Fisher Research and the Kings River Sustainable Forest Ecosystems Project: Current Results and Future Efforts [1]

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Figure 1—Fisher in a pine tree on the study area in the Sierra National Forest.

Abstract

The Kings River Sustainable Forest Ecosystems Project was initiated on the Kings River Ranger District of the Sierra National Forest, California, in 1993, with fieldwork beginning in 1994. Knowledge of the ecology of the fisher (*Martes pennanti*) in the Project area, and in the Sierra Nevada of California in general, is insufficient to develop empirically based management strategies or to respond to the challenge of sustaining viable local populations concurrent with projected human population growth in the Sierra. Using a combination of track-plate surveys, snowtrack searches, and live-trapping, we documented a reproducing population of fishers between 1,067 and 2,438 m in elevation within much of the Project area. Whether survivorship and reproductive rate are sufficient to maintain the population within the Project area is unknown. Given current viability concerns for fishers in the Sierra Nevada, it would be prudent that, concurrent with future research, management activities in the areas occupied by fishers that are outside the forest carnivore network also conserve or promote habitat elements used by fishers.

The Forest and Rangelands Renewable Resources Planning Act of 1974 and the National Forest Management Act of 1976 (NFMA) mandated additions to the process by which the USDA Forest Service manages its public lands (Dana and Fairfax 1980). A key section of the NFMA directed the Secretary of Agriculture to write regulations specifying guidelines that "provided for diversity of plant and animal communities based on the suitability and capability of the specific land area in order to meet overall multiple-use objectives." The challenge to meet this provision is significant for National Forests in the Sierra Nevada. Land area developed for human settlement within the mountains could quadruple from 1990 to 2040 as a result of a tripling in the human population within the region (Duane 1996). Ecological ramifications of the mosaic of forest ownership and differing owners' objectives are many.

Despite substantial efforts (Grenfell and Fasenfest 1979; Zielinski and others 1995b, 1997, 1999), knowledge of the ecology of fishers (*Martes pennanti*) in the Sierra Nevada (*fig. 1*) is insufficient for development of empirically based management strategies that will ensure viable local populations in the face of increased demands on forest resources that will inevitably accompany the projected growth of the human population in the Sierra Nevada (Graber 1996, Ruggiero and others 1994). Ruggiero and others (1994) recommended a comprehensive, programmatic approach of research to acquire the information needed for developing conservation strategies.

The Kings River Sustainable Forest Ecosystems Project (hereafter, the Project) was initiated in 1993 on the Kings River Ranger District of the Sierra National Forest, Fresno County, California, with fieldwork beginning in 1994 (Verner and

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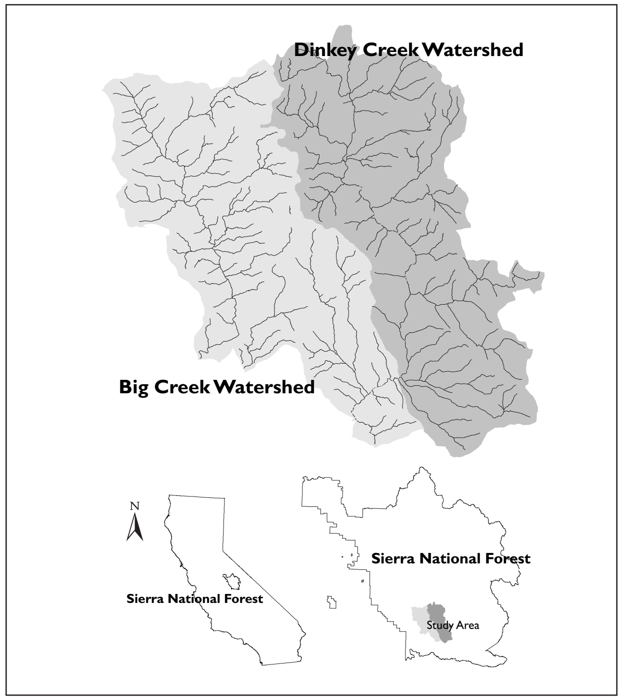

Figure 2—The Kings River administrative study area in the Sierra National Forest in central California includes the 64,000-acre Big Creek and Dinkey Creek watersheds (indicated by shading).

