Habitat Modeling Methods for the Fisher West Coast Distinct Population Segment Species Assessment

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This document describes the methods used to create the fisher habitat models for the Endangered Species Act listing evaluation status assessment for the West Coast distinct population segment (DPS) for fisher. The model information is useful to understand habitat value and distribution, habitat connectivity, and population distribution maps under current conditions.

Introduction

An Interagency Biology Team composed of nearly 20 representatives of wildlife and land management agencies and native tribes in the western U.S. and Canada (Lofroth et al. 2010, p. iii) was convened in 2005 and tasked with developing a comprehensive Conservation Strategy for the West Coast distinct population segment (DPS) of fishers (*Pekania pennanti*) in California, Oregon, and Washington, as well as adjacent areas in south-central British Columbia. This region, however, lacked comprehensive and accurate maps of fisher habitat value and connectivity that the team could use as decision-support models to assess likely effects of threats such as climate change, changing fire regimes, forest management, and other factors on fisher. As part of the species status assessment underway for the federal Endangered Species Act listing evaluation by the U.S. Fish and Wildlife Service, likely effects of threats were needed. Therefore, two models, a fitted Maxent model by the Conservation Biology Institute (CBI) and an expert model, were utilized to inform the scientific status assessment.

The fisher species assessment analysis area encompasses a range of ecoregions within the historical range of the West Coast DPS, and the availability of fisher location data varies widely between ecoregions. Therefore, in order to address data gaps and increase accuracy of ecological associations, the authors divided the analysis area into several modeling regions and used different modeling methods as appropriate in each region. Model inputs consisted of verified fisher detection locations (where available) and between four and eight environmental data layers, depending on modeling region. Model output consisted of a number between 0 and 1 representing habitat quality, which was then classified into "low quality," "intermediate quality," and "high quality" habitat. (Note that "low quality" habitat also includes non-habitat.)

Modeling regions

The study area was subdivided into 9 modeling regions (Figure 1), based on ecoregional subsection divisions; the Merced River, which divides the currently occupied and unoccupied portions of the Sierra

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Nevada; Interstate 5, a convenient dividing line running through mostly unsuitable habitat in the valleys between areas of potentially suitable habitat in the Cascades and the Coast Ranges; and measures of environmental similarity. Initially, Maxent was used to produce habitat models throughout all 9 modeling regions. However, for the Western Cascades, Eastern Cascades, and Olympic Mountains, the final model output comes only from the expert model. In the remaining subregions, the final model output was generated using Maxent.

Model types used in each modeling region

In the three regions containing verified fisher detection locations (Southern Sierra Nevada, Klamath – Southern Cascades, and California Coast Range), models were fitted to the fisher data using Maxent. On the Washington and Oregon Coast and in the Northern Sierra Nevada, where verified fisher detection data were lacking and environmental conditions were similar to those in neighboring regions with fitted Maxent models, those models were projected into the region lacking fisher data. In the California Coast and Klamath overlap region and the Northern Sierra Nevada, models from the neighboring regions were combined using distance weighted averaging to account for geographic variation across the landscape, such as coastal to inland or north to south climate gradients. Projections were not used in the Western Cascades, Eastern Cascades, or Olympic Mountains, because the differences in environmental conditions between these regions and the neighboring regions were so great that they introduced large uncertainties in the statistical projections. The results of projections in these three regions were at odds with expert input of biologists familiar with potential fisher habitat suitability in the Cascades and Olympic regions. Instead, an expert model was constructed for these regions.

Model fitting using Maxent

Occurrence Data

Over 5,000 fisher detections and over 12,000 non-detections from the early 1900s through 2013 were submitted by 29 individuals from tribal, state and federal agencies, universities, non-profit organizations, and private companies. Not all the detections and non-detections were independent; some were reported in multiple submissions. Maxent uses only detection data, so submitted detections were compiled and filtered to create a set of independent detections for modeling. Fisher detection points were filtered by removing non-verified detections (no physical evidence to verify fisher identification), detections prior to 1970, detections of translocated animals, and telemetry detections. Remaining localities were further filtered to ensure spatial independence by using a minimum nearest-neighbor distance of 5 km. If two or more detections were within 5 km of one another, the most reliable and recent was retained, or in case of a tie, by random selection. A total of 456 detections remained after filtering for model calibration, with 72 from the Southern Sierra Nevada, 185 from the Klamath and Southern Cascades, and 199 from the California and Southern Oregon Coast.

Predictors

An array of 22 potential environmental predictor layers was created including vegetation, climate, elevation, terrain, and Landsat-derived reflectance variables at 30-m and 1-km resolutions (Table 1). Environmental variables were averaged over a 10-km^2 moving window and then resampled to 90 m. Urban and open water land covers were masked out. Predictor correlation (defined as $|r| \geq 0.7$) was tested for each model calibration region using ENMTools 1.3 (Warren et al. 2010, entire).

Variable Selection and Model Construction

Maxent was run separately on the three calibration regions, using 10-fold cross validation, logistic output, and default settings, initially using all 22 environmental predictors. Next, correlated variables ($|r| \geq 0.7$) were eliminated by retaining the one that yielded the maximum decrease in training gain when excluded from the model. Then variables that provided the minimum decrease in training gain when excluded were systematically removed using a stepwise procedure until obtaining a model with the fewest predictors having an average training gain not significantly different than the full model. Significance was defined as lack of overlap between 95% confidence intervals for training gain averages (calculated in R version 2.15.3; R Core Team 2013). In areas of overlap, regional models were combined using distance-weighted averaging.

Classification of low, intermediate, and high quality habitat

Modeled habitat was classified as low quality, intermediate quality, or high quality habitat based on strength of selection curves (Hirzel et al. 2006, p. 144). Habitat was considered to be low quality if habitat with equal or lower value was used at a rate at least 1.5 times less than would be expected based on habitat availability. Habitat was considered to be high quality if habitat with equal or higher value was used at a rate at least 1.5 times greater than expected based on availability. Intermediate quality habitat was used at approximately the same rate as expected based on availability. The model output values corresponding with these points on the strength-of-selection curves varied between regions, so habitat was classified separately in each region. In the Coast Range and Klamath overlap region, distance-weighted averaging was applied to the classification thresholds as it was to the model output.

Projections to regions lacking verified fisher data

The model from the California Coast Range was projected to the Oregon and Washington Coast Ranges. Model output was then classified using the strength-of-selection values from the California Coast Range. In the Northern Sierra Nevada, the models from the Southern Sierra Nevada and the Klamath – Southern Cascades were combined using distance-weighted averaging, similar to that used for the overlap between the Klamath – Southern Cascades and California Coast Range, both for the model output and for the classification thresholds.

Expert model

Expert model process

To predict fisher habitat suitability in the Olympic Mountains and the Oregon and Washington Cascades, we used an expert modeling process. First, we thoroughly reviewed the fisher literature for previous models and other habitat association studies from adjacent regions (California, British Columbia, and Northern Rocky Mountains). From the literature, we made a list of variables for which data layers were available for Washington and Oregon, and categorized them based on which functional aspects of fisher habitat use they represented (Table 2). We then gathered input regarding this list of variables from ten fisher experts (see acknowledgements), who commented on the importance and functional relationship of each variable to fisher habitat. Some of the experts also proposed additional variables that they thought were important to fisher habitat.

We used the experts' input, as well as our own expert knowledge of fisher biology, of relationships among environmental variables, and of habitat models, to select our final list of variables and data sources. The selected variables were dense forest, old-growth structure index, tasseled-cap greenness, a prey availability index, a "fluffy snow" variable combining winter temperature and precipitation as snow, and land cover types identifying non-forested areas (Table 3).

