United States Department of Agriculture

Forest Service

Pacific Northwest Research Station

General Technical Report PNW-GTR-306

January 1993

Inexpensive Camera Systems for Detecting Martens, Fishers, and Other Animals: Guidelines for Use and Standardization

Lawrence L.C. Jones and Martin G. Raphael

Authors

LAWRENCE L.C. JONES is a wildlife biologist and MARTIN G. RAPHAEL is a research wildlife biologist, Forestry Sciences Laboratory, 3625 93d Ave. S.W., Olympia, WA 98512.

Abstract

Jones, Lawrence L.C.; Raphael, Martin G. 1993. Inexpensive camera systems for detecting martens, fishers, and other animals: guidelines for use and standardization. Gen. Tech. Rep. PNW-GTR-306. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 22 p.

Inexpensive camera systems have been successfully used to detect the occurrence of martens, fishers, and other wildlife species. The use of cameras is becoming widespread, and we give suggestions for standardizing techniques so that comparisons of data can occur across the geographic range of the target species. Details are given on equipment needs, setting up the stations, checking and recording, summarizing data, and research needs.

Keywords: Camera, monitoring, marten, *Martes americana*, detecting, standardization, fisher, *Martes pennanti*.

Contents

Introduction

American martens (*Martes americana*) and fishers (*M. pennanti*) are classified as management indicator species of mature and old-growth forest conditions in most National Forests of the Western United States. Abundance trends of these species therefore must be monitored to meet the intent of the National Forest Management Act and its regulations. These species are inherently difficult to monitor, though, because of their secretive habits. Several techniques have been used to detect these and other furbearers, including smoked aluminum track plates (Barrett 1983, Taylor and Raphael 1988), hair snares (Jones and others 1991), and winter track counts (Raphael, in press). Raphael (in press) compares the use of different techniques to detect martens and fishers. Track plates work well but are bulky (Laymon and others 1991; Raphael, in press; Raphael and Rosenberg 1983). Positive identification of tracks of similar mustelids (marten, fisher, and mink [*Mustela vison*]) often is difficult, and the plates are not waterproof unless a cubby or waterproof roof is provided. Winter track counts are effective only for determining the presence of martens and fishers in areas of frequent snow with clearing periods and cold weather. Again, identification of similar mustelids is difficult. Hair snares are inefficient, at least with the present technology (Jones and others 1991; Raphael, in press). The use of these techniques may be insufficient to monitor martens and fishers, primarily because identification is tenuous and the techniques cannot be standardized across the geographic range of the species.

Another recent development is the use of cameras. High-technology systems including a 35-mm camera, infrared sensor, recorder, and battery pack are effective but expensive, averaging over $400 (Mace and others 1990). Joslin (1977, 1988) demonstrates that inexpensive cameras (less than $20) also can be effective. We developed an inexpensive camera system to detect martens and fishers.[1] A pilot study in summer 1990 indicated that such a system can effectively detect martens and other carnivores (Jones and Raphael 1990). The results of the pilot study, a subsequent large-scale study in western Washington, and a separate large-scale study in the southern Sierra Nevada of California will be reported elsewhere (see footnote 1). The purposes of this report are to provide users of these cameras with a summary of methods and materials for surveying martens, fishers, and other wildlife and to provide suggestions for standardizing camera survey protocols across the geographic range of these species.

Overview of the Technique

Simplicity is a primary benefit of inexpensive camera systems, but special attention must be paid to some details to ensure proper functioning. Our camera system includes four major components (fig. 1): the mounting stake, camera, label stake, and runner and bait. The camera is mounted on the top of the mounting stake, which is set securely in the ground. A monofilament line runs from the trigger mechanism on the camera, down the mounting stake, and out front through a runner (which keeps the bait in place). Bait is tied to a washer on the other end of the runner with a single strand of sewing thread. Behind and to the side of the bait is the label stake, which displays information that will be shown in the photograph. The camera is waterproofed with a plastic bag. When an animal comes to the station, it pulls on the bait, and a photograph is taken (see color plates in center spread). The thread breaks after the photograph is taken, so that the whole unit is not pulled down and dragged off.

[1] Raphael, Martin G. [and others]. Manuscript in preparation.

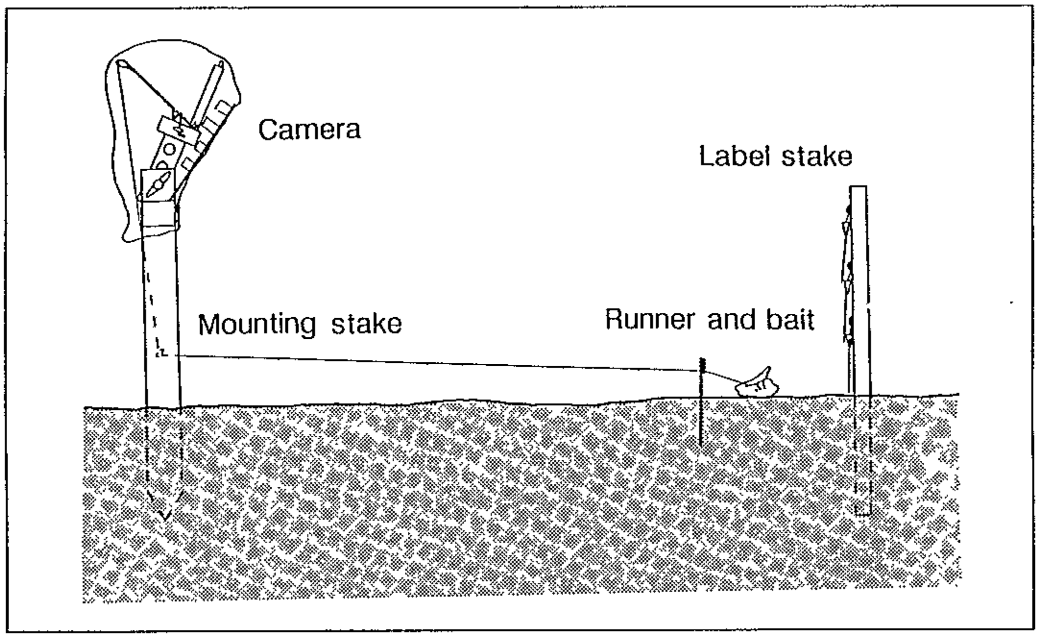

Figure 1—Major components of camera system, side view.

