small trees, respectively), and corroborates previous indications that male fishers are less selective of forested landscapes than females (Buck et al., 1994; Zielinski et al., 2004a).

In addition to tending to select for larger tree classes and less patchy environments for core area establishment, females clearly avoided forest openings to a greater degree than males (Figure 5). Weir and Corbould (2010) and Sauder and Rachlow (2014) both reported that the amount of open area was the best (negative) predictor of home range selection by fishers in central British Columbia and Idaho, respectively. Core areas of females and males on the Olympic Peninsula comprised about 12% and 26% natural forest openings, respectively, which were considerably higher than 5-10% reported for females and males in northwestern California (Zielinski et al. 2004a). Nonetheless, our findings support the broad consensus that fishers generally avoid non-forested cover types (Lofroth et al. 2010, Raley et al. 2012), but suggest that this may be particularly true for females.

We were surprised that few fishers established core areas in the extensive low-elevation old-growth forests on the western valleys and flanks of the Olympic Mountains (Figure 2). These forests were identified as highly suitable in the habitat assessment presented by Lewis and Hayes (2004), as they are renowned for the large stature of trees, complex forest structure, and the abundance of both standing and downed dead trees (Franklin and Dyrness, 1988). We hypothesize that differences in prey availability between old-growth forests and the low- to mid-seral stage forests areas may partially explain why fishers did not establish core areas in old-

growth. Fishers prey on a wide variety of small and medium-sized mammalian prey throughout their range (Martin, 1994; Zielinski et al., 1999; Weir et al., 2005), including snowshoe hares, sciurids, small mammals, and mountain beavers (*Aplodontia rufa*) (Lewis et al., 2010, 2011). Unfortunately, the relative abundance and distribution of potential prey on the Olympic Peninsula is poorly understood relative to gradients in either precipitation or forest succession. Recent inventories suggested the relative abundance and diversity of small mammals was lower in the western rainforest valleys of the park than in representative northern and southern drainages on the peninsula (Jenkins et al., 2002). Similarly, northern flying squirrels (*Glaucomys sabrinus*) appear to reach higher densities in drier Douglas fir forests than in the wetter Sitka spruce zone (Carey et al., 1995). Furthermore, the greater abundance of snowshoe hares and bushy tailed woodrats (*Neotoma cinerea*) in the diets of northern spotted owls in the eastern compared to the western Olympic mountains suggests that they may be more abundant in drier than moist mature coniferous forest ecosystems on the peninsula (Forsman et al., 2001). Information comparing prey abundance across successional stages that include recently harvested stands and old-growth forests are lacking on the peninsula. In general, mountain beavers are most abundant in regenerating (seedling, sapling) and young stands in managed forests, which support an abundance of herbaceous plants, woody shrubs, and seedlings that make up their diet (Hacker and Coblenz, 1993; Verts and Carroway, 1998; Feldhamer et al., 2003; Arjo and Nolte, 2006; Arjo et al., 2007). Our anecdotal observations also suggest that mountain beaver and snowshoe hare were abundant in early-seral forests following logging and at the high elevation ecotone with subalpine forests, but data are lacking. Clearly, additional research on prey selection by male and female fishers and the relative distributions of prey species would be useful to better understand habitat relationships of fishers on the peninsula.

The fisher is often referred to as a secretive carnivore because it generally avoids humans and areas of human activity (Powell, 1993); however, we did not detect avoidance by males or females of managed open areas (*e.g.*, agricultural fields, developed areas) or areas with greater densities of paved roads in relation to available areas. Such managed open areas comprised <4% of the study area (Table 3), however, and avoidance similar to that of natural openings (*i.e.*, clearcuts and natural meadows) might be more easily detected if managed openings were more extensive. Models that included effects of managed open areas and paved roads were among the lowest ranked models for both males and females, suggesting neither negative nor positive

associations between fisher core area selection and areas of human development. We documented several mortalities of fishers associated with vehicle collisions before home ranges were established (Lewis, 2014), suggesting that the initial use of developed areas by newly released fishers may have been greater than indicated from the study of established fishers, but that such habitats may have been local sinks due to high mortality risks.

Because we examined core area selection of male and female fishers relative to sex-specific movement distances prior to home range establishment (Lewis 2014), interpretations of male and female core area selection patterns could reflect differences in landscapes considered available to each. All animals select resources at hierarchically nested scales (Johnson, 1980). The nested levels of resource selection are interdependent, such that interpretation of resource selection at each level in the hierarchy is inextricably linked to the other nested levels, hence also to the scale of resources considered available for potential selection (Johnson, 1980; Porter and Church, 1987). Males dispersed considerably greater distances from their release sites than females on the Olympic Peninsula (Lewis 2014), thus encompassing a larger area available for core area establishment than females, as well as a greater proportion of low-elevation coastal plains and managed forests on the Olympic Peninsula (i.e., outside the National Park and National Forest). Because there were no obvious barriers to females dispersing as far as males, differences in the areas available to males and females for core area establishment entailed some level of spatial resource selection we did not explicitly consider. Males tended to select managed forest lands (small tree classes, more natural open areas) to a greater extent than females despite the greater proportion of these forests available to them. Females, by contrast, had proportionally more mid- to late-seral forests available to them than males, and yet they selected them at a disproportionately high rate compared to males. Consideration of the resource selection patterns observed in the context of post-release movements of males and females implies an even greater support for sex-specific differences in resource selection patterns than we discerned.

The segregation of male and female core areas we observed along gradients of tree size class, patch density, and forest openings is consistent with our predictions that habitat selection by fishers reflects sex-specific differences in reproductive requirements, security needs, body size, and vulnerability to predation. In California, Wengert et al. (2013) found that bobcat predation on fishers was limited to female fishers, which they attributed to the smaller size of females.

