DISTRIBUTION OF PACIFIC MARTEN IN COASTAL OREGON

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ABSTRACT—Information on the distribution of rare and little known species is critical for managers and biologists challenged with species conservation in an uncertain future. Pacific Martens (*Martes caurina*) historically resided throughout Oregon and northern California's coastal forests, but were considered extinct until 1996 when a population in northern California was rediscovered. Only 26 verified contemporary (1989–2012) records were known within Oregon prior to this survey. The coastal subspecies (*M. c. humboldtensis*) was petitioned for listing under the federal Endangered Species Act in 2010. We surveyed for martens during 2014–2015 with 3 separate, non-invasive surveys. We conducted exploratory surveys in 2014, and surveyed at 2 scales during 2015 to confirm the persistence of historical populations (<5 km prior detections) and to determine the limits of current distributions in the region (5–50 km). We surveyed 348 sample units using a total of 72 track plate and 908 remote camera stations for >14 d within a 25,330 km^2 area, yielding 355,018 photographs. Martens were detected (photographs, tracks, or genetically verified hair samples) at 72 sample units. We detected 28 individual martens in coastal Oregon using a combination of genetic confirmation and captured individuals. Marten observations were clustered in the Central and South Coast regions, suggesting existing populations have persisted since published observations prior to 1998. We did not locate new populations despite an extensive effort to survey new areas, but did learn a unique population exists in the coastal dunes of Central Oregon. Future research could include surveys at a finer-scale to refine population boundaries and estimate minimum population sizes, better define habitat conditions, and evaluate potential threats to population stability (such as disease, genetic bottlenecks). Until population estimates and trends are known, conservation efforts may benefit from local management actions, such as restricting or eliminating kill-trapping in the Coast Ranges, as well as broad efforts to increase connectivity, especially where existing populations face significant barriers to movement, such as a major roadway (Highway 101). Based on our observations, efforts to increase the size, number, and extent of populations could be valuable for long-term conservation of the species.

Key words: American Marten, camera trap, detectability, distribution, Humboldt Marten, *Martes caurina*, Oregon, Pacific Marten

Pacific Martens (*Martes caurina*), previously referred to as American Marten (*Martes americana*, Dawson and Cook 2012), once resided throughout the coastal forests of northern California, Oregon, Washington, and British Columbia (Merriam 1890; Grinnell and others 1937; Yocom 1974). Since the early 1900s, the range of these populations has declined by greater than 95% (Zielinski and others 2001; Slauson and others In Press), and the northern California subspecies was considered extirpated (Zielinski and Golightly 1996). Surveys during the past 20 y revealed at least 3 populations along the Pacific Coast, in northern California and southern Oregon, the central coast of Oregon, and the Olympic Mountains of Washington (Zielinski and others 2001). The size of the populations and range extents are unknown, but a considerable amount of sampling has recently occurred to address some of these uncertainties, including a description of the current range in Oregon (this study).

Pacific Marten historically occurred throughout coastal forests of Oregon and northern California (Grinnell and Dixon 1926; Grinnell and others 1937; Yocom 1974). Although previously described as 2 subspecies separated at the state border (Miller 1912; Grinnell and others 1937; Slauson and others 2009), there was evidence suggesting populations in northern California and Oregon comprise a single subspecies, the Humboldt Marten (*Martes caurina humboldtensis*), but genetic designations are unresolved (M Schwartz, USDA Forest Service Wildlife Genomics Laboratory, pers. comm.). Currently, this potential subspecies of Pacific Marten in the coast ranges may occur in 2 isolated populations in northern California and southern Oregon ("South Coast Population") and the central coast ("Central Coast Population") of Oregon (Zielinski and others 2001).