Bait and Lures

Martens and fishers have a naturally varied diet, including voles, squirrels, hares, birds, berries, insects, and carrion (Douglas and Strickland 1987, Strickland and Douglas 1987). Thus, martens and fishers are somewhat opportunistic, and any of several baits will work. In some studies (see footnote 1), chicken has been used for bait because it attracts animals, is inexpensive, is readily obtained, and is easily secured to the thread. Raphael and others (see footnote 1) also tested the effectiveness of raspberry jam and found that martens most often were detected at stations without jam, although Laymon and others (1991) found that the use of jam with chicken and a visual lure seems to increase the likelihood of fisher detections. Raphael and others (see footnote 1) used decayed chicken (unrefrigerated for 2 days before placement at a station) on occasion, in hopes of gathering early detections, but there was no indication that this was advantageous. Because chicken and other forms of protein provide a growth medium for bacteria that may pose a health problem to wildlife, domestic animals, and field crews, we recommend using fresh chicken. Wings and necks are inexpensive and easy to tie or sew. Field crews handling chicken should use latex gloves and wash their hands to avoid contamination.

The use of scents and other long-distance attractants is controversial, because martens and fishers may be drawn from outside the habitat or area being surveyed. If the objective of a study is merely to see if any animals are nearby, use of lures may be warranted, however. It is unknown how well lures work, let alone from what distance a lure will draw the target species. The use of lures needs further investigation.

Construction of Camera Components

Before cameras can be set up in the field, some components must be prepared in the laboratory. We recommend cameras requiring 110 film because they are inexpensive and the quality of prints is adequate. Cameras without a built-in flash can be left indefinitely without the risk of battery failure (batteries will die within a few days in cameras having a built-in flash). The connection with an external flash may be problematic, however; often the flash is not triggered (see footnote 1). One solution is to wire two D-cells to a camera with a built-in flash, thereby extending the life of the batteries for about 3 months.[2] Total cost of materials for one complete 110 camera set is $15-25, depending on choice of camera and other materials.

Construct the components as follows (the order is unimportant).

Mounting Stake

An angle iron is made from a 15- by 3.5-centimeter strip of perforated metal strapping, bent midway at a 90° angle. The top (horizontal surface) of the angle iron serves as the platform, where the camera will be attached (fig. 2). Glue the hook part of hook-and-loop tape onto the upper surface of the platform. If this does not provide for a secure mounting, a wider platform can be attached to the strapping, or the camera can be attached with wire, rubber bands, or duct tape.

Secure the vertical side of the angle iron to the upper part of the mounting stake. Drill an 8-millimeter hole through the mounting stake, 3.5 centimeters from the top. Put a washer on a bolt and push the bolt through the perforation of the angle iron and the hole in the stake. Secure the angle iron with a washer and wing nut on the opposite side of the stake.

Put an eye screw one-third to one-half of the way down the stake on the same side as the trigger mechanism. Size of the eyescrew does not matter, except that a large one is unnecessary.

Camera

Press a heated eye screw (4 millimeters inside diameter) into a location on the plastic camera body that will not interfere with the operation of the camera but will allow free movement of the trigger mechanism (fig. 3). Heat the eye screw with a Bunsen burner until it is *just* red hot. If the screw is not hot enough, it will not penetrate well; if it is too hot, it will melt the surrounding plastic in the camera, and the screw will fall out.

Glue the loop part of the hook-and-loop tape onto the lower side of camera; this will fit onto the hook part glued to the platform. Make certain that the loop material does not interfere with the winding mechanism of the camera.

Label the camera with a unique number (engraving works well).

Trigger Mechanism

Coat hanger wire is used to make the trigger mechanism, loop, and runner (fig. 4). Cut the hanger as shown in figure 4A. The hanger portion is not used, so one and a half coat hangers are needed to make the three components.

To make the trigger mechanism, first construct a prototype from one-half of a coat hanger. Bend the wire into a shape that will rotate freely in the eye screw(s) or strap holder and will trip the shutter release when downward pressure is applied. The distance from the shutter release to where the apex bends down needs to be 13 centimeters to ensure a consistent shutter tripping pressure. Place the prototype on a 5- by 10- by 30-centimeter board and hammer in heavy nails at the points where the wire bends (fig. 4B). Cut the heads off the nails. The board and nails then can be used as a template to mass produce trigger mechanisms. Each mechanism must be tested on a camera to ensure that unwinding off the template did not alter its shape.

---

[2]Personal communication. 1992. Richard Golighty, Department of Wildlife, Humboldt State University, Arcata, CA 95521.

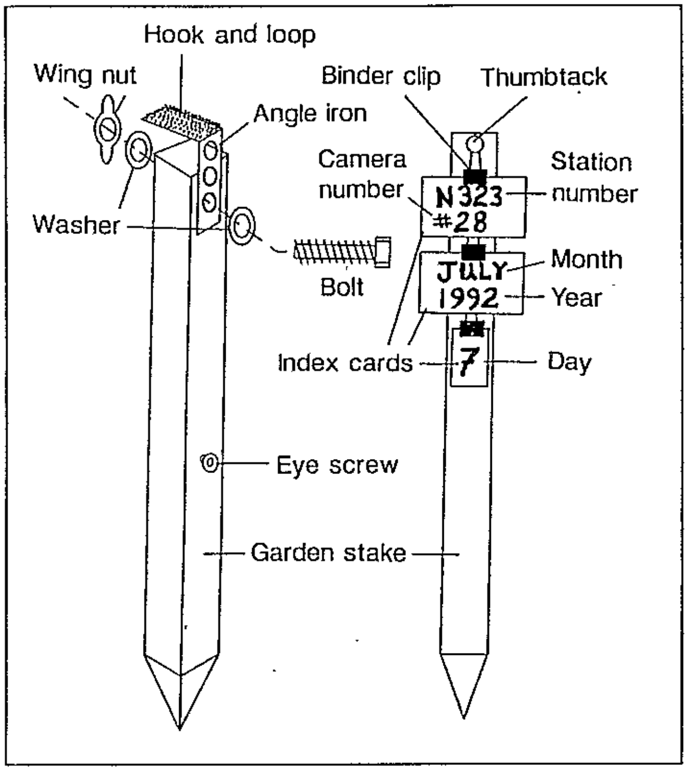

Figure 2—Mounting stake (left) and label stakes (right).

