A SURVEY FOR FISHER IN YOSEMITE NATIONAL PARK 1992-1994

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ABSTRACT: Sightings, track stations and camera traps confirm the presence of a small number of fisher (*Martes pennanti pacifica*) in Yosemite National Park during the early 1990's. Fisher prefer lower montane forest, high canopy cover, and habitat near permanent streams. The current fisher population is apparently lower in number and more restricted in distribution than in pristine times prior to heavy trapping and logging in the Park early last century. Regular monitoring using digital camera traps and modern DNA techniques is recommended to determine population trend. Research is needed to determine vital rates and causes of mortality to understand the factor(s) limiting the expansion of this small population at the northern edge of its range.

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Yosemite's Research Scientist identified the need for information about the status of mid-sized mammalian carnivores in 1972 (Yosemite Resources Management Plan 1972). However, efforts to address this need languished until November 1991 when the U.S. Fish and Wildlife Service (USFWS) expanded the list of Category II species being considered for protection under the Endangered Species Act (Federal Register, 21 November 1991, 56:58804-58836). The revised list included the Pacific fisher (*Martes pennanti pacifica*), Sierra Nevada red fox (*Vulpes vulpes necator*), and California wolverine (*Gulo gulo luteus*). As part of the listing process, the USFWS solicited interested parties for existing information on the status and distribution of these species. Unfortunately, there has been no recent evidence of red fox or wolverine in Yosemite; these species are apparently now locally extinct. Therefore, this paper will focus on the fisher.

My search through park files revealed that Yosemite's data on fisher were largely historic with scant information on current status and distribution in the Park. From the mid-1920s through the 1960s, population estimates and trends for selected wildlife species were included in the Superintendent's Annual Reports. During the 1970s, estimates were included in the Resources Management Annual Wildlife Report. Upon reviewing these reports it became apparent that population estimates were the result of expert opinion rather than empirical data. No one ever conducted a field census. The bulk of the information was sporadic, unverified sightings by park staff and visitors.

A survey of the Yosemite region, conducted between 1914 and 1920 (Grinnell and Storer 1924, Grinnell et al. 1937), documented the presence of fisher. Trapping locations for 19 specimens collected in Yosemite and sent to the Museum of Vertebrate Zoology (MVZ) between 1914 and 1919 suggest that fisher occurred within a narrow elevational band of mixed conifer habitat bounding the western edge of the park. However, Grinnell and Storer (1924) cautioned that this was probably an artifact of the limited area in which commercial trappers operated during the winter months. Grinnell and Storer (1924) related an instance of a fisher trapped in Yosemite Valley near Pohono Bridge, but dismissed this as an unusual occurrence since park rangers had caught very few fishers during their numerous coyote trapping campaigns in the Valley. They also cited an account of a fisher observed at 3350 m elevation near the head of Lyell Canyon.

During a trip to Yosemite in 1921, Joseph Dixon, an MVZ associate, met Jay Bruce, the California state mountain lion hunter. Bruce told Dixon that "Hazelgreen to Crane Flat is the best place to look for fisher tracks. John McCauley saw a fresh fisher track in this very vicinity two days ago (J. Dixon field notes, 15 June 1921)." On a return trip to the Park in January 1922, Dixon followed 3 different sets of fisher tracks in the snow near Hazelgreen (J. Dixon field notes, 12, 13 January 1922).

By 1926, Grinnell believed that fewer than 300 fisher remained in California (Grinnell et al 1937). He cited the significant decline in the number of fisher taken annually by commercial trappers as evidence and suggested that the trend extended statewide, even in protected areas like Yosemite, where a policy of removing predators had been rescinded only the previous year (Sellars 1998). Grinnell's fears were echoed in a 1929 memo to the Superintendent

(Yosemite National Park files) from Yosemite's first Chief Ranger, Forest Townsley, who wrote "For the past five or six years we have received very few reports of fishers being taken by any of the trappers operating in the vicinity of Yosemite National Park. Prior to that time, they seemed quite plentiful and I know no good reason why they should not increase very rapidly with the full protection they have in an area as large as Yosemite National Park."

Twenty-one years elapsed between Dixon's observation of fisher tracks at Hazelgreen Ranch and the next recorded fisher observation at Bridalveil Creek Campground in 1943. During the interim, information on the status of the Pacific fisher in Yosemite appears to have largely consisted of population estimates by the district rangers as part of the monthly animal census report. Unfortunately, most of these reports have been either lost or discarded. The few surviving copies that I was able to examine estimated a population size of 25 fishers in 1934 and 31 in 1943. The 1943 estimate included 25 animals in the Wawona and Chinquapin districts and 6 animals in the Mather district. Both, G. E. Mernin, the Wawona district ranger, and J. W. Bingaman, the Mather District Ranger, emphasized that these were estimates only, although Mernin noted that his estimate was based on "the observations and experiences of six old-timers of this region (Memorandum for the Chief Ranger, 4 November 1943, Yosemite NP files)."

Twelve fisher observations were recorded from 1943 to 1991. Half of these appear to be reliable based on the accompanying description of the animal. Two of the twelve observations were of fisher tracks identified by National Park Service employees judged to be reliable observers. I was unable to evaluate the validity of the remaining observations because they either failed to provide an adequate description of the animal they saw or did not indicate their qualifications as an observer.

In 1959, Cunningham (1959) submitted a note to the Journal of Mammalogy summarizing wolverine and fisher sightings for Yosemite National Park. The records for fisher consisted of one wildlife observation card (1954), three notes from the Yosemite Museum (1927 to 1942), and an article in Yosemite Nature Notes (22:80).

In 1973, the National Park Service (NPS) contracted with the University of California, Berkeley to assess the status and distribution of 7 carnivore species in Yosemite and 5 other NPS units in California. In their chapter on Yosemite, Schempf and White (1977) listed 21 records for fisher. Philip Schempf, a Berkeley graduate student, compiled the information from the literature, sighting reports, museum collections, agency records and interviews with local trappers and other knowledgeable individuals. Each record consisted of an observation date, a brief narrative describing the trapping or sighting location, and the source of the observation. Records that included sufficient location data were plotted on a map of the Park. Based on this information, Schempf and White (1977) concluded that fisher were uncommon in Yosemite. They also determined that the trend in the number of fisher sightings was declining. Although they could not ascribe causes for the observed trends, they speculated that relative changes in the number of observers and curtailment of licensed trapping may have influenced the number of records available.

The proposed listing of fisher by the USFWS, a dearth of information on the status of this species in Yosemite, and its apparent scarcity elsewhere in the Sierra Nevada prompted my initiating a study in Yosemite. Knowledge about the distribution and abundance of fisher in a relatively pristine area like Yosemite could provide a baseline for comparison with other areas. The study would also inform management plans for ensuring the continued existence of this important mesocarnivore in the Park.

METHODS

Study area

This study was conducted in Yosemite National Park, which encompasses just over 300,000 ha on the western slope of the Sierra Nevada in eastern central California. Elevation within the park ranges from 648 m to 3,997 m. Fault block uplift, subsequent stream erosion, and a series of Pleistocene glaciations combined to shape the region's dramatic landscape (Matthes 1927, Medley 2008). An extensive network of tributary streams funnels into two major drainages, the Tuolumne River in the north and the Merced River in the south. Although the park's geology is dominated by granite, scattered instances of volcanic and metamorphic rock are also present (Huber 1989).

Yosemite's climate is characterized by warm dry summers and cool wet winters. Temperatures at lower elevations (1,200 m to 2,130 m) range from 32º C in summer to -7º C in winter while higher elevation (>2,130 m) temperatures range between 27º C in summer and -23º C in winter. Precipitation in Yosemite Valley (1,200 m) averages 90.2 cm annually (National Climate Data Center, U.S. Historical Climatology Network, 6 August 2001, ftp://climate.ncdc.noaa.gov/pub/data/ushcn/) with most of it deposited from November through March. At higher elevations, winter precipitation falls mainly as snow. From 1930 through 2001, March snow depths at Beehive Meadow (2,000 m elevation) averaged 170 cm. During the same period, snow depth at Tuolumne Meadows (2,655 m) averaged 154 cm (California Department Water Resources, California Data Exchange Center, http://cdec.water.ca.gov/).

Yosemite's varied topography is reflected in the Park's great diversity of biotic communities (Botti and Sydoriak 2001, Barbour et al. 2007). Vegetation types (*sensu* Sawyer and Keeler-Wolf 1995) range from the foothill pine series at the lowest elevations to alpine habitats atop the highest peaks. Between these extremes lie tree-dominated series such as canyon live oak (*Q. chrysolepis*), black oak (*Quercus kelloggii*), mixed conifer, white fir (*Abies concolor*), red fir (*A. magnifica*), lodgepole pine (*Pinus contorta*), and mixed subalpine forest. Shrub dominated vegetation series are also present, the most common being greenleaf manzanita (*Arctostaphylos patula*), bush chinquapin (*Chrysolepis sempervirens*), and huckleberry oak (*Q. vaccinifolia*). Riparian communities border permanent streams while both wet and dry meadow types are frequently encountered across the landscape. Almost 95% of the Park is managed as wilderness by NPS. Most of the lands bounding the north, east, and south edges of the Park are also designated wilderness managed by the USDA Forest Service (USFS). Nearly 4 million visitors enjoy the Park annually, with most of the activity in Yosemite Valley.