Habitat of Pacific Marten in coastal northern California includes structurally complex late-seral forests as well as lower productivity forests with high shrub densities, including areas associated with serpentine soils (Slauson and others 2007). This marten population was affiliated with dense shrub layers, particularly ericaceous shrubs (for example, huckleberry [Ericacrae], blueberry [*Vaccinium* spp.], Salal [*Gautheria shallon*]), which produce edible berries during fall. Martens rest and den in locations that protect them from predation and weather elements, including: cavities, chambers, and broken tops (Raphael and Jones 1997; Bull and Heater 2001a; Slauson and Zielinski 2009; Joyce 2013). Marten resting structures in the coastal range included live trees and snags with cavities averaging >90 cm (35″) diameter at breast height (Slauson and Zielinski 2009) and large logs. These structures were often associated with forests >400 y old (Slauson and Zielinski 2009), and may be relatively rare within heavily managed, even-aged coastal forests. Due to the paucity of research on marten habitat characteristics in coastal forests of Oregon, we acknowledge the potential importance of habitat features not described here.

Humboldt Martens were petitioned for listing under the federal Endangered Species Act in September 2010 (Center for Biological Diversity 2010). In January 2012, the US Fish and Wildlife Service (USFWS) published a 90-d finding initiating a status review of the Humboldt Marten to determine if listing the species was warranted (USFWS 2012). Given the unresolved taxonomy of the coastal populations of martens in California and Oregon, the USFWS evaluated a Distinct Population Segment of the Pacific Marten that comprised coastal populations in Oregon and California. In April 2015, the USFWS found this Distinct Population Segment did not warrant listing (USFWS 2015), but this ruling has been litigated. The USFWS was sued by the Environmental Protection Information Center and Center for Biological Diversity in December 2015 (Center for Biological Diversity 2015).

The general lack of knowledge of marten distribution or habitat characteristics in coastal forests of Oregon catalyzed a multi-agency collaboration, which began unified survey efforts in the summer of 2014. Previous to this effort, the knowledge of population distribution in Oregon was largely based on contemporary roadkill carcasses collected from biologists and reported to the Oregon Department of Fish and Game (ODFW, Zielinski and others 2001, $n = 14$), records of legally-trapped animals reported to ODFW (Hiller 2011, $n=3$), and verified detections from non-invasive survey efforts (Zielinski and others 2001, $n = 9$, Fig. 1A). Our goal was to evaluate marten distribution in coastal Oregon by surveying at 2 scales: within 5 km and 50 km of prior detections. The 2 scales correspond with the intention to confirm the persistence of historical subpopulations (5 km), and then to determine limits to the current distributions of martens in the associated region. These surveys encompassed >70% of the marten's predicted historical range in Oregon (Zielinski and others 2001).

METHODS

Study Area

Our survey area included over 325 km of the Oregon coast north of the California boarder,