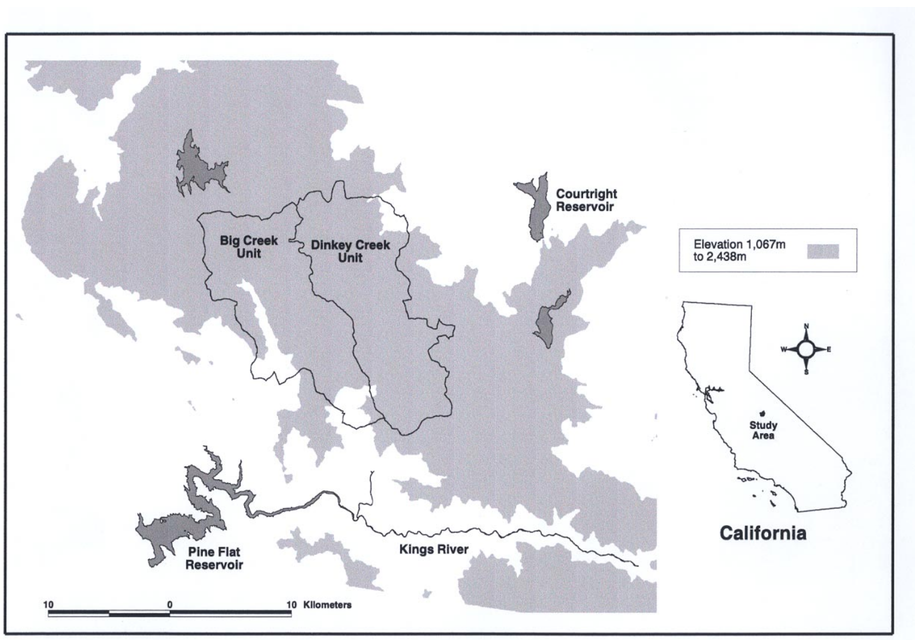

Figure 3—Big Creek and Dinkey Creek units treated by the Kings River Sustainable Forest Ecosystems Project, Sierra National Forest, Fresno County, California.

Smith, this volume). The Project area of 26,000 ha encompasses about 13,000 ha in both the Big Creek and Dinkey Creek watersheds (*figs. 2, 3*). This was a collaborative Administrative Study among Forest Service managers and researchers to investigate whether forest ecosystems in the southern Sierra Nevada can be managed to maintain essential ecosystems components, processes, and interactions and still support a variety of other uses (Gill and others 1997). The Project is a unique opportunity to meet existing information needs for conservation planning for fishers because it is within a geographic area of concern, it is highly integrated with other disciplines, and it is committed to developing a comprehensive body of knowledge through a long-term, adaptive-management approach.

This paper describes our general programmatic approach to understand use by fishers within the Project area, presents our current, preliminary results, and discusses the logical expansion of this research as the Project proceeds, with an ultimate goal of determining the fisher's responses to landscape-level silvicultural treatments in the two watersheds.

Study Area

Forest management in the Big Creek watershed is applying uneven-aged, small-group selection with a 200-year rotation, which will result in 0.5 percent of the land area being harvested each year and half of the landbase supporting forests at least 100 years old. The primary goal is to maintain a continuous forest canopy, retain mature vegetation in riparian areas, retain large trees (crown diameter >12.2 m) on half of the landscape capable of growing them, and maintain and enhance riparian systems in streamside-management zones.

In the adjoining Dinkey Creek watershed, a three-tiered forest landscape has been implemented—a riparian emphasis zone (20 percent of the landscape) at the bottom, a mid-slope zone of continuous forest cover (50 percent of the landscape) on side slopes, and a ridge-top zone managed as a shaded fuelbreak to provide a first line of defense against wildfires (30 percent of the landscape) (Smith and Exline, this volume).

