

## 15 Techniques for Monitoring Populations of Fishers and American Martens

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Fishers (*Martes pennanti*) and American martens (*M. americana*) are secretive forest-dwelling carnivores that are difficult to observe and study. Both are associated with late-successional coniferous forest (Buskirk and Powell, this volume), and martens are used as ecological management indicators of old-growth conditions in most national forests of the western United States that fall within the distribution of the species. Because martens are vulnerable to the loss of habitat through timber harvesting, reliable detection and monitoring techniques and protocols are needed so that agencies can watch for population declines and modify resource management practices to halt them when they occur. Monitoring techniques are also needed by landowners, researchers, and naturalists.

The current population status of American martens and fishers has been incompletely documented especially in the western United States (Gibilisco, this volume). Fisher populations are believed to be low and declining in the Sierra Nevada of California (Schempf and White 1977), but comprehensive surveys have not been completed there. Sighting and trapping records indicate that fisher populations are also small in Washington (Aubry and Houston 1993), Oregon, and the northern Rocky Mountains, leading to a recent petition to list the species as threatened (*Federal Register* 56[8]:1159-1161). Populations of American martens have declined on Newfoundland Island (Thompson 1991) but are believed to be relatively high and stable in suitable habitat elsewhere. Comprehensive field surveys have not been undertaken, however. The primary obstacle to such surveys has been the lack of reliable broadly applicable survey and monitoring techniques.

In this chapter I review available techniques for detecting American mar-

tens or fishers. I also discuss the relative advantages and disadvantages of each technique in relation to monitoring objectives.

### **Habitat Survey**

The most cost-effective, but likely the least precise, assessment of population status of American martens and fishers is based on an inventory of land area covered by suitable habitat. This method, used by many national forests of the United States, rests on two assumptions: that habitat suitability is well enough known to describe stands that are likely to meet the life requisites of martens or fishers; and that the amount of habitat classified as suitable is directly correlated with population size. The first assumption can be partially addressed through wildlife-habitat relationship models such as the Habitat Suitability Index (HSI) (Allen 1982, 1983; Schamberger and Krohn 1982; Cole and Smith 1983), Habitat Capability Model (Nelson and Salwasser 1982, Hoover and Wills 1984), and PATREC (Williams et al. 1977, Grubb 1988). The second assumption should be addressed through statistical comparison of model-based habitat evaluations with empirical data on abundance of a species in an area (Marcot et al. 1983, Salwasser et al. 1983, Fagen 1988). Unfortunately, existing models have received only limited testing (Thomasma et al. 1991). These models, to be reliable, must be tested, revised, and tested again in more than one study area. I know of no models that have received such testing. In addition, the second assumption is valid only if habitat is limiting. If other factors, such as predation, limit the population, population size will not be correlated with amount of habitat, and results of field tests of model reliability will be misleading.

The primary advantage of these models is their potential for evaluation of large areas of land without costly fieldwork. Existing timber inventory data may be sufficient to classify habitat suitability. For example, the HSI model for the fisher depends on four stand attributes: percent canopy closure, average diameter of canopy trees, number of canopy layers, and percent deciduous species in overstory (Allen 1983). All these attributes are routinely collected by land management agencies or can be derived from data they collect. For the American marten, however, stand attributes should include percent ground surface covered by woody debris greater than 7.6 cm in diameter (Allen 1982), an attribute not routinely collected. Application of the marten HSI model may therefore require additional field sampling.

The disadvantages of model-based monitoring are the high risks inherent in using untested relationships and the low resolution at which existing mod-

els classify habitat. These two disadvantages are multiplicative: in combination they could result in a high probability of failing to detect real trends in population abundance.

### **Animal Survey**

#### **Harvest Records**

A commonly used technique, especially among state agencies, is to infer population trend from commercial trapping results, either total catches or catches per unit effort (Douglas and Strickland 1987, Strickland and Douglas 1987). Such techniques are described in detail by Strickland (this volume). Harvest records can yield large sample sizes and statistically precise estimates of population parameters, especially when data are aggregated over broad regions. These samples can be used to infer relative productivity or abundance of *Martes* in broadly defined regions (e.g., fisher productivity in ecoregions of North America as summarized by Banci 1989). Comparisons of yearly catch, assuming that we know the harvest effort, may provide good estimates of regional population trends over time, in contrast with trends derived from site-specific studies, especially if trapping effort is well documented. Data from individual traplines can also be gathered and may yield estimates of population status in local areas.