<u>Creation of data layers</u>

Data layers were readily available for dense forest, old-growth structure index, and land cover types, and a tasseled-cap greenness layer had already been created for the Maxent models (see Table 1). These variables were sampled on a 30 m grid. Except for land cover types, these variables were then averaged over a 10-km^2 moving window. We prepared additional layers for prey index and snow conditions.

<u>Prey index</u>

Prey data layers for Washington (Johnson et al. 1997; Smith et al. 1997) were downloaded from the Washington Department of Fish and Wildlife GAP analysis website. For Oregon, we obtained the data layers used to create the habitat maps shown on the Oregon Wildlife Explorer webpage (OSU 2013, website; Bernert 2013, pers. comm.)

We included in our prey index (Table 4) all species that met the following criteria: (1) The species was a mammal or a bird of the order Galliformes. (2) The species belonged to a genus or larger group that was present in at least 5% of fisher scats and/or intestinal tracts examined in the studies listed in Lofroth et al. 2010 (pp. 161-163), and/or in any of the 4 study areas described by Golightly et al. (2006, pp. 16-22). One species, mountain beaver (*Aplodontia rufa*), did not fit this criterion but were included because fishers reintroduced to the Olympic Peninsula have been observed to prey on mountain beavers (Lewis 2013, pers. comm.). (3) The species had an average mass greater than 10 g. (4) The species was present in either Oregon or Washington, or both, and current habitat map data were available for the species. In one case (water shrew, *Sorex palustris*) , only historical habitat map data were available. However, based on the images shown on the Oregon Explorer website, the current and historical habitat appear to be very similar in extent, if not in quality, so we included the historical habitat data in place of the current data.

Habitat maps from Washington divided habitat into three categories for each species: core, peripheral, and non-habitat. Habitat maps from Oregon divided habitat into four categories for each species: good, fair, poor, and non-habitat. In each case, we maintained the non-habitat classifications, and reclassified all other categories (core, peripheral, good, fair, or poor) into one habitat category.

We obtained masses from each species from the following reference books and online reference databases: (Jameson and Peeters 2004, pp. 116-365; Nowak 1999, pp. 1297, 1460, 1466; Myers et al. 2013, website; Costello and Rosenberger 2013, website; Sibley 2003, pp. 122-132). When a source gave an average mass for the species, this was the value we used. If the source gave a range but no average, we used the midpoint between the minimum and maximum. If the source gave a single value for each sex, we used the midpoint between the two sexes' masses. If the source gave a range for each sex, we used the value midway between the minimum for the small sex and the maximum for the large sex. We divided the species list into quartiles by mass: 50 g or less, 50-250 g, 250-850 g, and 850 g or more.

In order to calculate the prey index for a given pixel, we determined which species had habitat present at that pixel. The index was calculated as a count of the number of species for which habitat was present, weighted by quartile. Each species in the lightest quartile was worth one point, the lower middle quartile species were worth two points, the upper middle quartile species were worth three points, and those in the heaviest quartile were worth four points. These points were added up to give the index for each pixel. The pixel values were the averaged over a 10-km^2 moving window.

<u>Snow layer</u>

Precipitation as snow and mean winter temperature data for the period from 1991 to 2010 were extracted using ClimateWNA (Wang et al. 2013, software). Climate data were sampled on a 450 m grid, except for on the Olympic peninsula, where the data were sampled on a 180 m grid. Sites with average winter temperature < 0 °C and with 225 mm precipitation as snow (PAS) are likely to have enough fluffy snow that fishers' movements may be impeded or it may be difficult to find prey (Iredale *et al.* 2012, pp. 10-11, 15, 19; Weir 2013, pers. comm.). In the Olympic Mountains, these thresholds identified as non-habitat many areas where fishers have been observed. After examining the fisher locations as portrayed in reports of the Olympic National Park fisher reintroduction (Lewis et al. 2010, pp. 10, 14; Lewis et al. 2011, pp. 9, 13; Lewis et al. 2012, pp. 6, 10), we adjusted the temperature threshold to -1 °C mean winter temperature for the Olympic peninsula only.

Non-habitat masking

Some variables appeared in the model as binary variables (presence/absence or a threshold) to distinguish possible habitat from definite non-habitat. Non-forested land cover types (generally defined as areas not capable of supporting at least 10% tree cover; see Appendix A) were assumed be non-habitat and received a model value of 0. At sites that exceeded the snow and temperature thresholds described above, the habitat was assigned a model value of 0. If the prey diversity index indicated that there were either no large prey species, or only a small number of any species present (prey index <16), we assumed that fishers would not be able to support themselves and the habitat was assigned a value of 0.

Logistic model

The remaining variables appeared in the model as continuous variables in a logistic equation. These variables were canopy cover, old growth structure index, tasseled-cap greenness, and prey index (for all sites with prey index > 16). For each variable, the logistic model contained two parameters: one to center the variable and another to weight it relative to the other variables. There were two additional parameters adjusting the entire equation: an intercept, which allows the average value across the range to be adjusted up or down; and a smoothing parameter, which controls the steepness of the curve, and therefore the sharpness of the contrast between low-quality habitat and high-quality habitat. The centering parameters for canopy cover and tasseled-cap greenness were derived from statistically fitted models of fisher habitat in California that used the same variables. The centering parameters for old growth structure index and for the prey index were chosen based on our best judgement and were adjusted during our evaluation of preliminary models. Weighting parameters were chosen based on the relative ranks of related variables in our survey of fisher experts, and were adjusted during evaluation of preliminary models. The intercept and smoothing parameter were chosen in order to best match the Maxent model in the areas where the two models overlapped. Model output was classified into three categories, with the classification thresholds chosen to best match the categorized Maxent models. Choosing the intercept, smoothing, and classification parameters to match the Maxent models allowed for a reasonably smooth transition between one modeling region and another. Because the input layers for the expert model covered the entire analysis area within Oregon and Washington, the output also covered the whole Oregon and Washington portions of the analysis area. However, the expert model was only used in those modeling regions that were too environmentally different from areas with fitted models for those fitted models to be usefully projected.

Combined model output

The Maxent and expert models were combined into one habitat model layer (Figure 2). This layer was used in the draft species assessment report of stressors affecting fishers in the West Coast DPS. See the Draft Species Report (USFWS 2014) for these analyses.