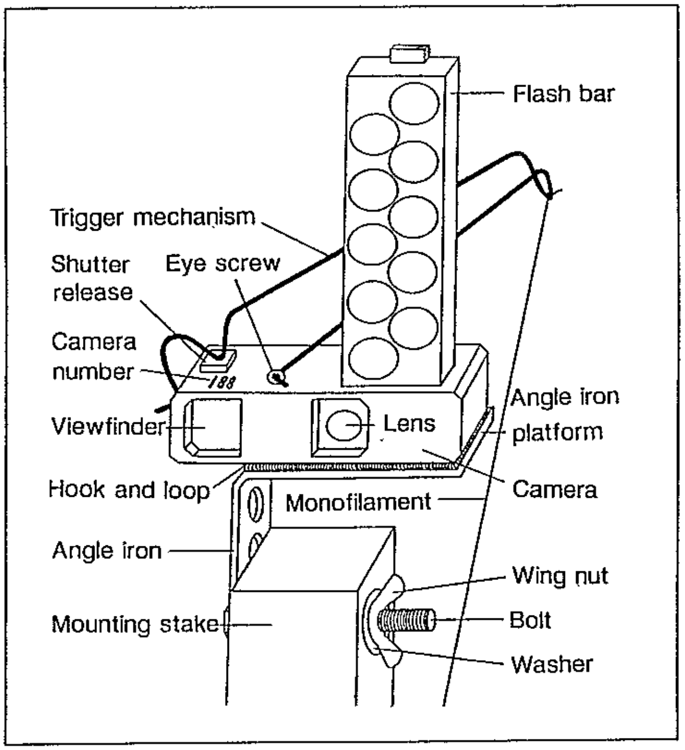

Figure 3—Components of camera at top of mounting stake. The loop and plastic waterproofing bag are not shown.

To make the loop, take another one-half of a coat hanger and widen it into a U-shape (fig. 4C). It must be wide enough to keep the plastic bag from obstructing the lens, or at least 8 centimeters. The loop can now be attached to the mounting stake at the front of the camera with duct tape.

The runner is used to secure the bait in the camera's field of view. Wrap the last one-half of a coat hanger around a nail to make a small loop at the apex of the coat hanger (fig. 4D). In soft ground, one-half of a coat hanger length should be sufficient; in hard ground, a shorter length (one-third of a coat hanger) may suffice.

Preparation in the Field

One person can set up the camera in the field, but it is easiest if two people do it; one person sets up the mounting stake and camera, while the other works on the runner, bait, and label stake. If one person is doing the entire setup, she or he should position the mounting stake and camera first to avoid getting the odor of the bait on the camera and mounting stake. Otherwise, animals may be attracted to the scent on the camera and cause damage or misalignment. The person preparing the mounting stake and camera uses the following steps:

1. Clear the area of brush and other debris to ensure an unobstructed view for the camera and that debris will not inhibit the functioning of the system.
2. Hammer the mounting stake securely into the ground so that the camera lens will be pointing toward the bait.
3. Put the trigger mechanism on the camera. The free ends are fed into the eye screws or strap holder, or both, depending on the camera.
4. Securely mount the camera on the mounting stake with the hook-and-loop tape. Make sure the winding mechanism is free of the platform.
5. Tie the monofilament onto the apex of the trigger mechanism. Feed this through the eye screw on the mounting stake and out 2.5 meters to the runner. Feed the monofilament through the runner and tie it to the washer on the other side.
6. Squeeze the free ends of the runner and push it into the ground (compression holds it in). Allow 2 centimeters of play in the monofilament.
7. Put film in the camera and advance it to exposure 1. This is done after the camera is attached to prevent accidental shots.
8. Insert the flash bar, if used. Make sure the flash bar clicks into place, or it will not make contact with the flash mechanism of the camera. If external batteries are used, they should be in a waterproof container (for example, a margarine tub) secured to the mounting stake or another nearby stake.
9. Place the plastic bag over the camera and flash. Cut out the area in front of lens, inside the loop. Use clear tape to fasten the plastic bag to the loop (fig. 5).
10. Use a thumb tack to attach the bottom of the bag to the mounting stake, below the loop, allowing the trigger mechanism and monofilament to remain movable.

The following is a list of steps the second person takes:

1. Securely sew a single strand of thread to the bait (or do this in the lab). Sew around a bone if possible. Alternative options for attaching bait are discussed in "Research Needs."
2. Tie the other end of the thread to the washer, leaving no more than 3 centimeters between the bait and the washer.

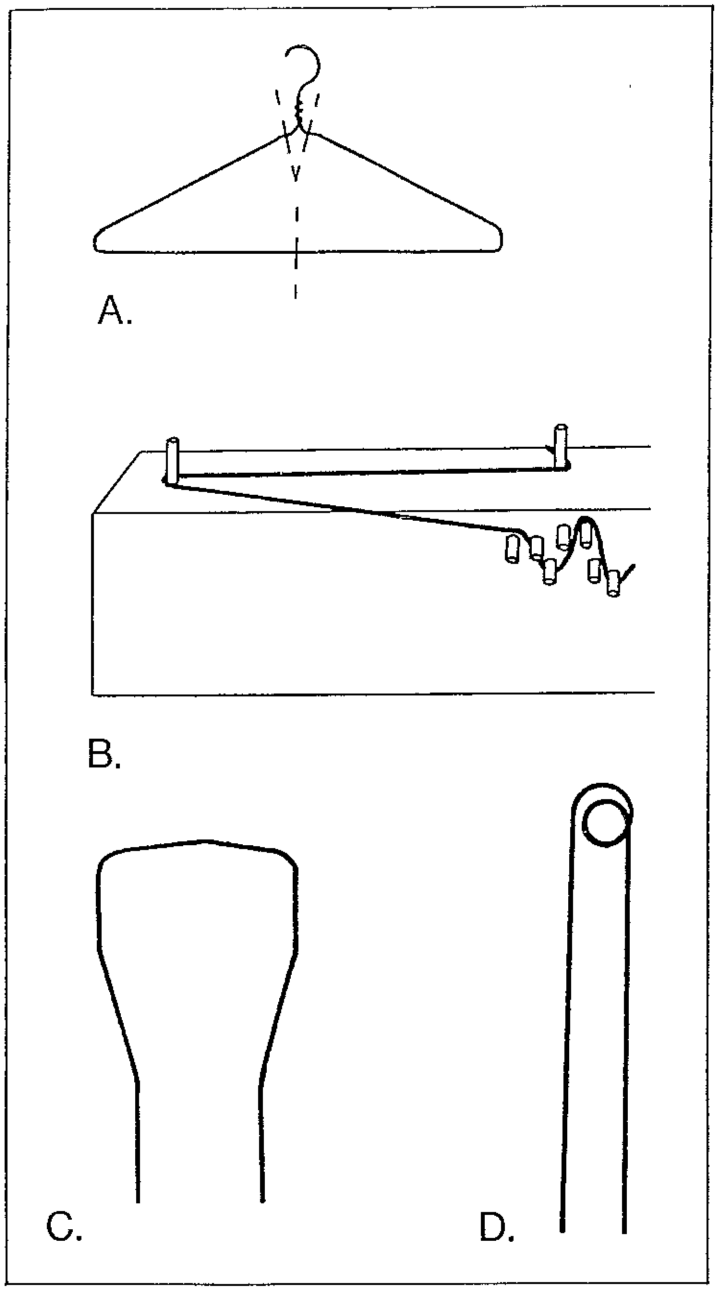

Figure 4—Coat hanger is cut in half (A) to make the trigger mechanism (B), loop (C), and runner (D). The coat hanger is bent around headless nails on a template to make trigger mechanisms in quantity (B).

