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American Marten, Fisher, Lynx, and Wolverine: Survey Methods for Their Detection

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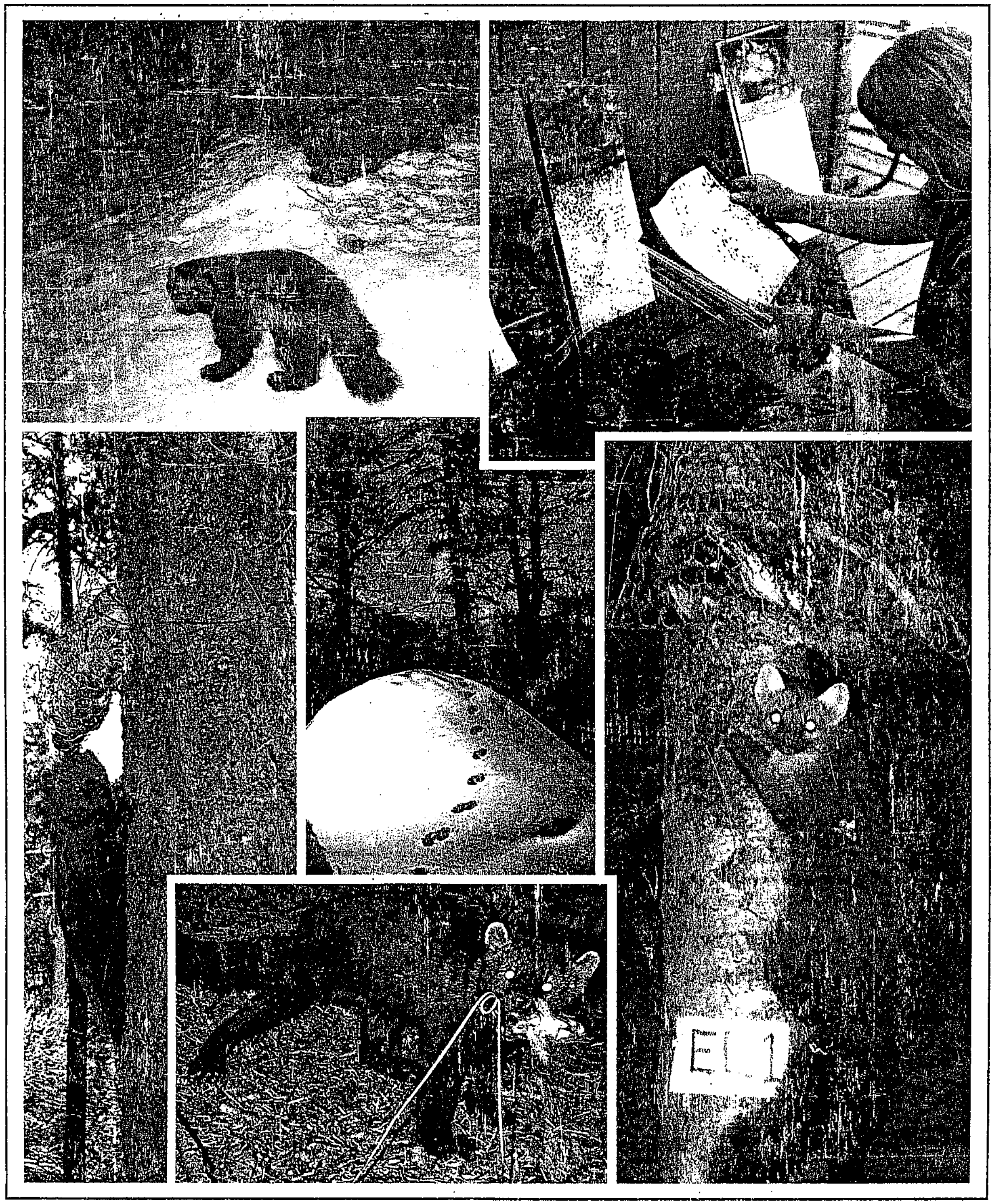

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Technical Editors: William J. Zielinski, Thomas E. Kucera

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Introduction to Detection and Survey Methods

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Background

The integrity of an ecosystem may be measured by the health of its vertebrate carnivore populations. Carnivores influence the structure and reflect the vigor of trophic levels on which they depend, and are sensitive to the abundance and behavior of the human populations with which they coexist (Eisenberg 1989). Concern for the conservation of mammalian carnivores in the western United States has centered on two large species, the gray wolf (*Canis lupus*) and the grizzly bear (*Ursus arctos*). The public is well acquainted with the plight of these species; a wealth of popular literature on their natural history and a long tradition of folk knowledge have built a foundation of awareness. In contrast, the four species that we address in this manual, the American marten (*Martes americana*), fisher (*Martes pennanti*), lynx (*Lynx canadensis*), and wolverine (*Gulo gulo*) (henceforth collectively referred to as MFLW), are no less important constituents of their biological communities than the wolf or grizzly bear, but much less familiar.

Fortunately, MFLW have begun to emerge from the shadows of public and scientific awareness (Kucera and Zielinski 1995). In the past 7 years in the Pacific Southwest Region of the USDA Forest Service, 58 actions such as timber sale appeals, lawsuits, and Freedom of Information Act requests were filed concerning the marten, 54 concerning the fisher, and 20 concerning the wolverine (lynx do not occur in California). Each species is receiving increased levels of administrative and legal protection. The wolverine is a "candidate" for Federal listing under the Endangered Species Act (Category 2 [C2]) in nine States, and listed as either "State Endangered" (SE) or "State Threatened" (ST) in three of them. A C2 designation indicates that more information is necessary to support a listing decision by the Fish and Wildlife Service (USFWS), U.S. Department of Interior. The lynx is a C2 species in nine states and either SE or ST in two states. The fisher is a C2 species in three states and SE or ST in two. The marten has no Federal status, but is SE in New Mexico. Each species is also listed as either "Sensitive" or as a "Management Indicator Species," as provided for in the National Forest Management Act, on most National Forests throughout its range (Macfarlane 1994). Sensitive species are those whose population viability is a concern because of significant current or predicted downward trend in abundance or habitat capability (Forest Service Manual 2670.32). Management Indicator Species are used by National Forests to reflect how particular habitats or habitat elements respond to management activities (Forest Service Manual 2670.5).