General Programmatic Approach

Balancing multiple-use on lands managed by the Forest Service is a significant challenge for the National Forest System. Uses change, technologies evolve, and ecosystems respond concurrently, but at different rates. The approach chosen by managers must ensure timely responses to these issues. The approach must also involve direct participation among practicing resource planners, managers, and a variety of specialists studying diverse topics. The general programmatic approach of the research presented here emphasizes our commitment to respond to information needs. For the duration of the Project, we propose to conduct annual, systematic surveys of the fisher population within the Project area using base funding. These surveys will be augmented by studies to examine specific questions that emerge from management activities that cannot be addressed through survey results.

Track-Plate Surveys

Our initial survey of the Project area was designed to determine the occurrence and distribution of forest carnivores, especially fishers and martens (*Martes americana*). Over two consecutive field seasons in 1995 and 1996, we placed sooted aluminum track-plates (Fowler and Golightly 1994) at 160 stations along 8 cross-elevation routes to cover all elevations in the Project area, based on 7-1/2 minute series maps (1:24,000 scale, U.S. Geological Survey, Menlo Park, California). The routes followed roads or trails accessible during fall when snow was present. Stations included one track plate in a wooden box, systematically placed at 1-km intervals along the eight routes (*fig. 4*). Stations were placed as far as 70 m from the road, although most were within 50 m. The boxes housing the sooted plates were positioned in the field with one open end against a tree, rock, or log and then camouflaged with forest litter. Stations were often located in drainages with the boxes facing down slope to prevent rain and snow from falling on the plate and destroying the soot or track impressions.

We conducted four (two each season) 22-day surveys because Fowler and Golightly (1994) reported that surveys at least this long maximized the probability of detecting martens. The first survey occurred from 17 October to 7 November 1995 and included 81 high-elevation stations (1,275-2,592 m) divided among four routes. The second occurred from 17 November to 8 December 1995 and consisted

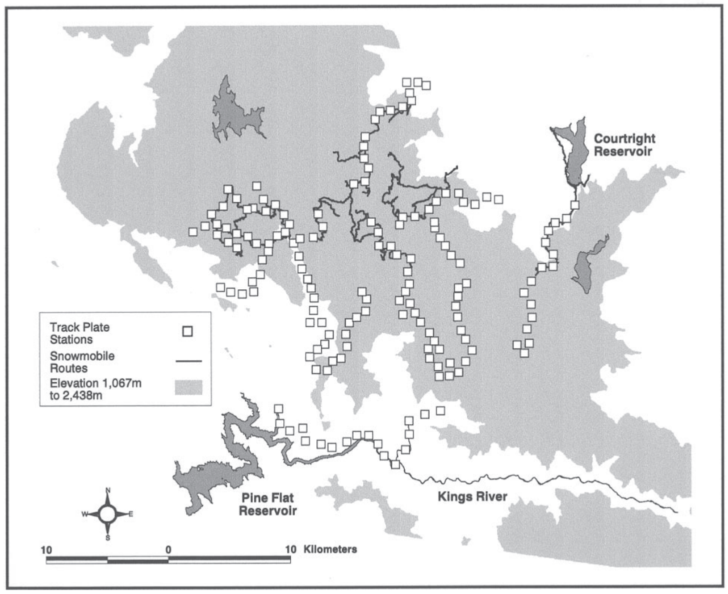

Figure 4—Track plate stations and snowmobile routes used to determine the occurrence and distribution of fishers and martens within the south zone of the Sierra National Forest.

of 79 stations divided among four routes at lower elevations (294-1,662 m). The same stations were surveyed again the following summer to measure potential seasonal variations in carnivore detection and increase our power to detect animals. The low-elevation stations were surveyed from 1 to 22 June 1996 and the high-elevation stations were surveyed from 7 to 28 July 1996. Each station was examined every other day. We replaced any track plate that contained tracks on either the soot or contact paper or if the soot had been disturbed so that it was no longer effective. Chicken wings were used as bait and replaced when desiccated or when rodents or insects removed meat.