Bobcats use all forest seral stages (from regenerating to old-growth stands; Witmer and DeCalesta, 1986); however, they appear to be particularly abundant in managed forest landscapes (Yengoyan, 1995; Wengert, 2013), which may be related to the abundance of mountain beavers and other prey in these environments (Brittell et al., 1979; Knick et al., 1984). We hypothesize that selection by female fishers for extensive areas of mid-sized and large trees in protected forests of Olympic National Park and Olympic National Forest may reflect avoidance of predator rich areas on managed forests. Further, we speculate that selectivity by females for predominantly protected forest landscapes may also reflect selection at finer spatial scales for suitable den sites or resting structures that are generally associated with older forests (Lofroth et al., 2010; Raley et al., 2012). Recent studies provide supportive evidence that females may be more selective of specific rest sites than males (Aubry and Raley, 2006; Zielinski et al., 2004b); for example, female fishers in California selected rest sites that were more enclosed and appeared more protective against potential predators than those selected by males (Zielinski et al., 2004b). Additional multi-scale studies of sex-based selection patterns by active and resting fishers would help to elucidate the observed patterns of landscape partitioning by male and female fishers (Raley et al., 2012).

Females in our study selected forested landscapes largely consistent with habitat suitability findings presented by Lewis and Hayes (2004); however, we offer the following caveats to this interpretation, emphasizing that a certain level of caution is needed when considering a short-term study of translocated animals. The limited overlap of male and female fisher core areas (and home ranges), and the relatively small portion of our study area being used by fishers, suggests that the study area was below its carrying capacity and not all suitable habitat was occupied. We expect that individuals in populations below carrying capacity might occupy the highest quality landscapes; consequently, our findings may not identify the full range of landscape characteristics, capable of supporting fishers on the Olympic Peninsula.

Core area choices of translocated fishers may also reflect behavioral conditioning, previous experiences, and habitat cues learned from their natal environment. The phenomenon known as natal habitat preference induction (NHPI; Davis and Stamps, 2004)—the tendency for dispersing or translocated animals to select ‘someplace like home’ (Stamps and Swaisgood, 2007) —is predicted when displaced animals have considerable experience identifying favorable habitats in

a natal environment but must subsequently gauge qualities in a new environment. Consequently, displaced individuals may not accurately or meaningfully judge prey density, predation risks, or other correlates of survival and fitness while exploring a novel environment. Broad cues from the environment, however, such as forest structure are easily interpreted and may be used to judge suitable habitat, albeit with uncertain consequences. NHPI has been observed in translocated mammals, including red squirrels translocated in the UK (Kenward and Hodder, 1998), and woodland caribou reintroduced into Idaho, USA (Warren et al., 1996). Although we did not examine concordance of habitat features selected by translocated fishers in Washington relative to those prevalent in British Columbia, the spruce-pine forests of central British Columbia are more similar to the forests of smaller trees found in mid-seral forests in the northern and northeastern Olympic Peninsula than they are to the peninsula's old-growth temperate rainforests. Additional cues from prey, snow, or other environmental factors could also influence the resource selection of translocated individuals (Stamps and Swaisgood, 2007).

Conspecific attraction has been reported for territorial species, whereby dispersing or newly released individuals tend to establish home ranges (or territories) in close proximity to those of resident individuals (Stamps, 1988; Smith and Peacock, 1990). As mentioned previously, exploring a new environment is time consuming, potentially risky, and not always likely to yield an optimal choice; cuing on the presence of conspecifics may provide information to naïve animals about the general suitability of habitat or the availability of potential mates. The fact that we found disparate distributions of male and female fishers lends little support for the idea that males and females were attracted to enhance mating opportunities. Rather, we recorded long-distant movements by both male and female fishers during the breeding season, followed by their return to previously established ranges (Lewis, 2014), suggesting that local habitat characteristics selected by male and female fishers were more important considerations for core area establishment than proximity to potential mates. The clustering of female core areas in the northeastern and southwestern Olympics suggests that core area establishment by females within the study area may reflect either responses to local variations in habitat conditions or conspecific attraction. The relative appeal of habitat versus conspecific cues as influences for core area establishment in a new environment warrants additional study.

Ultimately, habitat suitability will be judged based on empirical measures of individual fitness of translocated fishers (e.g., survival and reproduction) and long-term persistence of the population. While we recognize the fitness challenges to translocated individuals, we documented reproduction by at least 8 of 19 females included in this study; reproduction was suspected for 2 other females, whereas the reproductive success of 6 others could not be confirmed, and 3 females died before they could reproduce (Lewis et al., 2011; National Park Service, Unpublished data). We suspect that reproductive success was limited by mate availability for 6 or more females as indicated by unprecedented breeding season movements away from established home ranges during the breeding season (Lewis, 2014). Despite limited mate availability and a lack of familiarity with a new environment, the females in our study sample demonstrated a level of reproductive success and fidelity to home range areas (i.e., the return to pre-breeding season ranges), which suggested that these females exhibited meaningful selection for suitable habitats. Current ongoing studies of population expansion and occupancy dynamics within the landscapes settled by the founder population will help to confirm or augment our understanding of fisher habitat suitability in coastal forests of the Pacific Northwest.

5. Conclusions and management implications

Translocations have been instrumental in restoring the fisher to much of the southern portion of its historical range in North America (Lewis et al., 2012; Powell et al., 2012), and were the primary means identified for recovering fishers in Washington (Lewis and Hayes, 2004). The translocation of fishers to the Olympic Peninsula was the first recovery action for fishers in Washington State largely because this area had the largest amount and most contiguous distribution of suitable habitat (Lewis and Hayes, 2004). Suitable habitat was defined as low and mid-elevation landscapes dominated by late-seral conifer forests because such forests were thought to provide the highest quality habitat for both male and female fishers (Lewis and Hayes, 2004). Our results partially confirmed those expectations for females, but also suggested a greater diversity of stands may be suitable for females and particularly males. Fishers may have selected the most suitable habitats they encountered for home ranges after they were released. However the most reliable assessment of habitat suitability would require longer-termed studies of individual fitness of fishers in an established population (i.e., those in subsequent generations), including estimates of long-term survival and reproductive outputs in various

landscape configurations. Additional study is also needed of food habits and prey availability to more fully understand factors that are likely to influence habitat suitability. Until these factors are better understood, basing habitat suitability on the more restrictive selection patterns of females would be a more conservative approach for future planning.