On the negative side, harvest rates may not reflect true population size for a variety of reasons (Strickland, this volume). First, the size of the harvest depends on complex interrelationships among market condition (pelt prices), social forces (animal welfare, animal rights), general economic conditions (more effort by trappers when trapping income is more important), and environmental concerns. Second, unless regulations (e.g., in much of Canada) prevent him or her from doing so, a prudent trapper may move to a new area if capture rate declines. This results in a lag between changes in capture rate and true population size. Third, managers, especially in the United States, may not control trapping locations and intensity well enough to assure consistent effort across space and time. Without such control, use of harvest data for survey and monitoring is subject to biases of unknown magnitude. Thus, the value of harvest data depends on the specific regulations in effect for the geographic area of interest.

#### **Live-Trapping**

Estimates of occurrence or relative abundance may be obtained by live-traps deployed singly or in small clusters to determine the presence or ab-

sence of a species, or the traps may be arranged in larger transect lines or grids to estimate relative abundance. General guidelines for designing live-trap experiments and for analyzing results are available in other reports (Seber 1973, Otis et al. 1978, Pollock et al. 1990) but are not specific to *Martes*.

Live-trapping offers many advantages over other detection techniques. First, captured animals can be identified to species and marked and released for mark-recapture estimates of population size. Because animals are not removed from the population, intensive periodic trapping within a prescribed study area can lead to enumeration of nearly all individuals. If samples are large, sex ratio, age distribution, and reproductive status can be estimated, especially for studies lasting several years or more.

Disadvantages of live-trapping are primarily related to the costs of labor and materials. Capture rates are generally low, so large investments in time, traps, and personnel may yield only modest returns. Mean capture rates from 12 published studies of American martens varied from 0.25 to 3.36 individuals/100 trap-nights ( $\bar{x} = 1.31$ ,  $SD = 1.09$ ) (Table 15.1). Capture rates likely are lower for fishers, because of their lower density (Powell, this volume). Thus, many traps must be set to ensure adequate numbers of captures if the objective is to estimate population size. Unless the number of captures is high, abundance estimates will be biased and subject to large variances. In addition, individual animals may become trap-happy (repeatedly enter traps) or trap-shy (avoid traps after first capture), which further complicates analyses of capture data. For the studies summarized in Table 15.1, total captures, including repeated captures of the same individuals, averaged 5.8 captures/100 trap-nights ( $SD = 3.6$ ), indicating an overall crude rate of more than four captures per individual.

Live-trapping requires great care to avoid accidentally killing or injuring captured animals. Traps must be checked daily under favorable conditions and two or more times per day during cold or wet periods. Traps can be checked less often if they are fitted with protective nesting boxes. S. W. Buskirk (Univ. of Wyo., pers. commun.) experienced no trapping mortalities among more than 120 captures of American martens in such traps. Lowered labor costs and fewer risks to animals result if traps are fitted with radio transmitters to signal when captures occur (Arthur 1988).

#### Snow Transects

Snow transects (i.e., counting animal tracks intercepting a transect) have long been used in studies of *Martes* and have been recommended as a technique to estimate relative abundance (Douglas and Strickland 1987, Strick-

Table 15.1. Livetrap capture rates for American martens (*Martes americana*)

Location	Season	Total captures	No. indiv.	Total tn	Indiv./ 100 tn	Total captures/ 100 tn	Reference
British Columbia	Fall, winter	44	21	625	3.36	7.04	Miller et al. 1955
Montana	Summer, fall	70	29	1,025	2.83	6.83	Burnett 1981
Montana	Year-round	223	53	1,912	2.77	11.66	Newby & Hawley 1954
Montana	Year-round	778	112	6,507	1.72	11.96	Weckwerth & Hawley 1962
California	Year-round	72	18	1,566	1.15	4.60	Simon 1980
Wyoming	Summer	97	17	1,987	0.86	4.88	Campbell 1979
Maine	Summer	609	123	16,065	0.77	3.80	Soutiere 1979
Wyoming	Summer, fall	291	22	3,224	0.68	9.03	Clark & Campbell 1976
Wyoming	Summer, fall	142	20	3,234	0.62	4.39	Hauptman 1979
Idaho	Fall, winter	80	13	2,896	0.45	2.76	Kochler & Hornocker 1977
California	Year-round	49	11	3,641	0.30	1.35	Martin 1987
Ontario	Summer	573	89	35,670	0.25	1.61	Francis & Stephenson 1972

Note: tn = trap-night.

land and Douglas 1987). Thompson (1949) counted fresh tracks crossed in a day's travel and reported an apparent increase in marten population over a four-year period based on observations of increased numbers of tracks. Similarly, de Vos (1952) recommended snow tracking to obtain indices of abundance of martens and fishers. De Vos described differences in behavior between martens and fishers that influence track counts, especially the tendency of martens to meander more than fishers.