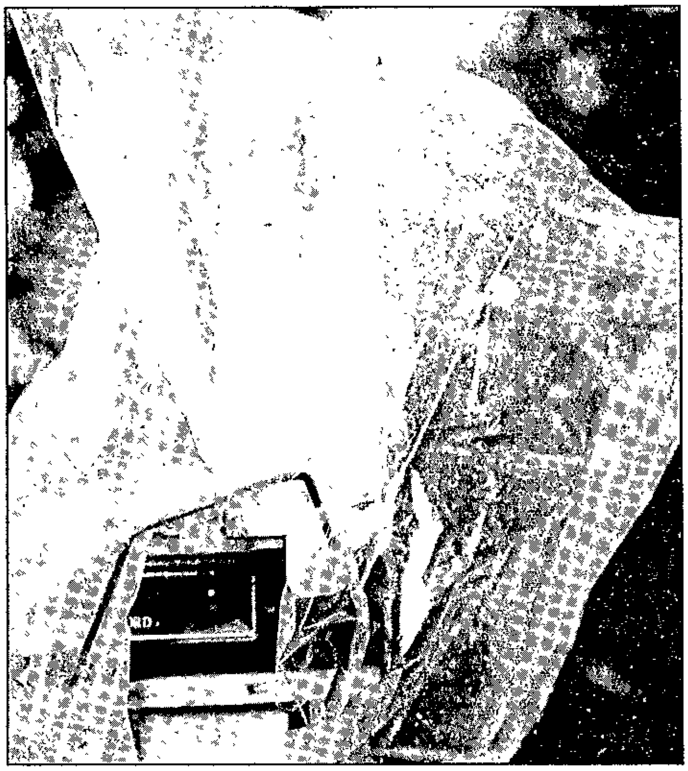

Figure 5—A plastic bag protects the camera from rain. The area in front of the lens is cut away and the bag is taped to the loop.

3. Put thumbtacks through the binder clips on the label stake. The binder clips are used to hold the label cards and allow easy removal and replacement.
4. Cards for labels should be some color other than white to reduce glare, with date, camera number, and station number in bold, black letters, at least 35 millimeters high. Use only indelible ink. Make sure the labels will be legible on the photograph and that they do not obstruct the view when the camera is triggered by an animal. The label stake should be about 1 meter behind the bait and off to the side about 0.5 meter. Be sure the label cards will not be so high as to be out of the upper range of the camera.
5. When the camera is set up, the horizontal and vertical aims need to be checked, as these can be substantial sources of error (Laymon and others 1991; see footnote 1). Do not do this by looking through the viewfinder. An easy and effective way to check the vertical aim is to look back at the camera from the bait. If the top of the camera is visible, it is pointed too far down; if the bottom of the platform is visible, the camera is pointed too far up. To check the horizontal aim, look down at the camera and monofilament line to see if the longitudinal axis of the camera is perpendicular to the monofilament line. Laymon and others (1991) suggest using a 3-meter section of monofilament line to determine both horizontal and vertical axes, with the bait being lined up at their coincidence. The vertical aim can be adjusted at the camera by swinging the platform up or down, and the horizontal aim is adjusted by moving the runner to one side or the other.

6. Always do an initial test shot to make sure the camera, flash, and setup are functioning properly. For the test shot, pull on the washer and do not block the view of the label stake. Be sure to advance the film to the next exposure number. When advancing the film, make sure the trigger mechanism is off the trigger, and that the film is being advanced as far as possible. Do test shots randomly after the camera is up and running to ensure its continued functioning.

Documenting Station Placement

Stations should be mapped on orthophotographic quadrangles. The Universal Transverse Mercator coordinates need to be recorded (this can be done after-the-fact with Geographic Information Systems [GIS]). Data on the position also should be recorded (for example, left or right side of road in direction of checking; near large log, snag, or stream; distance to the road; distance to an edge). Various amounts of data should be collected on vegetative and other parameters in the stand where the station is placed, but this depends on the objectives of the study. A great deal of habitat use information is attainable if the sample of first detections is adequate. The GIS overlays can aid in this respect, but it depends on the quality of the GIS data available.

Checking and Recording

Every time the camera is visited, change the date and check to see if the camera can be wound; if it can, an exposure has been made. Also check the flash to see if it needs to be flipped or replaced. Check to see if the bait needs to be replaced or retied to the washer. Glance at the entire camera system to see if it is looks functional; a variety of problems can arise after the initial set up, such as monofilament breaking or being chewed off, monofilament or thread wrapped around the runner, runner coming out of the ground, platform being tilted up or down, and bag obscuring the lens.

Record the following information at each camera station whenever it is checked: station number, camera number, date, nights run, bait type, bait condition, and comments (see appendices 2 and 3). The exposure number should be recorded only if an exposure has been made. These data are essential and should be used for standardization, although additional information may be recorded if the study objectives require such.

Tally Sheet and Film Change

To keep track of the number of exposures taken on each roll of film, it is important to keep a daily tally sheet. The sheet should include the camera numbers in columns and station numbers in rows. When an exposure is taken, a tick mark is put in the appropriate box. When the desired number of exposures has been made, the film can be pulled, and the date noted on the tally sheet. The desired number of photographs depends on the resources and desires of the crew. In general, it is a good idea to pull film early on, after only two or three exposures, to ensure correct functioning and aim of the cameras. For example, some people may have a tendency to point the camera too high, whereas others point it too low, or the label stake may be consistently out of the view. After an initial check of this sort, the film can be left in until all 12 exposures have been made. A word of caution, however: film left in a camera that is destroyed by a bear or stolen is lost data. It therefore is a good practice to pull film prematurely in areas of high risk from destruction by wildlife or thievery or when target species are suspected (such as when scats are found where the bait was—a common occurrence with martens).