Materials

During the 1992 and 1993 field seasons, I used a combination of carbon-sooted track plates (Lindzey et al. 1977, Linhart and Knowlton 1975) and line-triggered cameras (Martin and Raphael 1990, Zielinski and Kucera 1995). The track plate was a modified "cubby" design (Barrett 1983) that incorporated improvements introduced by Fowler and Golightly (1992a). My chief modification was replacing the plywood "cubby" box that enclosed the plate in Barrett's original design with a plastic canopy. This significantly reduced the weight of the track plate and increased its portability.

The track plate was a 30 cm x 76 cm sheet of 24-gauge, galvanized steel flat stock with its long edges bent 90° to create 1 cm high flanges that ran the length of the plate (Figure 1). The plastic canopy consisted of two 38 x 90 x 0.2-cm panels of flexible styrene plastic. Assembly involved holding the track plate over a smoky flame to coat the surface between the flanges with a fine layer of carbon-soot. The flame was produced by burning diesel soaked paper towels in a 1-pint paint can. I started at one end of the plate and applied soot to a third of its surface. I covered the middle third of the plate with a 22 x 30-cm piece of self-adhesive shelf paper (Con-Tact Brand, Decora Industries, Inc.), sticky side facing up. I oriented the Con-Tact paper to extend beyond the flanges on the plate so it was held in place by the styrene panels, which were bent to fit between the flanges to form the plastic canopy. I secured the canopy to the plate with short strips of fiber tape.

I baited the assembled track plate with a piece of chicken placed at the far end of the plate, beyond the soot and Con-Tact paper. The baited end was positioned against a tree or log with the sooted end facing out. When an animal attempted to retrieve the bait, it stepped on the soot and Con-Tact paper. Soot from the animal's foot stuck to the paper creating detailed positive prints that could be readily identified and archived. In 1994, I also used a commercial scent lure (Skunk-It, M&M Fur Company, Bridgewater SD) to attract fisher to the vicinity of the track plate.

In 1992 and 1993, I also placed a line-triggered camera (Jones and Raphael 1993) at each detection

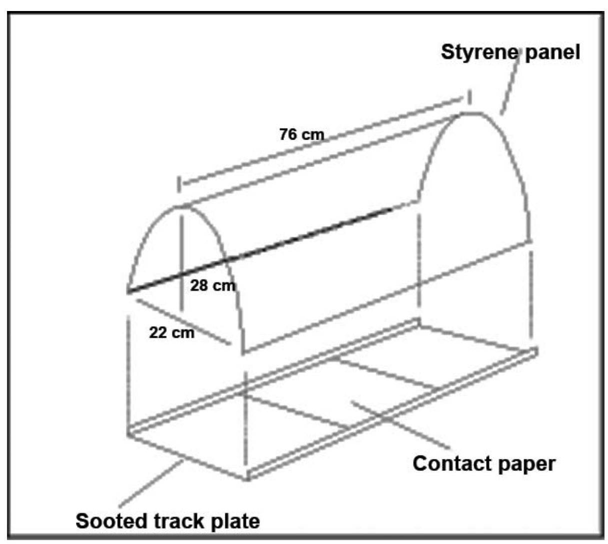

Figure 1. Track plate design.

station. I used Concord 110 electronic flash cameras (Concord Camera Corp., Hollywood, FL) modified according to the description provided by Zielinski and Kucera (1995). Bait was attached to the camera by a piece of nylon monofilament fishing line. The camera was remotely triggered when an animal took the bait. Because the success rate for cameras was too low to justify the high cost of buying and processing film, I discontinued their use after the 1993 field season.

I used Trailmaster camera systems (Goodson and Associates Inc., Lenexa, KS) in 1993 and 1994. Trailmaster systems consisted of a point-and-shoot, 35-mm camera triggered by an active infrared sensor. They functioned unattended for up to 36 days. Trailmasters were baited with chicken parts in burlap bags counterbalanced over a tree limb to prevent the bait being taken by bears.

Sample site selection in 1992

In 1992, sampling sites were identified using a stratified random design. I chose the Tioga Road corridor as a base of operations because it allowed efficient access to sampling sites and doubled as a natural transect across the Park's elevation and vegetation zones. Using the Park's Geographic Information System (GIS), I created a 5-km buffer along both sides of the Tioga Road. I had the GIS identify potential sampling sites within the buffer, stratified by the relative proportion of vegetation types within the park. This generated a list of 88 potential sites and randomly selected 36 of these. I planned to sample 18 sites the first year and the remainder the following year.

Sampling sites consisted of a 2 x 3 array of 6 detection stations spaced 1 km apart. The orientation of the array and location of each detection station corresponded to the intersections of a 1-km^2 grid, randomly placed over a map of the park. I determined the location of detection stations in the field by using a topographic map, compass, and pacing the distance between stations. Whenever possible, I used surrounding topography and a GPS receiver to confirm the location. I did not establish detection stations on slopes >50% or in locations that endangered the safety of personnel. Grid intersections that fell on a lake or stream were relocated by finding the nearest point on shore and moving perpendicularly from the shore for a distance in meters randomly selected from a table of numbers between 125 and 225.

Sample site selection in 1993 and 1994

The failure to detect any fisher in 1992 led me to modify my approach in 1993 to focus on areas previously known to support fisher along the western boundary of the park. I limited the use of track plates to tree-dominated habitats between 1,219 m (4,000 ft) and 2,438 m (8,000 ft) elevation. I used the Park's GIS to generate a list of potential sampling locations based on a set of selection criteria. In addition to elevation, I also specified habitat types that the California Wildlife Habitats Relationships (CWHR) System (Verner and Boss 1980, Airola 1988) considered suitable for fisher. The CWHR forest types included in the selection criteria were Montane Riparian, Montane Hardwood, Montane Hardwood-Conifer, White Fir, Sierran Mixed Conifer, Ponderosa Pine, Red Fir, and Lodgepole Pine (Mayer and Laudenslayer 1988). I also required sites to be within 100 m of a stream and within 100 m of a road. Locations within 500 m of another site were eliminated from consideration. Of the potential sampling sites, I used the GIS to randomly select starting points for lines of 3 to 5 detection stations that paralleled the nearby stream. After identifying the starting point, I plotted the locations of additional stations on a 1:24,000 scale topographic map. I located detection stations in the field using map and compass techniques, augmented with a GPS receiver. Track plates were placed in a relatively flat location as close as possible to the point indicated on the map. Photographs were taken from plot center in the four cardinal compass directions to record habitat characteristics.

I chose sites to deploy Trailmaster cameras at ridgelines, saddles, drainages, and meadow-forest edges. Secondary considerations were locations away from trails and popular hiking destinations and locations within a 1-day round trip walk from a road or trailhead. I made no effort to randomize the placement of Trailmaster systems.

Habitat characterization

In 1992, I sampled habitat characteristics using methods designed to complement ongoing efforts to verify satellite imagery of the Park's vegetation (P. Moore, U. S. Geological Survey, pers. comm.). Vegetation at detection stations was characterized within a circular plot with a radius of 100 m (3.1 ha). Within the plot, I established 6 belt transects, 2 m wide x 100 m long. Since no fisher were detected in

1992 further details of my habitat measurements for 1992 will be omitted here.

In 1993 and 1994, I scaled back vegetation sampling to increase the number of detection stations that could be visited in a day. I recorded plant community type (Holland1986) for the area within a 100 m radius of plot center. To characterize the site, I sampled vegetation on a 20 x 20-m plot surrounding the track plate (Figure 2). The corners of the plot were oriented in the cardinal compass directions. Within the plot, I established 2, 28.3-m transects corresponding to diagonal lines between opposite corners of the plot.

Within the plot, I recorded, by species, the number of live trees that were more than 10 cm in diameter and 1.37-m tall. Each tree and snag was also categorized by CWHR size class based on an ocular estimate (Mayer and Laudenslayer 1988). CWHR tree diameter classes are: 1) Seedling <1 in; 2) Sapling 1-6 in; 3) Pole 6-11 in; 4) Small Tree 11-24 in; Large Tree >24 in. I estimated the relative cover, by species, of shrubs on the plot using the line intercept method along the north-south transect. I estimated herb cover by recording frequency along 2-m segments of the north-south transect. I estimated canopy cover using a canopy densitometer at 2-m intervals along the transect. I also recorded physical site characteristics including slope, aspect, elevation, percent water and rock on each plot.