As used by contemporary investigators, snow transect sampling entails following predefined transect lines one or two days after snowfall. Transects can be traversed by skis, snowshoes, or snowmobile, the latter obviously permitting more extensive coverage. Observers tally each track that intercepts the transect line. Some investigators, (e.g., Thompson 1949, de Vos 1952) recommend not counting repeated crossings by the same animal. Because such determination is seldom possible, others (e.g., Thompson et al. 1989, Raphael and Henry 1990) recommend tallying all crossings.

Adjustments are necessary to account for time since last snowfall. Thompson et al. (1989) divided total numbers of tracks by the number of 12-hour periods since snowfall; Raphael and Henry (1990) divided by the number of 24-hour periods. Temperature and wind influence the quality and persistence of identifiable tracks. Temperature variation could have a major impact on results, so tracks should be counted only when weather conditions are suitable. Results can be reported as numbers of intercepts per kilometer. Mean numbers of intercepts per kilometer varied from 0.05 to 3.40 among seven studies (Table 15.2).

The basic assumption in this method is that number of intercepts is directly related to animal density. Because no existing sampling method is known to

**Table 15.2.** Results of American marten (*Martes americana*) track counts from snow transects in boreal forests, North America

Location	Total length (km)	Mean intercepts (n/km)	Reference
Ontario	21	3.40 <sup>a</sup>	Thompson et al. 1989
Washington	7	1.69	Koehler et al. 1990
Wyoming	329	0.81	Raphael & Henry 1990
Oregon	82	0.60	Bull et al. 1992
Washington	142	0.59	Jones & Raphael 1991
Manitoba	3102	0.09	Raine 1983
California	787	0.05 <sup>b</sup>	Nelson 1979

<sup>a</sup>Averaged over 5 years, uncut forest only.

<sup>b</sup>Includes tracks of both American martens and fishers.

yield unbiased, accurate estimates of density of *Martes*, the relationship between track intercepts and density has not been tested. One can, however, compare variation in track-intercept counts against independently derived estimates of relative abundance, perhaps from an intensive telemetry study. Thompson and Colgan (1987a) compared track counts with numbers of trapped and marked martens (expressed as total captures/100 trap-nights) and to total animals taken by trappers on traplines near the study area. All three population indices (track counts, capture rates, trapper records) suggested a declining population trend over the five-year study.

Other studies have documented correlations between track counts and relative abundance. Keith and Windberg (1978) found a direct relationship between track counts and snowshoe hare abundance. Van Dyke et al. (1986) found that variation in density of radio-collared mountain lions (*Felis concolor*) explained 61% of variation in track counts on roads. Kutilek et al. (1983) reported an increase in track counts with increasing estimates of mountain lion density in four study areas. They urged caution in comparing results from one area with another, however, because differences in topography and vegetation may affect carnivore behavior. Similarly, Van Sickle (1990) found a strong relationship ( $R^2 = 0.73$ ) between numbers of mountain lion tracks and numbers of home ranges intercepted by roads. He reported that monthly road-track counts could be used as an index of lion numbers over time, but, like Kutilek et al., he cautioned against using them to infer differences across study areas. Fitzhugh and Gorenzel (1983) and Bekker (1991) offered several sampling design considerations that, although directed toward other species, may be applicable to martens and fishers.

Numbers of track intercepts vary among months, possibly in relation to behavior. Raphael and Henry (1990), for example, computed mean numbers of monthly intercepts per kilometer from November to March over a four-year study in southeastern Wyoming. The mean was greatest in November and declined in successive months (analysis of variance, test for linear trend,  $F = 7.83$ ,  $P = 0.010$ ) (Fig. 15.1).

The primary advantage of the snow transect method is its lack of bias associated with baits or other attractants. Baits or scents introduce variables that are difficult to control. Animals are usually attracted to baits by odor. Distance of detection varies with topography, vegetation, type of bait, wind speed, temperature, and humidity. Thus, one cannot calculate the actual area sampled by a baited station. For most studies, tracks in snow reflect natural movements of the animals, rather than movements influenced by the attractiveness of a bait. In addition, snow tracking does not require special equipment for attracting, detecting, or trapping animals. Setup time is also minimized; all that is required is laying out transect lines and perhaps marking preassigned distance intervals.