In the early 1990's the Fish and Wildlife Service (USFWS) was petitioned to list the fisher as "Endangered" in California, Oregon, and Washington under the Endangered Species Act (Central Sierra Audubon Society and others 1990), and the lynx was petitioned to be listed in Washington (Greater Ecosystem Alliance and others 1991). Both petitions were denied on the basis of inadequate information (U.S. Department of Interior, Fish and Wildlife Service 1991, 1992). Recently the USFWS was again petitioned to list both species, this time throughout their ranges in the western United

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States (Biodiversity Legal Foundation 1994a, 1994b). The lynx petition was denied again (U.S. Department of Interior, Fish and Wildlife Service 1994), and the fisher decision is pending. A petition to list the wolverine as "Endangered" in the contiguous 48 United States (Biodiversity Legal Foundation 1994c) also was denied (U.S. Department of Interior, Fish and Wildlife Service 1995). The Natural Resources Defense Council challenged the USDA Forest Service in California to suspend logging of late-successional forests until a plan to ensure the viability of forest carnivore populations is in place (Yassa and Edelson 1994). The first major conference on the biology of martens and fishers occurred in 1991 (Buskirk and others 1994), and in the same year the Western Forest Carnivore Committee, an interagency group of managers and scientists, was created to address the conservation needs of MFLW. Recently, a conservation assessment was conducted for the four species considered here to evaluate the state of our knowledge on their ecology and to consider the management implications of this information (Ruggiero and others 1994). The second conference on the biology of martens and fishers occurred in 1995.

The list above indicates that managers, administrators, and citizens of many western states are concerned about the status of MFLW. This concern stems from the possible deleterious effect of trapping and from habitat loss. Several investigators suspect that the accelerated harvest of old-growth forest has reduced, in particular, the populations of fisher and marten (Buskirk and Ruggiero 1994, Powell and Zielinski 1994) and that human encroachment on the range of the wolverine has reduced its numbers (Banci 1994). There is growing consensus that the southern portions of these species' historic ranges in the western United States have recently contracted (Douglas and Strickland 1987, Gibilisco 1994, Maj and Garton 1994, Nead and Halfpenny 1985, Ruggiero and others 1994, Weaver 1993).

The relative obscurity of MFLW and the logistical and financial difficulty of studying them may explain why so little is known about their biology and the effect of land-use changes on their populations. These species occur at low densities, are primarily nocturnal, have inconspicuous mating behavior, leave little sign, and shun human activity. Unless they are commercially harvested by trapping, their presence will often go unnoticed. In addition, managers may have assumed that carefully regulated trapping programs would monitor the distribution of each species and detect declining populations. Whether this was ever possible is now moot; collectively, MFLW are no longer a significant part of the fur harvest in the conterminous western United States. Changing public attitudes regarding trapping, poorly regulated harvests, and suspicions about excessive mortality from commercial harvest have contributed to the closure or restriction of trapping seasons. MFLW are legally trapped in only a few (one, lynx; two, wolverines; two, fisher; six, marten) of the seven western States, excluding Alaska, and quotas have been as low as two per State (Ruggiero and others 1994). It is likely that none of these species, with the possible exception of marten, will continue to be commercially harvested in the western conterminous United States for long.

Historically, MFLW occurred throughout northern North America including mountainous regions of the western United States (Gibilisco 1994, Grinnell and others 1937, Hagmeier 1956, Koehler and Aubry 1994), but none occupies all of its recent historical range (Banci 1994, Douglas and Strickland 1987, Gibilisco 1994, Koehler and Aubry 1994, Kucera and others 1995, Nead and Halfpenny 1985, Zielinski and others 1995). In the western United States, most of the range of MFLW occurs within the Rocky Mountains, the Cascade Range, the Coast Range, and the Sierra Nevada. Within these regions all four species are associated with coniferous forest ecosystems. Marten and fisher occur primarily in late-successional forests (Buskirk and Powell 1994), lynx are associated with a variety of seral stages (Koehler and Aubry 1994), and the wolverine inhabits areas with a mixture of forested and non-forested habitats (Banci 1994, Hash 1987, Hatler 1989). All are primarily carnivorous. Marten and fisher eat predominantly small- to medium-sized mammals (e.g., rodents and lagomorphs) (Douglas and Strickland 1987, Martin 1994, Strickland and Douglas 1987). Lynx prey largely on snowshoe hares (*Lepus americanus*) (Koehler and Aubry 1994), and wolverines depend mostly on carrion, especially that of ungulates (Hornocker and Hash 1981).

In sum, these species have similar habitat associations, are sympatric over much of their range, often occur at low densities, have relatively low reproductive potentials, occupy somewhat similar niches in their respective communities, and may be affected in similar ways by human land-use practices. Range-wide, the densities of martens, fishers, lynx, and wolverines have been reported as low as one individual for every 2.5, 20.0, 200.0, and 700 km^2, respectively (Arthur and others 1989, Banci 1987, Nellis and others 1972, Thompson and Colgan 1987). In addition, each frequently occurs in small, scattered subpopulations, making them especially vulnerable to extirpation (Gilpin and Hanski 1991, Weaver 1993). For these reasons, it is appropriate to consider detection and survey methods collectively for these four species. Moreover, we recognize the need to focus whenever possible on collective components of ecosystems rather than individual species.