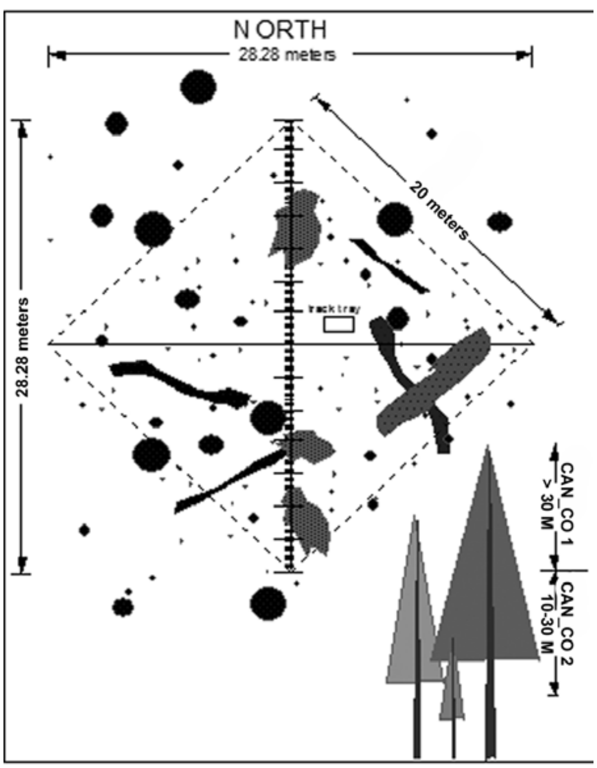

Figure 2. Layout of vegetation sampling plot used byYosemite Rare Mammal Study during the 1993 and 1994 field seasons.

Timing of sampling

I began fieldwork in May 1992 and sampled from spring through autumn for the next 3 years. I generally established the lowest elevation detection stations first and gradually moved up in elevation, following plant phenology and the retreating snow. I attempted to visit each active station every other day for 14 days to replace the bait, reapply soot to the track plate, and advance the film, if necessary. In 1992, two 2-person field crews each established 6 detection stations on the first day of a sampling period. The following day, each crew set up another 6 detection stations. Over the next 10 days, the crews alternately revisited each set of stations. In 1993 and 1994, field crews established and subsequently checked 8 stations a day for 14 consecutive days.

Analysis

To avoid bias introduced by single individuals making repeated visits, I considered multiple visits to a single plate as one occurrence unless there were obvious differences in track size or photographs clearly indicated that more than one individual was involved. I assumed that fisher do not use all areas within their home range with equal probability, thus track plates in areas used infrequently should have a lower probability of being visited. Placement of track plates in riparian corridors in 1993 and 1994 precluded hypotheses testing for habitat differences between observation locations and detection stations. Consequently I took a qualitative approach to compare habitat around locations where fisher were detected versus habitat available by elevation, CWHR habitat type, canopy cover class and distance to water as generated by a GIS analysis using a 0.25-ha circle around each location. Fisher's Exact Test and Student's T-test for independent means were used to determine statistical significance.

RESULTS

Sampling effort

I sampled a total of 295 detection stations during 3, spring through autumn field seasons. Sampling at the stations varied from 9 to 16 days ($\bar{X}$ = 12). Track plates were checked every other day, except on weekends. In 1992 and 1993, I sampled for 9 to 14 days. In 1994, I extended sampling to 16 days. The total sampling effort was 3,462 station days.

The stratified random sampling design used in 1992 identified 88 sites between 1,800 m and 3,400 m elevation (Figure 3). The 217 locations sampled in 1993 and 1994 ranged from 1,183 m to 2,600 m in elevation. During 3 years of fieldwork, 277 (77%) of the detection stations were between 1,800 m and 2,600 m elevation.

From 1993 through 1995, I monitored an additional 21 locations (Figure 4) using Trailmaster systems at elevations between 1,375 m and 3,100 m. During summer and autumn, I checked them at 2-week intervals. During winter, they were generally checked monthly. I could not calculate the total number of days Trailmaster systems were actually deployed because they were frequently disabled by bears.

Detection of fisher

I documented the presence of fisher in Yosemite with verified detections and sightings that were deemed credible. Verified detections consisted of road kills, photographs (Figure 5), and tracks. Sightings were evaluated for credibility based on the observer's experience and the likelihood of a correct identification given the description provided. I recorded 42 fisher observations comprising verified detections and reported sightings that I judged credible (Figure 6). Verified detections occurred in 6 of the 12 years I collected observations. Sightings were reported every year except 1992 and 1998. Sightings outnumbered verified detections by nearly 3:1. The number of verified detections and sightings averaged 0.8 (SD = 1.1) and 2.4 (SD = 2.2) per year, respectively. When combined, detections and sightings averaged 3.5 observations (SD = 2.6) annually. The maximum number of reported sightings in a single year was 8, in 2002. Nearly all of those (7 of 8) occurred within

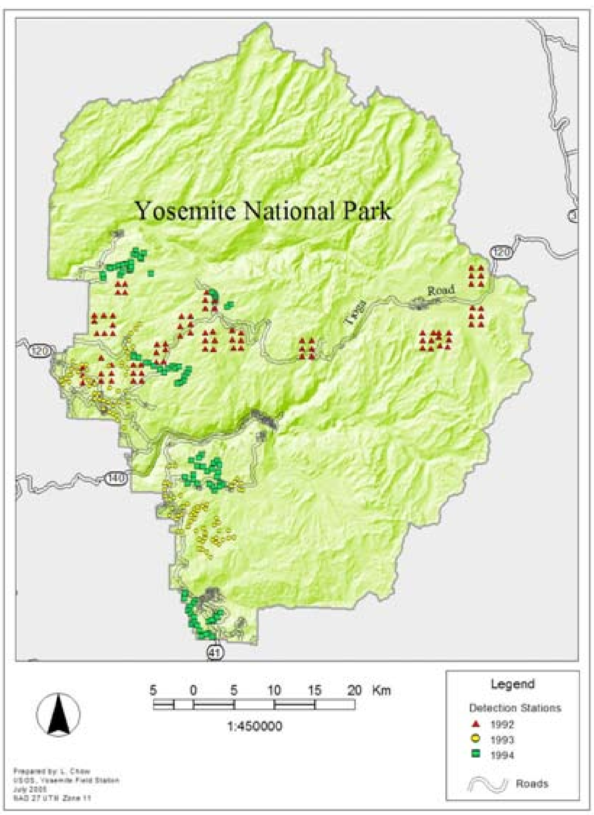

Figure 3. Rare Mammal Study detection station locations in Yosemite National Park, California, 1992-1994.

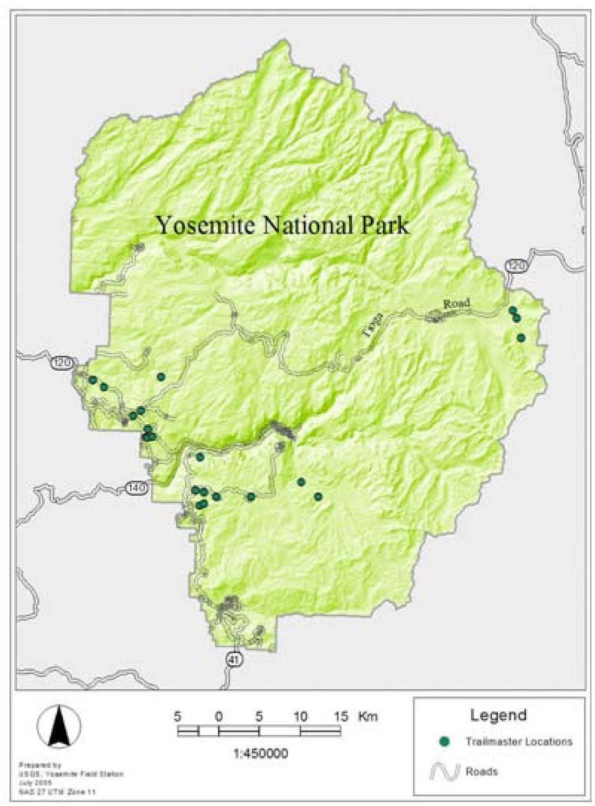

Figure 4. Rare Mammal Study Trailmaster locations in Yosemite National Park, California, 1993-1995.

0.5 km of the Wawona Road. Although Trailmaster cameras were only used from 1993 through 1995, they produced verified fisher detections each year they were deployed.

In addition to verified detections, I received 31 reports of fisher sightings I considered reliable. Reports from people in vehicles accounted for 20 sightings; 8 along the Wawona Road, 7 along the Big Oak Flat Road, with the remainder divided among the Glacier Point, Tioga, and El Portal Roads. Seven sightings were reported by hikers who observed fishers crossing trails while 4 sightings occurred in off-trail, wilderness settings. Most (86%) of the detections occurred along the western margins of the park. Some locations, most notably Bishop Creek on the Wawona Road, Rattlesnake Creek on the Big Oak Flat Road, and the Yosemite Institute Campus at Crane Flat, registered multiple observations (Table 1, Figure 7).

The elevation range for fisher observations was 1,156 m to 2,960 m ($\overline{X}$ = 1,918 m; Figure 8). With 1 exception, verified detections occurred at or below 2,250 m ($\overline{X}$ = 1,927 m, SD = 377.5), despite the fact that I had Trailmaster cameras deployed at several high-elevation locations. The mean elevation for reported sightings was 1,915 m (SD = 434.5).

I used the vegetation type map in the Park's GIS (National Park Service. [Yosemite National Park and environs]. [computer map]. Scale not given; based on 1:15,580 scale aerial photography. Final1997Veg [coverage]. 1997. Redlands: Aerial Information Systems.) to characterize habitat at fisher locations. I enumerated CWHR habitat types (Mayer and Laudenslayer 1988) and their extent within a 0.25-ha circle around each location. The GIS analysis identified 13 CWHR types overall (Figure 9). At 26 of 42 locations, habitat surrounding the observation location consisted of a single CWHR type. Fourteen locations incorporated 2 types and 2 encompassed 3 types. The CWHR Sierran Mixed Conifer habitat type was present at 29 of 42 observation locations and constituted all adjacent habitats at 19 locations.