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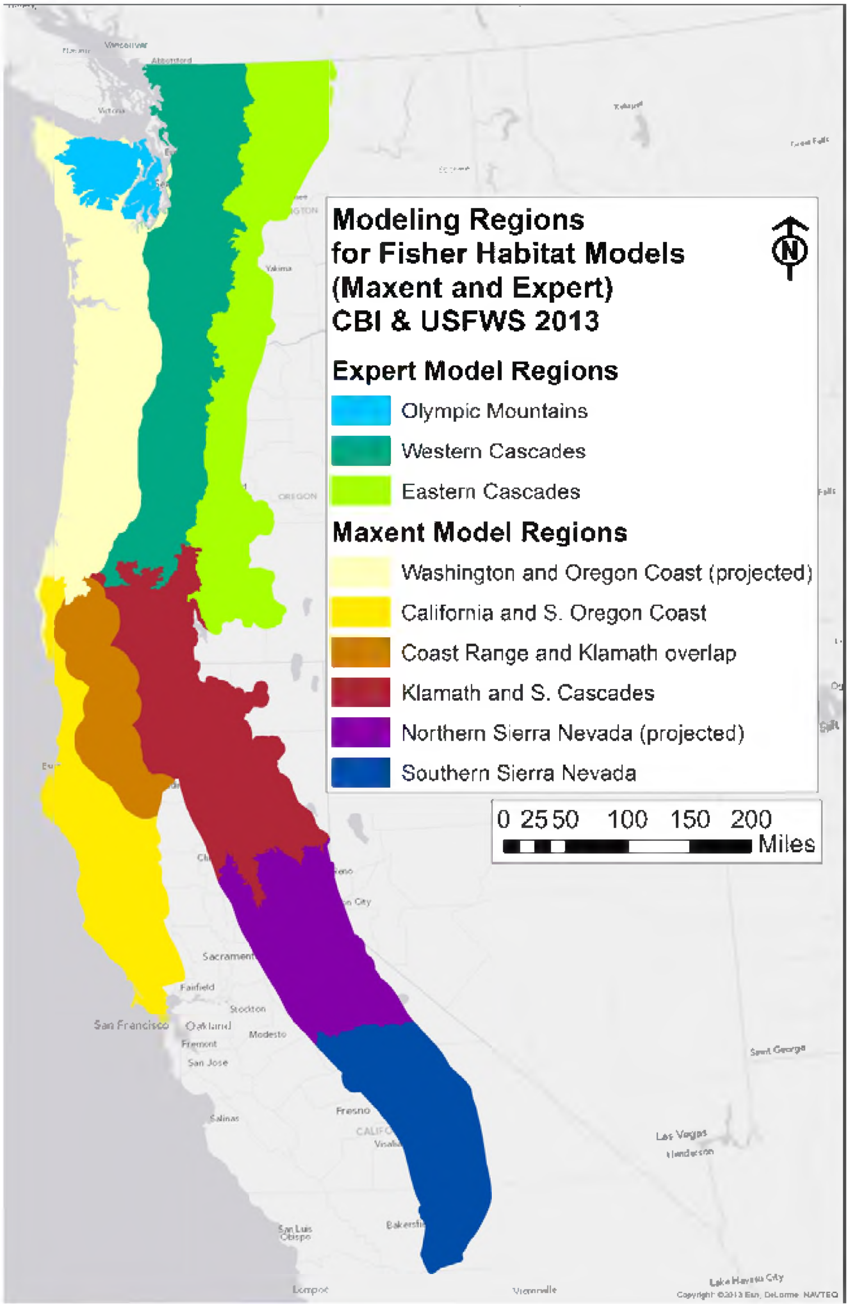

