Arcata Fish and Wildlife Office

Species Assessment for the Humboldt Marten (*Martes americana humboldtensis*)

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Photo credit: Six Rivers National Forest

Endangered Species Program

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INTRODUCTION

This document summarizes current information about the American marten (*Martes americana*) (marten), especially as it relates to its taxonomy, life history, management, and threats within the historic range of the Humboldt marten (*M. a. humboldtensis*), a subspecies described for northwestern California and southwestern-most Oregon. The results of recent surveys suggest that Humboldt marten population numbers remain low, with the current distribution restricted to a very small portion of the historic range. Through this document, the Arcata Fish and Wildlife Office provides a current (as of June 2010) summary of research and surveys within the described range of the Humboldt marten. We prepared this summary in hopes of stimulating additional research on the Humboldt marten, and encouraging proactive conservation. We anticipate that this document will be revised as new information becomes available.

BIOLOGICAL INFORMATION

Species Description

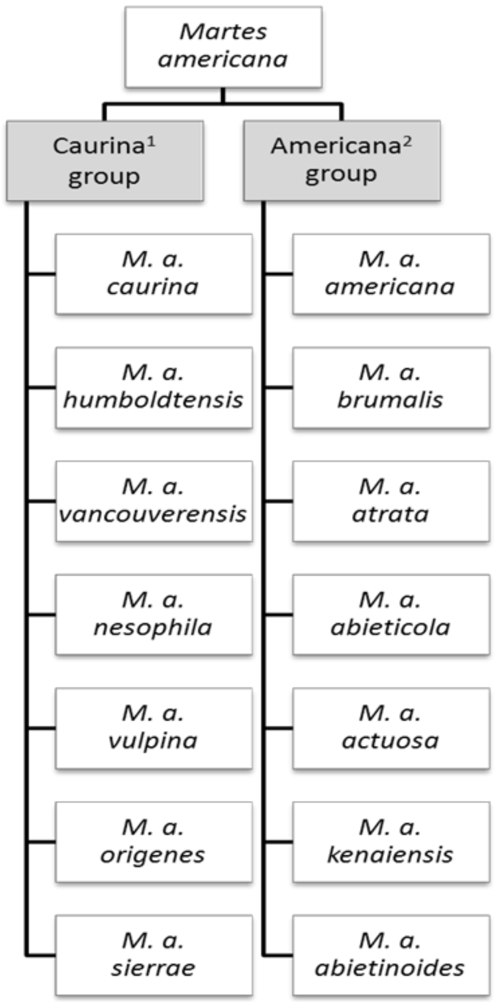
The American marten, a carnivorous mammal about the size of a mink, has a long, slender body with relatively large rounded ears, short limbs, and bushy tail (Clark et al. 1987, p.1). Martens have triangular faces with muzzles less pointed than those of foxes. The tail constitutes about one-third of the total body length (Powell et al. 2003, p. 636). Each digitigrade, well-furred paw includes five toes (Powell et al. 2003, p. 636). Their total length is between 20 and 24 in (500 and 680 mm) and adults weigh 1.2 to 3.4 lbs (0.5 to 1.4 kg) depending on sex and subspecies (Buskirk and McDonald 1989, p. 999). Males are 20 to 40% larger than females (Buskirk and Zielinski 1997, p. 17). The color of the long, silky, dense fur ranges from pale yellowish buff to tawny brown to almost black (Clark et al. 1987, p. 1). The color of the head is usually lighter than the body, and the legs and tail are darker (Clark et al. 1987, p. 1). A characteristic throat and chest bib ranges in color from pale straw to vivid orange (Clark et al. 1987, p. 1).

The American marten occurs in forested habitats throughout boreal North America, reaching its southernmost extent in the Sierra Nevada of California and the southern Rocky Mountains of New Mexico (Gibilisco 1994, p. 66).

Taxonomy

Martens are classified in the order Carnivora, family Mustelidae, subfamily Mustelinae, and genus *Martes* (Anderson 1994, p. 14). The only other North American member of the genus *Martes* is the larger fisher (*Martes pennanti*). The American marten is considered a single species (Clark et al. 1987, p. 1; Hall 1981, p. 983; Powell et al. 2003, p. 635). Fourteen subspecies have been described (Hall and Kelson 1959, p. 900), and the subspecies are traditionally separated into two morphologically distinct groups or types (*americana* and *caurina*) (Figure 1) (Stone et al. 2002, p. 2050; Powell et al. 2003, p. 635; Hagmeier 1961, p.

123). The *americana* group includes subspecies from Montana and Idaho northward to Alaska and eastward to the Atlantic Coast, while the *caurina* group includes subspecies from the Pacific Northwest and the Great Plains (Carr and Hicks 1997, p. 15; Stone et al. 2002, p. 2050).



[1] Distribution: parts of West Coast (California to British Columbia), Wyoming, Montana, and Idaho.
[2] Distribution: Montana and Idaho northward to Alaska and eastward to Atlantic Coast.

Figure 1. American marten subspecies by morphological group (Source: Powell et al. 2003, p. 635; Stone et al. 2002, p. 2050).

A phylogenetic analysis of mitochondrial cytochrome *b* DNA sequences by Carr and Hicks (1997, p. 21) supports splitting the *americana* and *caurina* groups into two distinct species. Although several studies have corroborated a separation into two groups, the level of distinctness has been debated (Stone et al. 2002, p. 2050). Stone et al. (2002, p. 2050) examined the extent of geographical variation in the mitochondrial cytochrome *b* gene across populations from the

Pacific Northwest. Their results corroborate and expand the findings of Carr and Hicks (1997) confirming two groups that correspond to the morphological groups *americana* and *caurina* (Stone et al. 2002, p. 2049). Powell et al. (2003, p. 635) considered *M. americana* to be a single species because evidence was not yet compelling that the two groups should be considered separate species. However, at the 5th International *Martes* Symposium in September 2009, Dawson and Cook (2009, abstract) presented information from their forthcoming new book on *Martes* that confirms the separation of *americana* and *caurina* groups into two distinct species.

The 14 currently recognized subspecies of American marten are based on morphological and pelage characteristics (Hall 1981, p. 983; Hall and Kelson 1959, p. 900). The American marten subspecies concept has been both challenged (Hagmeier 1958, p. 7) and defended (Dillon 1961, p. 64). Clark et al. (1987, p.1) tentatively recognized eight subspecies that differ from each other in cranial characters and their fossil history. However, throughout the debate, *M. a. humboldtensis* has continued to be recognized as a distinct subspecies (Hall 1981, p. 983; Clark et al. 1987, p. 1). The Humboldt marten is included in the *caurina* group (Clark et al. 1987, p.1).

Grinnell and Dixon (1926, p. 411) first described the Humboldt marten subspecies. Of the two subspecies of American marten that occur in California (*M. a. humboldtensis* and *M. a. sierrae*), the Humboldt marten is reported to be darker, with a richer golden tone and to have less orange and yellow in the throat patch, a smaller skull (Grinnell and Dixon 1926, p. 411), and smaller and less crowded premolars and molars (Buskirk and Zielinski 1997, p. 17). Grinnell et al. (1937, p. 207) added that the Humboldt marten had "... far less orange-yellow color on the throat and chest, and the usual area of this color is much broken up by coarse spots and marblings of body brown." Hagmeier (1961, p. 124) describes the Humboldt marten as a very small marten, perhaps the smallest subspecies.

M. a. humboldtensis is known from coastal northwestern California, and *M. a. sierrae* occurs from the Salmon-Trinity Mountains east to the Cascades and south throughout the Sierra Nevada (Zielinski et al. 2001, p. 479; Hall 1981, p. 983; Clark et al. 1987, p.1). The canyon of the Klamath River occurs between the two subspecies (Slauson and Zielinski (2004, p. 62). Slauson and Zielinski (2004, p. 62) suggest that the Klamath River and the less hospitable xeric forest types in the river's canyon may be barriers to movement for martens. The Humboldt subspecies is described as occurring in California chiefly within the coast redwood (*Sequoia sempervirens*) zone from the Oregon border south to Sonoma County (Grinnell 1933, p. 100). At the northern boundary of the coast redwood zone, *M. a. humboldtensis* is replaced by *M. a. caurina* which occurs in western Oregon, Washington, and British Columbia (Bailey 1936, p. 296; Hall 1981, p. 983; Zielinski et al. 2001, p. 479). The subspecific boundary between *M. a. humboldtensis* and *M. a. caurina* (Hall 1981, p. 983) is drawn largely coincident with the California-Oregon State boundary and aligns with the northern boundary of the coast redwood zone (Save the Redwoods League 2010).

In 1996, martens were detected at two track-plate stations in northwestern California (Zielinski et al. 1998, p. 1). These were the first verifiable records of a marten within the historical range of *M. a. humboldtensis* in approximately 50 years (Zielinski and Golightly 1996, p. 117). The location of the recently rediscovered coastal California marten population is in the north-central portion of the described range for *M. a. humboldtensis* (Grinnell and Dixon 1926, p. 413; Slauson et al. 2009a, p. 1338).