Detection ratios were calculated for fishers and martens by dividing the number of stations that had detected animals by the total number of available stations between the highest and lowest detection for each species, plus or minus 200 m. This allowed assessment within a range of realistically available habitat. No survey station was higher than the highest marten detection; therefore, we included stations from the highest to those as low as 200 m below the lowest detection.

Results of Track-Plate Surveys

Fishers occurred at elevations between 1,114 and 2,040 m, whereas martens were found at elevations between 1,992 and 2,520 m (*fig. 5*). The detection ratio for martens (0.38) was twice that for fishers (0.19). Martens were detected at 20 of 53 stations, 15 in 1995 and 7 in 1996; 2 stations had detections both years. Fishers were detected at 14 of 72 stations, 8 in 1995, and 7 in 1996; only 1 station detected fishers in both years.

Snow Track Searches and Camera Stations

With confirmation of the occurrence of fishers and martens in the Project area, and preliminary assessments of their distribution, study priorities were focused on fishers, especially on the size and composition of the areas used and how the habitats within these areas have changed over time. Answers to these questions for martens would be equally interesting, but limited resources and the fact that the Project area encompassed habitats mainly within the range of fishers led us to focus on this species.

These new objectives required live-trapping and radio-collaring fishers, which began in February 1999. Because it had been $2\frac{1}{2}$ years since our last survey, we needed more current information on areas being used by fishers. By

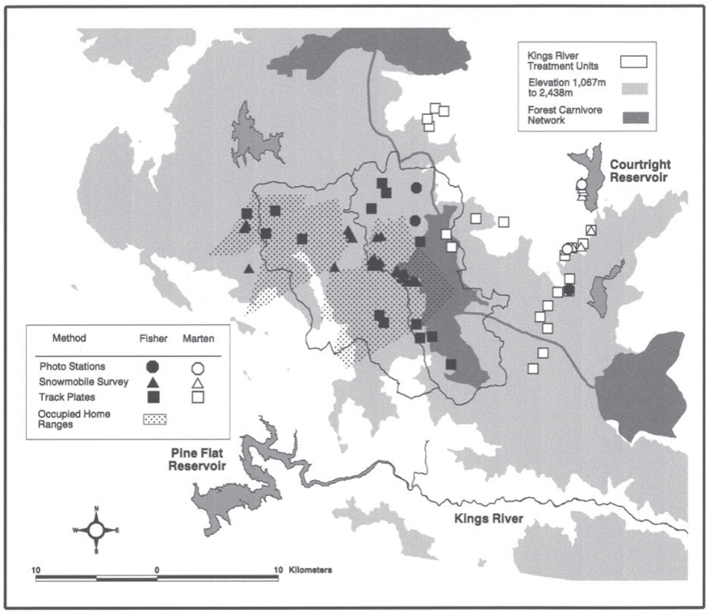

Figure 5—Locations where fishers and martens were detected in the Kings River Sustainable Forest Ecosystems Project Area, south zone of the Sierra National Forest, Fresno County, California. Occupied home ranges represent the aggregated minimum convex polygon home range estimates of nine animals.

using snowmobiles to travel along roads within the Project area, we searched for fisher tracks (*fig. 4*). To help resolve uncertainties about the distinctions between tracks of fishers and martens, we placed Trail Master passive infrared monitoring setups (Model TM500 with TM 35-1 camera kit)[6] at six locations above 1,830 m where we expected both species to occur. We used a combination of a scent call (Gusto by Caven Lures, Minnesota Trapline Products, Pennock, Minnesota) and approximately 5 kg of raw pork as attractants at each camera station. The pork was secured at least 2 m above the ground in trees with diameters exceeding 61 cm at breast height. The dimensions of snow tracks left by animals photographed at the camera stations were compared to previously identified tracks to confirm that they had been classified correctly.