Recent developments in the field of conservation biology suggest that we can no longer assume that the existing distribution of National Parks, and the prevailing management on National Forests, will guarantee the long-term persistence of large vertebrate populations (Newmark 1985, 1987; Salwasser and others 1987). Reserves cannot be created that are large enough to permit the persistence of MFLW populations; the multiple-use lands between reserves must also be managed with the conservation of these species in mind. Moreover, populations of lynx and wolverine in particular may depend on source populations in Canada; thus, conservation efforts must consider connectivity of habitat between the United States and southern Canada (Hatler 1989, Ruggiero and others 1994, Weaver 1993). Eventually, a spatially explicit conservation strategy should be developed for these species. This must include all land management agencies in western North America and model the viability of each species and population throughout the region. An initial step taken by the USDA Forest Service was a conservation assessment for MFLW that summarizes existing information and suggests research needs (Ruggiero and others 1994). In addition, general hierarchical guidelines for the conservation of fisher have been proposed for the western United States (Heinemeyer and Jones 1994). One of the key information needs identified in these documents is knowledge of the present geographic distribution of each species. Because commercial trapping is no longer a source of data on the distribution of these species, a new approach to the acquisition of distributional data must be developed.

Developing new methods to collect distributional data is a logistically and financially challenging problem, but it must be addressed and it must begin now. It is essential for several purposes: (1) to develop a contemporary benchmark for the geographic distribution of each species, (2) to generate data for habitat-relations models, (3) to evaluate the effects of land-use changes (e.g., timber harvest, mining, recreation) on populations, (4) to evaluate the effects of human density and disturbance on distribution, (5) to relate species occurrence to landscape physiognomy and composition (Fahrig 1988, Pulliam and others 1992), (6) to collect information that will assist the development of spatially explicit population viability models (e.g., Thomas and others 1990), (7) as an essential step in the development of a population-monitoring program, and (8) to assist in determining the necessity of protecting any of the species under the Endangered Species Act.

Others have addressed the issues of inventory and surveying populations of the carnivores considered here (Jones and Raphael 1993, Raphael 1994, Spowart and Samson 1986). However, they either address a particular technique or species or describe the issues in a general fashion. We hope that the present manual will facilitate the collection of distribution data for all four species in a standardized fashion, using methods that can be tailored to the local environment and particular target species. For this reason we expect it to be an important step toward addressing all of the objectives described above.

Species Detection

This publication is designed to help resource managers detect the *presence* of lynx, wolverines, fishers, and martens by using standardized, non-lethal methods. It should allow a biologist to conduct a search for MFLW that will provide reasonable assurance that the species are not present if they are not detected. However, until additional research is conducted on the probabilities of detecting individuals known to occur in an area, "failing to detect" should not be the same as concluding "absent" (see section on "Interpretation," below).

If the target species is detected, the location of the detection and the habitat features associated with it should become part of a larger database that includes all sites where each species was detected. Thus, detection efforts, if conducted in a standardized fashion, can describe the distribution of a species throughout a region of interest (see Chapter 2, "Definition and Distribution of Sample Units").

We describe three methods: cameras, sooted track plates, and snow tracking. Each offers ease of use, effectiveness, and economy. For each method we provide, in "cookbook" fashion, information about how to acquire or build the components and a protocol for using the method and recording the data collected. We do not recommend a particular method for a particular circumstance or geographic region. Instead, we describe the contexts in which each method works best, estimate the costs, and allow the biologist planning the survey to choose among the three techniques.

We considered other techniques such as habitat surveys, live trapping, and hair snares but decided not to include them in this manual. Habitat surveys are based on the assumption that habitat suitability is sufficiently well known that we can create a model that relates habitat attributes to species' presence. Unfortunately, existing models have had little testing, and factors other than habitat quality frequently affect distribution (Raphael 1994). Live trapping is uneconomical, given the low capture rates per unit effort for the species considered here. Snares that collect a sample of hair from individuals that visit a bait (e.g., Barrett 1983, Scotts and Craig 1988) are relatively inefficient, and species are not always readily identifiable by individual hairs (Fowler and Golightly 1993, Raphael 1994). However, DNA fingerprinting, which can determine the identity of species and individuals from DNA in cells at the base of the hair (e.g., Morin and others 1994), may soon resolve this issue. Individual marten have been identified using DNA extracted from hair collected from wooden "cubbies" lined with a sticky snaring medium (Minta and Heinemeyer 1995). Consequently, hair collected at station locations or encountered while snow tracking should be saved for future analysis.

It is important to emphasize that we recommend the use of the three methods for *detection only*. We assume here that the primary objective of a biologist responsible for the management of these species is to determine *whether* they occur in a particular locale and *where* they occur within the area. We refer to these as "Regional Surveys." Beyond this, biologists often are called upon to determine whether MFLW occur within a proposed management activity area ("Project Surveys"). This manual provides information on how to use standard methods to conduct both types of survey. Two of the chapters introduce detection methods that depend on "devices" (track plates and cameras); the final chapter describes snow tracking, which does not require a detection device.

Differences Among Survey Methods

No study has compared all of the methods and types of devices described in this manual, and therefore we cannot contrast their relative efficiencies. However, the methods differ in the following respects: the seasons during which they can be used, difficulty of identifying sign, amount of training necessary, labor and material costs, and whether they have successfully detected each species (*table 1*). No single method is better than the others in all categories (Raphael 1994).

Snow tracking and cameras have successfully detected all four species. Track plates have detected only fisher and marten. This is probably because track-plate boxes have not been enlarged to accommodate the larger species, and neither enclosed or unenclosed plates have received as widespread use in the western United States as the other methods. Because bobcats (*Lynx rufus*) have been detected at track plates, we know that felids can be attracted to the baits and will enter the boxes. Snow tracking, track plates, and line-triggered camera systems have the disadvantage of being limited to specific seasons. In addition, the difficulty of identifying the sign of the four species is greater for track-based methods than camera methods because images of the entire animal are almost always easier to identify than tracks. The extent of training necessary to use snow tracking and cameras successfully is greater than that required for track plates. Moreover, any method used in winter requires more training (for safety and travel) than methods used during other seasons.