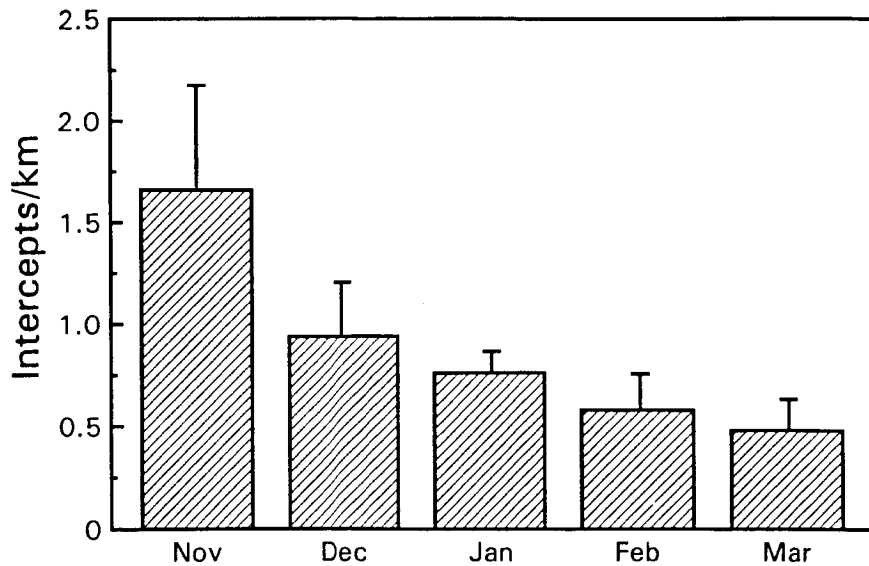


Figure 15.1. Mean numbers of intercepts of American marten (*Martes americana*) tracks in snow, 1986–1989, in the Sierra Madre, Wyoming. Vertical lines denote 1 standard error (Raphael and Henry 1990).

Snow transect's biggest disadvantage is its dependence on favorable snow conditions. Snow transects may never be feasible for western populations of fishers because they tend to occur at low elevations where snow is too infrequent for surveys. And in some areas, snow is too heavy or wet to provide adequate tracking conditions. In forests of western Washington, for example, I attempted snow tracking in the fall and winter of 1990 but was able to conduct surveys on only eight days despite repeated attempts; conditions were adequate for tracking on only one day. In contrast, researchers on the east side of the Cascade range, where snows are drier, were successful in conducting surveys (Bull et al. 1992). Similarly, I found conditions quite suitable in easterly ranges of the central Rocky Mountains. There, snowfalls were followed by long periods of snow-free weather, and snow was relatively dry and persisted from fall through spring. Adequate conditions for snow tracking are therefore highly site-specific.

Snow tracking can be expensive; snowmobiles are costly to purchase and operate. Without snowmobiles, researchers must check the transects on skis or snowshoes and, because little distance can be covered by an observer in one day, labor costs will be high.

Snow transect results also vary with the conditions of the transect, depend-

ing on placement, topography, habitat, home range spacing, and weather conditions. For ease of access and safety concerns, trackers on snowmobiles usually follow roads. But road placement is not random with respect to topography or habitat; roads are often associated with timber harvest and recreational areas. Also, wide roads may inhibit animals from crossing.

#### Sooted Track Plates

Track recording devices have been used extensively to provide indices of carnivore abundance. Typically, animals are lured to baited stations where tracks can be identified in fine soil (Cook 1949, Wood 1959, Linhart and Knowlton 1975, Lindzey et al. 1977, Roughton and Sweeny 1982). This technique has not been widely used to assess the abundance of martens and fishers because these species usually occur where soils are too rocky and where fine soils cannot be easily transported. A sooted surface was first used by Mayer (1957) to record tracks of small mammals. Barrett (1983) modified the technique for American martens in the Sierra Nevada of California. He used two aluminum plates measuring  $814 \times 407 \times 0.6$  mm for the tracking surface and applied soot by passing a torch of burning kerosene under the plates.