The affinity of female fishers for large protected forested landscapes may indicate that fisher recovery in western Washington will be limited to the Olympic Peninsula and Cascade Range, where such landscapes exist. Until more explicit measures of individual fitness can be estimated, we suggest that habitat mosaics dominated by mid-, and late-seral forests, and containing minimal area of forest openings will provide suitable habitats for female fishers, provided these components are maintained at the scale of individual home ranges. We note that the bulk of the mid-seral forest used by females occurred in areas protected from logging; most of these forests were naturally regenerated following fires and contained an abundance of residual large woody structures (i.e., large cavity trees, large snags, and large down logs) suitable as den sites and rest sites. The area required to support an individual fisher is large ($\bar{x} = 64 \text{ km}^2$ for females), and therefore, the area needed to support a self-sustaining population is much larger and likely to encompass multiple land ownerships (e.g., National Forests, National Parks, State Forests). Planning across the boundaries of ownerships (e.g., the Northwest Forest Plan: USDA Forest Service and USDI Bureau of Land Management, 1994) may be logistically and organizationally complex but is essential for wide-ranging species that require management at large spatial scales.

Acknowledgements

This research was supported by funding and in-kind contributions provided by the U.S. Geological Survey, National Park Service, U.S. Fish and Wildlife Service, Doris Duke Foundation and the Wildlife Conservation Society, Washington Department of Fish and Wildlife, Washington's National Park Fund, Conservation Northwest, and the U.S. Forest Service. Logistical support and access were provided by the Makah Indian Tribe, Quinault Indian Nation, Lower Elwha Klallam Tribe, Washington Department of Natural Resources, Rayonier Timber Company, and U.S. Forest Service. We thank pilots R. Mowbray, J. Well, C. Cousins, and M. Kimbrel for safely piloting hundreds of telemetry flights. We thank R. McCoy and the wildlife staff of the Makah Tribal Forestry Department for their assistance in tracking male M011, which resided in and around the Makah Reservation. J. Sauder and R. Weir shared

their insights on habitat selection and analyses. K. Beirne provided helpful assistance with home range estimation and I. Keren provided helpful assistance in addressing statistical questions. We thank H. Allen (WDFW, retired) for her valuable insights and guidance throughout the planning, implementation and monitoring phases of the translocation effort. Lastly, we are grateful to K. Aubry, R. McCaffery, C. Raley, and S. West for providing helpful comments on previous drafts of the manuscript. Use of trade names is for descriptive purposes and does not constitute endorsement by the U.S. government.

References

- Anderson, E. and M. Lovallo. 2003. Bobcat and lynx. Pages 758–786 in G. A. Feldhamer, B. C. Thompson, and J. A. Chapman (Eds.), *Wild Mammals of North America: Biology, Management, and Economics*. Johns Hopkins Press, Baltimore, Maryland.
- Arjo, W.M. and D.L. Nolte. 2006. Boomer or bust: managing a Pacific Northwest pest species. *Proceedings of the 22nd Vertebrate Pest Conference* 22:181-186.
- Arjo, W.M., R.R. Huenefeld and D.L. Nolte. 2007. Mountain beaver home ranges, habitat use, and population dynamics in Washington. *Canadian Journal of Zoology* 85:328-337.
- 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. 2006. Ecological characteristics of fishers (*Martes pennanti*) in the southern Oregon Cascade Range. Unpublished report, 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(5):965–974.
- Brittall, J.D., S.J. Sweeney and S.T. Knick. 1979. Washington bobcats: diets, population dynamics and movement. Pages 107-110 in P. C. Escherich and L. Blum, editors. *Proceedings of the 1979 bobcat research conference*. National Wildlife Federation, Wildlife Technical Series 6.
- Buck, S. G., C. Mullis, A. S. Mossman, I. Show and C. Coolahan. 1994. Habitat use by fishers in adjoining heavily and lightly harvested forest. Pages 368-376 in S.W. Buskirk, A.S. Harestad, M.G. Raphael and R.A. Powell, editors. *Martens, Sables, and Fishers: Biology and Conservation*. Cornell University Press, Ithaca, New York.
- Burnham, K.P. and D.R. Anderson. 2002. *Model selection and inference: a practical information-theoretic approach*, 2nd edition. Springer-Verlag, New York.