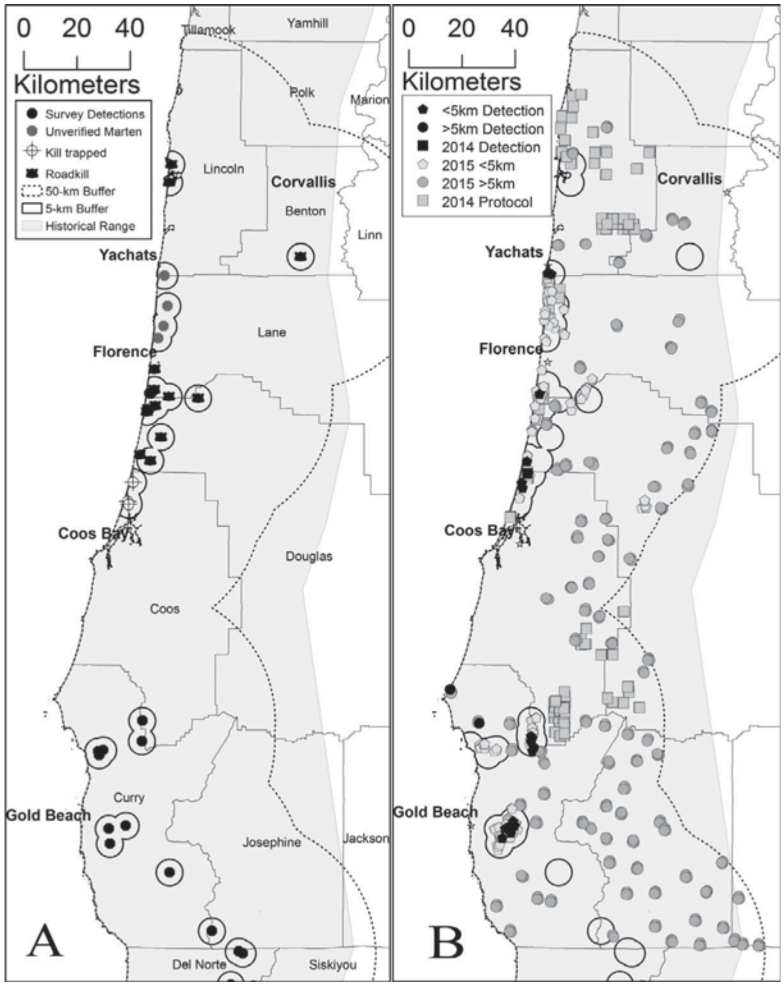

FIGURE 1. Our study occurred in the Klamath and Coastal Mountain Ranges of Oregon in Lincoln, Benton, Lane, Douglas, Coos, Curry, and Josephine counties (grey lines). Pacific Marten (*Martes caurina*) were verified in 26 locations from collected roadkill ($n = 14$), non-invasive surveys ($n = 9$), and reported kill-trapped individuals ($n = 3$) prior to 2014 (Fig. 1A). During 2014–2015, we surveyed 394 sample units and 908 stations (grey), detecting at least 13 individuals at 49 locations (black filled) in a portion of their historical range (grey polygon, Fig. 1B). We used survey methods congruent with Humboldt Marten (*M. c. humboldtensis*) surveys in California (squares, Slauson and Moriarty 2014), a protocol designed to assess detectability within 5 km of former detections (pentagons, Moriarty and others In review), and a modified monitoring protocol for carnivores (circles, Truex and others 2013). Dashed line indicates the 50 km extent of the study.

and encompassed an area extending 50 km from previous locations (exceeding 25,330 km^2) within the Klamath and Coastal Mountain ranges (Fig. 1). Moving from the coast inland, dominant landcover types include Sitka Spruce (*Picea sitchensis*) along the coast, Western Hemlock (*Tsuga heterophylla*) in the Coastal Mountains, and mixed evergreen forests in interior valleys of southwest Oregon (Franklin and Dyrness 1973). Sitka Spruce zones are very mild (annual average temperature 10–11°C), while rain and frequent coastal fog contribute to an average of 200–300 cm of precipitation annually. Western Hemlock zones, often co-dominated by Douglas-fir (*Pseudotsuga menziesii*) in areas with a history of fire, are also wet (150–300 cm annual precipitation), somewhat cooler (7–10°C), but with drier summers (6–9% of total precipitation).

Mixed evergreen zones transition to oak (*Quercus* spp.) woodlands and grasslands at elevations <800 m. Mixed zones are relatively warm (10–18°C), with wet winters and dry summers (60–170 cm annually). The valleys tend to be dominated by oak woodlands, conifer forests (mostly *Psuedotsuga menziesii*, *Pinus ponderosa*, and *Lobocerdrus decurrens*), and grasslands, and are the warmest and driest cover types west of the Cascade Range (50–100 cm annual precipitation; annual temperatures 3–32°C) with the highest fire frequency (Franklin and Dyrness 1973).