Although cameras are technically challenging and snow tracking requires extensive experience to conduct properly, track-plate surveys are simple by comparison. A record of the sign from enclosed track plates is easier to retrieve from the field and provide to another individual for identification than is the information provided in a snow track. The 35-mm cameras are the least labor intensive because, unlike the other methods,

Table 1—*Methods described in this publication and characteristics of their use for the detection of lynx, wolverines, fishers, and martens.*

Methods	Target species detected using the method[1]	Seasons of use	Difficulty of verifying identity	Amount of training necessary to use method	Labor intensity	Cost of materials
Cameras						
Line triggered	F, M	Summer primarily	Low	Moderate	Moderate	Low
Dual sensor	W, L, F, M	Summer and winter	Low	Moderate	Low	High
Single sensor	L, F, M	Summer and winter	Low	Moderate	Low	High
Track Plates						
Box-enclosed	F, M[2]	Summer primarily	Moderate	Low	Moderate	Low
Unenclosed	F, M[2]	Summer exclusively	Moderate	Low	Moderate	Low
Snow Tracking	W, L, F, M	Winter exclusively	Moderate—High	High	High	Very low

[1]L=lynx W=wolverines F=fishers M=martens.
[2]No lynx, but bobcats have been detected.

they can operate untended for weeks. However, the material costs for snow tracking are much less than for the 35-mm camera systems.

The benefits and limitations of each method should be evaluated for each location, budget, and the objectives of the survey. We will learn much more about the efficiency of each method when it can directly be compared to other methods. Therefore, we encourage users to take every opportunity to sample survey areas using more than one method, and to publish these results. The work of Jones and Raphael (1990), Bull and others (1992), Laymon and others (1993), Fowler and Golightly (1993), and Foresman and Pearson (1995) are a start toward this goal. In Washington State, unenclosed track plates detected somewhat fewer martens than did line-triggered cameras (Jones and Raphael 1990). However, because martens may have removed bait at track plates without detection and rain reduced the legibility of tracks, this difference is trivial. Bull and others (1992) compared snow tracking, enclosed track plates, and line-triggered cameras and concluded that when conditions permitted, snow tracking was the most effective method for detecting martens. Track plates were better than line-triggered cameras when snow was absent or of poor quality for tracking. However, only 16 sample locations along one 10-km transect were included in this study. Laymon and others (1993) found that more vertebrate species were detected at unenclosed track plates than at line-triggered cameras. In this study, unenclosed track plates and the single-sensor camera had equivalent efficiencies of detecting species, including martens. Fowler and Golightly (1993) compared enclosed track plates and line-triggered cameras at 76 stations and found that track plates were the more effective method to detect martens. This is consistent with the results of comparisons of marten detections in Yosemite National Park (L. Chow, pers. comm.). J. Copeland (pers. comm.) detected wolverines at photographic bait stations more frequently by tracks in the snow than by photographs. In a recently completed study comparing the Manley dual sensor camera, open and enclosed track plates, and snow-tracking methods, Foresman and Pearson (1995) favored the use of 35-mm cameras to detect marten, fisher, and wolverine. Cameras and track plates detected martens and fishers at the same survey units, but snow tracking failed to detect marten at some units, and fishers at all the units, where they were detected by another method. A wolverine was photographed at one survey unit but was undetected there by track plate or snow tracking methods. Snow tracking was considered the least effective method given its dependence on ideal snow conditions and well-trained technicians (Foresman and Pearson 1995). Additional experimentation is necessary before the effectiveness of each method for each of the four species can be properly evaluated.

Survey Durations

It is important to emphasize that surveys conducted only to determine presence should be terminated when the intended species is detected, or if undetected, after some reasonable amount of effort (a combination of duration and spatial extent of survey). Terminating surveys when the target species is detected is the most economical way to survey large areas. The amount and schedule of maximum effort (if target species are not detected) are necessarily different for the device-dependent methods and the snow-tracking methods, and are outlined in detail in Chapters 3, 4, and 5. General considerations of the distribution of survey sample units are provided in Chapter 2.

For the purposes of this publication we refer to the use of more than one device at a time, and running more than a trivial distance of snow-track transects, as a *Survey* (see Chapter 2: Definition and Distribution of Sample Units). We accept the definition that a survey is "an exercise in which a set of qualitative or quantitative observations are made, usually by means of a standardized procedure and within a restricted period of time and over a restricted area" (Hellawell 1991). A survey can be as superficial as using more than one device during a specified time period in the same general area, or traveling a significant distance searching for tracks. However, we dedicate much of this manual to recommending minimum survey durations and effort over specified areas. To restate this important point, we use detection methods to determine presence at a point location, either a camera or track-plate location or an intersection point on a snow transect. Our surveys are *not* methods for indexing population density, population size, or change in population size.

Population Monitoring

Censuses involve counts of individuals, *indices* are counts of some object related to the number of individuals (Caughley 1977), and *monitoring*, as we define it, is an attempt to detect change in population size over time, i.e., trend. Although we do not recommend particular monitoring methods here, we envision this publication as an important step in the development of monitoring schemes. The detection methods described herein are probably the same tools that will eventually be used to index changes in population size. Hiby and Jeffrey (1987) discussed photographic techniques for population studies of rare species, and Mace and others (1994) reported the first attempt that we are aware of to use photographic methods to estimate population size. Karanth (1995) used photographic methods to estimate the population size of tigers (*Panthera tigris*) in India. Camera stations, track-plate stations, and snow transects each could be the detection technique used as the basis for a monitoring program, in much the same way that the scent-station visit was used in an attempt to assess coyote (*Canis latrans*) population status (Roughton and Sweeny 1979, 1982) and scat transects were used to monitor change in bear (*Ursus americanus* and *U. arctos*) populations (Kendall and others 1992). In fact, plans for monitoring fisher population change using track plates (Zielinski and Stauffer, in press) and cameras (York and others 1995) recently have been proposed.