In 2009, Slauson et al. (2009a, p. 1338) compared mitochondrial DNA sequence diversity of contemporary martens from the described ranges of *M. a. humboldtensis*, *M. a. caurina*, and *M. a. sierrae*, with a 1927 museum specimen of *M. a. humboldtensis*. Martens from the rediscovered population shared a haplotype with the 1927 museum specimen supporting the hypothesis that the population currently in coastal northern California represents descendants of a relict population of martens that previously existed along the coast (Slauson et al. 2009a, p. 1337). This haplotype also occurred in coastal Oregon populations but is absent from the Oregon Cascades population of *M. a. caurina*, suggesting that coastal marten populations of California and Oregon are more similar to each other than to Oregon Cascades populations (Slauson et al. 2009a, p. 1340). The results suggest that the historic subspecific boundary between *M. a. humboldtensis* and *M. a. caurina* at the Oregon-California border may not be valid and that *M. a. humboldtensis* may also occur along the Oregon coast (Slauson et al. 2009a, p. 1340).

There are no known contemporary or historical biogeographic barriers to prevent north to south movement in the California-Oregon border region (Slauson et al. 2009a, p. 1337). Due to small sample sizes, additional genetic analyses are necessary to confirm these relationships (Slauson et al. 2009a, p. 1340). The results of the genetic analysis support the subspecific designation of *M. a. sierrae* distinct from both *M. a. humboldtensis* and *M. a. caurina* despite the relatively short geographic distances between these populations (Slauson et al. 2009a, p. 1340).

Populations of martens in coastal Oregon have declined and are known from only two disjunct locations (Slauson and Zielinski 2009, p.36). Species experts have serious concerns about the viability of the two known marten populations in coastal Oregon (Slauson et al. 2009a, p. 1340). If it is confirmed that coastal Oregon populations should be reclassified as *M. a. humboldtensis*, this species assessment will be updated to include the coastal Oregon populations.

In summary, results of the genetic analysis support the hypothesis that the rediscovered population in northern California represents descendants of a relict population of martens that previously existed along the coast; supported by a common haplotype present in both the museum specimen and the rediscovered population (Slauson et al. 2009a, p.1340). However, additional samples of historic specimens are needed to confirm this relationship (Slauson et al. 2009a, p.1340). Further support that the rediscovered population is descended from coastal martens is the fact that the population is located within the recognized boundary of the Humboldt marten subspecies. In addition, genetic results support the conclusion that *M. a. sierra* differs substantially from the rediscovered population (Slauson et al. 2009a, p. 1340). After review of the best available data, it is reasonable to conclude that the rediscovered population of martens in northern California is *M. a. humboldtensis*. The Humboldt marten continues to be recognized as a valid taxon by the Integrated Taxonomic Information System (ITIS, *www.itis.gov*).

Life History

Few published papers address life history and habitat requirements specific to the Humboldt marten. Therefore, the information discussed below is primarily from work on American martens, but augmented by information on the Humboldt marten where so indicated.

Reproduction

Sexual maturity for American martens occurs by one year of age, but effective breeding may not occur before three years of age (Powell et al. 2003, p. 638). Mating generally occurs in July or August (Strickland et al. 1982, p. 602). The gestation period is 220 to 276 days and can be variable (Strickland et al. 1982, p. 602). Birth occurs in late March or April, due to delayed implantation in which the embryos remain in a state of arrested development (Buskirk and Ruggiero 1994, p. 17). Kits are completely dependent at birth and weaned at about 42 days (Buskirk and Ruggiero 1994, p. 17). The male apparently takes no part in rearing the young (Strickland et al. 1982, p. 603). The young leave the company of their mother and disperse in late summer or autumn (Strickland et al. 1982, p. 603). Martens produce an average of slightly less than three young per female with one litter per year (Strickland et al. 1982, p. 602). For a mammal of their size, martens have low reproductive rates and high longevity suggesting a slow recovery from population-level impacts (Buskirk and Ruggiero 1994, p. 16).

Diet

The American marten is an opportunistic predator with a diverse diet that includes mammals, birds, carrion, eggs, insects, and vegetation (fruits, berries, nuts, fungi, lichens, grass, etc.) (Buskirk and Ruggiero 1994, p. 18; Martin 1994, p. 301). Voles (*Microtus* spp. and *Clethrionomys* spp.), squirrels (*Tamiasciurus* spp. and *Spermophilus* spp.), and chipmunks (*Tamias* ssp.) are important food items for martens across their range (Martin 1994, p. 298). In the Sierra Nevada of California, mammals were the most important food item with microtine rodents the most frequent prey throughout the year and chipmunks and squirrels increasing in importance during the summer (Zielinski et al. 1983, p.388). Seasonal variation in diets is universal with the importance of soft mast, such as berries of *Vaccinium* and *Rubus* peaking in the fall (Buskirk and Ruggiero 1994, p. 19). Two key prey species in the winter diet, red-backed voles (*Clethrionomys californicus* and *C. gapperi*) and Douglas squirrel (*Tamiasciurus douglasii*), are closely associated with late-successional (mature and old-growth age classes) forest conditions (Slauson 2003, p. 6).

Slauson and Zielinski (2007a, abstract) characterized the diet of Humboldt martens by analyzing 420 scats collected from July 2000 through October 2003. Mammals (93%) and berries (85%) were the most frequently occurring items, followed by birds (21%), insects (20%), and reptiles (7%) (Slauson and Zielinski 2007a, abstract). Sciurids (especially *Tamias*) and Murid voles (*Clethrionomys* and *Arborimus*) were the most common mammal species in the diet (Slauson and Zielinski 2007a, abstract). The frequency of berries and birds in the diet of the Humboldt marten is the highest reported in diet studies of the American marten (Slauson and Zielinski 2007a, abstract).

Home Range

Buskirk and McDonald (1989, p. 997) analyzed variation in home ranges reported in the literature for American martens and found that male home ranges were significantly larger than those of females and varied significantly among study sites, whereas female home ranges did not vary significantly among study sites. Strickland and Douglas (1987, p. 535) reported that male home ranges are usually 2 to 3 times larger than female home ranges. Martens exhibit intrasexual territoriality, which allows the home ranges of a male and a female to overlap (Powell et al. 2003, p. 641).

Buskirk and Ruggiero (1994, p. 27) averaged all the study site mean home ranges reviewed by Buskirk and McDonald (1989, p. 999) and found that marten home ranges are 3 to 4 times larger than predicted for a 2.2 lb (1 kg) terrestrial carnivore. They reported that the largest home ranges [male mean = 38,800 ac (15,700 ha), Minnesota] were about 25 times the smallest [male mean = 200 ac (80 ha), Montana]. In the Sierra Nevada of California, reported home ranges from 420 to 1,811 ac (170 to 733 ha) for males and from 173 to 1,433 ac (70 to 580 ha) for females [Simon 1980, p. 97; Martin 1987, p. 75; (Zielinski et al. 1997 as cited in Buskirk and Zielinski 1997, p. 18)].

Habitat quality has been reported to affect home range size for both males and females. In Ontario, Canada, home range sizes in young forest (i.e., less than 45 years after clear-cut) were significantly larger for both sexes compared with those in old forest (Thompson 1994). Male home ranges averaged 840 ac (340 ha) ± 346 ac (140 ha) in uncut forest and 1,236 ac (500 ha) ± 247 ac (100 ha) in cutover areas, whereas females occupied 247 ac (100 ha) ± 99 ac (40 ha) and 766 ac (310 ha) ± 272 ac (110 ha), respectively.

Limited information is available on home range size for the Humboldt marten. Slauson and Zielinski (2006 abstract) estimated seasonal (summer-fall) home range size for radio-collared individuals using the 100 percent minimum convex polygon method (100 percent MCP): adult male home ranges, 1,321.7 ac (534.9 ha) [SE = 719.6 ac (291.2 ha) (n = 5; range 302.9 to 4,179.4 ac) (122.6 to 1691.4 ha)]; single adult female with one kit, 315 ac (127.5 ha); and juvenile females, 1,490.8 ac (603.3 ha) [SE = 795.7 ac (322 ha) (n =3; range 142.3 to 2,975.3 ac) (57.6 to 1,204.1 ha)].

Martens position their home ranges to include an array of forest stands that provide for year-round life history needs and defend these against same-sex conspecifics (Slauson et al. 2007, p. 459). Slauson et al. (2007, p. 462) investigated habitat selection at the home range scale by Humboldt martens. In 2001 to 2002, radio-collared Humboldt martens were relocated in non-serpentine stands 61% of the time and serpentine areas 39% of the time (Slauson and Zielinski 2006, abstract). In non-serpentine areas, 77% of the relocations were in late-successional stands and 9% in early-mature stands with predominants (Slauson and Zielinski 2006, abstract). In serpentine areas, 48% of the relocations were in late-successional stands (Slauson and Zielinski 2006, abstract).