Figure 1. Modeling regions

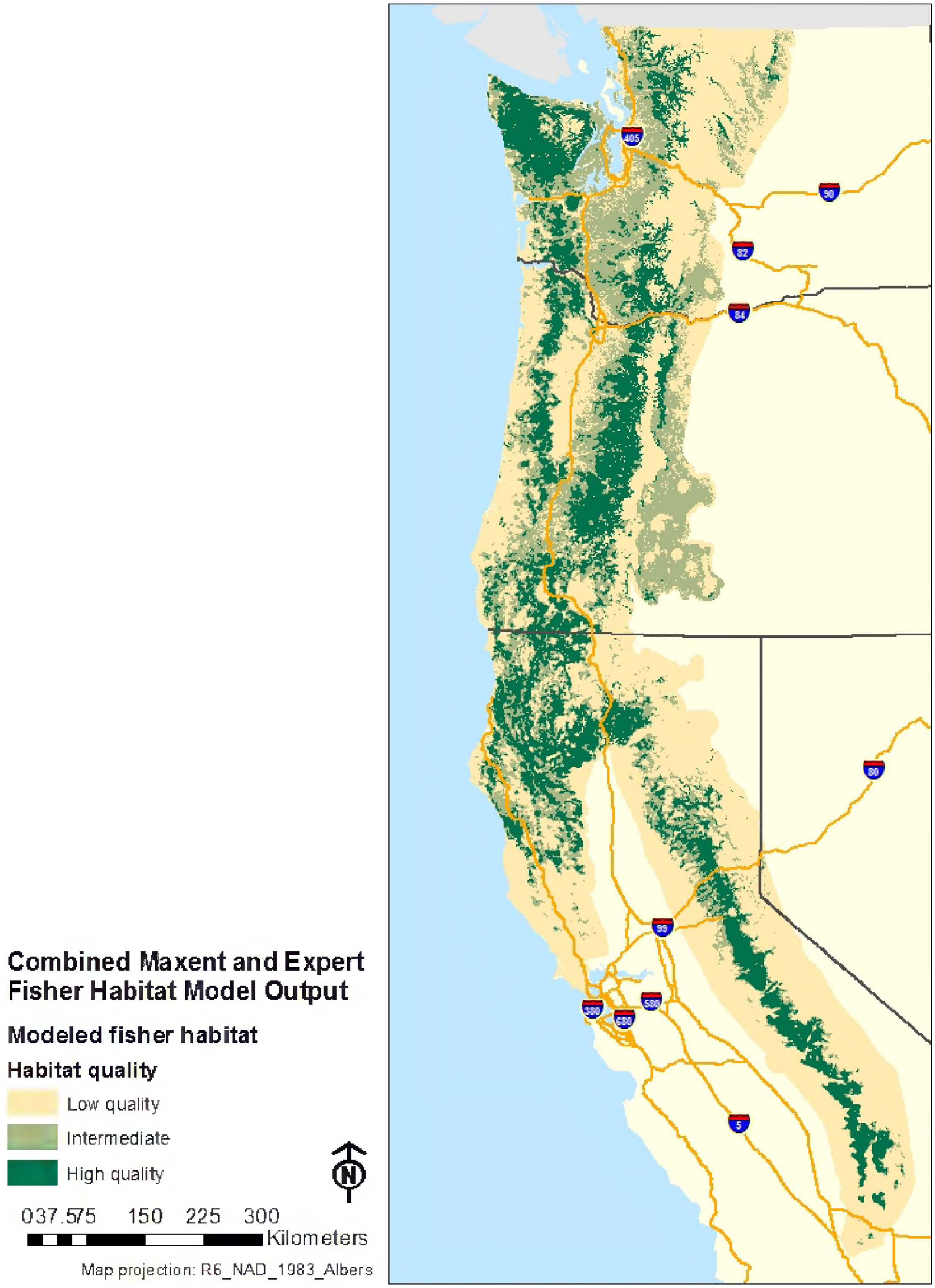

Figure 2. Combined model output

Table 1. Environmental predictors tested for Maxent models

Predictor	Citation	Resolution	Time Period	Source
Mean diurnal range (Mean of monthly (max temp - min temp)); °C * 10	Hijmans et al. 2005	30 arc second (~ 1 km^2)	1960-1990	http://www.worldclim.org/current
Isothermality ((Mean diurnal range / temperature annual range) * 100); °C * 10	Hijmans et al. 2005	30 arc second (~ 1 km^2)	1960-1990	http://www.worldclim.org/current
Max temp warmest month; °C * 10	Hijmans et al. 2005	30 arc second (~ 1 km^2)	1960-1990	http://www.worldclim.org/current
Min temp coldest month; °C * 10	Hijmans et al. 2005	30 arc second (~ 1 km^2)	1960-1990	http://www.worldclim.org/current
Mean temp coldest quarter, °C * 10	Hijmans et al. 2005	30 arc second (~ 1 km^2)	1960-1990	http://www.worldclim.org/current
Annual precipitation, (mm)	Hijmans et al. 2005	30 arc second (~ 1 km^2)	1960-1990	http://www.worldclim.org/current
Precipitation coldest quarter, (mm)	Hijmans et al. 2005	30 arc second (~ 1 km^2)	1960-1990	http://www.worldclim.org/current
Temperature seasonality, (standard deviation * 100)	Hijmans et al. 2005	30 arc second (~ 1 km^2)	1960-1990	http://www.worldclim.org/current
Slope, %	USGS 2009	1 arc second (~ 30 m)		http://viewer.nationalmap.gov/viewer/
Latitude-adjusted elevation (0.625m added to elevation for every km north from southernmost point in study area)	USGS 2009; Davis et al. 2007	1 arc second (~ 30 m)		http://viewer.nationalmap.gov/viewer/
Local relief, (standard deviation of elevation in 5x5 moving window)	USGS 2009; Davis et al. 2007	1 arc second (~ 30 m)		http://viewer.nationalmap.gov/viewer/
Ruggedness, (vector ruggedness measure, calculated in 5x5 moving window)	USGS 2009; Sappington et al. 2007	1 arc second (~ 30 m)		http://viewer.nationalmap.gov/viewer/
Insolation (solar insolation index, s = 2 – (sin((slope/90)180))* (cos(22 – aspect) + 1)	USGS 2009; Gustafson et al. 2003	1 arc second (~ 30 m)		http://viewer.nationalmap.gov/viewer/
Biomass (aboveground live dry biomass); kg/m^2 * 10.	Kellndorfer et al. 2000	30 m	2000	http://daac.ornl.gov/cgi-bin/dsviewer.pl?ds_id=1081

Predictor	Citation	Resolution	Time Period	Source
Canopy height (basal area-weighted canopy height, weights contribution of trees to stand height by their basal area); m * 10	Kellndorfer et al. 2000	30 m	2000	http://daac.ornl.gov/cgi-bin/dsviewer.pl?ds_id=1081
Conifer forest, % of 10 km^2 moving window classed as conifer forest	USGS 2010	30 m	2008	http://landfire.cr.usgs.gov/viewer/viewer.html
Mixed forest, % of 10 km^2 moving window classed as mixed conifer-hardwood forest	USGS 2010	30 m	2008	http://landfire.cr.usgs.gov/viewer/viewer.html
Dense forest , % of 10 km^2 moving window classed as forest with $\geq$ 60% canopy cover	USGS 2010	30 m	2008	http://landfire.cr.usgs.gov/viewer/viewer.html
Hardwood forest, % of 10 km^2 moving window classed as hardwood forest	USGS 2010	30 m	2008	http://landfire.cr.usgs.gov/viewer/viewer.html
Forest Stand Age	Pan et al. 2012	1 km	2006	http://daac.ornl.gov
Tasseled cap greenness (transformation to condense Landsat spectral data into component associated with vegetation characteristics).	Crist 1985; Huang 2002; Masek et al. 2006; USGS 2013; CBI 2013a	30 m	2000	Derived from Landsat Ecosystem Disturbance Adaptive Processing System (LEDAPS) Landsat-7 ETM+ data products freely available through the USGS EarthExplorer website, http://earthexplorer.usgs.gov/, using Landsat Climate Data Record (CDR) surface reflectance data circa 2000 with minimal cloud contamination
Tasseled cap wetness (transformation to condense Landsat spectral data into component associated with vegetation characteristics).	Crist 1985; Huang 2002; Masek et al. 2006; USGS 2013; CBI 2013b	30 m	2000	Derived from Landsat Ecosystem Disturbance Adaptive Processing System (LEDAPS) Landsat-7 ETM+ data products freely available through the USGS EarthExplorer website, http://earthexplorer.usgs.gov/, using Landsat Climate Data Record (CDR) surface reflectance data circa 2000 with minimal cloud contamination

Table 2 Environmental predictors considered for expert model

Variable	Measures used in previous studies	Citations
Biotic variables		
Dense forest	Percent of area with canopy cover >60%	Maxent models (this document)
		Zielinski and Yaeger, unpublished models
		Davis et al. 2007, pp. 2198-2208
	Canopy cover	Zielinski et al. 2012, pp. 38-40
	Crown closure	Iredale et al. 2012, pp. 9-12
	Canopy closure moving average	Carroll et al. 1999, pp. 1348-1357
		Carroll 2005, pp. 3-8
Tree size or age	Basal area-weighted canopy height	Maxent models (this document)
	Coniferous canopy height	Iredale et al. 2012, pp. 11-12
	Quadratic mean diameter	Iredale et al. 2012, pp. 9-10
		Carroll et al. 1999, pp. 1348-1355
	Size class of stands	Carroll 2005, pp. 3-5
		Zielinski et al. 2010, pp. 1582, 1585
		Spencer et al. 2007, pp. vi-24
	Mean age of dominant conifer trees	Zielinski et al. 2012, pp. 38-40
	Maximum forest age	Spencer et al. 2007, pp. vi-41
		Spencer et al. 2008, pp. 34-119
	Stand age	Iredale et al. 2012, pp. 9-10
		Jones and Garton 1994, pp. 379-383
Conifer forest	Percent of area with conifer forest	Maxent models (this document)
		Carroll et al. 1999, pp. 1348-1355
		Carroll 2005, pp. 3-7
	Mixed conifer, spruce, subalpine fir, or cedar-hemlock stands	Davis 2003, pp. 12-14
		Roy 1991, pp. 43-61, 82
Hardwood component	Percent area in mixed conifer-hardwood	Maxent models (this document)
	Proportion of area with hardwood forest	Zielinski et al. 2010, pp. 1583-1587
		Zielinski and Yaeger, unpublished models
		Spencer et al. 2007, pp. iv-17
	Hardwood stands	Roy 1991, pp. 42-82
	Proportion of area in large size class hardwood stands	Spencer et al. 2008, pp. xvi-37
	Hardwood basal area	Zielinski et al. 2012, pp. 38-40
	Biomass of black oak	Spencer et al. 2008, pp. 43-58
	Presence of cottonwood or aspen stands	Iredale et al. 2012, pp. 9, 12
		Davis 2003, pp. 12-14
	Deciduous percentage (check wording)	Iredale et al. 2012, p. 12
	Montane hardwood or montane hardwood-conifer rating	Davis et al. 2007, pp. 2198-2208
Landscape diversity	Shannon Diversity Index	Zielinski and Yaeger, unpublished models

Variable	Measures used in previous studies	Citations
Decadence	Coarse woody debris	Davis 2003, pp. 12-14
	Size of largest conifer snag	Zielinski et al. 2012, pp. 38-40
	Density of large snags	Zielinski et al. 2012, pp. 38-40
	Tree species' relative probabilities of producing a den cavity	Iredale et al. 2012, p. 9
	Structurally complex forest (compound variable)	Zielinski et al. 2010, pp. 1583-1587
		Davis et al. 2007, pp. 2198-2207
Primary productivity	Basal area	Zielinski et al. 2012, pp. 38-40
	Biomass	Spencer et al. 2007, pp. iv-41
		Spencer et al. 2008, pp. xvi-37
	Aboveground live dry biomass	Maxent models (this document)
	Biomass excluding red fir	Spencer et al. 2007, pp. vi-41
	Tasseled-cap greenness	Maxent models (this document)
Prey availability	Habitat suitability for mammalian prey	Zielinski et al. 2010, pp. 1582-1587
		Zielinski and Yaeger, unpublished models
		Iredale et al. 2012, pp. 11-12
	Habitat suitability for ruffed grouse	Iredale et al. 2012, p. 12
Abiotic variables		
Precipitation	Annual precipitation	Spencer et al. 2007, pp. vi-20
		Spencer et al. 2008, pp. ix-47
		Carroll et al. 1999, pp. 1348-1356
		Carroll 2005, pp. 3-7
		Davis et al. 2007, pp. 2198-2208
	Precipitation as snow	Iredale et al. 2012, pp. 9-19
Winter temperature	Minimum temperature of coldest month	Maxent models (this document)
	Mean temperature of coldest quarter	Maxent models (this document)
	Maximum winter temperature	Iredale et al. 2012, pp. 9-12
Summer temperature	Maximum temperature of warmest month	Maxent models (this document)
Temperature stability	Isothermality	Maxent models (this document)
	Mean diurnal temperature range	Maxent models (this document)
Elevation	Latitude-adjusted elevation	Zielinski et al. 2010, pp. 1582-1587
		Spencer et al. 2008, pp. ix-43
		Spencer et al. 2007, pp. iv-41
		Davis et al. 2007, pp. 2198-2208
Sun exposure	Insolation index	Zielinski et al. 2010, pp. 1582-1587
		Spencer et al. 2008, pp. xix-43
		Spencer et al. 2007, pp. iv-41
		Zielinski and Yaeger, unpublished models
Ruggedness	Percent slope	Maxent models (this document)
		Zielinski et al. 2012, pp. 38-40
		Davis 2003, pp. 12-14
	Relief (standard deviation of elevation)	Davis et al. 2007, pp. 2198-2207
		Zielinski and Yaeger, unpublished models
	Terrain ruggedness index (average elevation difference between a cell and its neighbors)	Carroll 2005, pp. 3-7