I also used Yosemite's GIS to characterize canopy cover within a 0.25-ha circle around the 42 fisher locations. Canopy at 23 observation locations consisted of a single cover class; 17 in the >60%

Figure 5. Pacific fisher photographed by a Trailmaster camera at Fort Monroe, Yosemite NP, September 1994.

category, 3 in the 40%-60% category, and 3 in the 25%-40% category. Canopy at the remaining 19 locations incorporated 2 or more classes. At 31 observation locations, more than 75 % of the canopy was in either the 40%-60% or >60% cover class (Figure 10). Fisher were detected at only 7 locations where the majority of canopy cover was less than 40 %.

Fisher detections were most numerous in locations within 200 m ($\bar{X}$=127 m, SD = 138.7) of water (Figure 11). Only 1 location was farther than 500 m from water.

Habitat preference

The failure to detect fishers at track plate stations prevented testing and refining existing HSI and CWHR models for fishers. Therefore I compared habitat characteristics at fisher detection locations with habitat surrounding an equal number of random points generated by Yosemite's GIS to explore habitat preference.

Fisher were detected between 1,156 and 2,960 m elevation. This contrasts markedly with the elevation distribution of the random points (Figure 12). The analysis rejected the null hypothesis (Fisher's Exact Test, point probability = 0.0042) implying that fisher detections disproportionately occurred at lower elevations.

A majority of the fisher detections occurred in CWHR Sierran Mixed Conifer habitat. Mapping habitat around random points in the GIS determined that Sierran Mixed Conifer, Montane Chaparral, Jeffrey Pine, and Red Fir were the most common CWHR types and occurred with nearly equal frequency. Sample size constraints prevented me from evaluating whether fisher were observed in Sierran Mixed Conifer habitat more than expected because many of the 13 CWHR habitats occurred only once or twice. I overcame this limitation by grouping CWHR types into 3 categories: lower montane forest, upper montane forest, and subalpine forest

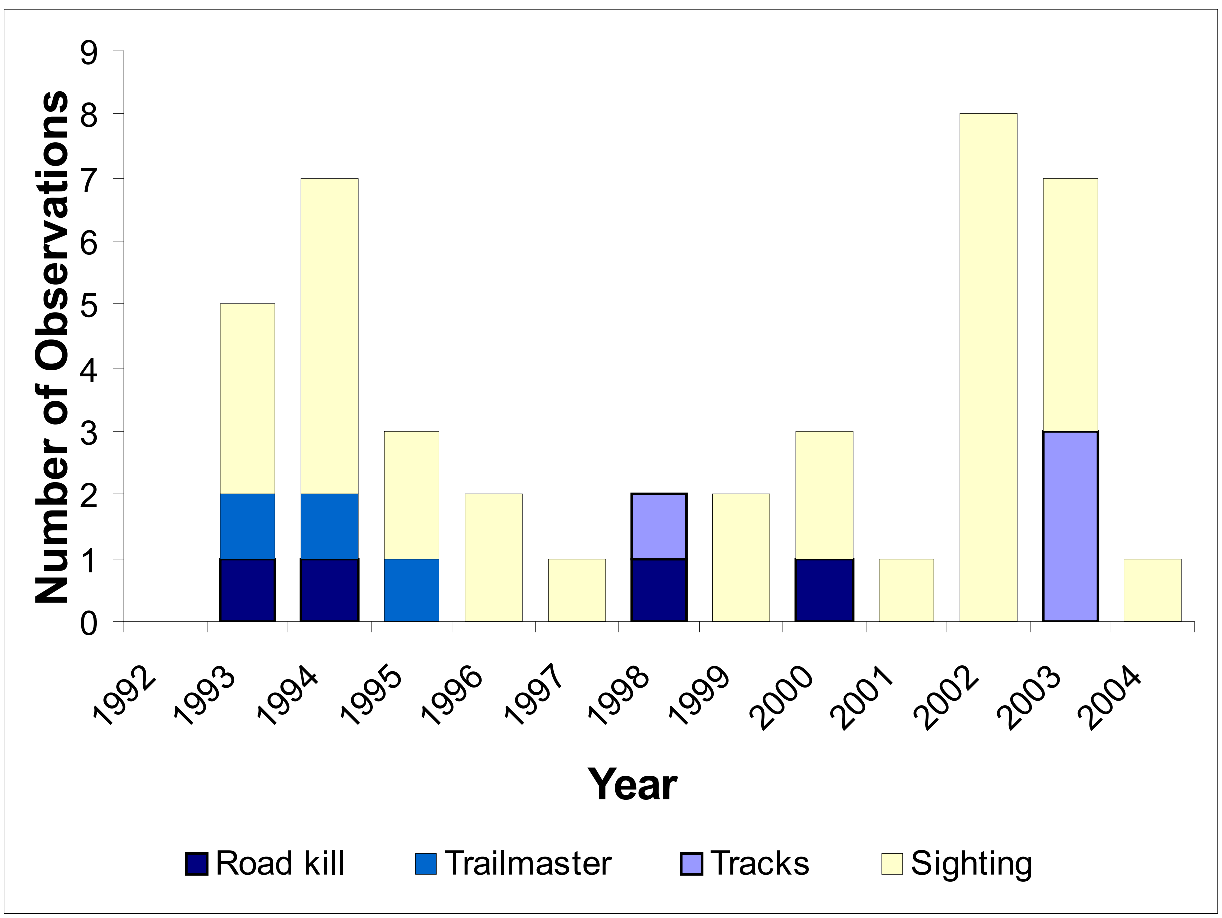

Figure 6. Distribution of verified fisher detections and reported sightings by year in Yosemite National Park, California.

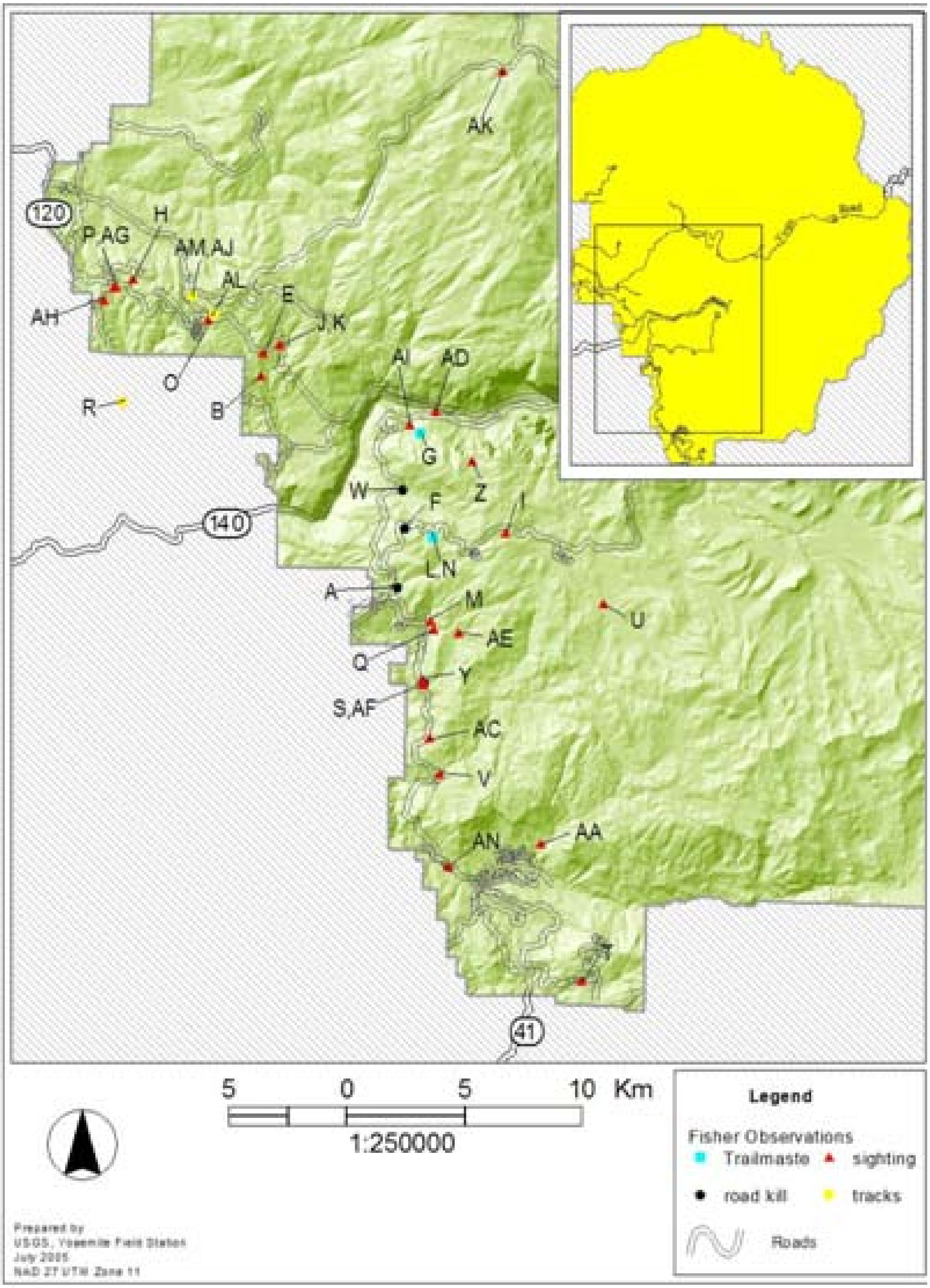

Figure 7. Locations of fisher detections and observations in Yosemite National Park, California from 1992 through 2004. (See Table 1 for key to locations)