Humboldt martens selected the largest available patch sizes of late-successional stands or serpentine habitat (Slauson et al. 2007, p. 466). Slauson (2003, p. 22) defined the Humboldt marten home-range scale as the area within a 0.62-mi (1 km) radius circle because it matches the reported average area of a marten home range. Slauson et al. (2007, p. 466) suggested that home range areas with larger patch sizes of late-successional stands or serpentine habitat within a 0.62-mi (1 km) radius are important for Humboldt marten occurrence. The probability that a Humboldt marten will be detected increases as the following home range characteristics increase in size; largest contiguous patch of late-successional forest, total amount of late-successional forest, and total area of serpentine habitat (Slauson 2003, p. 68). Study results suggest that a minimum patch size of late-successional forest and serpentine may be required for Humboldt marten occupancy (Slauson et al. 2007, p. 466). Minimum patch size occupied by Humboldt martens was greater than 205 ac (83 ha) and mean patch size occupied was 447 ac (181 ha) (Slauson et al. 2007, p. 466). In non-serpentine habitats, conifer-dominated, late-successional stands with dense shrub cover in patches ≥445 ac (180 ha) should be a minimum criterion to identify potential Humboldt marten home range areas (Slauson 2003, p. 71).

Dispersal

Juvenile martens disperse from their natal area at 4 to 6 months of age (Johnson 2008 p 32. ?). No information has been collected on dispersal distances for Humboldt martens. The range of dispersal distances for 26 juvenile (≤ 1 year old) American martens in Maine was 3 to 21.7 mi (4.9 to 35.1 km) for males [n = 13; median = 8.9 mi (14.3 km)] and 3.4 to 16.8 mi (5.5 to 27 km) for females [n = 13; median = 7.5 mi (12.0 km)] (Phillips 1994, p. 74). The range of dispersal distances for three juveniles in northeastern Oregon was 17.4 to 26.8 mi (28 to 43.2 km) [n = 3; mean = 20.7 mi (33.3 km)] (Bull and Heater 2001a, p. 9). An adult male in the Black Hills of South Dakota travelled 50 mi (74 km) (straight-line distance between capture site to location of death) (Fecske and Jenks 2002, p. 310). In Ontario, Canada, most juveniles remained within 3.1 mi (5 km) of their first capture site (Johnson et al. 2009, p. 3364).

Habitat

American martens are typically associated with closed-canopy, late-successional, mesic coniferous forests with complex physical structure near the ground (Buskirk and Ruggiero 1994, p. 22). Complex ground structure provides protection from predators and protective thermal microenvironments (Buskirk and Ruggiero 1994, p. 22). Structure near the ground may be provided by the lower branches of living trees, tree boles in various stages of decay, coarse woody debris, shrubs, and rockfields (Buskirk and Zielinski 1997, p. 18). Marten populations may be limited by lack of late-successional forest characteristics that are important for den sites, such as large diameter logs, medium and large diameter snags, and high overhead canopy cover (Ruggiero et al. 1998, p. 671). Martens in old uncut forest have a higher frequency of prey encounter, prey attack, and prey kill than martens in younger, logged forest despite similar small mammal densities (Andruskiw et al. 2008, p. 2273). Andruskiw et al. (2008, p. 2273) conclude that these differences in predator efficiency in their Canadian study area were linked to higher amounts of coarse woody debris in old, uncut forests.

In the western United States, martens are strongly associated with late-successional coniferous forests, but they may occur in earlier seral stages that contain remnants of late-successional forest, such as large logs and stumps (Baker 1992 cited in Buskirk and Zielinski 2003, p. 216). Martens generally avoid nonforested areas including prairies and clearcuts that lack overhead cover (Buskirk and Ruggiero 1994, p. 25). Studies reviewed by Powell et al. (2003, p. 642) in Maine, Utah, and Quebec found that martens tolerated an upper limit of 25 to 30% openings, including clearcuts and natural openings in the forest, within their home range.

Historical records of the distribution of Humboldt martens suggest that the subspecies was closely tied to late-successional coast redwood forests (Slauson and Zielinski 2003, p. 3). However, the one known remnant Humboldt marten population occurs in the north-central portion of the described range in an area dominated by Douglas-fir (*Pseudotsuga menziesii*) and tanoak (*Lithocarpus densiflora*) forest associations (Slauson et al. 2007, p. 459). Coast redwood associations occur on the western edge of the occupied range and white fir (*Abies concolor*) occurs at the higher elevations (Slauson et al. 2007, p. 459). This population uses two structurally distinct fog-influenced forest types, one on serpentine soils and one on more productive non-serpentine soils (Slauson 2003, p. 59; Slauson et al. 2009b, p. 3). The non-serpentine habitats contain late-successional Douglas-fir forests and the serpentine types contain mixed conifer [e.g., Douglas-fir, sugar pine (*Pinus lambertiana*), western white pine (*P. monticola*), and lodgepole pine (*P. contorta*)] forests (Slauson et al. 2009b, p. 3).

Recent studies have shown that the Humboldt marten occupies low elevation areas with little or no snowfall and selects forest habitats with some distinctly different features (e.g., dense, extensive shrub cover) than martens in the Sierra Nevada (Slauson et al. 2009b, p. 3). Serpentine habitats occupied by Humboldt martens have open tree canopies, dense shrub cover, and an abundance of boulder piles, while non-serpentine sites have closed, multi-layered tree canopies and dense shrub cover, and are in the oldest seral stages (Slauson 2003, p. 59). In serpentine habitats, the shrub and late-successional developmental stages appeared to be used disproportionately; although every seral stage, except pole, was used (Slauson et al. 2007, p. 462). Serpentine sites sometimes lacked trees suggesting that dense shrub layers may provide the necessary overhead cover (Slauson 2003, p. 61). Boulder-sized surface rocks in serpentine sites may be used for escape cover where tree boles are sparse and provide habitat for prey species, such as chipmunks and golden-mantled ground squirrels (Slauson 2003, p. 61). The combination of interstitial spaces created by rocks and dense shrub cover may allow Humboldt martens to use stands with highly developed shrub communities on serpentine sites (Slauson 2003, p. 63). Recent Humboldt marten population monitoring suggests that serpentine areas may be lower quality than late-successional Douglas-fir forest (Slauson et al. 2009b, p. 12) (See discussion under the Threats, Section on Disease and Predation). In Maine, American martens occupy open canopy conifer stands (typically less than 30%) with significant spruce budworm mortality (Chapin et al. 1997, p. 715). Chapin et al. (1997, p. 715) postulated that in these stands the abundance of snags and high volume of fallen dead trees and root mounds provided the necessary vertical and horizontal structure.

Martens appear to select habitat features at the following four spatial scales; microhabitat, stand, home-range, and landscape (Bissonette et al. 1997, p. 372). At the microhabitat scale, they select specific habitat features that provide foraging, resting, and denning opportunities (Slauson 2003, p. 4). Martens select stands with structural features that provide for life-history requirements such as prey populations and resting structures (Slauson 2003, p. 6). The home-range scale includes an array of forest stands that provide for year-round needs, such as seasonal prey bases and access to mates, while avoiding same-sex conspecifics (Slauson 2003, p. 7). At the landscape scale, dispersing martens select areas that are unoccupied by same-sex conspecifics (Slauson 2003, p. 8).

Microhabitat - Resting and Denning Structures

Martens select rest sites between periods of activity that provide thermoregulatory benefits and protection from predators (Slauson 2003, p. 5). In general, martens use more ground-based resting locations during the winter and more elevated sites in the summer (Slauson and Zielinski 2009, p. 35). A variety of large snags, stumps, and logs dispersed throughout the home range seem requisite for high quality marten habitat (Spencer 1987, pp. 620-621). Bull and Heater (2000, p. 179) described resting sites (n = 1,184) in their study area in northeastern Oregon as follows: 43% were located in trees with natural platforms; 23% were located in trees with cavities; 23% were subnivean; 7% were located in hollow logs or slash piles; and 3% were underground. Snags used as rest sites by martens in the Sierra Nevada were almost exclusively large diameter fir snags [mean = 40 in (102 cm); range = 23 to 58 in (58 to147 cm)] (Spencer 1987, p. 618). At the Sierra Nevada study site, martens selected resting sites among only the largest 15% of the available snags (Spencer 1987, p. 618).

Slauson and Zielinski (2009) described resting structures for Humboldt martens during the late summer and fall. Humboldt martens used cavities, chambers, and broken snag tops for 87% of their resting locations and branch platforms, ground sites, and basal hollows for 13% of their resting locations (Slauson and Zielinski 2009, p. 39). Large snags were the most frequently used resting structure with mean diameter-at-breast-height (dbh) for conifers of 36.6 in (93 cm) (Slauson and Zielinski 2009, p. 40). The mean age at death of 14 snags used as rest sites was 403 years (SE = 28, range 262 to 666) (Slauson and Zielinski 2009, p. 40). Conifer logs used as resting structures had a mean diameter of 29.6 in (75 cm) (Slauson and Zielinski 2009, p. 40). Forty-two percent of the resting structures used in serpentine habitats were located in rock and shrub clumps (Slauson and Zielinski 2009, p. 40).