Interactions		**Citation**
Canopy closure and percent conifer		Carroll et al. 1999, pp. 1350-1353
		Carroll 2005, p. 6
Tree size and annual precipitation		Carroll et al. 1999, pp. 1350-1356
		Carroll 2005, p. 6
Winter temperature and percent conifer		Maxent models (this document)
Winter temperature and summer temperature		Maxent models (this document)
Winter temperature and biomass		Maxent models (this document)

Table 3 Final variable list for expert model

Variable	Description	Explanation for inclusion	Citation for data source	Variable from data source	Form in model
Non-habitat	Land cover types that are clearly not habitat; see Appendix A for list	Some land cover types are not thought to provide fisher habitat, regardless of the value of other variables (e.g. prey habitat or primary productivity). Within the model, these locations may still contribute to the moving averages of other variables.	LEMMA 2008; LEMMA 2012	ESLF_NAME	Threshold: areas within the listed land cover categories were assigned a habitat value of 0.
Fluffy snow	Winter temperatures on average below freezing, precipitation as snow is > 225 mm	Deep, fluffy snow is likely limiting to fishers, as it is energetically costly for them to move through.	Wang et al. 2013	PAS and tave_wt (average of values 1960-2011; recent decades weighted more heavily)	Threshold: If tave_wt < 0 (tave_wt < -1 for Olympic Peninsula) and PAS > 225, habitat value is 0.
Prey diversity index	Body-mass weighted index of prey species habitat; see text and Table 4	Prey availability is clearly necessary in order to support predator populations.	Bernert 2013, pers. comm.; Johnson et al. 1997; OSU 2013; Smith et al. 1997	Composite variable; see text	Threshold and logistic: If index indicates all small body size or very low diversity, habitat value is 0. Otherwise, habitat value increases with prey diversity index.
Dense forest	Proportion of 10 km^2 neighborhood with canopy cover >60% (>40% for Eastern Cascades)	Dense forest is the variable most consistently associated with fisher habitat according to the experts and the literature.	LEMMA 2008; LEMMA 2012	cancov	Logistic: Habitat value increases with proportion of neighborhood in dense forest. The logistic form leads to a zero habitat value at low proportions and levels off at high proportions.

Variable	Description	Explanation for inclusion	Citation for data source	Variable from data source	Form in model
Decadence and tree size/age	Proportion of 10 sq km neighborhood with Old Growth Structure Index > 50.	Fisher den cavities (and often rest sites) are located in large old trees and snags. High diameter diversity and volume of large downed wood are likely to provide hiding cover for fishers.	LEMMA 2008; LEMMA 2012; Spies et al. 2007, pp. 51-52	OGSI (Incorportates tree age, density of large trees, diameter diversity, density of large snags, and volume of large downed wood. Values of 50 or greater indicate old-growth characteristics.)	Logistic: Habitat value increases with proportion of neighborhood in old growth conditions. The logistic form leads to a zero habitat value at the very lowest proportions and levels off at medium and high proportions.
Tasseled cap greenness	Derived from satellite data, gives a measure of photosynthesis. Smoothed over a 10 sq km neighborhood.	This variable is a proxy for primary productivity, which is expected to be important for fishers (as it is for many organisms). Of the measures of primary productivity we considered, tasseled cap greenness was the least correlated with the other model variables.	Crist 1985; Huang 2002; Masek et al. 2006; USGS 2013; CBI 2013a	Tasseled cap greenness	Logistic: Habitat value increases with tassel-cap greenness.

Table 4 Prey species included in prey diversity index

Name	Mass (g)	Source for mass	Weight in model	WA	OR	Notes
California quail *Callipepla californica*	170	Price (2000, p. 2)	2	x	x	Galliformes in 8.8% of BC fisher stomachs (Weir et al. 2005, p. 14)
Northern bobwhite *Colinus virginianus*	155	Chumchal (2000, p. 2)	2	x		Galliformes in 8.8% of BC fisher stomachs (Weir et al. 2005, p. 14)
Mountain quail *Oreortyx pictus*	220	Sibley (2003, p. 132)	2	x	x	Galliformes in 8.8% of BC fisher stomachs (Weir et al. 2005, p. 14)
Chukar *Alectoris chukar*	595	Peterson (2001, p. 2)	3	x	x	Galliformes in 8.8% of BC fisher stomachs (Weir et al. 2005, p. 14)
Ruffed grouse *Bonasa umbellus*	644	Haupt (2001, p. 2)	3	x	x	Galliformes in 8.8% of BC fisher stomachs (Weir et al. 2005, p. 14)
Spruce grouse *Dendragapus canadensis*	460	Sibley (2003, p. 126)	3		x	Galliformes in 8.8% of BC fisher stomachs (Weir et al. 2005, p. 14)
Blue grouse *Dendragapus obscurus*	1050	Sibley (2003, p. 127)	4		x	Galliformes in 8.8% of BC fisher stomachs (Weir et al. 2005, p. 14)
Wild turkey *Meleagris gallopavo*	7300	McCullough (2001, p. 2)	4	x	x	Galliformes in 8.8% of BC fisher stomachs (Weir et al. 2005, p. 14)
Gray partridge *Perdix perdix*	390	Sibley (2003, p. 122)	3	x	x	Galliformes in 8.8% of BC fisher stomachs (Weir et al. 2005, p. 14)
Ring-necked pheasant *Phasianus colchicus*	1263	Switzer (2011, p. 3)	4	x	x	Galliformes in 8.8% of BC fisher stomachs (Weir et al. 2005, p. 14)
Sharp-tailed grouse *Tympanuchus phasianellus*	880	Sibley (2003, p. 123)	4		x	Galliformes in 8.8% of BC fisher stomachs (Weir et al. 2005, p. 14)
White-tailed ptarmigan *Lagopus leucurus*	388	Hitztaler (2001, p. 3)	3		x	Galliformes in 8.8% of BC fisher stomachs (Weir et al. 2005, p. 14)
Mountain goat *Oreamnos americanus*	59450	Costello and Rosenburger (2014a)	4	x	x	Ungulates in >20% of ID fisher gastrointestinal tracts & scats (Jones 1991, p. 87)
Bighorn sheep *Ovis canadensis*	91500	Costello and Rosenburger (2014b)	4	x	x	Ungulates in >20% of ID fisher gastrointestinal tracts & scats (Jones 1991, p. 87)
Moose *Alces alces*	390000	Costello and Rosenburger (2014c)	4		x	In >10% of ID & BC fisher gastrointestinal tracts & scats (Jones 1991, p. 87; Weir et al. 2005, p. 14)
Elk *Cervus elaphus*	372500	Jameson and Peeters (2004, p. 244)	4	x	x	In >5% of ID fisher gastrointestinal tracts & scats (Jones 1991, p. 87)
Mule deer *Odocoileus hemionus*	125000	Burke Museum (2014)	4	x	x	*Odocoileus* spp. in 3-25% of CA, BC, MT & ID fisher gastrointestinal tracts & scats (Lofroth et al. 2010, p. 162)