We recognize the urgent need to develop monitoring schemes for the species considered here. The populations of MFLW in the conterminous United States appear to have declined, and population safeguards could be instituted if we had solid evidence of declines. However, we caution that population monitoring efforts require considerable planning and statistical evaluation before implementation (de la Mare 1984, Diefenbach and others 1994, Gerrodette 1987, Kendall and others 1992, Peterman and Bradford 1987, Taylor and Gerrodette 1993, Verner and Kie 1988). The objective of such monitoring is usually to detect a change in an index of population abundance over time. Thus, the null hypothesis that there has been no change in the population size between two points in time must be tested against the alternative that the population has changed (either increased or decreased: two-tailed test), or has declined or has increased (one-tailed tests).

The possible outcomes of testing the null hypothesis include two familiar types of errors. A Type I error occurs, with probability α, when we mistakenly reject the null hypothesis if it is true. A Type II error occurs, with probability β, when we mistakenly do not reject (i.e., 'accept') the null hypothesis when the alternative hypothesis is true. If we detect no change in a population and consider minimizing only the Type I error rate, there are two possible interpretations. Either there has been no change in the population and we are correct in our decision, or there has been a change in the population and we have insufficient information to detect this change. Small sample size and large variance reduce the ability to detect change (Cohen 1988). We must therefore ask the important question: if a significant population decline has occurred, what is the probability that we will detect it with our survey? The answer is critical to a monitoring program. However, the probability of detecting a change if it has occurred, i.e., rejecting the null hypothesis when the alternative hypothesis is true, called statistical power (1-β), is rarely determined. In developing a sampling design to monitor population change, it is essential to determine *a priori* the probability of detecting significant changes for varying sample sizes; this allows the investigator to choose an adequate sample size to detect population change with an acceptably high probability.

The literature is replete with examples of hastily implemented monitoring schemes that, after the expenditure of many of thousands of dollars, were determined to be insufficient to detect even catastrophic declines in populations over short periods. To embark on a monitoring scheme without complete familiarity with the detection method, without consultation with a competent statistician, and without simulating possible monitoring scenarios is a waste of time and money. For example, an established monitoring scheme thought to be sufficient to detect declines in whale stocks was found to be inadequate to detect a 50 percent change over a 10-year period (de la Mare 1984). Other examples of ill-fated monitoring schemes are documented in the fisheries literature (e.g., Peterman and Routledge 1983), and we cannot overemphasize the importance of conducting pre-monitoring evaluations of statistical power (Gerrodette 1987, Millard 1987, Peterman 1990, Taylor and Gerrodette 1993). Even the long-standing coyote monitoring program instituted by the U.S. Fish and Wildlife Service (Roughton and Sweeney 1979) suffered from poor planning that resulted in major changes years after the first data were collected (Roughton and Sweeney 1982).

The recent examples of monitoring schemes to track changes in bear (Kendall and others 1992) and bobcat (Diefenbach and others 1994) populations demonstrate the level of planning necessary before one considers population-level monitoring using sign surveys. Detection of even relatively large changes in population size (e.g., 25 percent) may require prohibitively large sample sizes to achieve sufficient power (Diefenbach and others 1994). Finally, one must realize that the conclusion from evaluating proposed monitoring schemes may be that it is not statistically valid or economically feasible to conduct population monitoring via inventory; demographic studies to estimate population growth rate may be preferable (Taylor and Gerrodette 1993).

Although much of the planning that goes into developing a monitoring scheme involves simulation modeling, the process also requires empirical data. For example, the probabilities of detecting (POD) animals that are known to occur in the survey area, after varying survey durations, need to be estimated. These can be estimated by determining how many radio-marked animals in the vicinity of the detection effort are actually detected (provided that previous capture does not affect subsequent detection), an approach taken by Fowler and Golightly (1993) for marten, or by using the data from multiple surveys where POD is a function of the distribution of "number-of-days-to-first-detection" (Azuma and others 1990, Zielinski and Stauffer in press). Regardless of method, POD should be estimated in a variety of habitats and physiographic provinces to determine whether regional differences exist.

A simple form of population monitoring may be possible using the system recommended in this publication. If detection surveys are conducted over a relatively short period of time, the collective information in a region can provide a "snapshot" of the local distribution of each species. A good example of this approach is represented by North American Breeding Bird Atlases (Smith 1990) and the Atlas of Mammals of the British Isles (Arnold 1978). Zielinski and others (in press) and Kucera and others (in press) describe the current distributions of fishers and American martens in California, based on techniques described in this document. Insofar as these distribution maps can be compared over time, the method can be interpreted as a way to monitor changes in species distribution.

This publication represents a significant first step toward the development of regional monitoring programs. They are urgently needed. If we are successful, and the methods described in this manual receive widespread use, biologists from private organizations and public land-management agencies will become familiar with the standard use of detection methods. They will be prepared to implement cooperative population monitoring schemes when the necessary research and planning have been done *and* when the results suggest that the effort is statistically and economically feasible.

Alaska and Canada

We expect that the methods described herein will be valuable to biologists throughout the range of each species. However, we recognize that in Alaska and Canada, where MFLW are most common, the emphasis will be less on their detection and more on the management of commercial harvest. Trapping still provides information on distribution and abundance of populations in the north, and the more open forests make aerial surveys for some species feasible (e.g., Becker 1991, Golden and others 1992). Thus, some of the methods described here may currently be less useful in Alaska and Canada. However, if the abundance of MFLW decreases and commercial trapping is reduced or prohibited, the methods described here for the conterminous western United States may have equal utility farther north.