Natal dens are used by mothers and neonatal young, and are typically located in cavities in very large logs, snags, or live trees (Ruggiero et al. 1998, p. 663). Maternal dens are used by mothers and older, dependent young, and tend to be in less-specialized structures that are similar to resting sites (Ruggiero et al. 1998, p. 663). Availability of denning habitat is essential to successful recruitment and persistence of marten populations (Ruggiero et al. 1998, p. 663). Natal and maternal dens (n = 30) in Bull and Heater's study area in Oregon are described as follows: 40% located in trees with cavities, 37% located in hollow logs, 17% underground, and 6% located in slash piles (Bull and Heater 2000, p. 179). At this study site, resting and denning sites located in cavities and hollow logs were found in large-diameter structures with extensive heartwood decay (Bull and Heater 2000, p. 179).

One adult Humboldt marten was observed with a single kit at three den structures (Slauson and Zielinski 2009, p. 40): in a live chinquapin (*Chrysolepis chrysophylla*) [dbh = 26 in (66 cm)]; a broken top of a live Douglas-fir [dbh = 44.5 in (113 cm)], and in a Douglas-fir snag [dbh = 45.3 in (115 cm)] (Slauson and Zielinski 2009, p. 40).

Forest Stand Characteristics

Late-successional conifer stands typically provide key structural elements, such as large woody structures for denning and resting, prey populations, such as *Clethrionomys* sp. and *Tamiasciurus* sp., and overhead and escape cover (Slauson et al. 2007, p. 464). Martens in the northern Sierra Nevada preferred stands with 40 to 60% canopy closure for resting and foraging and avoided stands with less than 30% canopy closure (Spencer et al. 1983, p. 1183). In non-serpentine stands, Humboldt martens used late-successional stands highly disproportionate to their availability, used late-mature stands similar to availability, and made little or no use of all other seral stages (Slauson et al. 2007, p. 462). All earlier seral stages were selected against, probably because of the lack of one or more key structural features (Slauson 2003, p. 62).

Dense shrub cover was the most consistent habitat feature at sites selected by Humboldt martens in both serpentine and non-serpentine stands (Slauson et al. 2007, p. 465). Humboldt martens showed the strongest selection for conifer stands with greater than 80% shrub cover and selected against stands with less than 60% shrub cover (Slauson and Zielinski 2007b, p. 242). All resting sites in serpentine and non-serpentine habitats had dense shrub cover (Slauson and Zielinski 2009, p. 42). Plant species dominating the shrub layers were shade tolerant, long-lived, mast and berry producing ericaceous species [salal (*Gaultheria shallon*), evergreen huckleberry (*Vaccinium ovatum*), Pacific rhododendron (*Rhododendron macrophyllum*)] and shrub oaks [huckleberry oak (*Quercus vaccinifolia*), bush tanoak *Lithocarpus densiflorus* var. *echinoides*)] (Slauson and Zielinski 2009, p. 42). Humboldt martens did not use disturbance-associated species of shrubs, such as *Ceanothus* sp. (Slauson and Zielinski 2009, p. 42). Dense stands of mature shrubs provide refuge from predators, cover for prey, mast (e.g., berries and acorns) for prey and martens, and may also deter larger-bodied competitors by limiting their foraging abilities (Slauson and Zielinski 2009, p. 42). Thick shrub layers also provide nesting and foraging areas for birds. The importance of the shrub layer is consistent with the high frequency of berries and birds in the diet of the Humboldt marten. Shrubs also contribute to the formation of some resting structures (Slauson and Zielinski 2009, p. 42).

The distribution of late-successional stands at the landscape-scale may be the primary determinant of marten distribution (Kirk and Zielinski 2009, p. 760). Landscape attributes that may be important to marten persistence are stand size, stand shape, area of stand interiors, amount of edge, stand insularity, corridors, and connectivity (Buskirk and Ruggiero 1994, p. 24).

Based on their survey of the extant population during 2000 to 2001 and 2008, Slauson et al. (2009b, p. 12) found that the biggest difference between sites occupied by Humboldt martens during both sampling periods versus during a single sampling period was the size of the patch of late-successional forest. Larger patches were more likely to be occupied during both sampling periods. Late-successional conifer stands with dense shrub cover provide overhead and escape cover, suitable resting and denning structures, and support important prey populations (Slauson 2003, p. 62). Early seral stages are lower quality habitat for Humboldt martens and likely pose higher predation risks due to the presence of larger-bodied mesocarnivores [e.g., bobcats (*Lynx rufus*)] (Slauson et al. 2009b, p. 12). Smaller late-successional patches, <124 ac (50 ha), are often adjacent to roads and younger stands and may be used by larger-bodied mesocarnivores that do not typically occur in larger patches; therefore, they may not provide the same quality of habitat as larger patches (Slauson et al. 2009b, p. 12).

Patch size and degree of connectivity have important implications for martens attempting to recolonize unoccupied stands. Highly fragmented forests may contain suitable habitat patches that are so separated by open areas that martens cannot make use of the habitat that is available (Buskirk and Powell 1994, p. 289). The more highly fragmented mature forest becomes, the lower the carrying capacity for martens (Thompson and Harestad 1994, p. 360). In Maine (Chapin et al. 1998, p. 1335), marten home ranges included a median of only 20% regenerating clearcuts, and maximum observed values were 40% and 31% for individual males and females, respectively. Johnson et al. (2009, p. 3366) found that juvenile martens raised in young, regenerating forests dispersed shorter distances and suffered higher mortality risk with increasing distance than juveniles raised in older uncut forest in Ontario, Canada. Hargis et al. (1999, p. 165) found that martens were rarely detected in sites with greater than 25% open areas, even though forest connectivity was still present. They recommended that the total amount of open areas due to timber harvests and natural openings should make up less than 25% of landscapes 2,200 ac (900 ha) and larger in size and that the spatial pattern of the open areas should also be a consideration (Hargis et al. 1999, p. 157). Chapin et al. 1998 (p. 1336) recommended maximizing residual patch area and minimizing the distance between large residual patches to maintain martens in forested landscapes.

In summary, martens are closely associated with late-successional mesic coniferous forest with large diameter trees, logs, snags, and high overhead canopy closure. The historical distribution of Humboldt martens was closely tied to the coast redwood zone, an area characterized by summer fog. The extant population uses two fog-influenced forest types, open mixed conifer forests on serpentine soils and late-successional Douglas-fir forests on non-serpentine soils on the eastern edge of the coast redwood zone. An extensive dense layer of shade tolerant shrubs is an essential feature of both forest types. Recent research indicates that the serpentine stands may be lower quality Humboldt marten habitat than late-successional Douglas-fir forests. Potential Humboldt marten home range areas should contain patches of at least 445 ac (180 ha) of late-successional forest with dense shrub cover.

Range and Distribution

Historical Range/Distribution

Grinnell and Dixon (1926, p. 413) describe the historical range of the Humboldt marten as occurring within 50 mi (80.5 km) of the coast in Humboldt and Del Norte counties and likely occurring south to Fort Ross in Sonoma County (Figure 2). Grinnell (1933, p. 100) and Grinnell et al. (1937, p. 209) describe the range as a narrow humid coastal strip chiefly within limits of the coast redwood belt from the Oregon border south historically to Fort Ross, and up to an altitude of about 3,000 ft. (914 m). Twining and Hensley (1947, p. 133) described the range as the northern coast ranges of California. Historical records of the distribution suggest that the subspecies occurred from northern Sonoma County to the California-Oregon border (Slauson and Zielinski 2003, p. 3). In 1947, Twining and Hensley (1947, p. 136) noted that martens had not been trapped in Lake or Sonoma counties for many years and records were scarce for Mendocino County. However, Hemphill (1952, p. 146) estimated that there were greater than 100 martens on the Mendocino National Forest, although no data were provided. Most historical records (20 of 24) occur in coast redwood and Douglas-fir forests within 15.5 mi (25 km) of the coast (Slauson and Zielinski 2007b, p. 241). The eastern boundary of the Humboldt marten's range may have coincided with the fog zone, as forests outside of this zone naturally lose the dense, spatially extensive shrub layers (K. Slauson, Redwood Sciences Laboratory, pers. comm. 2010).

Historic range reduction is likely the result of extensive fur trapping (Grinnel et al. 1937, p. 210) and habitat loss due to logging of late-successional coast redwood forests during the last century (Buskirk and Ruggiero 1994, p. 11; Proulx et al. 2004, p. 51). Coast redwood accounted for approximately 35% of the conifer forests within the historical range.

Figure 2. Current range of the Humboldt marten in California in relation to its historic range and conifer and mixed conifer/hardwood forest habitats.

Current Range/Distribution

Until 1996, the existence of martens within the historic range of the Humboldt marten was in doubt (Zielinski et al. 2001, p. 487; Kucera et al. 1995, p. 96). Zielinski and Golightly (1996, p. 117) could not document a single verified location within the historical range in the 50 years prior to 1996. However, in 1996, a single population was rediscovered on the Six Rivers National Forest in Del Norte County. Detections of Humboldt martens in 1996 and 1997 represented the first verified presence of martens within the range of the Humboldt marten subspecies since the trapping season was closed in 1946 (Zielinski et al. 2001, p. 487).