651 Buskirk, S.W. and R.A. Powell. 1994. Habitat ecology of fishers and American martens. Pages 283-296
 652 in S.W. Buskirk, A.S. Harestad, M.G. Raphael and R.A. Powell, editors. Martens, Sables, and
 653 Fishers: Biology and Conservation. Cornell University Press, Ithaca, New York.
 654 Cade, B.S. 2015.. Model averaging and muddled multimodel inferences. Ecology 96(9):2370-2382.
 655 Carroll, C., W.J. Zielinski and R.F. Noss. 1999. Using presence-absence data to build and test spatial
 656 habitat models for the fisher in the Klamath Region, U.S.A. Conservation Biology 13:1344-1359.
 657 Carey, A.B. 1995. Sciurids in Pacific Northwest managed and old-growth forests. Ecological
 658 Applications 5(3):648-661.
 659 Davis, J. M. and J. A. Stamps. 2004. The effect of natal experience on habitat preferences. Trends in
 660 Ecology and Evolution 19:411-416.
 661 Feldhamer, G.A., J.A. Rochelle and C.D. Rushton. 2003. Mountain beaver. Pages 179-187 in G.A.
 662 Feldhamer, B.C. Thompson and J.A. Chapman, editors. Wild Mammals of North America:
 663 Biology, Management and Conservation, 2nd edition. Johns Hopkins University Press, Baltimore,
 664 MD.
 665 Fonda, R. W. 1974. Forest succession in relation to river terrace development in Olympic National Park,
 666 Washington. Ecology 55:927-942.
 667 Forsman, E.D., I.A. Otto, S.G. Sovern, M. Taylor, D.W. Hays, H. Allen, S.L. Roberts and D.E. Seaman.
 668 2001. Spatial and temporal variation in diets of spotted owls in Washington. Journal of Raptor
 669 Research 35:141-150.
 670 Franklin, J.F. and C.T. Dyrness. 1988. Natural vegetation of Oregon and Washington. Oregon State
 671 University Press, Corvallis, Oregon.
 672 Gavin, D. G. and L. B. Brubaker. 2015. Late Pleistocene and Holocene Environmental Change on the
 673 Olympic Peninsula, Washington. Springer Ecological Studies 222.
 674 Hacker, A.L. and B.E. Coblenz. 1993. Habitat selection by mountain beavers recolonizing Oregon Coast
 675 Range clearcuts. Journal of Wildlife Management 57: 847-853.
 676 Hansen, A.J., T.A. Spies, F.J. Swanson and J.L. Ohmann. 1991. Conserving biodiversity in managed
 677 forests. BioScience 41:382-392.
 678 Hayes. G.E. and J.C. Lewis. 2006. Washington State recovery plan for the fisher. Washington Department of
 679 Fish and Wildlife, Olympia, Washington. 69 pp.
 680 <<http://wdfw.wa.gov/publications/00228/wdfw00228.pdf>> (accessed 15.02.16).
 681 Heinemeyer, K.S. 1993. Temporal dynamics in the movements, habitat use, activity, and spacing of
 682 reintroduced fishers in northwestern Montana. MS Thesis, University of Montana, Missoula,
 683 Montana.
 684 Henderson, J.A., D.H. Peter, R.D. Leshner and D.C. Shaw. 1989. Forested plant associations of the

685 Olympic National Forest. U.S. Forest Service Ecological Technical Paper 001-88, Portland,
686 Oregon. 502 pp.

687 Horne, J.S. and E. O. Garton. 2009. Animal Space Use 1.3
688 <http://www.cnr.uidaho.edu/population_ecology/animal_space_use> (accessed 15.02.16).

689 Hosmer, D.W. and S. Lemeshow. 2000. Applied Logistic Regression, 2nd edition. John Wiley and Sons,
690 Inc., New York, NY. 375 pp.

691 Houston, D.B. and E.G. Schreiner. 1994. The Olympic Mountains and Environs . Pages 14-26 (Chapter 2)
692 in D.B. Houston, E.G. Schreiner, and B. B. Morehead, editors. Mountain goats in Olympic
693 National Park: biology and management of an introduced species. Scientific Monograph
694 NPS/NROLYM/NRSM-94/25. USDI National Park Service. Port Angeles, Washington.

695 Johnson, D.H. 1980. The comparison of usage and availability measurements for evaluating resource
696 preferences. Ecology 61:65-71.

697 Jones, J.L. and E.O. Garton. 1994. Selection of successional stages by fishers in North- Central Idaho.
698 Pages 377-387 in S.W. Buskirk, A.S Harestad, M.G. Raphael and R.A. Powell, editors. Martens,
699 Sables, and Fishers: Biology and Conservation. Cornell University Press, Ithaca, New York.

700 Katnik, D.D. and R.B. Wielgus. 2005. Landscape proportions versus Monte Carlo simulated home ranges
701 for estimating habitat availability. Journal of Wildlife Management 69(1):20-32.

702 Kenward, R. E. and K. H. Hodder. 1998. Red squirrels (*Sciurus vulgaris*) released in conifer woodland:
703 the effects of source habitat, predation and interactions with grey squirrels (*Sciurus carolinensis*).
704 J. Zool., Lond. 244: 23-32.

705 Knick, S.T., S.J. Sweeney, J.R. Alldredge and J.D. Brittell. 1984. Autumn and winter food habits of
706 bobcats in Washington State. Great Basin Naturalist 44:70-74.

707 Krohn, W.B., K.D. Elowe and R.B. Boone. 1995. Relations among fishers, snow, and martens:
708 development and evaluation of two hypotheses. Forestry Chronicle 71:97-105.

709 Krohn, W.B., W.J. Zielinski and R.B. Boone. 1997. Relations among fishers, snow, and
710 martens in California: results from small-scale spatial comparisons. Pages 211-232, in G.H.
711 Proulx, H.N. Bryant and P.M. Woodard, editors. *Martes*: Taxonomy, Ecology, Techniques and
712 Management. Provincial Museum of Alberta, Edmonton, Canada. 474 pp.

713 Krohn, W.B., C. Hoving, D. Harrison, D. Phillips and H. Frost. 2004 *Martes* foot-loading and snowfall
714 patterns in eastern North America: implications to broad scale distributions and interactions of
715 mesocarnivores. Pages 115-131 in D.J. Harrison, A.K. Fuller and G. Proulx, editors. Martens and
716 Fisher (*Martes*) in Human-Altered Environments: An International Perspective. Kluwer
717 Academic Publishers, Norwell, Massachusetts, USA.