Habitat Assessments

Ideally, a standardized survey protocol should be integrated with a standardized method for describing the habitat of both the area surveyed and the locations of detections. However, for a number of reasons, we do not propose standardized vegetation sampling methods in this publication. First, to develop a habitat sampling protocol sufficient to encompass the myriad habitat types included within the ranges of the four species considered here would be an enormous task. Second, a variety of methods already are used by different agencies or states to describe habitat (Anderson and Gutzwiller 1994), some with the goal of achieving statewide standards (e.g., California Wildlife Habitat Relationships System; Mayer and Laudenslayer 1988). We are not prepared to propose methods that would have universal appeal nor do we wish to distract from ongoing efforts. Finally, although it may be possible to standardize the type of information collected at point locations (e.g., detection stations), the scales that are most appropriate for the species treated herein are the watershed and the landscape. Field and computer methods for characterizing the biological and physical attributes at these scales are just developing and will require the coordinated effort of wildlife biologists, landscape ecologists, geomorphologists, and plant ecologists, among others. Geographic Information Systems will be an essential element of this process. The approach to characterizing habitat at this scale is far beyond the scope of our objectives here.

Even though we do not recommend a particular scheme to characterize habitat, we believe habitat information is important. We strongly recommend that some habitat assessment be included in every survey. Track plates, in particular, have been used to assess habitat use by fishers (e.g., Raphael 1988, R. Golightly, pers. comm.; M. Higley, pers. comm.; R. Klug, pers. comm.). However, the number of stations visited and the frequency of detection at individual stations can be influenced by factors other than habitat quality (e.g., hunger, learning, age, sex, population density, weather, season), so this measure should be interpreted with caution. Habitat sampling should be standardized across the largest scale possible and designed to be compatible with protocols created for other purposes. Statewide standards are best, but standardization within agency boundaries (e.g., National Forest) is preferable to none at all. The recent assessment of the conservation status of MFLW (Ruggiero and others 1994) discusses stand and landscape features associated with the occurrence of each of the four species and combinations of species (Lyon and others 1994). Consult this and other published information when deciding how to characterize landscapes surveyed and vegetation at sampling points.

Interpretation of Results

Failure to detect a species has several implications. For the species considered here, additional research on probability of detection must be conducted before we will know whether failure to detect is equivalent to "absent." And, even when the failure to detect indicates a high probability of absence, the dynamic nature of populations suggests that areas of suitable habitat that are currently uninhabited could be occupied in the future. Because most management activities occur in small areas relative to the home ranges of the largest species considered here, communication with the managers of adjacent lands is essential. The existence of a nearby population (e.g., in an adjacent Ranger District) indicates the potential for recolonization of currently unoccupied but suitable habitat. Thus, management activities planned for the area being evaluated could indirectly or cumulatively affect the species even if it is not detected in the project area.

Cautions

The central concern in the management of MFLW is to determine if any occur in a region of interest. This publication is intended to provide the technical background to begin a search for each of the four species. However, the detection of these species requires specialized skills that are acquired only after specific training. The publication is designed for biologists inexperienced with the techniques and is a necessary element in preparation for detection work. However, we emphasize that reading this manual is no substitute for practice using the methods in the field. We recommend that those interested in conducting a survey assist in work being conducted by more experienced technicians before beginning their own studies.

We encourage readers, regardless of experience level, to submit their questions and comments about the information provided herein. The publication will be improved with the addition of experience from other practitioners and by evaluating data collected using the procedures described here. This feedback, and the development of new methodologies, may necessitate an improved second edition.

Disposition of Data

The Western Forest Carnivore Committee has recommended that a data clearinghouse be established for the storage and analysis of information on the distribution of lynx, wolverines, fishers, and martens (B. Ruediger pers. comm.). Although a structure for data input has been drafted (E. Burkett pers. comm.), a process for the transmittal of information to a central repository (or repositories) has not been established. We realize, however, that this publication may stimulate the implementation of numerous detection surveys. This will provide us the tools to standardize the process by which the data are collected and managed thereafter.

We recommend that whenever a target species is detected, a copy of the Species Detection form (sample form included in the appendix of each method chapter and in the pocket on the inside back cover) be submitted to the Natural Heritage program in the state where the species are detected. A list of the addresses of the Natural Heritage program offices for each state is provided in *appendix A*. A duplicate of the Species Detection form should also be archived in a local administrative office of the agency sponsoring the survey (e.g., Forest Supervisor's Office, USDA Forest Service). This assumes that the Natural Heritage program in the state maintains a database for the target species detected. Currently this will be a problem for marten because many states do not maintain records for this species. Until they do, copies of the form should at least be forwarded to a designated administrative office, perhaps at the regional level.

Because most state Natural Heritage databases record information only on positive results from surveys, we also recommend that a Survey Record form (sample form also included in the appendix of each chapter and in the pocket on the inside back cover) be completed and filed at the appropriate administrative office. These forms become an official record of where surveys have been conducted, regardless of results, and are just as important as the record of detections.

Finally, we encourage coordination, communication, and sharing of data among the individuals, agencies, and organizations conducting detection surveys to maximize our understanding of this poorly known group of species.

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Definition and Distribution of Sample Units

William J. Zielinski,[1] Thomas E. Kucera,[2] James C. Halfpenny[3]

Introduction

Objectives

We assume that a land manager may wish to conduct detection surveys for one of two reasons. The first is to determine the distribution of each species within a management or administrative area (Regional Surveys). For example, a biologist may want to know whether wolverines occupy any of the watersheds in the northern half of a ranger district or whether marten occur throughout the true fir (*Abies* spp.) forest types on the district. The second reason to conduct detection surveys is to determine whether any of the target species occur in an area where some management activity is proposed (Project Surveys). We will present general sampling schemes that address both needs.