Extensive surveys to detect forest mustelids using sooted track-plates and photographic bait stations have been conducted throughout northwestern California. These surveys have not detected any additional marten populations in the historical range of the Humboldt marten (U.S. Forest Service Redwood Sciences Lab 2009, p. 3). Kucera et al. (1995, p. 101) suggested that the failure to locate martens during these survey efforts indicated that Humboldt martens were at best extremely rare and may have been extirpated from the survey areas. Some of the California State Parks, especially Humboldt Redwoods State Park (HRSP), are the only significant areas within the historical range that have not been adequately surveyed to date (W. Zielinski, Redwood Sciences Laboratory, pers. comm. 2010) (HRSP represents approximately 0.9% of the historical range).

Zielinski et al. (2001, p. 481) summarized survey results for the coastal mountains of California, Oregon, and Washington from 1989 to 1998. During this period, a total of 237 sample units, using about 2,360 track-plate or camera stations comprising about 34,800 survey days were sampled (Zielinski et al. 2001, p. 483). The density and distribution of surveys were highest in California and were located primarily in the northern portion of the historical range of the Humboldt marten (Del Norte and Humboldt counties) (Zielinski et al. 2001, p. 483). Humboldt martens were detected at 4 of the 184 sample units in northern California (Zielinski et al. 2001, p. 483). All detections were clustered at the known population site in Del Norte County (Zielinski et al. 2001, p. 483).

Beyer and Golightly (1996, pp. 3-5) report the results of systematic track-plate surveys conducted within 31 mi (50 km) of the coast on private and public lands from the Oregon border to the southern end of HRSP in 1994 and 1995. A total of 234 track-plate stations were sampled for 22 days each with no marten detections. In 2002, Redwood National and State Parks (RNSP) were systematically sampled using a six track-plate station sampling unit array arranged in a grid pattern with 3.1 mi (5 km) separating each sampling unit array (Slauson and Zielinski 2003, p. 2). Martens were not detected during this sampling effort (Slauson and Zielinski 2003, p. 2). The authors believed the survey coverage was sufficient to conclude that a significant Humboldt marten population did not occur within RNSP (Slauson and Zielinski 2003, p. 9).

Historical occurrence of the Humboldt marten on the Mendocino National Forest was concentrated in the primarily true fir (*Abies* sp.) forests in the vicinity of Lake Pillsbury (Slauson and Zielinski 2007c, p. 2). Prior to 2006, this area represented one of the largest remaining survey gaps in the historical range in northern California (Slauson and Zielinksi 2007c, p. 2). Surveys in 2006 failed to detect any martens and the authors concluded that martens appear to be extirpated from the high elevation sites in the vicinity of Lake Pillsbury (Slauson and Zielinski

2007c, p. 2). They were unable to rule out that a population may still exist in the high elevations of the Yolla Bolly Wilderness because the survey effort was insufficient to conclude absence (Slauson and Zielinski 2007c, p. 8). Slauson and Zielinski (2007c, p. 8) recommended that future survey efforts target large areas of true fir forest in the Yolla Bolly Wilderness.

Green Diamond Resource Company owns approximately 416,000 ac (168,300 ha) of timberlands in Humboldt and Del Norte counties. In 1994, 40 survey segments consisting of 6 sooted track-plate stations at 0.62 mi (1 km) intervals (238 stations) were established throughout the ownership (Diller et al. 2009, p. 1). Surveys of these stations were conducted in 1994, 1995, and 2004 (Diller et al. 2009, pp. 1-2, 28). In 2006, 18 of the 40 segments were randomly selected and resurveyed (Diller et al. 2009, p. 28). The only Humboldt marten detected on Green Diamond Resource Company timberlands are in the vicinity of the population detected in 1996.

In 2000 and 2001, the extant Humboldt marten population was surveyed using track-plate stations (Slauson et al. 2002, p. 3). Using the minimum convex polygon method, the total area occupied by this population was estimated to be 165 mi^2 (424 km^2) (Slauson et al. 2002, p. 9). The area known to be occupied occurred from the headwaters of Rock Creek (drainage of the Smith River) in Del Norte County, east to the headwaters of Rock Creek (drainage of the Klamath River) in Siskiyou County, and south down to Fish Creek (drainage of the South Fork Eel River) in Humboldt County (Slauson et al. 2002, p. 9).

In 2008, new detections during the surveys increased the known occupied area to 246 mi^2 (637 km^2) (Slauson et al. 2009b, p. 9) (Figure 2). The known range was increased 6.8 mi (11 km) to the south to near Fish Lake in the Bluff Creek watershed within 1.2 mi (2 km) of the Klamath River and increased 2.5 mi (4 km) to the north to near the mouth of Rock Creek on the Smith River (Slauson et al. 2009b, p. 9). The addition of recent detections on private timberlands (Keith Hamm, Green Diamond Resource Company, pers. comm. 2010) increased the known occupied area to 267 mi^2 (170,900 ac) or 692 km^2 (69,200 ha). It should be noted that all of these estimates of known occupied area are best estimates based on minimum convex polygon methods that likely include substantial portions of the landscape that may be unsuitable for (and likely unoccupied by) martens.

Humboldt Redwood Company (formerly Pacific Lumber Company) owns approximately 210,000 ac (85,000 ha) of timberlands in Humboldt County. From 2000 through 2005, camera stations were monitored at 119 sample units across the ownership (Pacific Lumber Company 2005, pp. 1-4). Sample units were 4 mi^2 (10.4 km^2) areas that were sampled for a minimum of 35 nights (Pacific Lumber Company 2005, pp. 1-4). No martens were detected.

Jackson Demonstration State Forest in Mendocino County contains approximately 48,700 ac (19,700 ha) in Mendocino County. Mesocarnivore camera stations were monitored in 2003 (3 stations) and 2004 (8 stations) with no marten detections (California Department of Forestry and Fire Protection 2005, p. VII.6.6-106-107).

From 2004 to 2008, Mendocino Redwood Company initiated track-plate surveys in coastal Mendocino County from Westport to south of Point Arena. A total of 47 track-plate sites were surveyed during this period with no marten detections (Douglas et al. 2009, p. 10). In 2009, Campbell Timberland conducted 10 days of surveys (5 station visits) at 24 track-plates in their

Usal Management Area in Mendocino County with no marten detections (D. Meekins, Campbell Timberland Management, pers. comm. 2010).

In 2009, there were two Humboldt marten detections (photographs) southwest of the Klamath River in Prairie Creek Redwoods State Park (U.S. Forest Service Redwood Sciences Lab 2009, p. 3) (Figure 2): These detections were 6 mi (9.6 km) west of the nearest known occurrence. Detections occurred in late-successional coast redwood forest with a dense shrub and fern understory (U.S. Forest Service Redwood Sciences Lab 2009, p. 3). In 2002, RNSP was systematically surveyed with no Humboldt martens detected, suggesting that the 2009 detections may represent either a recent colonization (U.S. Forest Service Redwood Sciences Lab 2009, p. 3), or a lone dispersing individual. Since the status of these recent detections is not fully understood, they are not included in the calculation of estimated range of the species at this time. Ongoing surveys, and analysis of hair samples collected during these surveys, may shed light on this question in the future.

In summary, Humboldt martens have been consistently detected at one geographic location within the historical range which encompasses a known occupied area of approximately 267 mi^2 (692 km^2). Land ownership within the occupied range includes private timberlands, Smith River National Recreation Area and Orleans Ranger District of the Six Rivers National Forest, and Ukonom Ranger District of the Klamath National Forest. Two detections occurred at Prairie Creek Redwoods State Park; however, it is unknown if these detections represent a new population or a single individual.

Population Estimates

Historical information and recent survey data indicate that the Humboldt marten population has declined significantly during this century (Zielinski and Golightly 1996, p. 117). Humboldt martens were relatively common in the late nineteenth and early twentieth century (Zielinski and Golightly 1996, p. 115). The population decline was noted by Grinnell et al. (1937, p. 209) when they summarized that the Humboldt marten is "…of rather sparse occurrence, though in earlier years it was more generally distributed and fairly numerous." Declining trapping harvests led to the closure of the marten trapping season in northwestern California in 1946 (Zielinski et al. 2001, p. 479). In 1995, the subspecies was assumed to be either extremely rare or extinct (Zielinski et al. 2001, p. 479).

In 2000-2001, the first study was conducted to determine the distribution of the Humboldt marten population rediscovered in 1996 (Slauson et al. 2002, p. 2). The 2000-2001 survey design consisted of a 12 x 14 systematic grid with 1.2-mi (2 km) spacing encompassing all locations where Humboldt martens had been detected since 1996 (Slauson et al. 2001, p. 4). Martens were detected at 28 (17%) of the 168 sample units within the grid (Slauson et al. 2002, p. 2). In 2008, the 28 sample units where martens were detected during the 2000-2001 sampling effort plus 7 additional units, where predicted habitat suitability was the highest, were resampled to determine whether the population had remained stable or decreased (Slauson et al. 2009b, p. 5). To further delineate the range of the extant population, an additional 15 sample units were added in 2008 (Slauson et al. 2009b, p. 9). However, due to wildfire closures, five of the original sample units were not resampled in 2008 (Slauson et al. 2009b, p. 9). Martens were detected at 14 (47%) of the 30 sample units in comparison to 23 (76%) of the 30 sample units in 2000-2001.