- Lewis, J.C. 2014. Post-release movements, survival and resource selection of fishers (*Pekania pennanti*) translocated to the Olympic Peninsula of Washington. Ph.D. Dissertation. University of Washington, Seattle.
- Lewis, J.C., P.J. Happe, K.J. Jenkins and D.J. Manson. 2010. Olympic fisher reintroduction project: 2009 progress report. Washington Department of Fish and Wildlife, Olympia. < http://wdfw.wa.gov/conservation/fisher/olympic_reports.html> (accessed 15.02.16).
- Lewis, J.C., P.J. Happe, K.J. Jenkins and D.J. Manson. 2011. Olympic fisher Reintroduction Project: 2010 progress report. Washington Department of Fish and Wildlife, Olympia. < http://wdfw.wa.gov/conservation/fisher/olympic_reports.html> (accessed 15.02.16).
- Lewis, J.C. and G.E. Hayes. 2004. Feasibility assessment for reintroducing fishers to Washington. Washington Department of Fish and Wildlife, Olympia. 70 pp < <http://wdfw.wa.gov/publications/00231/>> (accessed 15.02.16).
- 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(3): e32726.
- Lewis, J.C. and W.J. Zielinski. 1996. Historical harvest and incidental capture of fishers in California. Northwest Science 70:291-297.
- 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. Volume I - Conservation Assessment for Fisher (*Martes pennanti*) in South-central British Columbia, Western Washington, Western Oregon, and California. USDI Bureau of Land Management, Portland, OR.
- Martin, S.K. 1994. Feeding ecology of American martens and fishers. Pages 297–315 in S.W. Buskirk, A.S. Harestad, M.G. Raphael and R.A. Powell, editors. Martens, Sables, and Fishers: Biology and Conservation. Cornell University Press, Ithaca, New York.
- Meidinger, D. and J. Pojar. 1991. Ecosystems of British Columbia. British Columbia Ministry of Forests, Victoria, Canada. < <https://www.for.gov.bc.ca/hfd/pubs/Docs/Srs/Srs06.htm> > (accessed 15.02.16)
- Naney, R.H., L.L. Finley, E.C. Lofroth, P.J. Happe, A.L. Krause, C.M. Raley, R.L. Truex, L.J. Hale, J.M. Higley, A.D. Kosc, J.C. Lewis, S.A. Livingston, D.C. Macfarlane, A.M. Myers and J.S. Yaeger. 2012. Conservation of fishers (*Martes pennanti*) in south-central British Columbia, western Washington, western Oregon, and California—Volume III: Threat Assessment. USDI Bureau of Land Management, Denver, Colorado, USA.

750 Ohmann, J.L. and M.J. Gregory. 2002. Predictive mapping of forest composition and structure with direct
 751 gradient analysis and nearest-neighbor imputation in coastal Oregon, U.S.A. *Canadian Journal of*
 752 *Forest Research* 32:725-741.

753 Peel, M.C., B.L. Finlayson and T.A. McMahon. 2007. Updated world map of the Köppen-Geiger climate
 754 classification. *Hydrology and Earth Systems Science* 11:1633-1644.

755 Porter, W.F. and K.E. Church. 1987. Effects of environmental pattern on habitat preference analysis.
 756 *Journal of Wildlife Management* 51:681-685.

757 Powell, R.A. 1993. *The fisher: Life history, ecology, and behavior*, 2nd edition. University of Minnesota
 758 Press, Minneapolis, Minnesota.

759 Powell, R.A., J.C. Lewis, B.G. Slough, S.M. Brainerd, N.R. Jordan, A.V. Abramov, V. Monakov, P.A.
 760 Zollner and T. Murakami. 2012. Evaluating translocations of martens, sables, and fishers: testing
 761 model predictions with field data. Pages 93-137, in K.B. Aubry, W.J. Zielinski, M.G. Raphael, G.
 762 Proulx, and S.W. Buskirk, editors. *Biology and Conservation of Martens, Sables, and Fishers: A*
 763 *New Synthesis*. Cornell Univ. Press. Ithaca, NY.

764 Powell, R.A. and W.J. Zielinski. 1994. Fisher. Pages 28-73 in L.F. Ruggiero, K.B. Aubry, S.W. Buskirk,
 765 L.J. Lyon and W.J. Zielinski, editors. *The scientific basis for conserving forest carnivores:*
 766 *American marten, fisher, lynx, and wolverine in the western United States*. U.S. Forest Service,
 767 General Technical Report RM-254.

768 Proulx, G.A., J. Kolenosky, M. Badry, M.K. Drescher, K. Seidel and P.J. Cole. 1994. Post-release
 769 movements of translocated fishers. Pages 197-203 in S.W. Buskirk, A. Harestad, M. Raphael and
 770 R.A. Powell, editors. *Martens, Sables, and Fishers: Biology and Conservation*. Cornell
 771 University Press, Ithaca, New York.

772 Purcell, K.L., A.K. Mazzoni, S.R. Mori and B. Boroski. 2009. Resting structures and resting habitat of
 773 fishers in the southern Sierra Nevada, California. *Forest Ecology and Management* 258: 2696–
 774 2706.

775 Raley, C.M., E.C. Lofroth, R.L. Truex, J.S. Yaeger and J.M. Higley. 2012. Habitat ecology of fishers in
 776 western North America: a new synthesis. Pages 231-254 in K.B. Aubry, W.J. Zielinski, M.G.
 777 Raphael, G. Proulx and S.W. Buskirk, editors. *Biology and Conservation of Martens, Sables, and*
 778 *Fishers: A New Synthesis*. Cornell University Press, Ithaca, New York.

779 Rodgers, A.R., A.P. Carr, H.L. Beyer, L. Smith and J.G. Kie. 2007. HRT: Home Range Tools for
 780 ArcGIS. Version 1.1. Ontario Ministry of Natural Resources, Centre for Northern Forest
 781 Ecosystem Research, Thunder Bay, Ontario, Canada.

782 Roy, K.D. 1991. Ecology of reintroduced fishers in the Cabinet Mountains of northwest Montana. MS
 783 Thesis, University of Montana, Missoula.

784 Sauder, J. and J.L. Rachlow. 2014. Both forest composition and configuration influence landscape-scale
785 habitat selection by fishers (*Pekania pennanti*) in the Rocky Mountains of Idaho. *Forest Ecology*
786 *and Management* 314:75-84.

787 Schreiner, E. G. 1994. Subalpine and alpine plant communities . Pages 242-250 (Appendix A2) in D.B.
788 Houston, E.G. Schreiner, and B. B. Morehead, editors. *Mountain goats in Olympic National Park:*
789 *biology and management of an introduced species.* Scientific Monograph
790 NPS/NROLYM/NRSM-94/25. USDI National Park Service. Port Angeles, Washington.