Study Design

2014 Surveys.—During summer 2014, we surveyed strategically in areas within the predicted marten range using a 2-km grid aligning with marten survey efforts in California (Slauson 2004; Slauson and others 2007). Because forest age is correlated with the likelihood of marten habitat use, we surveyed two 2-km grids of 18 sample units with an intended arrangement of 3 × 6, chosen to detect martens along a gradient of vegetation age. We also established 52 additional sample units randomly chosen at a 6-km scale within the areas of Lincoln, Coos, and Douglas counties because of historical marten population range extents (Fig. 1B). A 2-km-grid sample unit consisted of 2 non-invasive triangular track plate stations designed for martens (25.4 cm/side) with 3 internal gun brush hair snares for genetic sampling (modified from Cushman and others 2008). One station was at the grid location and another was strategically placed near a riparian area or oldest forested stand as determined from remote sensing maps within 500 m of the central grid point (Slauson and Moriarty 2014). Sample units at the 6-km scale were surveyed in fall 2014 at randomly chosen locations in the Central Coast and consisted of either 2 track plate hair snares or 2 remote cameras. Stations were baited with chicken (1 drumstick) and an olfactory lure (Gusto, Minnesota Trapline Company, Pennock, MN) and checked every 3 d to replace bait and collect data. We conducted surveys for a minimum of 21 d, July through September. Only 1 marten was detected during these surveys, so in 2015 we used 2 approaches to expand our efforts.

2015 Surveys; Areas 5–50 km from Known Detections.—To determine the limits of the current marten population, we sampled from May through October 2015 within 5–50 km of prior detections (Zielinski and others 2001, ODFW trap records, verified road kill), excluding non-forested areas (such as water, grassland). We used a stratified random sampling design to distribute the sample evenly among young, mature, and old forests when the majority of trees were <80 y, 80–195 y, and >195 y, respectively (Spies and Franklin 1991). To ensure we surveyed among a range of early-seral age classes that would have differing small mammal and thus prey communities (Anthony and Gomez 1998), we surveyed an even number of young stands in presumed open- (ages 0–20 y) and closed- (20–80 y) canopy classes. We expected canopy cover to increase and the stand to exhibit competitive exclusion following 20 y in the younger stands. Dominant-forest age class was approximated using gradient nearest neighbor (GNN) predictive maps (2012 version GNN) for forest composition and configuration (Ohmann and Gregory 2002), and then smoothed within a 9 pixel area (90 m x 90 m, ArcMap, Filter tool).

To sample a large geographic area, ensure crew access, and avoid duplicating prior efforts, we used Geospatial Modeling Environment to initially create 250 random points with a minimum of 6-km spacing between points within a 50 km land-based buffer of previous marten detections (Beyer 2014). Potential sampling locations were then further qualified and located within 750 m of a road or highway or 250 m of a trail, and not within 5 km of recent marten detections (2010–2015; Moriarty and others, unpubl. data), or in non-forested cover types (such as lakes, cities), providing us with 130 potential locations. Our sampling began in the south near the California border and proceeded northward every 3 wk.

Sample units consisted of 4 remote camera stations: 3 baited stations (separated by at least 500 m) and 1 unbaited trail-based camera. We abandoned or adjusted sample units if our access was restricted by non-permissioned private property, extreme terrain (>45° slope), or required hiking >2 km. Stations were active for a minimum of 14 d and were either checked, rebaited, or both every 5–8 d. The 3 baited stations were located in a triangular pattern congruent with the current Sierra Nevada Forest Carnivore protocol (Truex and others 2013), which has been used to survey Fisher (*Pekania pennanti*) for over a decade (Zielinski and others 2013). We placed remote cameras (Moultrie M990-i No-Glow [~5% of stations], Browning DarkOps [~10%], Bushnell 2012 Trophy Cam HD Black LED [~15%], Bushnell 2012 Trophy Cam HD Infra-Red [~10%], and Bushnell 2015 Aggressor No-Glow [~60%]) at baited stations and on trees or logs along game trails or log crossings of streams to increase the likelihood of imaging smaller carnivores (Linnell 2014). Cameras were placed >50 m from maintained roads to minimize edge effects, 0.5–1.0 m above the ground, in areas with >20% foliar cover, and facing north to reduce direct sunlight and poor exposures. We standardized camera mode (still pictures), time stamps, sensor sensitivity (high or normal if excessive vegetation shots were taken), capture delay (5 s between shots), and capture number (3 pictures/shot). Baited stations had a combination of chicken (1 drumstick), cat food (5.5 oz wet and fish flavored, perforated to increase spread of smell), and an olfactory lure (soaked sponge; Gusto, Minnesota Trapline Company, Pennock, MN) nailed or tied 0.5 m above the ground on a tree 1.5–3.0 m from the camera. The baited tree also included a 60–100 cm long reflective measuring strip to help distinguish sex, and station-specific signs for photo record keeping. As a control for animals which may be repelled by baited stations (such as Bobcats, *Lynx rufus*), we paired unbaited stations with the northernmost baited stations in each sample unit. We placed un-baited stations 50–150 m from a baited station, with the camera oriented parallel to a game trail or overgrown road, 0.5–1.0 m above the ground on a tree, angled 0 to 45° to the ground (with adjustments for slope), facing north, and with the focal spot located 2.5 m from the camera. We used only black LED cameras on all un-baited sets to increase the probability of detecting animals that may be deterred by shorter-wavelength infra-red or white flash.