Table 1. Pacific fisher detections, sightings, and tracks recorded in Yosemite National Park, California, 1993 through 2004

Key	Date	Location	Obs type
A	05/23/1993	Wawona Road at Indian Creek	road kill
B	09/01/1993	Crane Creek/Davis Cutoff Road	sighting
C	10/13/1993	Marioulmne Dome	sighting
D	Fall 1993	Upper Twin Lakes, 2.25 miles W of Grace Meadow	sighting
E	02/24/1994	Big Oak Flat Road, 0.2 miles W of Big Meadow Overlook	sighting
F	06/11/1994	Glacier Point Road at El Portal View	road kill
G	09/01/1994	Fort Monroe, Old Wawona Road	Trailmaster
H	10/19/1994	1.6 Km NW of Crane Flat Lookout	sighting
I	10/31/1994	Glacier Point Road, Summit Meadow	sighting
J	10/01/1994	Big Oak Flat Road, 0.2 miles W of Rattlesnake Creek	sighting
K	12/01/1994	Big Oak Flat Road, Rattlesnake Creek	sighting
L	01/25/1995	Badger Pass Road	sighting
M	01/21/1995	Wawona Road, ~3.2 Km S of Chinquapin	sighting
N	01/01/1995	Glacier Point Road,	Trailmaster
O	01/10/1996	Big Oak Flat Road, 0.4 km W of Tioga Road Jct.	sighting
P	01/18/1996	Big Oak Flat Road, 0.1 Km E of Merced Grove Trailhead	sighting
Q	03/03/1997	Wawona Road at Strawberry Creek	sighting
R	05/29/1998	Jct FS road 1S12 X Merced Grove Road, Stanislaus NF	tracks
S	12/11/1998	Wawona Road at Bishop Creek	road kill
T	05/24/1999	Mariposa Grove Outer Loop trail	sighting
U	09/09/1999	Ostrander Lake Tr., 1.5 Km SE of Bridalveil Campground	sighting
V	03/02/2000	Crossing Alder Ck., ~ 50m E Wawona Road	sighting
W	06/01/2000	Wawona Road at Grouse Creek	road kill
X	09/01/2000	Crossing Tioga Road, Tuolumne Meadows	sighting
Y	03/26/2001	Wawona Rd., 200 ft. S of Bishop Creek	sighting
Z	04/04/2002	Old Inspiration Point Trail at Meadowbrook Creek	sighting
AA	05/16/2002	Chilnualna Falls Trail, 1.01 miles NE of the trailhead	sighting
AB	10/18/2002	Ten Lakes Basin	sighting
AC	11/06/2002	Wawona Road, between Alder and Bishop Creeks	sighting
AD	11/12/2002	El Portal Road, 200 m W of Jct. with Big Oak Flat Road	sighting
AE	07/21/2002	Trail between Chilnualna and Alder Creek	sighting
AF	12/09/2002	Wawona Road at Bishop Creek	sighting
AG	02/06/2003	Big Oak Flat Road, 150 yards E of Merced Grove parking	sighting
AH	02/25/2003	Merced Grove Trail, 0.5 mi S Big Oak Flat Road	sighting
AI	03/18/2003	Wawona Road, 0.5 km W of Wawona Tunnel	sighting
AJ	04/28/2003	Yosemite Institute Crane Flat Campus	tracks
AK	06/23/2003	Tioga Road, ~ 1 mile W of White Wolf	sighting
AL	01/01/2003	near Crane Flat Campground	tracks
AM	01/03/2003	Yosemite Institute Crane Flat Campus	tracks
AN	01/15/2002	Near Wawona Campground	sighting
AO	10/19/1993	Mono Pass Trail	Trailmaster
AP	06/10/2004	Along river behind Puppy Dome, Tuolumne Meadows	sighting

(Figure 13). The analysis rejected the null hypothesis (Fisher's Exact Test, point probability = 0.0002) indicating that fisher used lower montane forest more frequently than would be expected by chance.

Fisher observations were strongly associated with dense canopy cover (Fisher's Exact Test, point probability = 0.000002, two sided p-value, p[O>E|O<E] = 0.000514). Nearly 75% occurred in locations where canopy cover exceeded 40%. In contrast, 20 of 33 random points (60.1%) were in locations where canopy cover was below 40% (Figure 14). During 1993 and 1994, 12% of the 207 detection sites had no cover while sparse and open cover characterized 1% of sites. Moderate cover characterized 9% of the sites while 77% exhibited dense cover.

More than 85% of the fisher detections and sightings occurred within 200 m of water, and the mean distance to water was 127 m. For random points, the mean distance to water was 269 m. Student's T-test for independent means indicated that that fisher observations occurred closer to water than would be expected by chance (p=0.001, t=-3.551).

DISCUSSION

Given the low number of verified detections recorded during this study, I conclude that Pacific fisher inhabit Yosemite National Park at very low population densities. The primary basis for this conclusion is the low detection rate at track plate and Trailmaster camera stations. Although sighting reports collected over the past decade suggest fisher are uncommon rather than rare, the timing and location of sightings lead me to believe that at least some of these were repeated observations of a single individual.

My inability to detect any fishers with track plates, despite documented evidence of their presence in the form of road kills and photographs was unexpected. Although the lack of detections could have resulted from using inappropriate materials and methods, track plates have been successful in detecting fishers elsewhere (Zielinski 1995, Zielinski and Truex 1995,

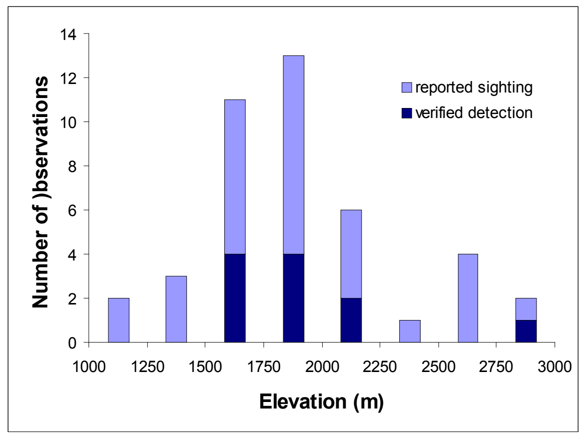

Figure 8. Distribution of fisher observations from 1992 through 2004 by elevation in Yosemite National Park, California.

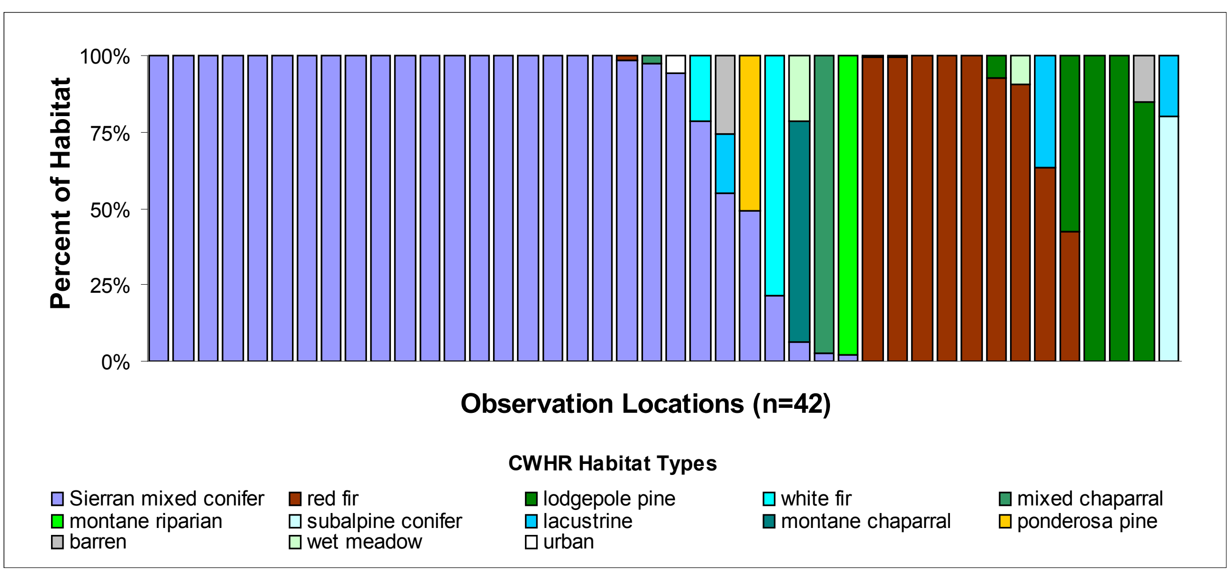

Figure 9. CWHR habitat at fisher observations in Yosemite National Park. Each bar represents an observation location. Colors within bars show the relative proportion of CWHR habitat types at that location.