Background

The theoretically "ideal" survey is to place only one detection device (a camera or track plate) or a short snow-transect in a frequently used portion of each potential home range for only as long as it takes to detect the resident. However, this manner of sampling is unrealistic for several reasons. First, we will never have *a priori* knowledge of the home ranges of target individuals. Second, even if we knew the locations of home ranges, we do not understand enough about home range use to know exactly where to place our station or snow transect so that we could detect the resident in a reasonable period of time. Although a single detection device or transect would not maximize the possibility of detecting a resident, dozens of stations (or many kilometers of snow transects) per home range would probably be more than necessary; the optimum of this trade-off lies somewhere between.

Detection surveys should be designed to maximize the probability of detecting target species while simultaneously minimizing multiple detections of the same individuals. A single detection is all that is necessary to document the presence of a species in a survey area. Multiple detections, especially when individuals cannot be distinguished, provide no new information in this regard. However, with animals as rare as those considered here we believe that survey effort must be somewhat redundant; the density of detection devices and snow transects within the sample unit should exceed some minimum effort. Likewise, the distance between sample units should minimize the possibility of overlooking an occupied area within the region. This approach will probably result in some situations where the same individual is detected at more than one device or on more than one sample unit (especially with wolverines and lynx). We prefer this potential redundancy because it reduces the chance that occupied areas will be overlooked.

We explain the characteristics of survey protocols (e.g., duration of survey, frequency of visits to sample units) for cameras, track plates, and snow tracking in Chapters 3, 4, and 5, respectively. This chapter provides suggestions for allocating effort to the sample

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unit and for distributing sample units. We have modeled our approach on the American Breeding Bird Atlas (Smith 1990) and the Atlas of Mammals of the British Isles (Arnold 1978). These surveys provide a "snapshot" of the distribution of target taxa by recommending minimum survey effort within cells created by a grid overlaid on the geographic area of interest. The resulting distribution of cells with and without evidence of occurrence is a database of distribution. Here, we suggest a sample unit size (analogous to the grid cells in atlas methods) and recommend minimum effort to detect MFLW. This is an unprecedented survey approach for these species; we solicit alternative ideas if they can be demonstrated to be more useful or efficient.

The Sample Unit

The sample unit is the smallest division of a detection survey. It is the same size regardless of the target species, and is scaled to be large enough to include the entire home-range size of the smallest species, American marten. The sample unit we propose is a 4-mi^2 area that is aligned with section boundaries (*figs. 1-3*) and is the basis for all detection methods (camera, track plate, and snow tracking). This standard unit is recommended for simplicity, comparability, and ease of application using available maps. In those locations in the western United States where township and range designations are not used (e.g., National Parks), sampling units will need to be identified using the Universal Transverse Mercator (UTM) projection. In these locations, create sample units that are 3.2 km (3200 m) on a side.

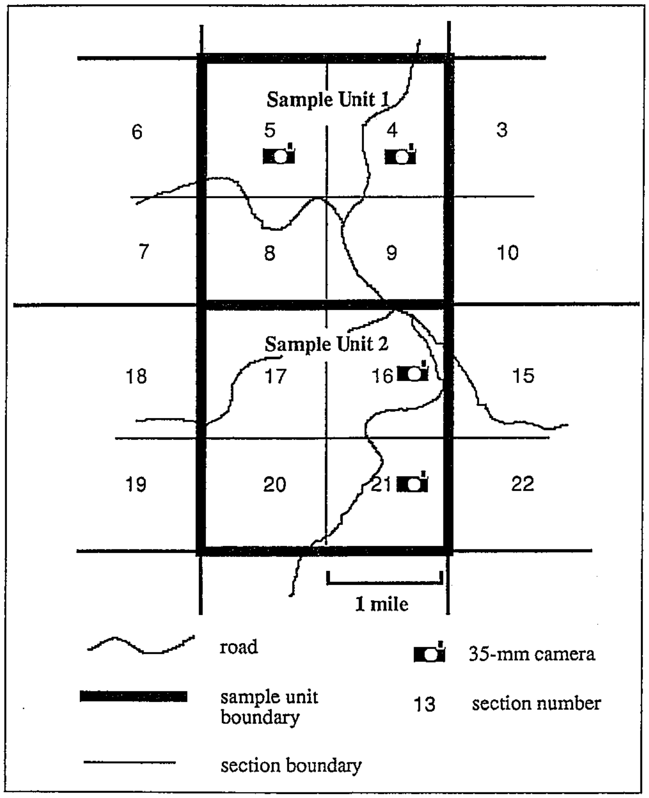


Figure 1—Schematic representation of two adjacent sample units surveyed using 35-mm cameras. The cameras are located one mile apart. The location of the cameras within each sample unit is assumed to coincide with either the most appropriate habitat or a site of an unconfirmed observation (Sections 4 and 5 of Sample Unit 1 and Sections 16 and 21 of Sample Unit 2).

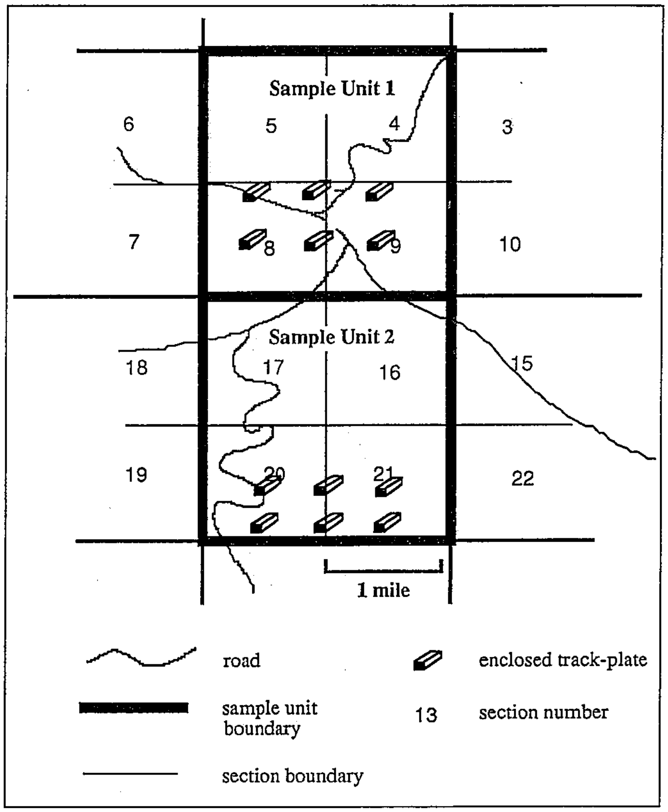


Figure 2—Schematic representation of two adjacent sample units surveyed using a grid of track-plate stations or line-triggered cameras with the objective of detecting marten or fisher. The stations are located 0.5 mile apart. The location of the grid within each sample unit is assumed to coincide with either the most appropriate habitat or a site of an unconfirmed observation (central portion of Sample Unit 1 and southern portion of Sample Unit 2).