Results of Snow Track Searches and Camera Stations

We traveled 157 km of roads in 10 days between 3 February and 14 April 1999. Identifiable tracks of fishers and martens were found crossing these routes in 38 locations, 28 by fishers and 10 by martens (*fig. 5*). Fishers or martens were detected at five of the six camera stations but never both species at a single station (*fig. 5*). Multiple pictures at each station confirmed fishers at 2,160 m and 2,360 m and martens at 2,490 m and 2,550 m. The presence of two separate martens at the station located at 2,490 m was confirmed by an image with both animals in the same frame. Snow depths where tracks or images of fishers were recorded ranged from 5 to 124 cm. Marten tracks and images occurred at locations with snow depths ranging from 87 to 185 cm.

Live-Trapping

Capture and radio collaring began in August 1999. Live traps (Model 207 Tomahawk Live Trap Company, Tomahawk, Wisconsin) modified to include wooden nest boxes (Seglund 1995) were placed in areas where track-plate surveys and track searches had detected fishers (*fig. 5*). Traps were typically placed next to downed logs within 10 m of a stream and preferably where two or more streams met. To attract fishers, the Gusto scent call was poured onto Prowick™ scent dispensers (by Wildlife Research Center, Inc. available through Minnesota

[6] Mention of trade names or products is for information only and does not imply endorsement by the U.S. Department of Agriculture.

Table 1—*Physical parameters measured on anesthetized fishers live-trapped within the Sierra National Forest, Fresno County, California*

Weight
Length (nose to end of vertebrae of tail, axis of body to vertebrae of tail)
Hind foot length (heel to end of longest claw)
Ear length (lateral notch to tip)
Neck circumference
Canine lengths (each tooth)
Canine diameters (base and tip of each tooth)
Dimensions of the testes (anterior to posterior and medial to lateral)
Diameter and height of each nipple

Trapline Products, Pennock, Minnesota) suspended above each trap. A chicken leg was securely tied within the trap on the side along the log and in the rear next to the wooden nest box. Traps were checked daily and re-baited or re-scented at least every fourth day depending on the condition of the bait and potency of the scent call.

Captured animals were coaxed into a handling cone attached to the rear of the nest box following methods of Seglund (1995) and anesthetized with a mixture of ketamine and diazepam (1 mg of diazepam per 200 mg of ketamine) injected intramuscularly at a dosage of 11-24.2 mg/kg of body weight (California Department of Fish and Game 1996, Seglund 1995). Anesthetized fishers were removed from the handling cone, weighed, and examined. In addition to determining the sex of the animal and assessing overall condition, we assessed the development of the sagital crest, mammae, or testes and baculum. A series of measurements used by Zielinski and others (1999) were made to describe the morphological characteristics of each animal (*table 1*).

We implanted subcutaneous, passive, integrated transponders (125 kHz, TX1405L, Biomark™, Boise, Idaho) in the nape of each fisher for permanent and unique identification. In addition, color-coded ear tags were fastened into each ear to outwardly identify animals recaptured or recorded at future camera stations. The small amounts of ear tissue displaced by the tags were preserved for genetic analysis.

Each animal was also fitted with a radio transmitter with a 16-hour on- and 8-hour off-duty cycling option to extend battery life (Models 080 for females, 205 for males, Telonics, Mesa, Arizona) and a mortality sensor to alert biologists when an animal had died. Animals were placed back in the wooden nest box of the trap after being processed and then released after about an hour, when fully recovered from the anesthesia.

Live-Trapping Results

Three females and six males were caught on 11 occasions during 326 trap nights between 4 August and 15 November 1999—a capture rate of 0.0337 animals/night. That is, 10 traps open for 10 nights were likely to capture fishers on about 3 occasions. This capture rate was 2.8 times that reported by Zielinski and others (1999) for their work in the Sequoia National Forest from 26 May to 6 July 1999. The trap design, microhabitat placement, bait, and scent call were similar in the two studies. Trap latency (the mean number of nights that traps for fishers remained open before a fisher was captured) for the two studies provides evidence of this similarity. Our trap latency was 6.1 trap nights ($n = 9$, range 1 to 15); that of Zielinski and others (1999) was 7.7.