Foresman and Pearson 1998). It is possible that surveys coincided with a cyclical population decline (DeVos 1952) triggered by low prey availability (Bulmer 1974, Keith and Cary 1991, Haydon et al. 2001, Bowman et al. 2006). Declining detections of non-target species during the last 2 years of the survey support this possibility, as do fluctuations in the number of fisher sighting reports we received. But predator population cycles typically lag prey declines (Powell 1993) while inter-annual variation in the number of fisher sightings was more likely the result of multiple observations of a few individuals.

During the 3 field seasons the proportion of track plates visited by bears steadily increased. At the same time, the rate of detection for other species steadily decreased. It is possible that I did not detect fishers at track plates because of high visitation and subsequent destruction by bears.

Ultimately, I concluded the most likely explanation for not detecting fishers at track plates is the low probability of detecting a rare species. I based this conclusion on detecting only 1 fisher per year with Trailmaster cameras deployed throughout suitable fisher habitat and near locations where fishers

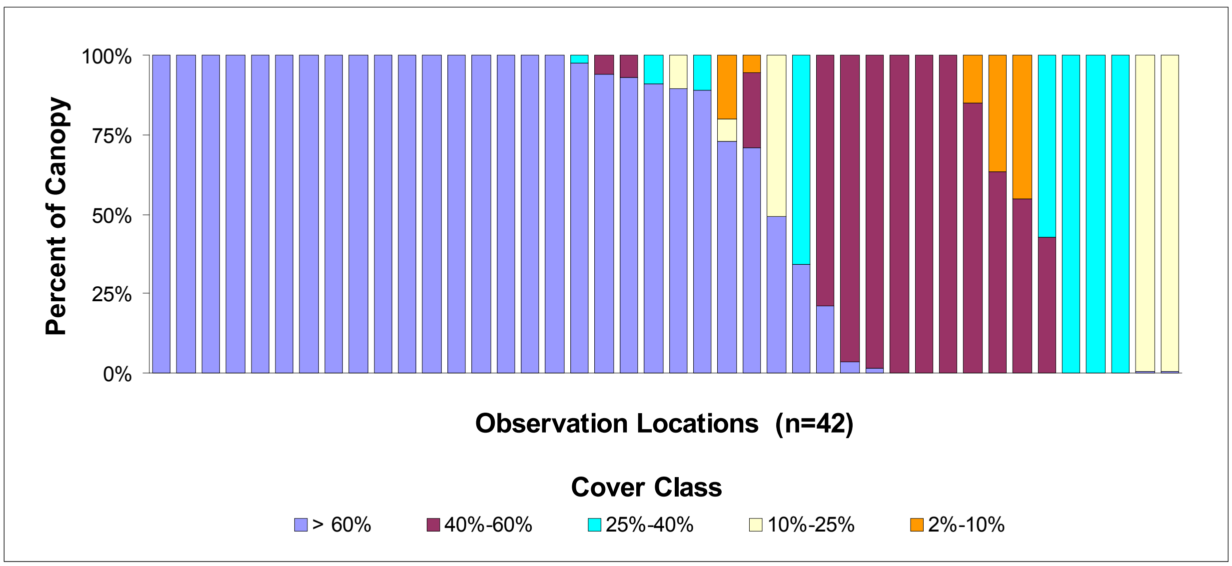

Figure 10. Distribution and relative proportion of canopy cover classes at fisher observation locations in Yosemite National Park. Each bar represents an observation location. Colors within bar show the relative proportion of cover classes at that location.

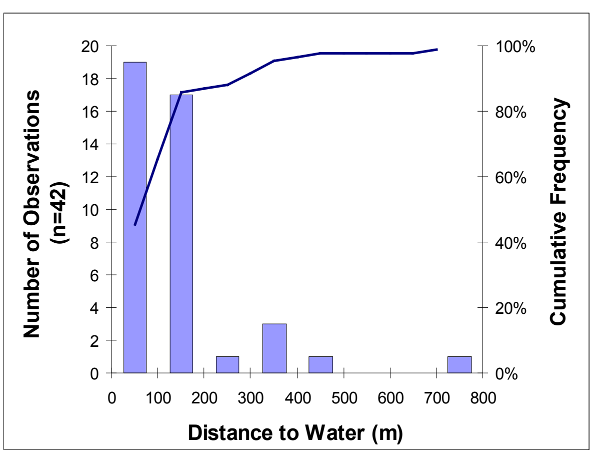

Figure 11. Distribution of fisher observation sites based on distance to water in Yosemite National Park.

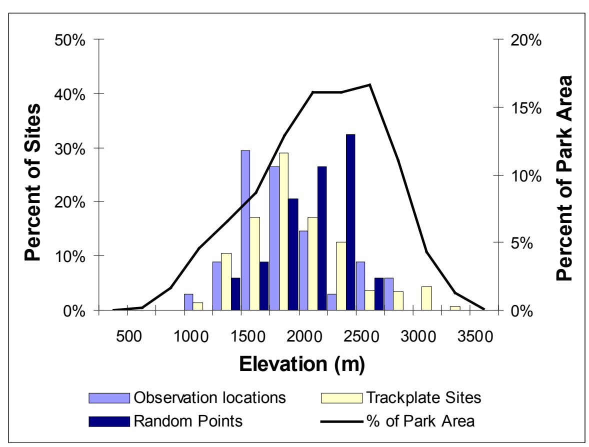

Figure 12. Elevation distribution of fisher observations, detection stations, and random points, and elevation as a percent of park area in Yosemite.

had been observed. This interpretation is bolstered by subsequent Trailmaster surveys which yielded similar results in 1999 (Campbell 2003) and 2007 (R. Truex, USDA Forest Service, pers. comm.).

Although fisher are currently rare within the Park, museum records and historic accounts show this has not always been the case. It is unlikely that fisher were ever common (Grinnell et al 1937, Powell 1993), but both direct and indirect evidence suggest that the Park's population went from uncommon to rare in the early to mid-1920s. The most direct evidence of higher population numbers are fisher specimens at the Museum of Vertebrate Zoology (MVZ). From 1915 through 1918, Army personnel, and subsequently rangers staffing Yosemite, provided MVZ with an average of 2 fishers a year. During the winters of 1919 and 1920, Chief Ranger Forest Townsley sent MVZ 12 specimens. The 12 fishers Townsley trapped in just 2 years offers the strongest evidence they were uncommon rather than rare.

I attribute the decline in Yosemite's fisher population to the cumulative impacts of predator control, excessive commercial trapping, and habitat loss via logging. Predator control was likely responsible for the initial reduction in Yosemite's fisher population and over harvesting at a regional scale may have impeded its recovery. In addition, logging within the Park reduced the availability of suitable fisher habitat, further hampering population recovery. From the time Yosemite was established in 1898 until NPS policy officially changed in 1925, Army personnel and rangers eliminated predators to protect animal species favored by tourists (Sellars 1997). Mountain lions and coyotes were the principal targets because they preyed on deer, but fisher trapping was also authorized and encouraged by allowing rangers to supplement their salaries with earnings from the sale of pelts (Sellars 1997). The 19 fisher sent to MVZ provide a minimum estimate of the number removed by predator control. However, the specimens were all collected within a 6-year period, and I suspect, given the premium prices of prime pelts and the fisher's susceptibility to capture (Grinnell et al 1937, Coulter 1960, Lewis and Zielinski 1996), more fishers were removed during nearly 3 decades of predator control.

Given the fisher's apparent preference for forested areas with continuous overhead canopy and large diameter trees (Buck et al. 1994, Zielinski et al. 1994b), logging likely resulted in habitat loss that exacerbated the impacts of predator control and overharvesting. Logging commenced in Yosemite in 1913, continued through 1929, then occurred sporadically until 1935. Descriptions of logging practices and historic photographs show that timber harvesting removed virtually all vegetation (Johnson 1988, McKelvey and Johnson 1992). Based on narratives in the Superintendent's Monthly and Annual Reports (YNP Archives) describing the location and amount of timber removed, I calculated that logging cleared at least 11,800 m^3 (5 billion board ft) of lumber from nearly 5,260 ha inside the Park's western boundary. This is nearly half the total amount of timber that Fitch (1900) estimated was present on the Yosemite quadrangle during his survey of the area prior to logging. The relatively

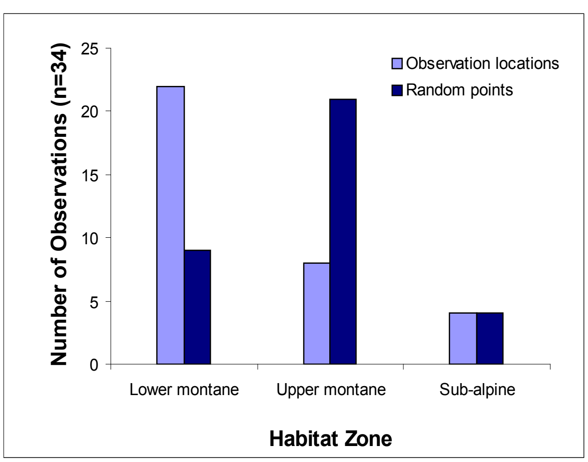

Figure 13. Comparison of fisher observation sites and random points by habitat zone in Yosemite National Park, California.