791 Sikes, R.S., W.L. Gannon, and the Animal Care and Use Committee of the American Society of
792 Mammalogists. 2011. Guidelines of the American Society of Mammalogists for the use of wild
793 mammals in research. *Journal of Mammalogy* 92(1):235-253.

794 Spies, T.A. and J.F. Franklin. 1991. The structure of natural young, mature, and old-growth Douglas-fir
795 forests in Oregon and Washington. Pages 91–109 in L.F. Ruggiero, K.B. Aubry, A.B. Carey, and
796 M. Huff, technical coordinators. *Wildlife and vegetation of unmanaged Douglas-fir forests.*
797 General Technical Report PNW-GTR-85. U.S. Department of Agriculture Forest Service, Pacific
798 Northwest Research Station, Portland, Oregon.

799 Smith, A. and M.M. Peacock. 1990. Conspecific attraction and the determination of metapopulation
800 colonization rates. *Conservation Biology* 4:320–323.

801 Stamps, J.A. 1988. Conspecific attraction and aggregation in territorial species. *American Naturalist*
802 131:329–347. Smith, A. and M.M. Peacock. 1990. Conspecific attraction and the determination of
803 metapopulation colonization rates. *Conservation Biology* 4:320–323.

804 Stamps, J.A. and R.R. Swaisgood. 2007. Someplace like home: experience, selection, and conservation
805 biology. *Applied Animal Behaviour Science* 102:392-409.

806 Thompson, C.M., W.J. Zielinski and K.L. Purcell. 2011. Evaluating management risks using landscape
807 trajectory analysis: a case study of California fisher. *Journal of Wildlife Management* 75(5):1164-
808 1176.

809 USDA Forest Service and USDI Bureau of Land Management. 1994. Record of decision for amendments
810 to Forest Service and Bureau of Land Management planning documents within the range of the
811 northern spotted owl. USDA Forest Service and USDI Bureau of Land Management, Portland,
812 Oregon.

813 U.S. Fish and Wildlife Service. 2014. Endangered and threatened wildlife and plants; threatened species
814 status for West Coast distinct population segment of fisher (proposed rule). *Federal Register*
815 79(194):60419-60443.

816 Verts, B.J. and L.N. Carroway. 1998. *Land Mammals of Oregon.* University of California Press,
817 Berkeley, CA. 668 pp.

818 Vittinghoff, E. and C.E. McCulloch. 2007. Relaxing the rule of ten events per variable in logistic and Cox
819 regression. *American Journal of Epidemiology* 165(6):710–718.

820 Voigt, D.R. and W.E. Berg. 1987. Coyote. Pages 345-357 in M. Novak, J.A. Baker, M.E. Obbard and B.
821 Malloch, editors. *Wild Furbearer Management and Conservation in North America*. Ministry of
822 Natural Resources, Ontario, Canada.

823 Warren, C. D., J. M Peek, G. L. Servheen and P. Zager. 1996. Habitat use and movements of two
824 ecotypes of translocated caribou in Idaho and British Columbia. *Conservation Biology* 10:547-
825 553.

826 Washington Department of Natural Resources. 1997. *Habitat Conservation Plan*. Washington Department
827 of Natural Resources, Olympia.

828 Weir, R.D. 1995. Diet, spatial organization, and habitat relationships of fishers in south-central British
829 Columbia. MS Thesis, Simon Fraser University, Burnaby, British Columbia, Canada.

830 Weir, R.D. and F.B. Corbould. 2010. Factors affecting landscape occupancy by fishers in north-central
831 British Columbia. *Journal of Wildlife Management* 74(3):405–410.

832 Weir, R.D., F.B. Corbould and A.S. Harestad. 2004. Effect of ambient temperature on the selection of rest
833 structures by fishers. Pages 196-210 in D.J. Harrison, A.K. Fuller and G. Proulx, editors. *Martens*
834 *and Fisher (Martes) in Human-Altered Environments: An International Perspective*. Kluwer
835 Academic Publishers, Norwell, Massachusetts, USA.

836 Weir, R.D. and A.S. Harestad. 1997. Landscape-level selectivity by fishers in south-central British
837 Columbia. Pages 252-264 in G. Proulx, H. N. Bryant and P. M. Woodward, editors. *Martes:*
838 *Taxonomy, ecology, techniques, and management*. Provincial Museum of Alberta. Edmonton,
839 Alberta, Canada.

840 Weir, R.D., A.S. Harestad and F.B. Corbould. 2009. Home ranges and spatial organization of fishers in
841 central British Columbia. *Canadian Field-Naturalist* 123(1):126-132.

842 Weir, R.D., A.S. Harestad, and R.C. Wright. 2005. Winter diet of fishers in British Columbia.
843 *Northwestern Naturalist* 86:12-19.

844 Weir, R.D., M. Phinney and E.C. Lofroth. 2012. Big, sick, and rotting: Why tree size, damage, and decay
845 are important to fisher reproductive habitat. *Forest Ecology and Management* 265:230-240.

846 Wengert, G.M. 2013. *Ecology of Intraguild Predation on Fishers (Martes pennanti) in California*. PhD
847 dissertation. University of California, Davis. 119 pp.

848 Wengert, G.M., M.G. Gabriel, J.E. Foley, T. Kun and B.N. Sacks. 2013. Field and molecular techniques
849 for identifying intraguild predators of fishers and other North American small carnivores.
850 *Wildlife Society Bulletin* 37:659-663.

851 Witmer, G.W. and D.S. DeCalesta. 1986. Resource use by unexploited sympatric bobcats and coyotes in

852 Oregon. Canadian Journal of Zoology 64:2333-2338.

853 Worton, B.J. 1989. Optimal smoothing parameters for multivariate fixed and adaptive kernel methods.

854 Journal of Statistical Computation and Simulation 32:45-57.

855 Yengoyan, L.P. 1995. Habitat utilization and home range size of the bobcat in managed forests of western

856 Washington. MS thesis. University of Washington, Seattle. 86 pp.

857 Zielinski, W.J., R.L. Truex, G.A. Schmidt, F.V. Schlexer, K.N. Schmidt and R.H. Barrett. 2004a. Home

858 range characteristics of fishers in California. Journal of Mammalogy 85(4):649-657.