Film Processing and Recording

Before pulling film from a camera for processing, it should be advanced to the end to prevent light leaks. The camera number, station number, and roll number or date need to be recorded immediately on the film cartridge. When the film is taken in for processing, the same information should be written on the envelope and receipt. This is important, because label cards may be obscured by large animals or may otherwise be out of the photograph. The data on the envelope, along with the exposure number on the data form and photograph negative, are useful in determining when and where every photograph was taken.

After the film is developed, the back of each photograph should be labeled with the species identification (four-letter code of scientific name for mammals, reptiles, and amphibians; four-letter code of common name for birds), date (as shown on label stake, because a time lag occurs between the actual exposure and checking), station number, and camera number. After the photograph is labeled, the four-letter code of the species is entered on the data sheet. Some species may be difficult to distinguish from one another (such as species of chipmunks), and they can be given a code with the first two letters of the genus, followed by "SP" (for species). If an animal is in the photograph but cannot be positively identified, it should be entered as "UNKN." If exposures are indicated on the data sheet but lack a species code or "UNKN," it indicates that either the camera was stolen (or film otherwise ruined) or some other problem occurred. For exposures on stolen or ruined film (for example, from a bear ripping open the camera and exposing the film), the code is "STOL" or "RUIN," respectively. All other exposures taken are given the code "NPIC," for no picture. The NPICs can occur for various reasons, such as the flash not firing, incorrect vertical or horizontal aim, runner pulled out of the ground, excessive glare, half or double exposures, shaky mounting, or simply nothing visible in the photograph (see footnote 1). By itemizing the NPICs, it is possible to determine the major sources of error and, if human error, which persons in particular are having difficulty.

Census Nights

Census nights (CNs) are analogous to trap nights and are determined by the number of nights run (NR), nonfunctional cameras (NFUN; analogous to sprung traps), and the visit frequency (VF). One NR equals one 24-hour period, starting from the time the camera is set up. If the camera is nonfunctional, the species code block on the data form should have "NFUN" entered while in the field. The camera is considered functional if an exposure is taken. Examples of NFUN include having the thread wrapped around the runner or chewed through by insects, or the trigger mechanism hung up on the plastic bag. The VF is the number of NRs between checks of the cameras. The number of CNs run during a transect is most accurate if the cameras are checked daily (VF = 1), but this is not always feasible or necessary. In addition, daily checking may compromise the amount of surveying that can be done. Regardless of the VF (below the threshold level, see below), the NR will remain the same. To determine the number of CNs, use the following formula, where NR equals cameras used times number of nights run:

$$CN = NR - \frac{NFUN * VF}{2}.$$

A

B

C

D

Examples of photographs taken with 110 film at camera stations: (A) marten, (B) marten with radiocollar, (C and D) fisher, (E) western spotted skunk, (F) raccoon, (G) bobcat, and (H) red-tailed hawk. Fisher photographs courtesy of Teresa Ritter and Mike Knowles, Cannell Meadow Ranger District, Sequoia National Forest.

Example: 12 cameras are run for ten 24-hour periods; they are checked every other day; on three visits, a camera is not functioning:

$$CN = 120 - \frac{3x2}{2} = 117 .$$

A threshold level of 20 percent visitation rate (by all species of animals to cameras) per check should be established. If more than 20 percent of the cameras are registering exposures with a particular VF, then they should be checked more often (a minimum of daily). The threshold level is established to minimize the number of potential photographs lost when an animal visits a station that has already registered an exposure. This should allow for better comparisons between areas of a lesser and greater visitation rate. We recommend a VF of 2 (every other day), unless the threshold level is surpassed.

Thievery

Humans, being curious by nature, have a tendency to investigate any unknown structure. And some of them feel that a camera in the forest is certainly lost, so it is appropriate to take it home. Therefore, it is necessary to take precautions to keep cameras from being stolen. The best way to do this is to hide them, or at least make them inconspicuous. We have found that using fluorescent flagging to mark camera locations off roads is a bad idea, so we switched to using white with blue dots. This resulted in a marked decrease in camera thefts, and this type of flagging did not conflict with other color schemes in the forest. Still, it is best to check with the land managers to see if a certain flagging color is acceptable. In areas with a high level of human activity, the station can be offset from the flagging by a consistent distance and azimuth (for example, 40 meters from flagging, southeast when east of a road or southwest when west of a road). In addition, small tags inscribed with text explaining the purpose of the camera may be helpful.

Data Summaries

The simplest summary of a camera survey should include three tables. A monitoring parameter table (appendix 4) should include basic information about the study design: number of transects, number of stations per transect, total number of stations, census period, number of NFUN, CN (do not include NFUN), VF, pattern, spacing between stations, habitat selectivity, bait type used, use of lures, and any other information that may have a bearing on the results or determine interarea bias.

A detection rate summary (appendix 5) is used to calculate relative abundances. The parameter table should reflect consistencies to effectively demonstrate relative abundances. Relative abundance comparisons are based on detection rates and not on individual animals, because one animal may visit more than one station and several animals may visit a single station. The detection summary should include a list of species (avoid lumping nontarget species into broad categories, such as "squirrels"), number of photographs per species, detection rates for each species, number of stations with detections, and station detection rates (number of stations with detections divided by total number of stations). This should be done for each area (or transect if monitoring is not extensive). These figures should be subtotaled, with UNKN, NPIC, STOL, and RUIN entered into the total.

A target species worksheet (appendix 6) includes specific information on the detections of those species of concern, with some inferences about the number of animals that may be in the area. The information summarized should include the total number of target species photographs (TSPs), the number of stations with TSPs, the number of the night run (NR) when each photograph was taken, the NR and station number of first detections, the distance to the nearest station that also had a TSP, number of nearest station with a TSP, and suspected number of individuals of each target species. A word of caution: the number of individuals is a best guess and probably has a low degree of precision. The best guess is based on spatial and temporal detections. An estimate must reflect information gathered on natural history (particularly home range size and age classes of target species present at a given time). The estimate of individuals present may be important as a tool to identify areas where target species have a low density vs. high density but may never be statistically powerful.

Optional summaries and analyses may include habitat use information gathered from either the field or GIS, or both. Data gathered from the field are useful for determining microhabitat parameters, such as tree species composition, canopy closure, stem basal area, snag or coarse woody debris density, nearness to streams (can be done on GIS if overlays exist, but GIS may not cover ephemeral streams), vertical canopy hierarchy, ground cover, and an assortment of other parameters. Again, clearly outline your objectives so you can develop a sound data form. Information from GIS has less resolution than field data, and generally is applicable to landscape level variables, such as stand age class of each station and surrounding stands, elevational and aspect parameters, perennial riparian usage, and distribution of stations with or without detections in relation to one another.