Plates must be protected from inclement weather, especially precipitation. A plastic tent could be placed over each plate. Barrett (1983) and Martin (1987) reported successful use of these box-enclosed plates in winter. They placed their plates inside rectangular wooden boxes attached to trees. Martin's plates measured  $0.06 \times 18 \times 45$  cm and were placed in  $25 \times 25 \times 45$  cm plywood boxes. Shephard and Greaves (1984) reported that a mixture of ethanol and lampblack, painted onto vinyl floor tiles, was resistant to light rain or running water, either of which render sooted plates unusable.

Track stations have been deployed in a variety of patterns. Barrett (1983) placed boxes at  $200 \times 200$ -m intervals in a large grid that covered a 2500-ha study area. Martin (1987) placed boxes at  $400 \times 400$ -m intervals within a grid over a 3900-ha area. Raphael (1988) placed uncovered track plates within each 10-ha study plot; adjacent plots were spaced at least 360 m apart.

Length of tracking session is an important consideration. Longer sessions increase the probability of detection at each station but decrease the total number of stations that can be deployed over several tracking sessions. Raphael and Barrett (1981) found that the cumulative richness of carnivore species increased up to day 11 of a 15-day survey and concluded that 8 days were sufficient to achieve high detection probabilities. Comparison of several studies (Table 15.3) shows that visitation rates of each species of *Martes*

**Table 15.3.** Results of surveys of American martens (*Martes americana*) and fishers (*M. pennanti*) conducted using sooted track stations

Location	No. stations	Avg. no. days per station	% Stations visited	Reference
MARTENS				
Sierra Nevada, Calif.	42 <sup>a</sup>	15	34	Barrett 1983
Sierra Nevada, Calif.	80 <sup>a</sup>	28	38	Martin 1987
Western Cascades, Wash.	46	14	36	Jones & Raphael 1991
Southern Cascades, Wash.	57	30	33	Criss & Kerns 1990
FISHERS				
Southern Cascades, Calif.	57	30	12	Criss & Kerns 1990
Klamath Mts., Calif.	466	8	12	Raphael 1988

<sup>a</sup>Track stations were placed in wooden boxes mounted on trees.

varied little among studies, even though the average sample period (number of days per station) varied markedly.

Track stations have many desirable characteristics. As long as bait is present, the plates will accumulate detections until they become smeared from too many tracks. Observers do not need to attend stations daily, unless weather conditions require plate replacement. As the number of days between observer visits increases, larger numbers of stations can be monitored by each observer. In addition, recordings of multiple visits by multiple species are possible (Raphael and Rosenburg 1983), making the technique highly efficient. Track impressions are easily saved for verification and voucher specimens by using transparent tape (Raphael and Barrett 1984, Raphael et al. 1986). Keys are available to aid identification (Taylor and Raphael 1988).

The technique also has disadvantages. Most important, the application of soot must be done under carefully controlled conditions to assure adequate sensitivity for clear prints. Such control is difficult to achieve under most field conditions. The plates are sensitive to temperature and moisture. Identifying tracks can be difficult, especially when tracks are only partial. Applying soot with a burning torch is hazardous and must usually be done at the shop or laboratory rather than at a field site to reduce risk. Finally, because animals must be attracted to the station with bait or other lures, the sampling radius is variable and difficult to control. For studies of trends over a wide geographic area, this variability may not be a problem as long as the same bait is used. Conversely, it is a considerable problem if one is attempting to assess microhabitat use.

### Hair Snares

Hair characteristics such as shaft size, the amount and distribution of pigments, and the type of cuticular scale pattern can be used to distinguish mammalian species (Mayer 1957, Day 1966). Various snares have been developed to collect hair for subsequent identification. Suckling (1978), for example, lined small baited tubes of PVC pipe with double-sided adhesive tape to detect small mammals in Australia. Winnett and DeGabriele (1982) and Scotts and Craig (1988) described improvements to Suckling's design and reported successful detections of both small and medium-sized mammals.

Several investigators have used hair snares to survey *Martes*. In the Sierra Nevada of California, Barrett (1983) deployed 39 snares at 200-m intervals; the snares consisted of 610 × 254-mm cylinders of welded mesh wire containing coils of barbed wire and a bait box of hardware cloth, and were attached vertically to tree trunks. Snares were checked at about 15-day intervals for 22 weeks, resulting in an overall detection rate of 7%.