859 Zielinski, W. J., R. L. Truex, G. A. Schmidt, F. V. Schlexer, K. N. Schmidt, and R. H. Barrett. 2004b.

860 Resting habitat selection by fishers in California. Journal of Wildlife Management 68:475-492

861 Zielinski, W.J., N.P. Duncan, E.C. Farmer, R.L. Truex, A.P. Clevenger and R.H. Barrett. 1999. Diet of

862 fishers (*Martes pennanti*) at the southernmost extent of their range. Journal of Mammalogy

863 80:961-971.

864

864

865 Table 1. Environmental variables and sources of data used to evaluate landscape-scale habitat
 866 selection by fishers on the Olympic Peninsula, Washington. We assessed each variable within
 867 established core areas (50% utilization contour) of fishers and in pseudo core areas.

Variable	Definition	Data source ^a
Canopy cover	Mean pixel value (%) for percent canopy cover of all live trees	LEMMA – CANCOV
Mean QMDA	Mean pixel value (cm) for QMDA of all dominant and co-dominant trees, an index of relative abundance of large woody structures (e.g., large snags, cavity trees, and logs).	LEMMA – QMDA_DOM
Small tree class ^b	% of pixels with CANCOV >40% and QMDA_DOM <25 cm	LEMMA –STRUCCOND 3
Mid-sized tree class ^c	% of pixels with CANCOV >40% and QMDA_DOM of 25-50 cm	LEMMA –STRUCCOND 4
Mid-sized to large tree class	% of pixels with CANCOV >40% and QMDA_DOM ≥25 cm	LEMMA –STRUCCOND 4, 5, or 6
Large tree class	% of pixels with CANCOV >40% and QMDA_DOM >50 cm	LEMMA –STRUCCOND 5 or 6
Mean elevation	Mean elevation (m) of the pixels	USGS 10-meter digital elevation models
Natural open area ^d	% of pixels that are classified as natural open area	National Landcover Database (2006) ^e
Managed open area ^d	% of pixels within a contour that are classified as human-managed open area	National Landcover Database (2006) ^e
Patch density	Number of patches/km ² where patches were groupings of contiguous pixels of sparse/open forest (STRUCCOND 1, 2 combined), small tree class (STRUCCOND 3), and mid-sized to large tree class (STRUCCOND 4-6combined)	LEMMA – STRUCCOND
Paved roads ^f	% of pixels classified as a paved road	Washington Department of Natural Resources, Transportation data: using the

---

^aLEMMA is the Landscape Ecology, Modeling, Mapping & Analysis project of the U.S. Forest Service and Oregon State University (<http://www.fsl.orst.edu/lemma/>; accessed 15.02.16) CANCOV is canopy cover; QMDA_DOM is Quadratic mean diameter of dominant trees; STRUCCOND refers to structure condition classes; ROAD_SUR_TY refers to road surface classification.

^bThe small tree class was composed of both early-seral regenerating forests at low elevations and in older subalpine forests at higher elevations. Overstory trees are defined as the dominant and co-dominant trees within a stand, or the evaluated pixel.

^cThe mid-sized tree class was composed primarily of mid-seral, even-aged stands resulting from forest harvesting outside of Olympic National Park, as well as considerably older forests that regenerated following wildfires at higher elevations, primarily within Olympic National Park and Olympic National Forest.

^dNatural open areas included open water, perennial snow/ice, barren land, shrub/scrub and, herbaceous vegetation (including seral stages resulting from clear-cut logging), and wetlands, and where managed open areas included developed open space, low to high intensity developed areas, hay/pasture, cultivated crop fields.

^eNational Landcover Database (2006) data was available at: <http://www.mrlc.gov/nlcd2006.php> (accessed 15.02.16)

^fPaved road data from Washington Department of Natural Resources was available at: <http://www.dnr.wa.gov/GIS/>; accessed 18.02.16).

883

884 Table 2. Hypotheses, corresponding *apriori* models, and predicted responses for evaluating
 885 landscape-scale selection of male and female fishers on the Olympic Peninsula, Washington.
 886 Landscape-scale habitat selection is based on comparisons of used core areas with pseudo core
 887 areas within the study area. Model predictions (in parenthesis) for habitat hypotheses reflect the
 888 expectation of selection (+) or avoidance (–) for both sexes. Model predictions for sex-based
 889 differences reflect the expectation for greater selection (+) or avoidance (–) by females relative to
 890 males.

Hypotheses	Models ^a	Reference(s)
Habitat: Fishers will select core areas encompassing the following characteristics:		
Canopy cover: moderate to dense forest cover	1) Canopy cover (+)	Carroll et al., 1999, Zielinski et al., 2004a
Large-diameter woody structures: For example, cavity trees, snags, large logs	2) QMDA of all dominant and co-dominant trees (+)	Purcell et al., 2009, Weir et al., 2012
Forest structure class: primarily mid-sized or large tree classes	3) Large tree class (+)	Jones and Garton, 1994, Zielinski et al., 2004a
	4) Mid-sized to large tree class (+)	
	5) Mid-sized tree class (+)	
	6) Small tree class (–)	
Elevation: low or mid-elevations	7-12) by adding “elevation” to models 1-6 above (–)	Buskirk and Powell, 1994, Raley et al., 2012
Forest openings: low amounts of open-canopied habitat	13) Natural open areas (–)	Weir and Corbould, 2010; Sauder and Rachlow, 2014
	14) Managed open areas (–)	
	15) Natural + managed open areas (–)	

Forest fragmentation: low patch densities	16) Patch Density (–)	Weir and Harestad, 1997, Thompson et al., 2011
Paved roads/vehicle traffic: low percentage of paved roads	17) Paved roads (–)	Naney et al., 2012
Sex: Females will be more selective of habitats than males. Core areas of females will differ from those of males.	1-16) (+/–, above, refers to female selection pattern relative to males)	

---

^a Variables included in these models are defined in Table 1.