Name	Mass (g)	Source for mass	Weight	WA	OR	Notes
White-tailed deer *Odocoileus virginianus*	97000	Dewey (2003, p. 3)	4	x	x	*Odocoileus* spp. in 3-25% of CA, BC, MT & ID fisher gastrointestinal tracts & scats (Lofroth et al. 2010, p. 162)
Striped skunk *Mephitis mephitis*	2900	Jameson and Peeters (2004, p. 185)	4	x	x	Mephitinae in 9.5% of fisher scats on Shasta-Trinity NF (Golightly et al. 2006, p. 18)
Western spotted skunk *Spilogale gracilis*	500	Jameson and Peeters (2004, p. 186)	3	x	x	Mephitinae in 9.5% of fisher scats on Shasta-Trinity NF (Golightly et al. 2006, p. 18)
American marten *Martes americana*	1000	Jameson and Peeters (2004, p. 182)	4	x	x	In 10.7% of BC fisher stomachs (Weir et al. 2005, p. 14)
Marsh shrew *Sorex bendirii*	16	Jameson and Peeters (2004, p. 116)	1	x	x	*Sorex* spp. in 0.8-14.9% of OR, CA & BC fisher GI tracts & scats (Lofroth et al. 2010, p. 161)
Water shrew *Sorex palustris*	11	Jameson and Peeters (2004, p. 118)	1	x	x	*Sorex* spp. in 0.8-14.9% of OR, CA & BC fisher GI tracts & scats (Lofroth et al. 2010, p. 161)
Fog shrew *Sorex sonomae*	10	Costello and Rosenburger (2014d)	1	x		*Sorex* spp. in 0.8-14.9% of OR, CA & BC fisher GI tracts & scats (Lofroth et al. 2010, p. 161)
Shrew-mole *Neurotrichus gibbsii*	12	Jameson and Peeters (2004, p. 125)	1	x	x	In 5.7% of NW CA fisher scats (Golightly et al. 2006, p. 17)
Broad-footed mole *Scapanus latimanus*	22	Jameson and Peeters (2004, p. 126)	1	x		In 12.5% of CA fisher stomachs (Grenfell and Fasenfast 1979, p. 188)
Coast mole *Scapanus orarius*	58	Jameson and Peeters (2004, p. 127)	2	x	x	*Scapanus* spp. in 14.7% of NW CA fisher scats (Golightly et al. 2006 ,p. 17)
Townsend's mole *Scapanus townsendii*	133	Jameson and Peeters (2004, p. 127)	2	x	x	*Scapanus* spp. in 14.7% of NW CA fisher scats (Golightly et al. 2006, p. 17)
Pygmy rabbit *Brachylagus idahoensis*	422	Costello and Rosenburger (2014e)	3	x	x	Lagomorphs in up to 50% of OR, CA and ID fisher gastrointestinal tracts & scats (Lofroth et al. 2010, p. 161)
Snowshoe hare *Lepus americanus*	1000	Jameson and Peeters (2004, p. 361)	4	x	x	In up to 50% of BC, MT and ID fisher gastrointestinal tracts & scats (Lofroth et al. 2010, p. 161)
Black-tailed jack rabbit *Lepus californicus*	1750	Jameson and Peeters (2004, p. 362)	4	x	x	Lagomorphs in up to 50% of OR, CA and ID fisher gastrointestinal tracts & scats (Lofroth et al. 2010, p. 161)
White-tailed jack rabbit *Lepus townsendii*	3500	Costello and Rosenburger (2014f)	4	x	x	Lagomorphs in up to 50% of OR, CA and ID fisher gastrointestinal tracts & scats (Lofroth et al. 2010, p. 161)
Brush rabbit *Sylvilagus bachmani*	700	Jameson and Peeters (2004, p. 365)	3	x		In 12.5% of CA fisher stomachs (Grenfell and Fasenfast 1979, p. 188)
Eastern cottontail *Sylvilagus floridanus*	1167	Costello and Rosenburger (2014g)	4	x	x	Lagomorphs in up to 50% of OR, CA and ID fisher gastrointestinal tracts & scats (Lofroth et al. 2010, p. 161)
Mountain cottontail *Sylvilagus nuttallii*	815	Jameson and Peeters (2004, p. 366)	3	x	x	Lagomorphs in up to 50% of OR, CA and ID fisher gastrointestinal tracts & scats (Lofroth et al. 2010, p. 161)
American pika *Ochotona princeps*	125	Jameson and Peeters (2004, p. 359)	2	x	x	Lagomorphs in up to 50% of OR, CA and ID fisher gastrointestinal tracts & scats (Lofroth et al. 2010, p. 161)