Nelson (1979) used three different designs to sample mustelid hairs in northwestern California. First, he wrapped barbed wire loosely 10–12 times around the trunk of a 20–50-cm dbh (diameter at breast height) tree and suspended a salmon carcass by rope from a higher branch. Second, he constructed a wire mesh cylinder with barbed wire spiraled within and bait near the top. Third, he used a 50-cm diameter barbed wire cage with salmon suspended in the center. All traps were attached to tree trunks 2–3 m above the ground, and all three types successfully snagged hairs. Traps were checked at approximately one- to two-week intervals over four months (Dec—Mar). From 210 traps, 62 hair samples were collected (at 35% of the traps), including 10 samples identified as fisher hair.

Jones et al. (1991) used a device similar to that described by Scotts and Craig (1988). They placed baited PVC tubes with sticky materials at 39 stations in the Washington Cascades for 410 days (averaging 10.5 days/station). Hairs were collected on only four occasions, including two detections of marten.

Hair snares allow repeated visits by animals without requiring an observer to reset the station; they are low in cost because materials are readily available; and they require almost no maintenance except to check bait. Most important, they can be used in any weather and are not affected by precipitation, provided that bait is protected. On the other hand, like other baited devices, biases caused by different bait types are difficult to control. Barbed wire is awkward to handle and transport, and hair snares require considerable

setup time. Not all hairs are easy to identify; existing keys are usually based on dorsal guard hairs (Day 1966). So far, all investigators report low detection rates, implying that animals are either rare or reluctant to enter such devices, or that when they do, they fail to leave hairs.

#### Cameras

Use of remote camera systems to photograph *Martes* is a relatively recent and promising technique. This approach involves setting a flash-equipped camera system activated by a mechanical or electronic device. The systems range from simple and inexpensive plastic cameras (Joslin 1977, 1988; Jones and Raphael 1993) to complex and expensive motor-driven 35-mm cameras (Mace and Manley 1991).

Jones and Raphael (1991) tested low-cost camera systems in California and Washington. They reported results of two years of summer field tests with small plastic cameras that use 110 film cartridges, flashbars (plug-in flash units that do not require batteries), and mechanical linkages between bait and shutter release. Cameras were set out at about 1-km intervals and checked every 1–2 days over 10-day sessions. Numbers of stations varied from 23 to 1081 and detection rates (percentage of stations where *Martes* were detected) varied from 0 to 57%, averaging about 14%. Bull et al. (1992) tested low-cost cameras during winter and recorded martens at 30% of 47 stations, each run for five weeks.

More sophisticated systems have been used primarily to detect larger carnivores such as brown bears (*Ursus arctos*) but have incidentally recorded *Martes* (e.g., Mace and Manley 1991). These systems consist of motor-driven 35-mm cameras equipped with battery-powered flash units and date-time recorders. They are triggered by emitted infrared radiation and respond to the body heat of an animal within range. In tests conducted on 246 stations (14–18 nights per station) from 1989 to 1990 in Montana, 3 American martens and 40 fishers were photographed. Assuming each photograph represented a different animal, the detection rate was about 17%.

Camera systems offer ease of standardization for comparing results from different study areas, but they are subject to sampling biases because they use bait to attract animals to the station. Preliminary results suggest that detections recorded by photography are more often identified than tracks on sooted plates, but further research is needed to test the two techniques fully. Photographs certainly provide a valuable permanent record of occurrences. Coupled with techniques to mark individuals, photographs can be used in mark-recapture experiments. For example, I have used photographs to tally

uncaptured American martens and previously captured animals equipped with conspicuous radio collars. Most camera systems are easily protected from weather, making them useful over a broad geographic range.

Camera systems also have disadvantages. Unless expensive motor-driven systems are used, one can obtain only one photograph per animal visit. Some low-cost systems use a flashbar that may fail to flash, and the rate of failure seems to be related to weather conditions. Like other baited devices, camera detections are subject to biases associated with the attractiveness of bait and the inclination of the animal to approach a novel stimulus. In addition, these systems are subject to theft and must be camouflaged in areas frequented by people.

### **Design Considerations**

The design of any survey or monitoring program depends on the program objectives. Once these objectives are clearly understood, an investigator must choose the detection device and sampling protocol. In addition, the investigator must make decisions about other design attributes of monitoring programs.

#### **Spacing of Stations**

The optimum distance between detection stations is a function of the study objective, the probability of detecting the target species, and economics or logistics. Stations should be close enough together to maximize the probability of detecting animals within a reasonably short time but far enough apart to assure that they are not recording the same animals (Roughton and Sweeney 1982). The longer the sampling period and the more stations located in an animal's range, the greater the chance that the animal will visit at least one station. Therefore, the spacing of stations is a trade-off between number of stations and number of days they are run.