Storing or Moving Cameras

The camera sets can be kept intact during moving or storage by carefully winding the monofilament around the mounting stake. Use duct tape to keep the monofilament from forming a "bird's nest" and to keep the runner in place. If the cameras and flashes are left on the stake, they often will fire in transit, so we recommend removing them.

Research Needs

Using inexpensive cameras to document occurrence or monitor population trends is a new and little-tested technique. Additional research is needed to improve the camera system design, determine optimal surveying schemes, and determine how well the cameras detect target species, especially when compared to other techniques.

Several suggestions have been made on improvements to the basic design. Some of these include:

- Using wire rather than monofilament for the trip line.
- Using polyvinyl chloride (PVC) pipe to cover the monofilament.
- Using a plastic tent stake with a hole drilled near the top as a runner.
- Putting bait in a cheesecloth bag to protect it from insects.
- Using surgical thread to tie bait.
- Using an alligator clip to attach bait to monofilament.
- Putting a cover over the bait to protect it from ravens, bears, and other common nontarget species.

- Using a U-shaped piece of metal strapping as the mounting stake in areas of loose soil.
- Housing the camera in a plywood box for use in snowy areas (Bull and others, in press).
- Attaching the camera directly to a tree to minimize shaky photography.

Whatever modifications are made to the camera system, they should not cause the camera to function differently. For example, using a trigger mechanism made from an L-shaped piece of metal and tightened by a nut and bolt may present problems. The tightness of the bolt may differ from camera to camera, which causes a differential trigger pressure and introduces a source of bias.

Temporal and spatial influences on detection success need investigating. The time it takes to get a desired proportion of first detections is not well known and may differ among geographic areas and target species. Raphael and others (see footnote 1) noted that first detections of martens at different stations averaged about day 8 in their 1990 survey, and they got first detections up to 29 days after the cameras had been set up. On one transect that they ran for more than 8 days in their 1991 survey, they found that most first detections occurred after day 8. It was not known how many individuals were being photographed, or which of the photographs were repeats of martens already photographed at other stations. A relation probably exists between the spacing of the stations and detection success, but it currently is not known. There also is the possibility that the target species will be leery of camera stations early on and may not visit the stations until they get comfortable with their presence. Optimal spacing and length of running time need to be researched in different areas for different target species. Radio telemetry alone is not sufficient to do this, because several individuals of the target species may be present in the area being surveyed. Individuals must be marked in a manner allowing for their recognition in a photograph. This means that as many individuals as possible (preferably all of them) must be live-trapped, marked, and released before the camera survey period, which is a time-consuming endeavor. Suggestions for marking include hair shaving, freeze-branding, and attaching colored collars or ear tags. Ear tags may be a problem with animals that have thin ear tissue and the animal must be posed in just the right position to determine its identity. Until further research is done, we recommend running cameras for 3 weeks. We recommend a spacing regime allowing four cameras inside the home range (the average home range of the sex with the smaller average) of the target species. Use a home range size based on a study done in the same geographic area if possible, or in the most similar habitat. Home ranges rarely are circular, but if four cameras are placed within a radius of a home range, it is hoped that at least one will fall within the true home range.

Cameras are most easily checked along roads or trails, but the influence a road has on the behavior of an animal is unknown. Also, roads tend to follow topographic features such as riparian areas or ridgetops or areas of timber harvest or development. Target species may find some of these features preferable, whereas other features may be avoided. Research needs to be done in roaded areas (experimental transects) concomitantly with areas away from roads (control transects) to determine inherent biases associated with road surveys. The best study would include control and experimental areas in the same stand.

The best time of year to survey depends on the geographic area, natural history of the target species, objectives of the study, and logistics. Cameras are easiest to run during the late spring through early fall when snow is absent, but detections are probably most difficult to get in the summer, when prey and other food items are in abundance. Because most animals give birth in the spring or summer, nonresident animals may be present during this time. Transects run during the spring before inclusion of young will not be comparable to transects run after young have started foraging in the summer.

Other techniques for monitoring target species exist, and some may be quite effective. More research is needed to determine how well cameras detect target species when compared to other techniques. Cameras have mostly been used to detect martens, fishers, and other forest carnivores. Track plates also have been used successfully. These two techniques in particular need further comparisons in several areas to weigh the costs and benefits of each technique.

Request for Feedback on Information

The authors would like to receive feedback on how well this system works for others; include data summaries, as described above, and any helpful suggestions. By compiling information from various locations, we can make better recommendations on the use and efficiency of cameras for detecting occurrence or monitoring. The address is given on the inside front cover.

Acknowledgments

We thank Paul Joslin for demonstrating this simple and cost-effective technique to us. Jim Swingle, Gus Bekker, Warren Michaelis, and Deborah Ferber monitored cameras in the field and supplied valuable input on improvements and troubleshooting. Teresa Ritter, Mary Rasmussen, Diane MacFarlane, Mike Knowles, and crews of the Sequoia and Stanislaus National Forests contributed summaries of their camera monitoring efforts and many helpful suggestions. Many others have contributed to our knowledge of monitoring with cameras, and we thank them all. We thank Janet Jones for her editorial assistance. The manuscript benefitted from review by William Zielinski and Steve Laymon.

References

Barrett, Reginald H. 1983. Smoked aluminum track plots for determining furbearer distribution and relative abundance. California Fish and Game. 69(3): 188-190.

Bull, Evelyn L.; Holthausen, Richard S.; Bright, Larry. [In press]. Comparison of three techniques to monitor marten. Wildlife Society Bulletin.

Douglas, Carman W.; Strickland, Marjorie A. 1987. Fisher. In: Novak, M.; Baker, J.A.; Obbard, M.E.; Malloch, B., eds. Wild furbearer management and conservation in North America. Toronto: Ontario Ministry of Natural Resources: 511-529.

Jones, Lawrence L.C.; Raphael, Martin G. 1990. Ecology of marten in the Pacific Northwest. 44 p. Progress report. On file with: Pacific Northwest Research Station, Forestry Sciences Laboratory, 3625 93d Ave., SW, Olympia, WA 98512.

Jones, Lawrence L.C.; Ruggiero, L.F.; Swingle, J.K. 1991. Ecology of marten in the Pacific Northwest: technique evaluation [Abstract]. In: Ruggiero, L.F.; Aubry, K.B.; Carey, A.B.; Huff, M.H., tech. coords. Wildlife and vegetation of unmanaged Douglas-fir forests. Gen. Tech. Rep. PNW-GTR-285. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station: 532.