Name	Mass (g)	Source for mass	Weight	WA	OR	Notes
Mountain beaver *Aplodontia rufa*	900	Jameson and Peeters (2004, p. 256)	4	x	x	Observations of fisher predation on *A. rufa* from Olympic population (Lewis 2013, pers. comm.)
American beaver *Castor canadensis*	18500	Jameson and Peeters (2004, p. 285)	4	x	x	In 5.5-28.6% of ID & BC fisher gastrointestinal tracts & scats (Jones et al. 1991, p.87; Weir et al. 2005, p. 18)
Western jumping mouse *Zapus princeps*	23	Jameson and Peeters (2004, p. 288)	1	x	x	In 5.5% of ID fisher scats (Jones et al. 1991, p.87)
Pacific jumping mouse *Zapus trinotatus*	20	Jameson and Peeters (2004, p. 288)	1	x	x	*Zapus* spp. in 0.2-5.5% of OR and ID fisher scats (Jones et al. 1991, p.87; Aubrey & Raley 2006)
Common porcupine *Erethizon dorsatum*	14000	Jameson and Peeters (2004, p. 254)	4	x	x	In 1.8-19.5% of OR, BC, MT and ID fisher gastrointestinal tracts & scats (Lofroth et al. 2010, p. 162)
Botta's pocket gopher *Thomomys bottae*	156	Jameson and Peeters (2004, p. 291)	2	x		In 3.8-6.1% of CA fisher scats (Zielinski et al. 1999)
Western pocket gopher *Thomomys mazama*	105	Jameson and Peeters (2004, p. 292)	2	x	x	*Thomomys* spp. in 0.5-6.1% of OR, CA and ID fisher scats (Lofroth et al. 2010, p. 161)
Northern pocket gopher *Thomomys talpoides*	110	Costello and Rosenburger (2014h)	2	x	x	*Thomomys* spp. in 0.5-6.1% of OR, CA and ID fisher scats (Lofroth et al. 2010, p. 161)
Camas pocket gopher *Thomymys bulbivorus*	401	Costello and Rosenburger (2014i)	3	x		*Thomomys* spp. in 0.5-6.1% of OR, CA and ID fisher scats (Lofroth et al. 2010, p. 161)
White-footed vole *Arborimus albipes*	23	Jameson and Peeters (2004, p. 341)	1	x		*Arborimus* spp. in 9.2% of Six Rivers NF fisher scats (Golightly et al. 2006, p. 17)
Red tree vole *Arborimus longicaudus*	36	Costello and Rosenburger (2014j)	1	x		*Arborimus* spp. in 9.2% of Six Rivers NF fisher scats (Golightly et al. 2006, p. 17)
Gapper's red-backed vole *Myodes gapperi*	24	Costello and Rosenburger (2014k)	1		x	In 5.5-28.6% of ID & BC fisher gastrointestinal tracts & scats (Jones et al. 1991, p. 87; Weir et al. 2005, p. 14)
Western red-backed vole *Myodes californicus*	28	Nowak (1999, p. 1460)	1	x		*Myodes* spp. in 0.2-28.6% of CA, ID & BC fisher gastrointestinal tracts & scats (Lofroth et al. 2010, p. 161)
Sagebrush vole *Lemmiscus curtatus*	28	Costello and Rosenburger (2014l)	1	x	x	Unknown voles in 27.7% of ID fisher scats (Jones et al. 1991, p. 87)
California vole *Microtus californicus*	54	Jameson and Peeters (2004, p. 346)	2	x		*Microtus* spp. in 0.5-12.5% of CA, MT & BC fisher stomachs & scats (Lofroth et al. 2010, p. 161)
Gray-tailed vole *Microtus canicaudus*	45	Costello and Rosenburger (2014m)	1	x	x	*Microtus* spp. in 0.5-12.5% of CA, MT & BC fisher stomachs & scats (Lofroth et al. 2010, p. 161)
Long-tailed vole *Microtus longicaudus*	39	Jameson and Peeters (2004, p. 347)	1	x	x	*Microtus* spp. in 0.5-12.5% of CA, MT & BC fisher stomachs & scats (Lofroth et al. 2010, p. 161)
Montane vole *Microtus montanus*	48	Jameson and Peeters (2004, p. 348)	1	x	x	*Microtus* spp. in 0.5-12.5% of CA, MT & BC fisher stomachs & scats (Lofroth et al. 2010, p. 161)
Creeping vole *Microtus oregoni*	20	Jameson and Peeters (2004, p. 349)	1	x	x	*Microtus* spp. in 0.5-12.5% of CA, MT & BC fisher stomachs & scats (Lofroth et al. 2010, p. 161)

Name	Mass (g)	Source for mass	Weight	WA	OR	Notes
Meadow vole *Microtus pennsylvanicus*	49	Costello and Rosenburger (2014n)	1		x	*Microtus* spp. in 0.5-12.5% of CA, MT & BC fisher stomachs & scats (Lofroth et al. 2010, p. 161)
Richardson`s (Water) vole *Microtus richardsoni*	114	Costello and Rosenburger (2014o)	2	x	x	*Microtus* spp. in 0.5-12.5% of CA, MT & BC fisher stomachs & scats (Lofroth et al. 2010, p. 161)
Townsend's Vole *Microtus townsendii*	79	Jameson and Peeters (2004, p. 350)	2	x	x	*Microtus* spp. in 0.5-12.5% of CA, MT & BC fisher stomachs & scats (Lofroth et al. 2010, p. 161)
Bushy-tailed woodrat *Neotoma cinerea*	328	Jameson and Peeters (2004, p. 325)	3	x	x	*Neotoma* spp in 0.2-7% of CA, BC & MT fisher stomachs & scats (Lofroth et al. 2010, p. 161)
Dusky-footed woodrat *Neotoma fuscipes*	271	Jameson and Peeters (2004, p. 326)	3	x		*Neotoma* spp in 0.2-7% of CA, BC & MT fisher stomachs & scats (Lofroth et al. 2010, p. 161)
Common muskrat *Ondatra zibethicus*	1250	Jameson and Peeters (2004, p. 351)	4	x	x	In 17.2% of BC fisher stomachs (Weir et al. 2005, p.14)
Canyon mouse *Peromyscus crinitus*	17	Costello and Rosenburger (2014p)	1	x		*Peromyscus* spp in 0.5-25% of CA, BC, MT & ID fisher stomachs & scats (Lofroth et al. 2010, p. 161)
Forest deer mouse *Peromyscus keeni*	20	Costello and Rosenburger (2014q)	1		x	*Peromyscus* spp in 0.5-25% of CA, BC, MT & ID fisher stomachs & scats (Lofroth et al. 2010, p. 161)
Deer mouse *Peromyscus maniculatus*	20	Jameson and Peeters (2004, p. 336)	1	x	x	In 15.8% of BC fisher stomachs (Weir et al. 2005, p. 14)
Pinyon mouse *Peromyscus truei*	25	Jameson and Peeters (2004, p. 336)	1	x		*Peromyscus* spp in 0.5-25% of CA, BC, MT & ID fisher stomachs & scats (Lofroth et al. 2010, p. 161)
Heather vole *Phenacomys intermedius*	38.	Nowak (1999, p. 1466)	1	x	x	*Peromyscus* spp in 0.5-25% of CA, BC, MT & ID fisher stomachs & scats (Lofroth et al. 2010, p. 161)
Western harvest mouse *Reithrodontomys megalotis*	12	Jameson and Peeters (2004, p. 337)	1	x	x	In 12.5% of CA fisher stomachs (Grenfell and Fasenfast 1979, p. 188)
Northern flying squirrel *Glaucomys sabrinus*	118	Nowak (1999, p. 1297)	2	x	x	In 0.5-8.4% of OR, CA & BC fisher scats & stomachs (Lofroth et al. 2010, p. 161)
Hoary marmot *Marmota caligata*	5500	Costello and Rosenburger (2014r)	4		x	*Marmota* spp in 5.5-14.3% ID fisher gastrointestinal tracts & scats (Jones et al. 1991, p. 87)
Yellow-bellied marmot *Marmota flaviventris*	2750	Jameson and Peeters (2004, p. 269)	4	x	x	In 5.5-14.3% ID fisher gastrointestinal tracts & scats (Jones et al. 1991, p. 87)
Olympic marmot *Marmota olympus*	6000	Costello and Rosenburger (2014s)	4		x	*Marmota* spp in 5.5-14.3% ID fisher gastrointestinal tracts & scats (Jones et al. 1991, p. 87)
Yellow-pine chipmunk *Neotamias amoenus*	43	Jameson and Peeters (2004, p. 278)	1	x	x	*Tamias* spp in 1-11.3% of OR, CA, MT & ID fisher stomachs & scats (Lofroth et al. 2010, p. 161)
Least chipmunk *Neotamias minimus*	44	Costello and Rosenburger (2014x)	1	x	x	*Tamias* spp in 1-11.3% of OR, CA, MT & ID fisher stomachs & scats (Lofroth et al. 2010, p. 161)
Allen's chimpunk *Neotamias senex*	84	Jameson and Peeters (2004, p. 282)	2	x		*Tamias* spp in 1-11.3% of OR, CA, MT & ID fisher stomachs & scats (Lofroth et al. 2010, p. 161)