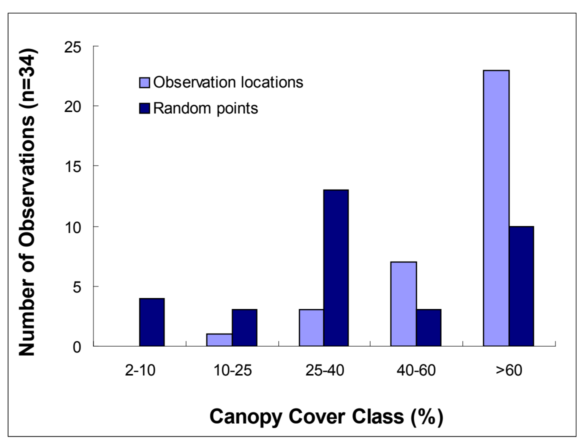

Figure 14. Distribution of fisher observation locations and randowm points by canopy cover class in Yosemite National Park, California.

low percentage of Yosemite subjected to logging may belie its importance because much of the ponderosa pine and sugar pine that remained was at higher elevations where deep winter snow reduces its value as suitable fisher habitat (Raine 1983, Krohn et al. 1997). Logging not only eliminated habitat, but also created large open areas that can pose barriers to fisher dispersal (Buskirk and Powell 1994, Jones and Garton 1994).

Current status of fisher in Yosemite National Park

Predator control ceased in 1925 and major logging operations ended 4 years later. Over the past 80 years, areas that were logged have regrown as Sierran Mixed Conifer habitat (Mayer and Laudenslayer 1988) capable of supporting fishers. My analyses of habitat around fisher observation sites yielded results consistent with recent studies conducted in the Sierra Nevada (Zielinski et al. 2004a, 2004b, Mazonni 2002, Green 2007, Jordan 2007). Given full protection from trapping since 1925, the presence of resident fishers, and the availability of apparently suitable habitat, why has the density of fisher in Yosemite not returned to historic levels? The data presented here confirm the presence of fisher in Yosemite, but are insufficient to evaluate population dynamics. Without information about reproduction, dispersal, survival, and causes of mortality, one can only speculate as to the factor(s) limiting this fisher population.

Although the NPS ended its predator control program in 1925, California permitted fisher trapping until 1946 (Lewis and Zielinski 1996). State trapping records were not broken down by county until the 1937-1938 season, but from 1937 through 1946, none of the licensed trappers operating in the 3 counties adjoining the Park ($\overline{X}$ = 16.9/county/year, SD = 7.2) reported taking any fishers (California Department of Fish and Game, unpublished data). I suspect that areas outside Yosemite became population sinks for fishers dispersing from the Park (Lidicker 1975, Pulliam 1988). The absence of immigration to counter the effects of emigration may have further depressed the low growth rate inherent in very small populations. Accidental deaths, like the 4 vehicle induced mortalities I recorded, may have exacerbated the situation because this type of mortality is likely to be additive rather than compensatory. As population size decreases, the potential for environmental, demographic, and genetic stochasticity to adversely affect species survival increases (Schaffer 1981).

It is also possible that areas previously logged and now considered suitable fisher habitat still remain lower in quality than they were before logging. Prior to 1913, forest communities between 914 m and 2000 m elevation were dominated by mature stands of sugar pine and ponderosa pine. These stands averaged nearly 100 sugar pines >127 cm dbh/ha. There was little young growth, "and everywhere the forest is open with little underbrush" (Fitch 1900). Areas harvested 80 years ago are now stands dominated by white fir (McKelvey and Johnson 1992). Vegetation sampling at detection stations during the study revealed that white firs outnumber ponderosa and sugar pines by ratios of 24:1 and 13:1, respectively. Furthermore, 55% of the white firs were in CWHR size classes 2 and 3, while only 15% had attained size class 4 (>51 cm dbh). My data, although not directly comparable with historic records, suggest present forest composition and structure are not the same as they were pre-European contact. Fisher are considered one of the most habitat specific mammals in North America (Powell 1993) whose home ranges include disproportionate numbers of large diameter trees and snags (Zielinski et al. 2004a). Current forest composition and structure may require larger home ranges to meet the needs of reproduction and survival, resulting in a lower density of fishers. It is possible that a combination of isolation, the increased potential for stochastic events such as road kills to affect small populations, and lower habitat quality may explain why fisher population density in Yosemite remains so low.

Management implications

The low rate of verified fisher detections prevents drawing conclusions about fisher population trends in Yosemite. Until that information becomes available, conserving the existing population should be a priority. Habitat loss to severe wildfire is among the most serious threats to fisher in Yosemite. Recent studies in the Sierra Nevada have investigated fisher distribution and habitat associations (Zielinski et al. 1995, Zielinski et al. 2005, Green 2007), home range characteristics (Zielinski et al. 2004a), and rest site selection (Zielinski et al. 2004b, Mazonni 2002). These studies consistently concluded that large diameter trees and continuous canopy cover are important components of fisher habitat. Decades of fire suppression and fuel accumulation in the absence of regular burning have produced conditions conducive to large, severe fires (Schmidt et al.

2006). Large wildfires that consume large trees and remove continuous canopy cover can dramatically alter forested landscapes rendering them unsuitable for fisher. Prescribed fires that remove high fuel accumulations and reduce the likelihood of severe wildfires can play an important role in preserving fisher habitat (NPS 2004). However, during the planning and implementation of prescribed fires, consideration and care should be given to preserving large diameter trees and snags.

The small size of Yosemite's fisher population increases the risk of extirpation triggered by environmental, demographic, and genetic stochasticity (Schaffer 1981). Stochastic events like vehicle-induced mortality can be a serious problem because these losses are likely additive rather than compensatory. To reduce vehicle induced mortality to fisher and other wildlife, I recommend reducing vehicle speed on park roads. Rolley and Lehman (1992) found the road-kill rate of raccoons was significantly correlated with traffic speed. Higher speeds increase stopping distance and reduce vehicle maneuverability. At higher speeds, drivers and animals have less time to react. During this study at least 4 fishers died after being struck by vehicles. To minimize fisher losses to vehicles, drivers should be educated about park speed limits, the need for speed limits, and the potential for excessive speed to endanger wildlife. It will also require increased enforcement of current speed limits.

Continued and expanded monitoring of fisher distribution within Yosemite is essential. Using the Park's GIS, I estimated that 26,887 ha of suitable habitat are available. I conservatively defined suitable habitat as CWHR (Mayer and Laudenslayer 1988) Sierran Mixed-conifer, Montane Hardwood-conifer, Montane Riparian, and Ponderosa Pine types below 1981 m elevation with overhead canopy cover exceeding 40% (Verner and Boss 1980). This estimate does not consider the availability of special habitat elements which could significantly influence habitat quality (Airola 1988). Nor does it consider distance to water which appears to have predictive value for determining whether a location will be used by fishers. Information about the quantity and quality of fisher habitat in Yosemite as indicated by fisher occupancy is requisite for determining whether the Park can support higher fisher densities.

Finally, a monitoring program will provide information on fisher population trends. Identifying and understanding the factors that affect fisher population density in Yosemite are critical for any conservation effort. New technologies like digital camera traps and DNA analyses using samples from hair snares (Zielinski et al. 2006) make monitoring more cost effective while providing better data. This effort should include a DNA analysis comparing genetic diversity within the Yosemite fisher population versus those found elsewhere in the Sierra Nevada and other, more distant populations. New techniques in genetic analysis may also be used to monitor population trends, sex ratios, and dispersal patterns (Jordan 2007). With time, forest succession may lead to conditions more favorable for habitat specialists like the fisher, bolstered by dispersers from more southerly populations. Meanwhile, I urge making every effort to conserve the Park's fisher population until this important mesocarnivore can fully reclaim its niche in Yosemite.

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LITERATURE CITED

Airola, D. A. 1988. Guide to the California Wildlife Habitat Relationships System. California Department of Fish and Game, Sacramento, CA, USA.

Barbour, M. G., T. Keeler-Wolf, and A. A. Schoenherr (eds.). 2007. Terrestrial vegetation of California, 3rd ed. University of California Press, Berkeley, CA, USA.

Barrett, R. H. 1983. Smoked aluminum track plots for determining furbearer distribution and relative abundance. California Fish and Game 69:188-190.

Botti, S. J. and W. Sydoriak. 2001. An illustrated flora of Yosemite National Park. Yosemite Association, El Portal, CA, USA.

Besag, J., and J. T. Gleaves. 1973. On the detection of spatial pattern in plant communities. Bulletin of the International Statistical Institute 45:153-158.

Bowman J., D. Donovan, and R. C. Rosatte. 2006. Numerical response of fishers to synchronous prey dynamics. Journal of Mammalogy 87:480-484.

Buck, S., C. Mullis, and A. Mossman. 1979. A radio telemetry study of fishers in northwestern California. Transactions of the Western Section of the Wildlife Society 15:166-172.

Bulmer, M. G. 1974. A statistical analysis of the 10-year cycle in Canada. Journal of Animal Ecology 43:701-718.

Buskirk, S. W., Powell, R. A. 1994. Habitat ecology of fishers and American martens. Pages 283–296 *in* S. W. Buskirk, A. S. Harestad, M. G. Raphael, and R. A. Powell, editors. Martens, sables and fishers: biology and conservation. Cornell University Press, Ithaca, New York, USA.