Spacing should relate to the average size of the target species' home range. Assume that home range is circular with a radius  $W$ . Otis et al. (1978:77) recommended four stations per home range as a general guideline, so that the distance between stations ( $S$ ) should be  $S \leq W/2$  (Fig. 15.2). For an animal with a home range of 10 km<sup>2</sup>, spacing would be about 0.9 km to assure four stations per home range (Fig. 15.2). Because home ranges of males are larger than those of females (Buskirk and McDonald 1989; Powell, this volume), optimal spacing for one sex may not be optimal for the other. Placing multiple stations within the home range of an animal increases the probability of

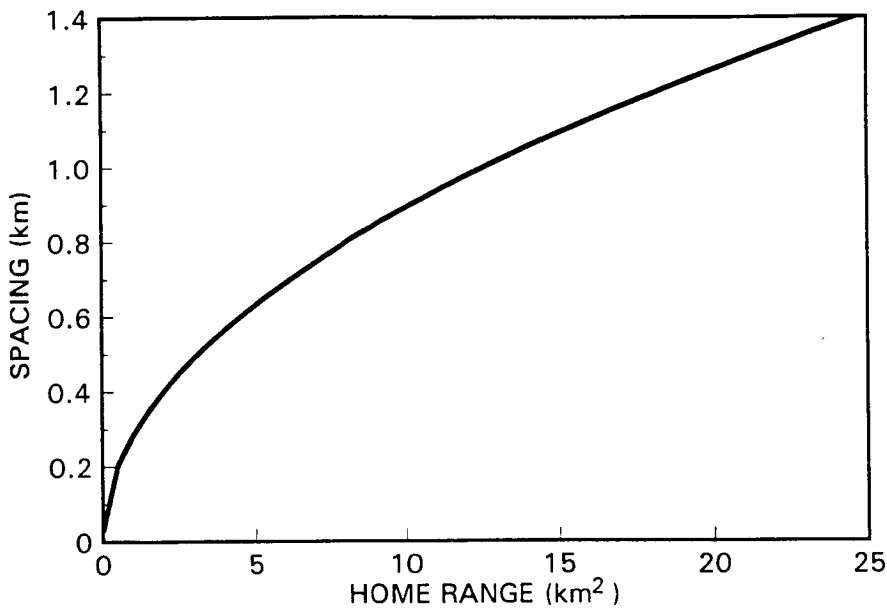


Figure 15.2. Spacing of sample stations needed to approximate an average of four stations per home range.

detection at the risk of decreased independence of observations. Where stations are deployed along transects, these spacing guidelines would yield an average of two stations per home range.

#### Sample Duration

Length of a sampling session is important. A longer session leads to a higher probability of a station's being visited; however, the longer the session, the more likely the same animal will visit the same station more than once or visit adjacent stations (Roughton and Sweeny 1982). If the objective is to estimate relative abundance, multiple visits by the same animal will decrease both accuracy and precision. Interpretation of rates of detection as indices of abundance is difficult when one cannot clearly distinguish between detections of several individuals and repeated detections of the same individual. If, on the other hand, the objective is to record presence or absence, this should not be a problem. If the objective is to evaluate population trends, the variance of detection rate must be computed; variance is underestimated when the same animal is detected at multiple stations (Burnham et al. 1981, Roughton and Sweeny 1982).

The variable to be observed at each sampling unit is presence of the target species. The parameter likely to be estimated under most designs is the proportion ( $P$ ) of occupied stations. Changes in presence can be tracked over time as an index of population trend. There is some probability of failing to detect an animal within the prescribed time interval or number of visits. The estimate ( $\hat{P}$ ) will be biased in relation to the likelihood of missing animals. Azuma et al. (1990) developed a procedure for estimating this bias to adjust  $\hat{P}$ . Their method assumes a constant probability of detecting an animal at each visit and that each visit to a station is an independent and identical Bernoulli trial that can result in one of two outcomes: detected or undetected.

#### Timing of Sampling

Behavior of American martens and fishers undergoes seasonal changes associated with weather and reproductive status, and these changes can influence survey results. For example, I have found that American martens in my study site in Wyoming are two to three times more difficult to trap in summer than in other seasons. The number of trap-nights spent for each capture averaged 123 for three summers, 38 for two fall periods, and 55 for four winters. The presence of young-of-the-year in early fall is another important influence on detection rate. Males and females change their spacing behavior during mating and this too can affect detection rates.