Joslin, Paul. 1977. Night stalking: setting a camera 'trapline' for nocturnal carnivores. Photo Life. 7: 34-35.

Joslin, Paul. 1988. A phototrapline for cold temperatures. In: Freeman, H., ed. Proceedings of the fifth international snow leopard symposium; 1986 October; Srinagar, India. Bombay, India: Conway Printers Private Ltd.: 121-128.

Laymon, Steven A.; Overtree, Lynn; Collins, Gary; Williams, Pamela L. 1991. Final report on the distribution of marten, fisher, and other carnivores in the Starvation, Tyler Creek, and Capiro Creek and White River drainages of the Sequoia National Forest: summer 1991. 13 p. Report. On file with: Kern River Research Center, P.O. Box 990, Weldon, CA 93283.

Mace, Richard; Manley, Tim; Aune, Keith. 1990. Use of systematically deployed remote cameras to monitor grizzly bears. 25 p. Report. On file with: Montana Department of Fish, Wildlife, and Parks, Box 67, Kalispell, MT 59901.

Raphael, Martin G. [In press]. Techniques for monitoring fishers and American martens. In: Buskirk, S.W.; Harestad; A.S.; Raphael, M.G: Powell, R.A., eds. Biology and management of martens and fishers [Location of publisher unknown]: Cornell University Press.

Raphael, Martin G.; Rosenberg, Kenneth V. 1983. An integrated approach to wildlife inventories in forested habitats. In: Bell, J.F.; Atterbury, T., eds. Renewable resource inventories for monitoring changes and trends: Proceedings of an international symposium; 1983 August 15-19; Corvallis, OR. SAF 83-14. Corvallis, OR: College of Forestry, Oregon State University: 219-222.

Strickland, Marjorie A.; Douglas, Carman W. 1987. Marten. In: Novak, M.; Baker, J.A.; Obbard, M.E.; Malloch, B., eds. Wild furbearer management and conservation in North America. Toronto: Ontario Ministry of Natural Resources: 531-546.

Taylor, Cathy A.; Raphael, Martin G. 1988. Identification of mammal tracks from sooted track stations in the Pacific Northwest. California Fish and Game. 74(1): 4-11.

Appendix 1

Materials

Materials needed for camera sets are as follows:

- Camera: 110 type that will take flash bar and has no battery. Alternatively, a 110 with built-in flash with two D-cells wired to camera battery connections.
- Film: 12 exposure. We have found that 100 ISO works well; 200 ISO is rather grainy.
- Flash: whatever type fits the camera.
- 35- by 35- by 600+-millimeter garden stake for mounting camera.
- 35- by 20- by 600+-millimeter garden stake for label cards.
- Label cards: 76- by 127-millimeter nonwhite cards to label station number, camera number, and date. We typically use one card with the month, one with the day (reusable), and one with the station and camera number.
- Thumbtacks: for anchoring plastic bag and binder clips.
- Binder clips: small ones attached to label stake with thumbtacks to hold label cards.
- Plastic bag: 1-gallon freezer bag (not sealing type) with the part over and in front of the lens cut away.
- Clear tape: to attach freezer bag to loop of coat hanger.
- Duct tape: to attach loop of coat hanger to mounting stake and securing the system while moving or storing.
- Glue: to glue hook-and-loop tape. Airplane glue or similar works well.
- Strapping: perforated metal strapping 35 millimeters wide and 150 millimeters long for the angle iron and platform. The perforations should be 9 millimeters in diameter.
- Bolt and wingnut: to attach platform to stake; 8-millimeter size.
- Hook-and-loop tape: to attach camera to platform.
- Coat hangers: for (1) triggering mechanism, (2) runner, and (3) loop over lens to support waterproofing bag. Use templates to make these in quantity.
- Eye screw: one or two small ones in camera, attached by heating them and sinking into camera body. Another eye screw is put in the stake to guide the monofilament.
- Monofilament: 10-kilogram test; strung from triggering mechanism to washer.
- Washers: one attached to monofilament and bait thread just past runner and another for the bolt and wingnut; 9-millimeter size.
- Thread: normal gauge sewing thread to tie to bait and washer.
- Bait: chicken wing or other small piece of chicken (back, neck).

Tools needed:

- Tool box or tacklebox to carry items.
- Hatchet or hammer.
- Scissors.
- Pliers (lineman and needle-nose).
- Waterproof marker.
- Flagging.
- Extras of everything listed under "Materials."
- All normal field gear and data sheets.

Appendix 2

Data Form

OBS JKS WEATHER 3 TEMP 24 TRANSECT NUMBER 2 P 1 OF 3

LOCALITY OLYMPIC PENINSULA - HUMPTULIPS DRAINAGE

GENERAL COMMENTS MANY HUNTERS AROUND

STN NUM	CAM NUM	EXP NUM	SPECIES	DATE	NIGHTS RUN	BAIT	BAIT COND.	COMMENTS
P201	146	—		22/08/92	7	1	1	
P202	017	—	NFUN			2	3	monofil. around runner
P203	018	—				1	0	
P204	014	6	MAAM			2	3	SCAT - MAAM
P205	107	3	CAFA			1	3	DOG
P206	019	3	MAAM			2	3	GOOD PIC!
P207	133	—				1	0	
P208	137	—				2	0	
P209	108	—				1	0	
P210	001	4	NPIC			2	3	SCAT - MAPE?
P211	139	3	MAPE			1	3	
P212	011	—				2	0	
P213	029	4	STOL			1	3	CAM STOLEN 24/08/92
P214	059	—				2	0	
P215	041	—			↓	1	4	REPLACED BAIT
P216	147	—	NFUN		8	1	2	BAG ON TRIGGER M.
P217	101	—				2	0	
P218	119	4	GRJA			1	2	GRAY JAYS WAITING
P219	140	12	URAM			2	3	
P220	006	7	NPIC			1	3	monofil. around runner
P221	062	—				2	0	
P222	118	3	SPGR			1	2	smells like skunk!
P223	023	—		↓	↓	2	0	

Appendix 3

Explanation of Codes

Code sheet and explanations of codes for Camera Monitoring Data Form (appendix 2).

Header—

OBS: Observer's initials.

WEATHER:

1 = dry	7 = moderate snow
2 = fog/mist	8 = heavy snow
3 = light rain/drizzle	9 = mixed rain/snow
4 = moderate rain	10 = freezing rain
5 = heavy rain	11 = hail
6 = snow drizzle/light snow	12 = other (explain)

TEMP: Temperature in Celsius.