2015 Surveys; Areas <5km from Known Detections.—We sampled January through March and June through October 2015 in areas within 5 km of prior marten detections (Zielinski and others 2001, ODFW trap records, verified road kill). The survey protocol differed because in addition to distribution we were interested in quantifying seasonal detectability with differing bait and height treatments (Moriarty and others, unpubl. data). We randomly selected sampling units along access routes (roads and trails) within 5 km of historical marten detections. Each sampling unit was separated by a minimum of 750 m and placed at least 75 m from the access route. A sample unit consisted of 2 stations: a baited and trail set. Baited sets had 2 randomized treatments: height (high, low) and bait (chicken and gusto, cat food). For bait, we used either cat food or chicken with an olfactory lure (Gusto, Minnesota Trapline Company, Pennock, MN). Bait was nailed to a tree or log at 0.5 m (low), or 1.5–2.0 m (high). Trail sets were placed on the access route within 50–100 m from the baited set. Our survey period was 21 d, and we checked and re-baited sets weekly following setup.

When martens were detected for either 2015 protocol, genetic samples useful for determining sex or population estimates were obtained using triangular track plate boxes with gun brush hair snares. Track plates were composed of triangular corrugated plastic enclosures and aluminum plates coated with printer toner, a piece of tacky white paper for track collection, and bait (Ray and Zielinski 2008). These snares extended the station sample period by a maximum of 21 d. Track plate boxes were baited with chicken and cat food, contained 1–3 hair snares which were either bolts or gun brushes smeared with mouse glue. Collected hair samples were stored in vials containing desiccant and placed in coolers to prevent exposure to light, temperature, and moisture extremes.

Hair samples were sent to the US Forest Service National Genomics Laboratory (Missoula, MT) for genetic analyses. Whole genomic DNA was extracted from hair samples using the QIAGEN Dneasy Tissue Kit (Qiagen, Valencia, CA) with modifications for hair samples (Mills and others 2000). Hair samples were tested for species identification using the control region of mitochondrial DNA (mtDNA) using universal primers (Kocher and others 1989). Samples were analyzed using 13 microsatellite loci that were previously successful for mustelids (Dallas and Piertney 1998; Davis and Strobeck 1998; Duffy and others 1998; Flemming and others 1999; Jordan and others 2007). We accepted data from hair samples as error free only if the microsatellites produced consistent scores using a multitube approach (Eggert and others 2003; McKelvey and Schwartz 2004). Data was checked for genotyping errors using program Dropout

TABLE 1. We detected over 28 species in the Oregon Coast Ranges in 2015 while surveying for Pacific Marten (*Martes caurina*). We used 3 survey methods, but only summarize images taken from remote-cameras during 2015 conducted in areas outside (>5km) and within a 5km buffer of previous verified marten detections (Zielinski and others 2001). We report the total number of photos (No. Photos), sample units with detections ($n = 277$ surveyed), and percent for each species or group. Data are ordered by class (carnivores, small mammals, other) and by percent of sample units with detections (Overall Percent).