The change between 2000-2001 and 2008 marks a significant decline in site occupancy, representing a change in occupancy rate $\lambda = 0.58$ (SE = 0.13, 95% CI = 0.31 to 0.81) or a 42% decline in sample unit occupancy over the 7-year period (Slauson et al. 2009b, p. 10).

In 2009, the size of the Humboldt marten population was estimated with data from the 2000-2001 and 2008 surveys using the multi-state occupancy method (Slauson et al. 2009b, p. 11). Population estimates for the 30 sample units were 31.5 (95% C.I. = 24-40) in 2000-2001 and 20.2 (95% C.I. = 11-30) in 2008 (Slauson et al. 2009b, p. 11). Notably, female occupancy declined the most substantially from 2000- 2001 to 2008 (Slauson et al. 2009b, p. 11). This population estimate should be considered a minimum estimate for several reasons, including the fact that the sampling grid does not fully cover all potentially occupied habitats (Slauson et al. 2009b, p. 13). Slauson et al. (2009b, p. 13) suggest a more realistic population estimate would be to double these estimates; that is, 60 Humboldt martens in 2000-2001 and 40 in 2008. They conclude that it is likely the entire Humboldt marten population contains fewer than 100 individuals (Slauson et al. 2009b, p. 13).

THREATS

Habitat Loss

Loss, degradation, and fragmentation of late-successional forests and/or key habitat elements (e.g., large standing and dead conifers, down woody debris, and dense shade tolerant shrubs) due to timber harvest, wildfire, fuels reduction projects, and roads, are threats to the Humboldt marten.

Timber Harvest

Timber harvest has eliminated most late-successional forests on private lands in coastal California. About 2.7 million ac (1.1 million ha) of late-successional coast redwood forests were present in California during the early to mid-1800s (USDI Fish and Wildlife Service and USDC National Marine Fisheries Service 1999). Currently, there are approximately 70,000 ac (28,000 ha) of late-successional coast redwood forest remaining in California (U.S. Fish and Wildlife Service 1996, p. 26262), representing about 2.6% of the original late-successional coast redwood forest. This remaining late-successional coast redwood occurs primarily in reserves on State and Federal land where it is protected from future timber harvest.

The majority of coast redwood forests have been logged one or more times, primarily using clear-cutting silvicultural methods. Privately owned industrial timber lands are currently managed under short 50-year rotations. These logging practices preclude development of late-successional forest characteristics that are important to Humboldt martens, such as large diameter logs, snags, and trees. In the coast redwood region, a shrub layer dense with evergreen huckleberry, salal, or salmonberry (*Rubus spectabilis*) was a common structural component in mature forests (Sawyer et al. 2000b, p. 46). Managing coastal forests on short rotations has reduced the complexity of the shrub and herb layers (Slauson and Zielinski 2007b, p. 241). The Humboldt marten population currently occurs only in coastal forest habitats with a dense, spatially-extensive, shade tolerant shrub cover (Slauson and Zielinski 2007b, p. 243) primarily on Forest Service lands, where little timber harvest has occurred. Maintenance of this shrub layer may be critical to the restoration of this subspecies (Slauson and Zielinski 2007b, p. 243).

Zielinski et al. (2001, p. 487) believe the effect of past and current timber harvest in the coast redwood region is the most plausible reason for the absence of Humboldt martens throughout most of the coastal portions of their historic range. Slauson et al. (2007, p. 458) estimated that Humboldt martens have been extirpated from greater than 95% of their historic range, with only a single population occupying an area of about 267 mi2 (692 km2). Historic range reduction is likely the result of habitat loss due to logging of old-growth coast redwood forests during the last century (Buskirk and Ruggiero 1994, p. 11; Proulx et al. 2004, p. 51). Chapin et al. (1998, p. 1328) summarized studies of the effects of clearcutting on martens, which reported selection against clearcuts (Steventon and Major 1982; Snyder and Bissonette 1987; Frederickson 1990; Katnik 1992) and reduced density of martens in logged landscapes (Soutiere 1979; Bissonette et al. 1989; Philips 1994; Thompson 1994).

Humboldt martens use structural features of late-successional forests, such as large diameter live trees, snags, and logs. Most resting structures used by Humboldt martens require more than a century to develop (Slauson and Zielinski 2009, p. 43). Loss of these elements can reduce the suitability of forested areas for martens (Slauson and Zielinski 2004, p. 61). The probability of detecting Humboldt martens increased with increasing maximum patch size of late-successional forest (Slauson 2003, p.67). The minimum patch size to identify potential Humboldt marten home range areas is 445 ac (180 ha) of late-successional forest with dense shrub cover (Slauson 2003, p. 71). Little habitat with the necessary structural characteristics for Humboldt martens is expected to regenerate over the next several decades. Future occupancy of regenerated habitat by Humboldt martens will depend on factors, such as its proximity to currently occupied sites, population size, and connecting corridors.

Reduction in the total amount of late-successional forest is only one of the timber harvest related threats facing the Humboldt marten. The continued simplification of the structure of forests and their fragmentation into smaller, more isolated, patches (Cooperrider et al. 2000, p. 163) is also a concern. For example, RNSP contain approximately 41,400 ac (16,700 ha) of late-successional coast redwood forest. This includes 41,100 ac (16,600 ha) in stands greater than 0.5 ac (0.2 ha) and 362 ac (146 ha) of isolated late-successional trees surrounded by mature tree buffers. Late-successional forests in RNSP are fragmented with only three stands containing more than 5,000 ac (2,023 ha). The majority (83%) of the late-successional stands in RNSP are 100 ac (40 ha) or smaller with 31% of the stands less than 5 ac (2 ha) in size. RNSP also contains over 50,000 ac (20,235 ha) of second growth forest most of which was harvested between 1950 and 1978 (Redwood National and State Parks 1998, p. 192).

Stands dominated by conifers other than coast redwood account for approximately 65% of the coniferous forest in the Humboldt marten's historical range. These forests on private and public lands have also been altered by timber harvest during the last century.

Since 1994, the Six Rivers and Klamath National Forests have been managed under the Northwest Forest Plan (NWFP; USDA Forest Service and USDI Bureau of Land Management 1994a, pp. 1-73). NWFP land allocations within the occupied Humboldt marten area include matrix, wilderness, late-successional reserve, and administratively withdrawn areas. Matrix lands are available for future timber harvest, while wilderness, reserves and administratively withdrawn areas are not. Approximately 38% of the occupied range occurs on lands currently available for timber harvest: matrix and private industrial timber land. On Forest Service lands, approximately 28% of matrix lands are on serpentine soils (Slauson 2003, p. 25). Due to the open nature and small-sized trees on serpentine sites, it is unlikely that timber harvest will occur in these stands; however, because of their dense shrub understory component both wildfire and fuels reduction projects pose potential threats to these stands.

Public lands are disjunct and represent only a small proportion of the total area of coastal forest in northern California, with most forestland in industrial or non-industrial private ownership. Public lands in coastal northwestern California include state parks, one national park, a Bureau of Land Management conservation area, and portions of the Six Rivers and Klamath National Forests. Humboldt martens were detected proportionately more frequently on lands managed by the Forest Service than on private timberlands (Slauson 2003, p. 68). Greater than 80% of the private timberlands in the 2000- 2001 Humboldt marten study area were logged prior to surveying and martens appeared to avoid all but the edge of this landscape (Slauson 2003, p. 68).

The only lands within the occupied range currently managed to protect late-successional forest are the NWFP reserves. The potential exists on public and private lands to implement experimental silvicultural treatments in young stands to accelerate the development of late-successional forest characteristics. Carefully designed treatments in existing younger, even-aged stands can open up the canopy, thereby increasing diversity and accelerating the transition to a forest with mature characteristics (USDA Forest Service and USDI Bureau of Land Management 1994a, p. C-12). It is uncertain whether treatments of these stands could also be conducted to maintain and/or enhance the understory shrub layer. Projects that have the dual goals of restoring the shrub understory in the short-term and increasing the development of large trees, a multi-layered canopy, and recruitment of large snags and logs will likely benefit Humboldt martens over the long-term (Slauson et al. 2007, p. 466).

Wildfire

Fire frequency and intensity increase with distance from the ocean and elevation (Sawyer et al. 2000c, p. 111). The influence of natural fires on coast redwood stands vary from very strong to virtually nonexistent depending on location, exposure, and moisture conditions (Noss 2000, p. 265-266). Fire has been, and continues to be an important disturbance factor in the Douglas-fir and tanoak series on the Six Rivers National Forest (Jimerson et al. 1996, p. A-21) where the extant population is located.

The potential for stand-replacing wildfire has increased in areas where fire suppression and regeneration timber harvest have played a role in raising fuel load to levels that place late-successional forest at increased risk (USDA Forest Service and USDI Bureau of Land Management 1994b, p. 3 & 4-49). Fire effects vary with high-severity fires tending to eliminate all late-successional forest. The largest recent fire in coastal southern Oregon and northern California was the 2002 Biscuit fire, which burned approximately 499,960 acres (202,300 hectares) in the Rogue River Basin (USDA Forest Service 2009). Fifty percent of the area burned very hot, killing more than 75% of the vegetation (USDA Forest Service 2009).