The sex ratio of captured fishers (6 males: 3 females) is probably not representative of the population in the Project area, as the sample is small and it

Table 2—*Physical measurements (weight in kg, lengths in cm) from anesthetized fishers captured on the Sierra National Forest, Fresno County, California*

Parameter	Sex	n	Median	SD	Min.	Max.
Weight	Male	6	3.6	0.5	3.3	4.5
	Female	3	2.1	0.1	2.0	2.2
Total length	Male	6	100.1	2.2	98.7	105.0
	Female	3	89.0	2.5	87.5	92.3
Tail length	Male	6	37.6	1.0	36.8	39.7
	Female	3	35.0	0.5	34.5	35.5
Right hind foot length	Male	6	12.7	0.4	12.0	13.0
	Female	3	10.9	0.6	10.0	11.2
Left hind foot length	Male	6	12.1	0.4	11.9	12.9
	Female	3	10.5	0.5	10.0	11.0
Right ear length	Male	5	10.5	0.7	3.5	5.1
	Female	3	4.3	0.8	3.0	4.4
Left ear length	Male	5	4.9	0.7	3.0	5.0
	Female	3	3.9	0.7	3.2	4.5
Neck circumference	Male	6	20.9	2.2	17.0	23.8
	Female	3	16.0	1.2	14.9	17.3

is well known that both live-trapping and fur-trapping methods for mustelids are biased toward males (Buskirk and Lindstedt 1989, King 1975).

The number of animals handled thus far is too small for multivariate analyses of body weight, length, or tooth measurements. Sexual dimorphism has been reported in the species elsewhere in California (Seglund 1995, Zielinski and others 1995a). Our male fishers were significantly larger than the females (Mann-Whitney U test, $P < 0.05$), based on every physical parameter measured except ear length ($P = 0.09$) (*table 2*). Preliminary tests also suggest that additional data will reject the hypothesis that canine lengths and diameters are the same for the two sexes (*table 3*). Given only tooth size, we found canine diameter at the base of the tooth most useful to distinguish between the sexes. The diameter at the tips of the canines appears to be similar between the sexes, and canine length is subject to more variability than diameter at the base due to breakage.

Nipple dimension (length x width) in female fishers can provide information on their breeding status (Frost and others 1999, Zielinski and others 1999). Frost and others (1999) reported mean anterior nipple sizes of 45 mm^2 for current breeders, 12 mm^2 for former breeders; and 6 mm^2 for nonbreeders, and Zielinski and others (1999) reported a mean anterior nipple size of 21 mm^2 for a lactating female and values of 2 mm^2 and 8 mm^2 for nonlactating females. The nipple dimensions on two of the three females we captured suggest that they had previously produced offspring (*fig. 6*) and that the third female was a nonbreeder.

Six of the animals had signs of past physical damage that included broken canines, torn ears, and scars, but all nine animals appeared healthy based on body weight, the relative amount of fat covering the ribs, coat condition, and external parasite loads. External parasites were rare on the nine animals trapped, agreeing with Powell (1993) that fishers exhibit a low incidence of parasites. Our assessment of their health at the time of capture was supported by the survivorship of the all individual animals through winter, at least to April 1, 2000.

Table 3—*Median canine length (mm) and diameter (mm) for fishers captured on the Sierra National Forest, Fresno County, California. Three broken canines were removed from the length measures*

Characteristic	Sex	Right tooth length (n)	Left tooth length (n)
Upper canine			
Length	Male	14.73 (5)	15.68 (5)*1
	Female	11.44 (3)	11.62 (3)*
Diameter of base	Male	6.74 (5)*	6.75 (5)*
	Female	5.02 (3)*	4.81 (3)*
Diameter of tip	Male	2.50 (5)	1.90 (5)
	Female	2.50 (5)	1.90 (5)
Lower canine			
Length	Male	14.50 (5)*	15.32 (6)*
	Female	9.47 (3)*	9.57 (3)*
Diameter of base	Male	7.00 (5)	7.07 (5)*
	Female	5.47 (3)	5.59 (3)*
Diameter of tip	Male	1.83 (5)	2.00 (5)
	Female	1.73 (3)	1.58 (3)

[1] Asterisks represent significant differences between the sexes, based on a Mann-Whitney U statistic an and alpha level of 0.05.