Species	>5km (%)	<5km (%)	No. photos	Sample units	Overall percent
Black Bear (*Ursus americana*)	81	23	23,995	106	47
Spotted Skunk (*Spilogale gracilis*)	54	41	16,777	106	47
Bobcat (*Lynx rufus*)	32	26	814	64	28
Grey Fox (*Urocyon cinereoargenteus*)	23	29	12,266	60	26
Opossum (*Didelphis virginiana*)	22	25	18,151	54	24
Pacific Marten (*Martes caurina*)	3	25	4316	36	16
Raccoon (*Procyon lotor*)	11	14	2195	29	13
Short-tailed Weasel (*Mustela erminea*)	7	8	304	17	7
Striped Skunk (*Mephitis mephitis*)	14	2	118	16	7
Domestic Dog (*Canis familaris*)	0	11	269	15	7
Mountain Lion (*Puma concolor*)	11	3	197	14	6
Fisher (*Pekania pennanti*)	10	0	803	9	4
Coyote (*Canis latrans*)	4	4	83	9	4
Long-tailed Weasel (*Mustela frenata*)	4	1	31	5	2
House Cat (*Felis cattus*)	0	2	25	3	1
Ringtail (*Bassariscus astutus*)	0	2	117	2	1
Mice and Voles (*Peromyscus*, *Myodes*, *Microtus*)	67	61	13,689	144	63
Douglas Squirrel (*Tamiasciurus douglassii*)	51	53	2128	118	52
Chipmunk (*Tamias* spp.)	65	29	6082	99	44
Northern Flying Squirrel (*Glacomys sabrinus*)	47	23	1058	75	33
Woodrat (*Neotoma* spp.)	26	11	3381	39	17
Cottontail (*Sylvilagus* spp.)	23	8	1217	33	15
California Ground Squirrel (*Otospermophilus beecheyi*)	6	0	272	6	3
Gray Squirrel (*Scirus griseus*)	0	5	27	6	3
Golden-mantled Ground Squirrel (*Callospermophilus lateralis*)	2	0	9	2	1
Birds	82	63	20,814	161	71
Deer (*Odocoileus* spp., *Cervus* spp.)	70	29	4880	104	46

(McKelvey and Schwartz 2005). The samples were also tested using an SRX/SRY analysis to determine sex (Hedmark and others 2004). Genetic samples were stored at the National Genomics Laboratory. Detectability was evaluated only within stations <5 km of previous detections during the 2015 winter and summer surveys because martens were detected frequently enough to estimate parameters. We also collected samples opportunistically (such as road-killed individuals) throughout the surveys.

Results

The combination of sampling efforts used in this study resulted in 348 sample units (908 stations), and represents the largest carnivore survey conducted in Oregon. During 2014, 87 sample units (174 stations) were surveyed with remote cameras (62%) or track plates (38%). One marten was detected during fall surveys via track plate. During 2015, 80–120 cameras were deployed in the field at any given time. We surveyed 98 sample units using 394 camera stations >5 km from prior detections in summer 2015. Cameras were operational for 5516 camera nights and took 200,718 photographs. We detected at least 1 marten at 2 sample units near the Southern Coast Population, producing 11 photographs (Fig. 1B). Within 5 km of known detections, we surveyed 163 sample units using 340 camera stations during winter and summer 2015. Cameras were operational for a minimum of 7140 trap nights and took 154,313 photographs. Martens were detected in 70 sample units (43%) and 8646 marten photographs were obtained; however, 1 sample unit accounted for 16% of those photos ($n = 1370$) during its 21-d sample period.

We incidentally detected a minimum of 28 additional mammalian species using remote cameras (Table 1). Of the carnivores, Black Bear (*Ursus americana*) and Spotted Skunk (*Spilogale gracilis*) were detected most frequently, at 47% of our sample units. Long-tailed Weasel (*Mustela frenata*) and Ringtail Cat (*Bassariscus astutus*) were detected least (Table 1).