While fire poses a low risk in coastal redwood communities, the extant Humboldt marten population primarily utilizes Douglas fir-tanoak communities and thus are more vulnerable to lightning ignited fires. Frequency of these types of fires have increased in recent years and while climate change scenarios are not well developed for this area, there is a potential that climate change issues may further exacerbate this issue.

We compared the size of wildfires in Douglas-fir in the Klamath Ecoregion (Humboldt, Del Norte, and Siskiyou counties) during the past 20 years (1990-2010) with historic (1909-1989) wildfires. Recent fires burned an average of 55,212 ac (22,344 ha) per year [n = 18 years; SD = 125,797 ac (50,909 ha); range = 38-504,764 ac (15-204,275 ha)] while historic fires averaged only 7,337 ac (2,969 ha) per year [n = 73 years; SD = 27,290 ac (11,044 ha); range = 6-216,236 ac (2-87,510 ha)].

In the past 12 years, approximately one-third of the occupied range has burned due to the wildfires. A fire in 1998, a 23,300 ac (9,430 ha) wildfire burned 8% of the occupied range. In 2008, a complex of lightening fires burned approximately 191,000 acres (77,300 hectares) on the Six Rivers and Klamath National Forests in and adjacent to the occupied marten range. Approximately 20% of the Humboldt marten occupied range occurred within the boundaries of these wildfires (Slauson et al. 2009b, p. 11). Post-fire site visits to some of the burned areas showed that the dense shrub understory was removed likely reducing the suitability of these areas for martens over the short-term (Slauson et al. 2009b, p. 11).

In three recent years, more acres burned per year in Douglas-fir forest in the Klamath Ecoregion than the entire Humboldt marten occupied range [170,900 ac (69,200 ha) (1987 burned 216,236 ac (87,510 ha); 2002 burned 504,764 ac ((204,275 ha)]; and 2008 burned 221,333 ac (89,572 ha).

Effects of the 2008 fires may have contributed to the 42% decline in occupancy detected in the Humboldt marten population between 2000-2001 and 2008. Due to small population size and limited range, wildfires are a significant on-going threat to the Humboldt marten and its habitat on all land allocations; this threat is expected to continue and increase in the future.

Fuels Reduction Projects

Fuels management projects designed to lower fire risks, such as prescribed burning and mechanical treatments may be key in reducing potential for catastrophic wildfire impacts to Humboldt marten. However, these same practices may have the potential to negatively affect Humboldt martens and their habitat by reducing important features such as shrubs, canopy cover, snags, or logs if not done properly. Prescribed burning may impact natal dens during the breeding season or displace Humboldt martens. Significant loss of the shrub layer due to fuels reduction projects may reduce habitat suitability, due to reduction in prey abundance or improved access by competitors (Slauson and Zielinski 2004, p. 63). However, there are also potential long-term benefits from carefully designed fuels management projects that may minimize the loss of late-successional stands due to wildfires. Effects of fuels reduction projects will depend on amount and type of fuel removed and location of treatment relative to suitable and occupied habitat. Other forest management activities, such as salvage and hazard tree removal, also have the potential to degrade habitat by reducing the number of large trees, snags, and logs. On the Six Rivers National Forest, salvage and fuels management activities can occur in all land allocations except wilderness.

Roads

Potential impacts from roads include direct habitat removal, habitat fragmentation, road kill mortality, and disturbance from noise and human activities. Roads and highways may be significant dispersal barriers for some species (Meffe and Carroll 1994, p. 248). Roads may fragment populations into smaller demographic units that are more vulnerable to extinction (Meffe and Carroll 1994, p. 248). The U.S. Highway 101 corridor separates the known Humboldt marten population from suitable habitat in RNSP. Large areas of early-seral industrial forest, the Klamath River, and U.S. Highway 101 corridor likely represent three significant barriers that Humboldt martens from the known population would have to cross to reach late-successional coast redwood forests in RNSP (Slauson and Zielinski 2003, p. 14). Roads may also modify habitat by creating linear openings, which facilitate the presence and abundance of forest generalists [e.g., cougar (*Puma concolor*), gray fox (*Urocyon cinereoargenteus*), and bobcat] in forest interiors increasing predation risks for Humboldt martens (Slauson and Zielinski 2010, abstract).

Trapping

Because American martens were highly valued in the fur trade and trapping was virtually unregulated before the 1920s, populations were severely reduced by the early 1900s (Strickland 1994, p. 149). Marten populations that are reduced by excessive harvest may take years to recover, and long-term loss of genetic variation may result (Strickland 1994, p. 151). In 1937, Grinnell et al. (1937, p. 209) noted that the Humboldt marten was already rather sparse, though fairly numerous in earlier years. Grinnell et al. (1937, p. 210) recount records of individual trappers taking 35 and 50 martens in one winter within a few miles of the coast (e.g., east of Big Lagoon and Loleta).

Six trappers in Humboldt and Del Norte counties caught an average of two martens each in 1941 and eight trappers caught an average of two martens each in 1942 (Twining and Hensley 1947, p. 136). In 1946, the California Fish and Game Commission closed the trapping season in all or parts of Del Norte, Humboldt, Siskiyou, and Trinity counties due to declining harvests (Twining and Hensley 1947, p. 136). In the 1920s and 1930s, extensive coyote control (*Canis latrans*) using poisoned baits occurred on the Mendocino National Forest with unknown effects on martens (Slauson and Zielinski 2007c, p. 8). Single or combined effects of trapping and poisoning likely contributed to the decline and extirpation of historical Humboldt marten populations (Slauson and Zielinski 2007c, p. 8). However, decades of protection from trapping has not resulted in the recovery of Humboldt marten populations in coastal northwestern California (Slauson and Zielinski 2004, p. 61).

It is currently legal to trap other mammals that may occur in Humboldt marten habitat, including bobcat and gray fox. It is no longer legal to use any body-gripping traps in California. Trapping is still legal in southern coastal Oregon. Although no data exists to determine incidental trapping-related injury or mortality from non-body gripping traps, use of box traps suggests that if trapped, Humboldt martens should be released unharmed. Due to the remote location of the occupied habitat and the above restrictions, it is assumed that current mortalities and injuries from legal incidental capture of Humboldt martens are infrequent.

Disease and Predation

Mortality from disease or predation may be a significant threat to the Humboldt marten substantially as a result of the small population size. Species with small populations are subject to rapid decline in numbers as a result of environmental fluctuations, such as a disease outbreak or increased predation (Primack 1993, p. 255). The smaller a population becomes the more susceptible it is to stochastic (random) demographic and environmental variation, and genetic factors that tend to reduce population size even more and push the population to extinction (Primack 1993, p. 274).

Strickland et al. 1982 (p. 607) noted that American martens in their study area in central Ontario, Canada tested positive for toxoplasmosis, Aleutian disease, and leptospirosis; however, none of these were known to be a significant mortality factor in martens. From 2004 through 2007, Gabriel et al. (2008, p. 49) investigated the prevalence of several pathogens within the mesocarnivore community on the Hoopa Valley Indian Reservation in northeastern Humboldt County. A combined total of 63 gray foxes, ringtails (*Bassariscus astutus*), raccoons (*Procyon lotor*), and spotted and stripped skunks (*Spilogale putorius* and *Mephitis mephitis*) showed prior exposure to canine distemper virus (2% of individuals), canine parvovirus (30%), canine adenovirus (9%), West Nile virus (6%), *Anaplasma phagocytophilum* (50%), and *Toxoplasma gondii* (40%). Of 20 individuals tested for active infections, 15% were found infected by *A. phagocytophilum* and 19% were found to be actively shedding canine parvovirus. Disease has the potential to be a threat due to the extremely small population size of less than 100 individuals; however, we are not aware of any evidence suggesting that the Humboldt marten is currently threatened by disease.

Mortality from predation could also be a significant threat for the Humboldt marten because of its small population size. Strickland et al. (1982, p. 607) summarize reports of martens being preyed upon by coyotes, fishers, red foxes (*Vulpes vulpes*), cougars, eagles (*Aquila chrysaetos*, *Haliaeetus leucocephalus*), and great horned owls (*Bubo virginianus*). Bull and Heater (2001b, p. 3) in their northeastern Oregon study area documented 18 martens killed by predators: 44% by bobcats, 22% by raptors, 22% by other martens, and 11% by coyotes.

Distributions of several mesocarnivores in coast redwood forests have changed over the last 80 years (Slauson and Zielinski 2007b, p. 242). Logging of coastal forest has reduced the complexity of the shrub and herb layers due to various factors such as mechanical treatments, prescribed burning, herbicides, and densely stocked conifer stands (Slauson and Zielinski 2007b, p. 241). Distribution of Humboldt martens has dramatically declined in coastal forests, while fisher and gray fox, potential marten predators, have maintained their interior distributions and appear to have expanded their distributions in coastal forests (Slauson and Zielinski 2007b, p. 242). Fishers and gray foxes typically occupy forest types where shrub densities are naturally lower and are rarely detected in coastal forest with extensive shrub cover (Slauson and Zielinski 2007b, p. 242). Dense, spatially extensive shrub layers may provide smaller-bodied martens an advantage over other larger-bodied carnivores (Slauson et al. 2007, p. 466). Logging practices that reduce the shrub layer may have made Humboldt martens more vulnerable to predation by larger mesocarnivores, such as fishers and gray foxes.