897

898 Table 3. Mean values and standard errors (SE) of landscape variables within used and pseudo
 899 core areas of female and male fishers on the Olympic Peninsula, Washington, 2008 to 2011. All
 900 variables are defined in Table 1.

Variables	Females				Males			
	Used		Pseudo		Used		Pseudo	
	(n=19)		(n=950)		(n=12)		(n=600)	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE
% canopy cover	71.84	1.88	69.94	0.25	66.13	1.87	68.87	0.22
Mean QMDA (cm)	34.74	1.35	36.34	0.29	30.00	1.78	33.37	0.29
% small tree class	20.37	3.67	19.63	0.50	32.49	3.45	24.98	0.66
% mid-sized tree class	42.91	3.03	29.97	0.49	31.93	2.59	30.94	0.53
% mid-sized to large tree class	68.35	4.29	63.09	0.73	50.20	4.99	56.66	0.90
% large tree class	25.43	3.28	33.12	0.85	18.28	3.76	25.73	0.97
Mean elevation (m)	811	106	642	13	565	168	517	16
% natural open area	12.23	2.26	20.68	0.58	25.90	3.38	23.53	0.63
% managed open area	3.04	1.77	3.47	0.30	3.23	0.88	3.74	0.30
Patch density (patches/km ²)	6.03	0.64	6.39	0.14	7.99	0.55	6.41	0.12
% paved roads	0.32	0.15	0.43	0.04	0.58	0.17	0.47	0.04

901

902

Table 4. The 95% model set (based on cumulative w_i) used to examine landscape-scale habitat selection by fishers on the Olympic Peninsula, Washington, 2008-2011. Model evaluations were based on data from used and pseudo core areas for 19 female and 12 male fishers. Odds ratios were provided for highly supported models (i.e., $\Delta AIC_c < 2.0$)

Model	Odds	Odds	K	AIC _c	ΔAIC _c	w _i
	Ratio	Ratio				
<u>Females</u>						
Mid-sized tree class + elevation	1.079 ^a	1.002 ^a	4	131.164	0.000	0.960
<u>Males</u>						
QMDA + elevation	0.864 ^a	1.001	4	92.052	0.000	0.200
Patch density	1.200		3	93.043	0.991	0.122
Small tree class + elevation	1.052 ^a	1.001	4	93.120	1.068	0.117
QMDA	0.926		3	93.466	1.414	0.099
Canopy cover	0.925		3	93.754	1.702	0.086
Small tree class	1.026		3	94.030	1.978	0.075
Null			2	94.371	2.319	0.059
Canopy cover + elevation			4	94.821	2.769	0.050
Large tree class			3	95.057	3.005	0.045
Mid-sized to large tree class			3	95.385	3.333	0.038
Large tree class + elevation			4	95.844	3.792	0.030
Natural open			3	96.108	4.056	0.026
Paved roads			3	96.265	4.213	0.024
Mid-sized tree class			3	96.315	4.263	0.024
Managed open			3	96.316	4.264	0.024

^aThe 95% confidence interval for this odds ratio did not include 1.

Table 5. The 95% model set (based on cumulative w_i) used to distinguish landscape characteristics of core areas used by 19 female and 12 male fishers on the Olympic Peninsula, Washington, 2008-2011. Odds ratios were provided for highly supported models (i.e., $\Delta AIC_c < 2.0$)

Model	Odds Ratio	Odds Ratio	K	AIC_c	ΔAIC_c	w_i
	Variable 1	Variable 2				
Natural open	0.894 ^a		3	35.794	0.000	0.461
Natural open + managed open			4	38.231	2.437	0.136
Mid-sized to large tree class			3	39.338	3.544	0.078
Mid-sized tree class			3	39.382	3.588	0.077
Mid-sized tree class + elevation			4	40.101	4.307	0.054
Small tree class			3	41.096	5.302	0.033
Patch density			3	41.378	5.584	0.028
QMDA			3	41.448	5.654	0.027
Mid-sized to large tree class + elevation			4	41.637	5.843	0.025
Canopy cover			3	41.818	6.024	0.023
Canopy cover + elevation			4	43.337	7.543	0.011

^aThe 95% confidence interval for this odds ratio did not include 1.

Figure headings

Figure 1. Study area and land ownerships on the Olympic Peninsula, Washington, where fishers were reintroduced and monitored using aerial and ground-based telemetry from 2008 to 2011. Stars indicate general areas where fishers were released.

Figure 2. Spatial distribution of core areas (50% utilization distributions) of reintroduced male and female fishers on the Olympic Peninsula, Washington, from 2008 to 2011. Olympic National Park is delineated by the black line; Olympic National Forest is adjacent to the park and is delineated by the dashed white line.

Figure 3. Relative probability of female use of core areas based on the percentage of forest with an overstory of mid-sized trees and mean elevation (the best model for explaining female selection of core areas) for the range of values found within pseudo core areas. Probability calculations are relative because no intercept values are produced in conditional logistic regression for calculating a true probability.

Figure 4. Relative probability of male use of core areas based on the mean QMDA and mean elevation for the range of values found within pseudo core areas. Relative probability predictions were determined from model-averaging predicted outcomes of models that comprised 95% of cumulative model weights (w_i). We used median values for all variables in models except elevation and QMDA. Probability calculations are relative because no intercept values are produced in conditional logistic regression for calculating a true probability.

Figure 5. Predicted probability of female versus male use of a core area in relation to the percentage of natural open area and the percentage of large and medium-sized trees. Probability predictions were determined from model-averaging predicted outcomes of models that comprised 95% of cumulative model weights (w_i). We used median values for all variables in models except % natural openings and % mid-sized and large trees.

Figure 1.

Figure 2.

Figure 3.

992   Figure 4.

993

994

995

996

997

998

999

1000

1001

1002

1003

1004

1005

1006   Figure 5.

1007