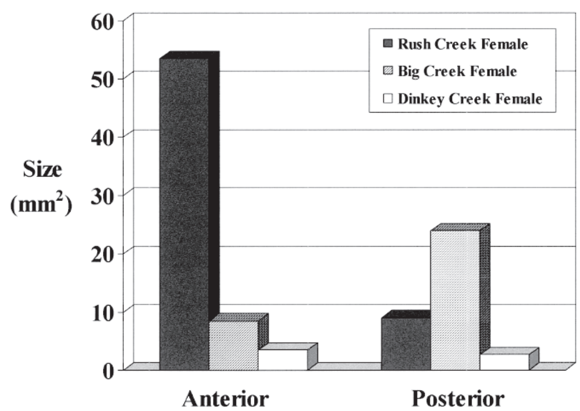

Figure 6—Nipple dimensions (length x width) of three female fishers captured in autumn within three drainages on the Sierra National Forest, Fresno, County, California.

Home-Range Size

Locations used to estimate home-range size came from trap sites and radio telemetry locations between August 1999 and May 2000. Trap sites where animals were captured were treated as known locations. Relocations using radio telemetry relied on a scanner/programmer with a receiver (Models TS-1, TS-2, Telonics Inc., Mesa, Arizona) to detect radios. Receivers were attached to a 2- or 3-element, hand-held antenna or a truck-mounted, manually rotated, Yagi direction-finding antenna array. Walking to the animal and identifying the physical structure it occupied was the preferred method of relocation, but locations in some instances were determined by a minimum of three azimuths from known locations. Azimuths were measured using a hand-held compass (Model Type 15T, Silva, Binghamton, New York). Locations of trap sites and physical structures occupied were determined using a global position system with real-time correction capability (Centurion, Trimble Navigation, Inc., Sunnyvale, California or PLGR, Rockwell International Corporation, Cedar Rapids, Iowa).

We used the minimum convex polygon method (Mohr 1947) to estimate home-range size because of the small number of locations currently available for each animal, and all locations were used for each animal because outliers were difficult to identify with the small samples.

Home-Range Results

The cumulative area used by the three female and six male fishers with radio collars included much of the Project area within the elevations that fishers inhabit (*fig. 5*). Preliminary estimates of home-range size were derived from as few as 10 locations for males (n = 6, median = 13, range = 10-23) and 19 locations for females (n = 3, median = 26, range = 19-42). Median home range area for males (2,150 ha; sd = 1,873) was more than twice that for females (964 ha; sd = 748). The lack of power to detect a significant difference (alpha level 0.05) between the areas used by males and females emphasizes the preliminary nature of these results (Mann-Whitney U = 3, P = 0.12, X^2 = 2.4, 1 df).

Changes in Habitat Within Home Ranges

The distribution and numbers of fishers have decreased in California over the past few decades, despite their receiving protection from trapping. Because of this, Zielinski and others (1995b) suggest that the decline is attributable to a reduction in suitable habitat. In the summer of 2000, we began to examine changes in habitat composition and patterning within fisher home ranges in the Project area by comparing current conditions to those existing in 1958. Aerial photographs taken in 1996 were interpreted to produce a classification scheme similar to that produced by a timber stand-vegetation cover map completed in 1958. Descriptions of habitat within each home range will be determined by using a geographic information system to intersect the boundaries of the home ranges with the 1996 aerial photo data and the 1958 vegetation cover map. Timber growth models, data on fire frequency and intensity, and timber harvest activities since 1966 will be used to explain changes in composition and patterning over the 38-year period.