Recent work (Slauson and Zielinski 2010, abstract) shows that bobcats and gray foxes tend to frequently use roads in the coast redwood region. Roads may be facilitating the presence and abundance of these species in dense-shrub landscapes and increasing the risk of intraguild predation for martens if encounters with larger-bodied carnivores are more likely to occur on roads, where martens are more vulnerable than in forest interiors (Slauson and Zielinski 2010, abstract). Potential threats hypothesized to be the most likely cause for the Humboldt marten decline include disease and intraguild predation (Slauson and Zielinski 2010, pp. 3-6).

Summary of Threats Discussion

Loss, modification, and fragmentation of habitat are significant ongoing threats to the remaining Humboldt marten population. The Humboldt marten has been extirpated from as much as 99% of its historical distribution, with the current range reduced to one small area of about 170,900 ac (69,200 ha). Historic timber harvest has eliminated most late seral forests on private lands, and from large areas of public lands in coastal California. Martens have specialized habitat requirements, such as large diameter live trees, snags, and logs, which take centuries to develop. Therefore, little habitat with the necessary structural characteristics to support Humboldt martens is expected to regenerate over the next few decades. Approximately 38 percent of the occupied range is on lands currently available for timber harvest. Without a management strategy to maintain key habitat elements it is unlikely these lands will support a viable marten population. Humboldt martens and their habitat in the remaining occupied area are patchily distributed. Further loss or degradation of suitable habitat could appreciably reduce the likelihood of survival of this subspecies.

Wildfire has the potential to greatly alter habitat essential to martens when that wildfire removes structural components including overstory canopy, large logs or dense understory shrubs. Fuels reduction projects, while potentially beneficial to martens by reducing overall risk of large-scale, intense wildfire, need to be carefully planned to minimize the loss of essential habitat components or fragmenting existing suitable habitat.

Roads may fragment suitable habitat and provide corridors for movement of potential predators such as bobcats and coyotes.

While direct trapping of martens in California has not been legal for several decades, incidental capture of martens while targeting other species may still be a risk, and should be monitored to assess that risk. Trapping of martens remains legal in coastal Oregon.

Management activities that encourage populations of other mesocarnivores to increase may place additional pressure on the remaining marten population, as several of these species, especially fishers, may opportunistically kill martens when encountered.

POPULATION VIABILITY

The entire Humboldt marten population may number less than 100 individuals (Slauson et al. 2009b, p. 13). Small isolated populations are vulnerable to extinction for the following four main reasons: 1) genetic problems due to loss of genetic variability, inbreeding, loss of heterozygosity, and genetic drift; 2) demographic fluctuations due to random variations in birth and death rates; 3) environmental fluctuations due to variation in predation, competition, disease, and food supply; and 4) natural catastrophes resulting from single events that occur at irregular intervals, such as fires, storms, or droughts (Primack 1993, p. 255). The smaller a population becomes the more likely the above factors will reduce the population size even more and drive the population to extinction (Primack 1993, p. 274).

Population size is the best predictor of extinction probability. It is possible that the only extant population of Humboldt marten is below the population size needed to maintain long-term population viability. Populations of at least several hundred reproductive individuals are needed to ensure the long-term viability of vertebrates with several thousand individuals being a desirable goal for many vertebrate species (Primack 1993, pp. 335-336). For a mammal their size, martens have low reproductive rates suggesting a slow recovery from population-level impacts (Buskirk and Ruggiero 1994, p. 16). Species with low rates of population increase are often unable to rebuild their populations fast enough to avoid extinction following habitat destruction (Primack 1993, p. 102).

Monitoring of the Humboldt marten population in 2008 showed a 42% decline in sample unit occupancy over a 7-year period (Slauson et al. 2009b, p. 2). It is unknown at this time whether the decline in occupancy is part of a natural population fluctuation or is due partially or entirely anthropogenic factors (Slauson et al. 2009b, p. 14).

The documented decline in Humboldt marten occupancy appears to be more pronounced in serpentine habitats on the western edge of the occupied range and in areas where late-successional forests are highly fragmented (Slauson et al. 2009b, p. 12). These findings suggest that serpentine habitats may be lower quality habitat than non-serpentine late-successional Douglas-fir forest (Slauson et al. 2009b, p. 12). The serpentine habitats occur on the western edge of the occupied range adjacent to intensively managed private industrial timber lands where larger-bodied mesocarnivores (e.g., fisher, gray foxes) are more abundant (Slauson et al. 2009b, p. 12). Slauson et al. (2009b, p. 12) recommend that further research is needed to confirm the value of serpentine habitats and determine whether competitive interactions are significant factors affecting marten populations.

RECOMMENDED CONSERVATION MEASURES

The primary objectives of a conservation strategy should include: increasing the size of the current population so that genetic, demographic, and environmental uncertainties are less threatening; and establishing multiple populations so that a single catastrophic event (such as wildfire) cannot eliminate the subspecies and the subspecies is more resilient to climate change. The following actions could be undertaken to lower the risk of the threats facing the extremely small population of Humboldt martens.

- Maintain all currently occupied habitat.
- Restore habitat to increase and reconnect suitable habitat patches in the vicinity of the known population (Slauson and Zielinski 2004, p. 63).
- Increase the overall size of suitable patches toward the mean size of 447 ac (181 ha) (Slauson et al. 2007, p. 466).
- Restore functional landscape connectivity to enable recolonization of suitable, but currently unoccupied habitat (Slauson and Zielinski 2003, p. 13) and establish connectivity with habitat corridors between populations.
- Establish high priority restoration areas that enlarge small suitable patches, such as late-successional conifer-dominated stands and serpentine stands with dense shrub cover, so that they exceed the minimum patch size occupied by martens [greater than 205 ac (83 ha)]. This will reconnect suitable patches currently separated by unsuitable habitat.
- Restore or maintain dense, productive shrub layers and reduce road densities in the short-term and accelerate development of late-successional stand conditions, such as large diameter live trees, multilayered canopy, and large snags and logs over the long-term (Slauson et al. 2007, p. 466).
- Develop specific stand recommendations to manage early-seral conifer stands with lower tree densities to encourage maintenance of a productive shrub layer and increase tree growth rates (Slauson 2003, p. 71).
- Develop silvicultural recommendations to promote growth of relatively shade-tolerant, long-lived berry and mast producing shrubs (e.g., *Rhododendron*, *Vaccinium*, *Lithocarpus*, and *Gaultheria* spp.) and not to shrub species that occur in clear cuts (e.g., *Ceanothus* sp. and *Arctostaphylos* sp.) (Slauson et al. 2007, p. 466).
- Protect currently suitable resting and denning structures and plan for the future recruitment of new structures (Slauson and Zielinski 2009, p. 43).
- Evaluate the need to establish additional populations within the historical range. Establishment of additional populations in the cooler, coastal portions of the historical range may be critical to facilitate the Humboldt marten's adaptation to accelerating climate change and to protect a subset of the population from wildfires that are frequent where the current population resides.
- Develop and implement Candidate Conservation Agreements to increase population size, increase geographic extent, and reduce threats.

- Monitor the existing population to determine population trend and cause(s) of the recent documented decline. If the cause(s) are identified, management actions should be taken to address any known threats (Slauson et al. 2009b, p. 14).
- Conduct additional surveys in the vicinity of the recent marten detections in RNSP to determine whether the individual(s) detected is part of a larger population or a disperser from the known population to the east.
- Conduct additional research to investigate resting habitat needs during winter and spring (Slauson and Zielinski 2009, p. 43), competitive interactions with larger-bodied mesocarnivores (e.g., fisher, gray foxes), and the value of serpentine habitats (Slauson et al. 2009b, p. 12).

In the occupied range, the only lands currently being managed to protect late-successional forests are the NWFP reserves. In addition to protecting these stands in existing reserves, experimental silvicultural projects could be undertaken in an attempt to accelerate the development of late-successional forest conditions in younger stands.

There are few blocks of coastal late-successional coast redwood forest remaining large enough to support marten populations (U.S. Forest Service Redwood Sciences Lab 2009, p. 3).

Recent work, using mitochondrial DNA has revealed that the unique haplotype shared by both the remnant population of Humboldt marten and a Humboldt marten museum specimen is also shared by martens found in coastal Oregon. Martens in coastal Oregon are currently recognized as *M. a. caurina*, but occupy similar low elevation late-successional forests with dense shrub cover as *M. a. humboldtensis* in coastal California. The recent genetic work suggests that the Humboldt marten may be distributed farther north into coastal Oregon, which could have important implications for conservation planning (e.g., the restoration of connectivity between populations currently fragmented). Further genetic work is needed to confirm the relationship of coastal martens in Oregon and California.

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