Name	Mass (g)	Source for mass	Weight	WA	OR	Notes
Siskiyou chimpunk *Neotamias siskiyou*	75	Jameson and Peeters (2004, p. 283)	2	x		*Tamias* spp in 1-11.3% of OR, CA, MT & ID fisher stomachs & scats (Lofroth et al. 2010, p. 161)
Townsend`s chipmunk *Neotamias townsendii*	104	Costello and Rosenburger (2014y)	2	x	x	*Tamias* spp in 1-11.3% of OR, CA, MT & ID fisher scats (Lofroth et al. 2010, p. 161)
Western gray squirrel *Sciurus griseus*	818	Jameson and Peeters (2004, p. 270)	3	x	x	In 0.2-12.5% of OR & CA fisher stomachs & scats (Lofroth et al. 2010, p. 161)
California ground squirrel *Spermophilus beecheyi*	475	Jameson and Peeters (2004, p. 262)	3	x	x	In 3.8-11.1% of OR & CA fisher scats (Lofroth et al. 2010, p. 161)
Belding's ground squirrel *Spermophilus beldingi*	216	Jameson and Peeters (2004, p. 263)	2	x		*Spermophilus* spp in 1-11.1% of OR, CA & ID fisher scats (Lofroth et al. 2010)
Colulmbian ground squirrel *Spermophilus columbianus*	576	Costello and Rosenburger (2014t)	3		x	*Spermophilus* spp in 1-11.1% of OR, CA & ID fisher scats (Lofroth et al. 2010, p. 161)
Golden-mantled ground squirrel *Spermophilus lateralis*	191	Jameson and Peeters (2004, p. 264)	2	x	x	*Spermophilus* spp in 1-11.1% of OR, CA & ID fisher scats (Lofroth et al. 2010, p. 161)
Cascade golden-mantled ground squirrel *Spermophilus saturates*	250	Costello and Rosenburger (2014u)	3		x	*Spermophilus* spp in 1-11.1% of OR, CA & ID fisher scats (Lofroth et al. 2010, p. 161)
Townsend`s ground squirrel *Spermophilus townsendii*	150	Costello and Rosenburger (2014v)	1		x	*Spermophilus* spp in 1-11.1% of OR, CA & ID fisher scats (Lofroth et al. 2010, p. 161)
Washington ground squirrel *Spermophilus washingtoni*	210	Costello and Rosenburger (2014w)	2		x	*Spermophilus* spp in 1-11.1% of OR, CA & ID fisher scats (Lofroth et al. 2010, p. 161)
Douglas' squirrel *Tamiasciurus douglasii*	250	Jameson and Peeters (2004, p. 273)	3	x	x	In 2.6-11.1% of OR & CA fisher scats (Lofroth et al. 2010, p. 161)
Red squirrel *Tamiasciurus hudsonicus*	195	Costello and Rosenburger (2014z)	2		x	In 14.3-33.5% of BC & ID fisher gastrointestinal tracts & scats (Weir et al. 2005, p. 14; Jones et al. 1991, p. 87)

Appendix A: Full list of non-habitat land cover classifications (ESLF_NAME: LEMMA 2008, LEMMA 2013)

California Central Valley and Southern Coastal Grassland; Southern California Coastal Scrub; Central California Coast Ranges Cliff and Canyon; Emergent Herbaceous Wetlands; Grassland/Herbaceous; Unconsolidated Shore; Northern Rocky Mountain Lower Montane Riparian Woodland and Shrubland; Rocky Mountain Alpine Fell-Field; Barren Land (Rock/Sand/Clay); Cultivated Crops and Irrigated Agriculture; Rocky Mountain Alpine Bedrock and Scree; Invasive Annual / Perennial Grassland / Forbland; Agriculture; Conservation Reserve Program; California Mesic Serpentine Grassland; California Northern Coastal Grassland; California Xeric Serpentine Chaparral; Columbia Basin Foothill and Canyon Dry Grassland; Columbia Basin Foothill Riparian Woodland and Shrubland; Columbia Basin Palouse Prairie; Columbia Plateau Ash and Tuff Badland; Columbia Plateau Low Sagebrush Steppe; Columbia Plateau Scabland Shrubland; Columbia Plateau Silver Sagebrush Seasonally Flooded Shrub-Steppe; Columbia Plateau Steppe and Grassland; Great Basin Foothill and Lower Montane Riparian Woodland and Shrubland; Great Basin Xeric Mixed Sagebrush Shrubland; Inter-Mountain Basins Alkaline Closed Depression; Inter-Mountain Basins Big Sagebrush Shrubland; Inter-Mountain Basins Big Sagebrush Steppe; Inter-Mountain Basins Cliff and Canyon; Inter-Mountain Basins Greasewood Flat; Inter-Mountain Basins Mixed Salt Desert Scrub; Inter-Mountain Basins Playa; Inter-Mountain Basins Semi-Desert Grassland; Inter-Mountain Basins Semi-Desert Shrub-Steppe; Inter-Mountain Basins Volcanic Rock and Cinder Land; Klamath-Siskiyou Cliff and Outcrop; Mediterranean California Alpine Bedrock and Scree; Mediterranean California Alpine Dry Tundra; Mediterranean California Alpine Fell-Field; Mediterranean California Eelgrass Bed; Mediterranean California Foothill and Lower Montane Riparian Woodland; Mediterranean California Northern Coastal Dune; Mediterranean California Serpentine Barrens; Mediterranean California Serpentine Fen; Mediterranean California Serpentine Foothill and Lower Montane Riparian; Mediterranean California Subalpine Meadow; Mediterranean California Subalpine-Montane Fen; North American Alpine Ice Field; North American Arid West Emergent Marsh; North Pacific Alpine and Subalpine Bedrock and Scree; North Pacific Alpine and Subalpine Dry Grassland; North Pacific Avalanche Chute Shrubland; North Pacific Bog and Fen; North Pacific Coastal Cliff and Bluff; North Pacific Dry and Mesic Alpine Dwarf-Shrubland, Fell-field and Meadow; North Pacific Herbaceous Bald and Bluff; North Pacific Hypermaritime Shrub and Herbaceous Headland; North Pacific Intertidal Freshwater Wetland; North Pacific Lowland Riparian Forest and Shrubland; North Pacific Maritime Coastal Sand Dune and Strand; North Pacific Maritime Eelgrass Bed; North Pacific Montane Grassland; North Pacific Montane Massive Bedrock, Cliff and Talus; North Pacific Montane Riparian Woodland and Shrubland; North Pacific Montane Shrubland; North Pacific Serpentine Barren; North Pacific Shrub Swamp; North Pacific Volcanic Rock and Cinder Land; Northern and Central California Dry-Mesic Chaparral; Northern California Claypan Vernal Pool; Northern California Coastal Scrub; Northern Rocky Mountain Montane-Foothill Deciduous Shrubland; Northern Rocky Mountain Subalpine Deciduous Shrubland; Rocky Mountain Lower Montane Riparian Woodland and Shrubland; Rocky Mountain Subalpine-Montane Riparian Shrubland; Temperate Pacific Freshwater Aquatic Bed; Temperate Pacific Freshwater Emergent Marsh; Temperate Pacific Freshwater Mudflat; Temperate Pacific Intertidal Mudflat; Temperate Pacific Subalpine-Montane Wet Meadow; Temperate Pacific Tidal Salt and Brackish Marsh; Willamette Valley Upland Prairie and Savanna; Willamette Valley Wet Prairie; Inter-Mountain Basins Montane Sagebrush Steppe; Open Water; Perennial Ice/Snow; Developed, Open Space;

Developed, Low Intensity; Developed, Medium Intensity; Developed, High Intensity; Pasture/Hay; Cultivated Crops; Introduced Upland Vegetation – Shrub; Introduced Upland Vegetation - Annual and Biennial Forbland; Introduced Upland Vegetation - Annual Grassland; Northern Rocky Mountain Subalpine-Upper Montane Grassland; Recently burned grassland; Recently burned shrubland; High Structure Agriculture; Northern Rocky Mountain Lower Montane, Foothill and Valley Grassland; Rocky Mountain Cliff, Canyon and Massive Bedrock

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