TRANSECT NUMBER: Chronological.

P____ OF_____: Page number of total pages—if more than one person runs the transect, then total pages are combined.

LOCALITY: General locality of transect.

GENERAL COMMENTS: Anything that concerns overall pattern of checking stations.

Data entry—

STN NUM: Station number, chronological; may use abbreviations of locality (for example, "N" for North Cascades) and transect number. Example: N323 = North Cascades, third transect, 23d station of this transect.

CAM NUM: Number inscribed on camera.

EXP NUM: Exposure number—recorded *only* when the shutter has been tripped by an animal (does not include test shots, accidental firings).

SPECIES: Four-letter code for species is entered or one of the following: NPIC = nothing in photo or exposure problem; UNKN = animal in photo, but unidentifiable; STOL = film from stolen camera; RUIN = film ruined by animal, falling tree, etc.; NFUN = nonfunctional camera (NFUN entered in field—no exposure number can accompany it).

DATE: Use European method of entering dates; for example, 10 Oct 1992.

NIGHTS RUN: Number of nights elapsed since set-up day.

BAIT: Type of bait used: 1 = chicken; 2 = chicken/jam; add additional codes as needed.

BAIT COND: Condition of bait when checking the camera: 0 = untouched; 1 = gnawed (by anything from martens to ants), not replaced; 2 = gnawed, replaced; 3 = bait gone; 4 = thread chewed off; 5 = untouched, replaced (for example, when chicken is dried out).

COMMENTS: Anything to help decipher photos in lab, such as accidental firings, scats found, target species seen in area, malfunctioning camera or flash, stolen camera info, and so forth.

Appendix 4

Monitoring Parameter Worksheet

The following is a monitoring parameter worksheet. It is filled out for each general area monitored (for example, a Ranger District, drainage, mountain range, and so forth, depending on the extent of monitoring).

Recorder ____________________

Affiliation and address ____________________

____

Contact phone (and DG, if applicable) ____________________

Location of study area (area reporting on) ____________________

____

Census period ____________________

Number of transects ____________________

Transects per station ____________________

Total stations ____________________

Number of NFUN ____________________

CNs (subtract NFUN) ____________________

Checking frequency ____________________

Pattern (grid, irregular, road transect, etc.) ____________________

Spacing (distance between stations) ____________________

Habitat selectivity (old growth only, towards streams, random, etc.) ____________________

____

Bait used ____________________

Lures used (include olfactory, auditory, visual) ____________________

____

Observations and recommendations ____________________

____

____

____

____

____

____

Other comments ____________________

____

____

____

____

____

____

Appendix 5

Example of a Detection Summary Table

Example of a simple detection summary table. Assume 1,000 CNs and 40 stations. Note that the subtotal and total will usually not be the summation of items listed above for stations with detections or station detection rates, because more than one species may be detected per station.

Species and other photo designations	Number of photos	Detection rate[a]	Stations having detections	Station detection rate[b]
Marten	4	0.40	4	0.10
Common raven	39	3.90	22	.55
W. spotted skunk	21	2.10	10	.25
Ermine	17	1.70	5	.13
Baird's tapir	1	.10	1	.03
Subtotal	82	8.20	31	.78
Unknown	2	.20	2	.05
STOL	21	2.10	2	.05
NPIC	77	7.70	40	1.00
Total	182	18.20	40	1.00

[a] Detection rates are photographs per 100 CNs.

[b] Station detection rates are the number of stations with detections per number of stations monitored.

Appendix 6

Example of Target Species Worksheet

Target Species MARTEN
Recorder J. K. SWINGLE
Affiliation and Address PNW RESEARCH STATION, 3625 93rd AVE SW, Olympia, WA 98502 - US Forest Service
Contact Phone (and DG, if applicable) (206) 956-2345; DG- S26L09A
Study Area Location OLYMPIC PENINSULA
Number of Target Species Photographs (TSPs) 23
Number of Stations with TSPs 7
Suspected Number of Individuals 3
Station Detection Rate (number of stations with TSPs divided by total number of stations monitored) 7/45 = 0.16

	STATION NUMBER							
	201	204	205	206	211	229	232	
DATE FIRST DETECTION	23/08	21/08	20/08	22/08	17/08	17/08	17/08	
NIGHTS RUN FIRST DETECTION	8	7	6	7	5	3	3	
NIGHTS RUN NEXT DETECTIONS	12	8	7	8	11			
		9	8	9				
		11	18	10				
		12		11				
		14		12				
				14				
NEAREST STATION WITH DETECTION	204	205	204/206	205	206	232	229	
DISTANCE TO NEAREST STATION WITH DETECTION	1.5 km	0.5 km	0.5 km	0.5 km	2.5 km	1.5 km	1.5 km	

COMMENTS suspect 1 marten at 201-206; 1 at 211; 1 at 229-232; However, young-of-year expected this time of year.

Jones, Lawrence L.C.; Raphael, Martin G. 1993. Inexpensive camera systems for detecting martens, fishers, and other animals: guidelines for use and standardization. Gen. Tech. Rep. PNW-GTR-306. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 22 p.

Inexpensive camera systems have been successfully used to detect the occurrence of martens, fishers, and other wildlife species. The use of cameras is becoming widespread, and we give suggestions for standardizing techniques so that comparisons of data can occur across the geographic range of the target species. Details are given on equipment needs, setting up the stations, checking and recording, summarizing data, and research needs.

Keywords: Camera, monitoring, marten, *Martes americana*, detecting, standardization, fisher, *Martes pennanti*.

The **Forest Service** of the U.S. Department of Agriculture is dedicated to the principle of multiple use management of the Nation's forest resources for sustained yields of wood, water, forage, wildlife, and recreation. Through forestry research, cooperation with the States and private forest owners, and management of the National Forests and National Grasslands, it strives—as directed by Congress—to provide increasingly greater service to a growing Nation.

The U.S. Department of Agriculture is an Equal Opportunity Employer. Applicants for all Department programs will be given equal consideration without regard to age, race, color, sex, religion, or national origin.

Pacific Northwest Research Station
333 S.W. First Avenue
P.O. Box 3890
Portland, Oregon 97208-3890

☆ U.S. G.P.O.: 1993—791-582

U.S. Department of Agriculture
Pacific Northwest Research Station
333 S.W. First Avenue
P.O. Box 3890
Portland, Oregon 92708

Official Business
Penalty for Private Use, $300

do NOT detach label