Investigators should ascertain whether the proposed design adequately accounts for seasonal variation in behavior. Any study involving comparisons among years or among study areas should be standardized so that the same months are sampled in each case. Preliminary investigations should be undertaken to be sure that results are not confounded by unanticipated changes in behavior such as maternal care or the presence of foraging young.

#### Number of Stations

Reliable estimates of occurrence, relative abundance, or trends in population size over time require a sufficiently large sample. Sample size refers, in this context, to the number of sample units, which might be individual stations or closely spaced clusters of stations. Total detections will vary with detection probabilities, the spacing of stations, the duration of sampling bouts, and the number of stations per sample unit. The optimum number of stations depends on the average probability of detection for the target species and on the precision of the estimated detection rate.

In addition, if the objective is to estimate trends over successive years, the sample size must also be large enough to assure sufficient power—that is, the

ability to detect a real trend (Toft and Shea 1983, Harris 1986, Gerrodette 1987, Link and Hatfield 1990). In general, a larger sample size will reduce the difference between the sample mean ( $\hat{P}$ ) and the true (population) mean ( $P$ ). Thus, a larger sample size increases the investigator's ability to detect a difference between populations or over time. Each additional sample, however, has its cost of supplies and time, and one must evaluate the benefits and costs of an additional sample.

A variety of procedures can be used to estimate appropriate sample sizes, given study objectives and known variabilities of mean detection rate. If estimates of variability are not available from previous studies, a pilot study should be conducted to estimate variance. Pilot studies have the added advantage of providing an opportunity to refine techniques.

### Standardization

Any monitoring program to compare estimates of abundance over geographic areas or among years must be standardized. An investigator should be able to demonstrate that differences in detection rate reflect differences in population size, not differences in methodology. Care must therefore be taken to use a standardized bait; to run stations for the same length of time and during the same months each year; to visit each station at regular, consistent intervals; and to lay out stations with consistent spacing.

Large-scale surveys over broad geographic areas will require careful coordination to achieve reliable results. For example, there is a current need to determine the status and trend of fisher populations in the western United States. To accomplish such a survey, a large number of agencies and administrative jurisdictions must be willing to develop and use a standardized sampling protocol; and in this case, standardization is especially critical.

### Conclusions

None of the techniques I have described will fully meet all monitoring objectives for both American martens and fishers (Table 15.4). Each has its advantages and disadvantages, and each needs further study to understand its utility and limitations. Research is needed to evaluate the efficiency of each method; to refine design of detection devices; to select the best baits or lures; and to evaluate effects of station placement, numbers of stations, sample duration, and timing of sampling.

For small-scale studies, live-trapping, snow transects (if weather conditions are appropriate), sooted plates, and cameras all appear to be suitable.

**Table 15.4.** Application of various techniques to meet different monitoring objectives

Technique	Local presence	Geogr. dist.	Relative abund. <sup>a</sup>	Trend <sup>b</sup>	Density	Demographics <sup>c</sup>
Habitat survey		1	1	1		
Harvest records	2	1	1	1	1	
Live-trapping	2	2	2	2	2	2
Snow transects	2	2	2	1		
Sooted plates	2	2	2	1		
Hair snare	2	2	1	1		
Cameras	2	2	2	1	1	

*Note:* Numbers indicate relative efficacy of each technique: blank = not useful, 1 = moderately useful, 2 = very useful (if used in well-designed survey).

<sup>a</sup>Usually, an index of relative abundance for comparison of different study areas at the same time.

<sup>b</sup>Trend in an index of relative abundance over time.

<sup>c</sup>Estimates of birth and death rates, immigration, and emigration.

For larger-scale studies that require comparable results among sites, sooted plates and cameras offer the greatest promise. Both can be deployed in a design that can be carefully standardized. Although either type of device can be affected by moisture, both can be protected with inexpensive enclosures or protective covers. Both can yield recognizable images under most circumstances. I encourage further study of these devices to increase their reliability and maximize their ability to detect animals. I also encourage research to better understand appropriate study designs and data analyses to develop reliable monitoring systems. Martens and fishers are sensitive to loss of habitat (Buskirk and Powell, this volume), and resource management agencies need to implement sound monitoring strategies to know whether their land management practices are affecting habitat and populations in accordance with managers' objectives.

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