Campbell, L. A. 2003. Distribution and habitat associations of mesocarnivores in the central and southern Sierra Nevada. Dissertation, University of California, Davis. California, USA.

Coulter, M. W. 1960. The status and distribution of fisher in Maine. Journal of Mammalogy 41:1-9.

Cunningham, J. D. 1959. The wolverine and fisher in the Yosemite region. Journal of Mammalogy 40:614-615.

DeVos, A. 1951. Recent findings in fisher and marten ecology and management. Transactions of the North American Wildlife Conference 16:498-507.

Fitch, C. H. 1900. Yosemite Quadrangle, California. Pages 571-574 *in* C. D. Walcott, editor. Twenty-First Annual report of the Director of the United States Geological Survey, 1899-1900: Part V - Forest Reserves. Government Printing Office, Washington D.C., USA:

Foresman, K. R., and D. E. Pearson. 1998. Comparison of proposed survey procedures for detection of forest carnivores. Journal of Wildlife Management 62:1217-1226

Fowler, K. H., and R. T. Golightly. 1994. Fisher and marten survey techniques on the Tahoe National Forest. Final report to the U.S. Forest Service, California Department of Fish and Game, Wildlife Management Division, Nongame Bird and Mammal Section Report 94-9.

Grinnell, J., J. S. Dixon, and J. M. Linsdale. 1937. Fur-bearing mammals of California. Two volumes. University of California Press, Berkeley, California, USA.

Grinnell, J., and T. I. Storer. 1924. Animal life in the Yosemite. University of California Press, Berkeley, California, USA.

Green, R. E. 2007. Distribution and habitat associations of forest carnivores and an evaluation of the California Wildlife Habitat Relationships model for American marten in Sequoia and Kings Canyon National Parks. M.S. Thesis, Humboldt State University, Arcata, California, USA.

Haydon, D. T., N. C. Stenseth, M. S. Boyce and P. E. Greenwood. 2001. Phase coupling and synchrony in the spatiotemporal dynamics of muskrat and mink populations across Canada. Proceedings of the National Academy of Sciences 98:13149-13154.

Holland, R. F. 1986. Preliminary descriptions of the terrestrial natural communities of California. Unpublished document, California Department of Fish and Game, Natural Heritage Division, Sacramento, CA, USA.

Huber, N. K. 1991. The geologic story of Yosemite National Park. Second printing. Yosemite Association, Yosemite National Park, California, USA.

Johnson, H. 1988 Railroads of the Yosemite Valley. Trans-Anglo Books, Corona Del Mar, California, USA

Jones, L. L. C., and M. G. Raphael. 1990. Ecology and management of marten in fragmented habitats of the Pacific Northwest. Progress report, U.S. Forest Service, Pacific Northwest Research Station, Olympia, Washington, USA.

Jones, J. L., and E. O.Garton. 1994. Selection of successional stages by fishers in north-central Idaho. Pages 377–387 in S. W. Buskirk, A. S Harestad , M. G. Raphael, and R. A. Powell, editors. Martens, sables and fishers: biology and conservation. Cornell University Press, Ithaca, New York, USA.

Jordan, M. J. 2007. Fisher ecology in the Sierra National Forest, California. Dissertation, University of California, Berkeley, California, USA.

Keith, L. B., and J. R. Cary. 1991. Mustelid, squirrel, and porcupine population trends during a snowshoe hare cycle. Journal of Mammalogy 72: 373-378.

Krohn, W. B., W. J. Zielinski, and R. B. Boone. 1997. Relations among fishers, snow, and martens in California: results from small-scale spatial comparisons. Pages 211-232 *in* G. Proulx, H. N. Bryant, and P. M. Woodard, editors. Martes: taxonomy, ecology, techniques, and management. Provincial Museum of Alberta, Edmonton, Alberta, Canada.

Lewis, J. C., and W. J. Zielinski. 1996. Historical harvest and incidental capture of fishers in California. Northwest Science 70:291–297.

Lidicker, W. Z. Jr. 1975. The role of dispersal in the demography of small mammals. Pages 103-128 in F. B. Golley, K. Petrusewicz, and L. Ryskowski, editors. Small mammals, their productivity and population dynamics. Cambridge University Press, New York, USA.

Lindzey, F. G., S. K. Thompson, and J. I. Hodges. 1977. Scent station index of black bear abundance. Journal of Wildlife Management 41:151-153.

Linhart, S. B., and F. F. Knowlton. 1975. Determining the relative abundance of coyotes by scent station lines. Wildlife Society Bulletin 3:119-124.

Matthes, F. E. 1927. Sketch of Yosemite National Park and an account of the origin of the Yosemite and Hetch Hetchy valleys. USDI, National Park Service, Washington, D.C., USA.

Mayer, K. E., and W. F. Laudenslayer. 1988. A guide to wildlife habitats of California. California Department of Forestry and Fire Protection. Sacramento, California, USA.

Mazzoni A. K. 2002. Habitat use by fishers (Martes pennanti) in the southern Sierra Nevada. Thesis, California State University, Fresno, California, USA.

McKelvey, K. S., and J. D. Johnson. 1992. Historical perspectives on forests of the Sierra Nevada and the Transverse Ranges of southern California, forest conditions at the turn of the century. Pages. 225–246 in J. Verner, K. S. McKelvey, B. R. Noon, R. J. Gutierrez, G. I. Gould, and T. W. Beck, editors. The California spotted owl: a technical assessment of its current status. U.S. Forest Service, General Technical Report PSW-GTR-133, Albany, California, USA.

Medley, S. P. 2008. The complete guidebook to Yosemite National Park. Heyday Books, Berkeley, CA., USA

National Park Service. 2004. Yosemite fire management plan/Environmental Impact Statement. U.S. Department of the Interior, Washington D.C., USA.

Powell, R. A. 1993. The fisher, life history, ecology, and behavior. Second edition, University of Minnesota Press, Minneapolis, Minnesota, USA

Pulliam, H. R. 1988. Sources, sinks and population regulation. American Naturalist 132:652-661

Raine, R. M. 1983. Winter habitat and responses to snow cover of fisher (*Martes pennanti*) and marten (*Martes americana*) in southeastern Manitoba. Canadian Journal of Zoology 61:25-34.

Rolley, R. E., and L. E. Lehman. 1992. Relationships among raccoons, road-kill surveys, harvests, and traffic. Wildlife Society Bulletin 20:313-318.

Sawyer, J. O., and T. Keeler-Wolf. 1995. A manual of California vegetation. California Native Plant Society, Sacramento, California, USA.

Schempf, P. F., and M. White. 1974. A survey of the status of seven species of carnivores on National Park Service lands in California. National Park Service, San Francisco, California, USA.

Schempf, P. F., and M. White. 1977. Status of six furbearer populations in the mountains of northern California. U.S. Forest Service, San Francisco, California, USA.

Schmidt, L., M. G. Hille, and S. L. Stephens. 2006. Restoring northern Sierra Nevada mixed conifer forest composition and structure with prescribed fire. Fire Ecology 2: 20-33.

Sellars, R. W. 1997. Preserving nature in the National Parks: A history. Yale University Press, New Haven, Connecticut, USA.

Shaffer, M. L. 1981. Minimum population sizes for species conservation. BioScience 31:131-134.

Verner, J., and A. S. Boss. 1980. California wildlife and their habitats: western Sierra Nevada. U.S. forest Service General Technical Report PSW-37.

U.S. Fish and Wildlife Service. 1991. Endangered and threatened wildlife and plants; animal candidate review for listing as endangered of threatened species, proposed rule. Federal Register 56:58804-56900.

Zielinski, W. J. 1995. Track plates. Pages 67–86 *in* W. J. Zielinski and T. E. Kucera, editors. American marten, fisher, lynx and wolverine: survey methods for their detection. U.S. Forest Service General Technical Report PSW-GTR-157.

Zielinski, W. J., F. V. Schlexer, K. L. Pilgrim, and M. K. Schwartz. 2006. The efficacy of wire and glue hair snares in identifying mesocarnivores. Wildlife Society Bulletin 34:1152-1161.

Zielinski, W. J., and R. L. Truex. 1995. Distinguishing tracks of marten and fisher at track-plate stations. Journal of Wildlife Management 59:571-579.

Zielinski, W. J., R. L. Truex. G. A. Schmidt, R. V. Schlexer, K. N. Schmidt, and R. H. Barrett. 2004a. Resting habitat selection by fishers in California. J. Wildlife. Management 68:475-492.

Zielinski, W. J., R. L. Truex. G. A. Schmidt, R. V. Schlexer, K. N. Schmidt, and R. H. Barrett. 2004b. Home range characteristics of fishers in California. Journal of Mammalogy 85:649-657.

Zielinski, W. J., R. L. Truex. R. V. Schlexer, L. A. Campbell, and C. Carroll. 2005. Historical and contemporary distributions of carnivores in forest of the Sierra Nevada, California, USA. Journal of Biogeography 32:1385-1407.

Zielinski, W. J., and T. E. Kucera. 1995. American marten, fisher, lynx, and wolverine: survey methods for their detection. U.S. Forest Service General Technical Report PSW-GTR-157.

Zielinski, W. J., T. E. Kucera., and R. H. Barrett 1995. Current distribution of the fisher, Martes pennanti, in California. California Fish and Game 81:104-12.