Monitoring Long-Term Trends

Monitoring of fisher populations is difficult. Individuals are solitary outside the breeding season, densities are low, and sample sizes needed to detect change can be large (Zielinski and Stauffer 1996). In light of the fisher's status (Lamberson and others 2000), the population of these animals within the 26,000-ha Project area must be monitored for both population numbers and demographic parameters. Baited track plates have been successful for monitoring local project areas (Fowler and Golightly 1994) and have been proposed for use to detect regional changes in an index of the occurrence and distribution of fishers throughout California (Zielinski and Stauffer 1996). Indeed, we have successfully used them to determine the occurrence and distribution of fishers within the Project area. Live trapping and telemetry will provide data on population parameters, including the number of individuals, age structure, survivorship, and possibly gene flow. Our preliminary results on nipple dimensions suggest that information on the past reproductive activity of females might also be obtained. Continuing research with radio-collared animals will also provide a marked population with a known distribution on which to assess biases associated with the live-trapping method.

Systematic live-trapping is proposed to occur from July through October within a 168-cell grid that spans elevations from 1,067 m to 2,438 m across the Project area (*fig. 7*). This trap period was chosen because access is good, it is still

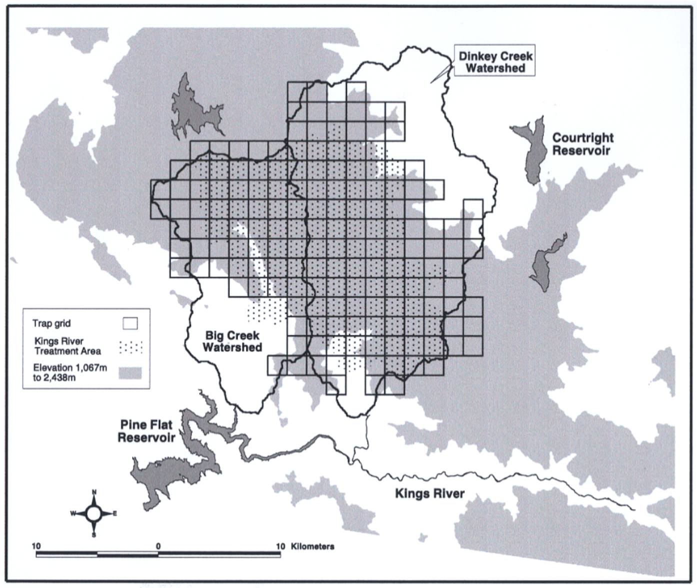

Figure 7—Systematic trap grid proposed for use to monitor fishers within the Kings River Sustainable Forest Ecosystems Project Area, Sierra National Forest, Fresno County, California.

possible to examine nipple enlargement to assess breeding status in females (Frost and others 1999), capture rates are good during this period, and it occurs after the nursing period. A single trap would be placed within suitable habitat for fishers within each 2.56-km^2 cell and used to trap animals at that locale for 12 days. Only once has it taken us longer than 12 days to capture a fisher at a trap site where one was eventually caught. On the basis of our preliminary estimates of home-range sizes, a grid cell size of 2.56 km^2 will result in an average of three traps per female home range and eight traps per male home range. This design would enable three biologists to complete 2,016 trap nights in 4 months and handle fishers on 68 occasions, based on our previous trap success. Fewer captures than this are expected, however, because our previous efforts targeted the highly suitable habitat between 1,372 m and 1,829 m in elevation.

Conclusions

We found a reproducing population of fishers inhabiting much of the land base between 1,067 and 2,438 m in elevation within the Project area. Whether survivorship and reproductive rate within the Project area are sufficient to maintain the population is unknown. The fate of the population depends primarily upon the management direction taken by the Forest Service, which administers 85 percent of the land base within the Project area. A regional management directive has deferred activities that would significantly decrease the persistence of large-diameter live trees, snags, and downed logs in forest carnivore habitat networks not covered by standards set for the California spotted owl (*Strix occidentalis occidentalis*) (Verner and others 1992). The current forest carnivore network within the Sierra National Forest, however, encompasses only 18 percent of the Project area (*fig. 5*). Given current viability concerns for fishers in the Sierra Nevada, and because we still know too little about the survivorship and reproductive rate of fishers within the Project area, it would be prudent that, concurrent with future research, management activities in areas occupied by fishers that are outside the forest carnivore network also conserve or promote habitat elements used by fishers.

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