We collected 83 hair samples from 29 sample units with marten detections. Of the hair samples that were suspected to be marten from photographs or tracking plates ($n = 87$), 74% were genetically confirmed. From these samples, 81% had enough high-quality DNA to infer sex and individual identity: 5 females and 8 males. In addition, 3 road-killed martens (2 adult females, 1 young male) were found during 2015–April 2016 in the Central Coast, and 14 individuals were captured live during recent efforts to summarize home range and movement patterns in the Central Coast (Linnell and Moriarty, unpubl. data). Thus, based on confirmed genetic detections, captures, and locations with scat samples that were determined to be from marten although not verified genetically to individual and >5 km apart (assuming independence with an average marten home-range size), a minimum of 28 martens were identified between the 2 populations in Oregon in 2015. Our detections within the Central Coast Population were west of Highway 101 (Fig. 1B).

DISCUSSION

Evidence from this study suggests that there may be 2 disjunct populations of marten in coastal Oregon. The Central Coast Population appears to only occur west of Highway 101, while the South Coast Population may be connected to populations in California, but this has not been verified. Our detections affirmed the range reported over a decade ago (Zielinski and others 2001), suggesting stability within the range. However, mangers would prefer to see population expansion over a period of 3 marten generations, given concerns for species viability throughout the subspecies range (Slauson and others In Press).

Although there are few records of marten home range characteristics in coastal forests, the number and distribution of verified individuals in the Central Coast Population was consistent with prevailing information that suggests that they maintain relatively small home ranges. A majority of our detections were tightly clustered, and often with multiple individuals in close proximity (<5 km), indicative of small territories. Male home ranges generally encompass 3–4 km^2 (Slauson and others In Press, $n = 3$, p 46). These estimations were similar to fall season averages of 2.8 ± 0.17 and 0.65 ± 0.12 km^2 ($\bar{x} \pm$ SE) in the Oregon Coast Range for males ($n = 3$) and females ($n = 8$), respectively (Linnell and Moriarty, USDA Forest Service, unpubl. data). In comparison, 1.7–27 km^2 and 1–14 km^2 are the ranges of average home range sizes for male and female martens in other parts of the western United States (Spencer 1981; Martin 1987; Powell 1994; Bull and Heater 2001b). However, as a whole, we detected fewer individuals than expected given our efforts, and conclude martens in coastal forests are rare and likely limited by unknown factors, especially compared to their former range.

Landscape-level surveys are logistically difficult, and this study represents one of the largest survey efforts for carnivores completed in Oregon. We may have missed individuals with our survey methods due to the relatively short survey period and comparatively distant spacing in comparison to a marten home range; however, our efforts were unlikely to miss a thriving, sizable population. Adult martens are territorial and traverse the perimeter of their home range in less than a week (Moriarty and others, unpubl. data). It is therefore not surprising that most surveys often detect martens within 10 d of deploying survey devices (Zielinski and Stauffer 1996). For marten in the Coastal Ranges in California, the average latency to capture was 5.2 d in areas with prior detections (Slauson 2004:33). Our per-visit probability of detection ranged between 0.2 and 0.5, equating to >75% survey-level probability of detection within 14 d (Moriarty and others, unpubl. data), similar to marten detectability in montane forests (Zielinski and others 2015). However, at low population densities, detecting individuals with >90% probability may require survey efforts up to 50 and 35 d during summer and winter, respectively, as demonstrated for Fisher (Sweitzer and others 2016). As such, it is important to consider survey goals to determine the minimum sampling period: short periods may be sufficient for assessing population status, whereas longer durations would increase confidence of detecting more individuals, assuming sufficient sample units and spacing for assessing the study question.

Our goal was to evaluate contemporary marten population distributions in coastal Oregon. Although our methods were appropriate for such a task, it is important to realize that individuals were likely missed due to imperfect detection of the animals whose home ranges were sampled, as well as animals whose home ranges fell entirely between sample units. We used a spacing distance of an average male home range (Powell 1994), meeting the assumption of independence for occupancy modeling (MacKenzie and others 2006). This spacing may not be able to accurately estimate the number of individuals because multiple sample units would need to be within each home range. In the areas that we did survey, we have high confidence of detecting individuals when present due to multiple survey devices (4) being in a clustered design, which increases accuracy for density and abundance estimation (Roughton and Sweeney 1977; Sun and others 2014; Wilton and others 2014). Using 4 stations within a sample unit during our surveys increased by one the number of cameras specified in the protocol for carnivore and Fisher monitoring in the Sierra Nevada Mountains (Truex and others 2013). In another study evaluating marten occupancy, Zielinski and others (2008) surveyed with sample units 636 m apart and a cluster of 2 or 3 stations at 250 m spacing. Thus, survey efforts to determine whether individual martens are present within a localized area may benefit from sampling units consisting of clustered devices spaced <1 km apart to increase device overlap within home ranges. Current efforts are underway to evaluate protocol effectiveness and minimum efforts required to detect individuals when present (Moriarty and others, unpubl. data).

Marten populations in coastal Oregon and California are currently vulnerable to local extirpation. The "Humboldt Marten Conservation Strategy and Assessment" suggests that the most impending threats include large-scale habitat fragmentation, high-severity and large-scale fire, and lethal disease (Slauson and others In Press). In areas where marten populations persist, a conservative and proactive approach may increase the likelihood of persistence. Slauson and others (In prep) described a 3-pronged approach for subspecies conservation: (1) protect existing populations; (2) re-establish populations in areas with suitable habitat; and (3) restore or focus management efforts to improve habitat conditions. In Oregon, additional information is necessary to describe suitable habitat conditions, and significant information needs have been identified by Slauson and others (In prep).

While broader conservation strategies are being developed, several measures could help protect individuals within current populations. For instance, restricting lethal trapping of martens in the Coast Range could reduce anthropogenic pressure on small populations. It is unlikely that trapping is a large source of mortality; only 3 lethally-trapped Humboldt Martens have been reported in the past 5 y (Hiller 2011); however, any reduction of individuals may negatively affect populations. In Oregon, the most common verified mortality source has been vehicular strikes along Highway 101 ($n = 17$; 3 located during 2015, Moriarty, unpubl. data). Creating wildlife corridors under roadways using well-designed culverts have been effective for many species, but these may be logistically difficult to construct and require knowledge of crossing areas (Glista and others 2009). In areas suspected to be corridors, considerations for increased signage for wildlife crossing areas and reduced speed limits may decrease the number of vehicular mortalities (Glista and others 2009). However, vehicle strikes accounted for only 2% of documented Fisher mortalities near Yosemite National Park, California, even in heavy use areas (Gabriel and others 2015), so this cause may be trivial compared to predation, disease, and exposure to poison (such as rodenticides).

Habitat fragmentation through natural and anthropogenic alterations likely poses the largest threat to marten conservation. Marten populations decline with as little as 30% of the forest cover removed (Hargis and others 1999; Potvin and others 2000), and fuel reduction treatments typically decreased cover and connectivity in the Sierra Nevada (Moriarty and others 2015). Martens were deterred by low-canopy-cover openings, seldom moving 17 m beyond cover (Cushman and others 2011), and most often moving >50 m within forest patches to avoid such openings (Moriarty and others 2015). Despite potential vulnerabilities and avoidance from open understories, areas with high-fire risk may benefit from strategic variable-retention fuel-reduction treatments over a trajectory of several decades as suggested for Fisher habitat (Thompson and others 2011; Sweitzer and others 2016), but such information has not been assessed for martens in Oregon. Further, future conservation strategies in the current Central Coast Population may differ from interior forests due to the unique coastal ecosystem. For instance, it might be more important to focus on road crossing and connectivity in the Central Coast, whereas the South Coast population may be more at risk due to poisoning and fire danger. With our current knowledge, maintaining connectivity with both overstory trees and dense shrub cover (for example see Slauson and others 2007) would be a conservative measure in areas with extant populations, both for preservation and potential expansion.

This survey represents the first large-scale exploration of marten distributions in coastal Oregon, but we still have little data to describe the behaviors, habitats, threats, and fine-scale distributions of coastal marten. Ultimately, more marten populations in coastal Oregon and northern California could assist in reducing threat of extirpation. Additional surveys to understand the distribution extent, and focused hypothesis-based research linking habitat and demographic parameters should be considered for strategic planning.

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