The fact that the sample-unit size is *not* scaled to the density of particular target species, but is relatively small and invariant, assures that the rarer species with the largest home ranges (i.e., wolverine and lynx) will have the least chance of being overlooked in a survey area. However, if wolverine is the sole species of interest, larger sample units could be considered given that a detection in one 4-mi^2 area would guarantee that large adjacent areas are probably used as well. In this case, sampling immediately adjacent 4-mi^2 units for wolverines may not be the most cost effective. We encourage the use of 4-mi^2 sample units so that as data accumulate throughout the west they can be mapped using the same scale. Should one wish to create a distribution map with larger scale units at some later date, the information from the 4-mi^2 units can readily be aggregated.

Use of Detection Devices: Cameras and Track Plates

We describe camera and track-plate procedures in detail in Chapters 3 and 4; here we describe the number and distribution of the devices in general. The minimum number of devices per sample unit differs with the type of device. If 35-mm cameras are used, there should be *at least* two per 4-mi^2 sample unit, spaced 1.0 mile apart (*fig. 1*). However, if track plates (either enclosed or open) or line-triggered cameras are used, we recommend a *minimum* of six devices per sample unit (*fig. 2*). Because 35-mm cameras may be checked less frequently and larger, more attractive baits can be used

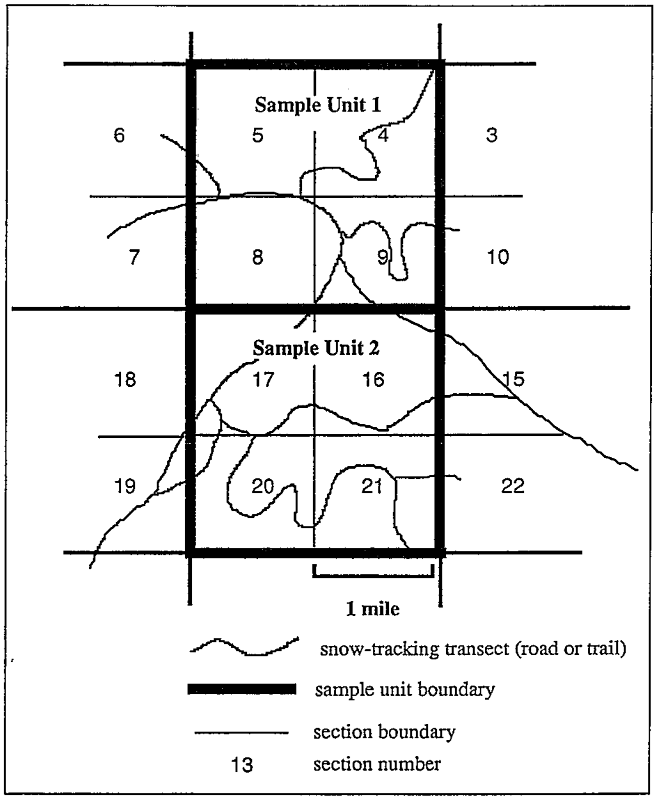


Figure 3—Schematic representation of two adjacent sample units surveyed using snow-tracking transects. Transects follow every road and trail. The route should begin at the access point to the sample unit that is nearest the most appropriate habitat for the target species, or nearest the site of an unconfirmed observation.

with them, fewer cameras are needed per sample unit. Fewer 35-mm cameras per sample unit may also be a financial necessity as they are considerably more expensive than the other devices.

Using more than one device is essential for several reasons. First, the distances from which target species are attracted to baits or lures at the devices are unknown, and a single station has a lower probability of being within the detection distance of a target species than two devices. Second, devices can be rendered ineffective from vandalism (by humans and bears) and mechanical failure. Therefore, it is better to have more than one detection device when their failure is influenced by unpredictable events.

Placement of Detection Stations

Place the array of devices (at least two 35-mm cameras or at least six track-plate boxes or line-triggered cameras) in the sample unit at a site where detections are most likely. This will be either where the habitat suitability appears highest (see Ruggiero and others 1994 for habitat descriptions) or where unconfirmed sightings are concentrated. This method approximates the "expert sampling" approach (Kish 1965) where professional judgment is used to select sample strata from a heterogeneous population. If habitat appears equally suitable throughout the sample unit, choose an area closest to the center of the sample unit with acceptable access.

Snow-Tracking Methods

We describe snow-tracking protocols in detail in Chapter 5; here we describe the essence of the procedures. We assume that snow tracking is conducted on foot using skis or snowshoes, or from a snowmobile; we expect that aerial surveys (e.g., Golden and others 1992, Stephenson 1986) will be difficult in the forested areas that comprise most of the habitat of MFLW in the conterminous western United States.

We discuss two methods for detecting the presence of the target species: "Searching for Tracks" and "Tracking at Bait Stations." The former and historically more common method involves traversing trails and roads in an area in search for tracks. The latter method involves the detection of tracks in the snow at bait stations.

When conducting a survey by searching for tracks, all roads and trails within the 4-mi^2 sample unit comprise the population of routes to be surveyed (*fig. 3*). An attempt should be made to travel all routes in the sample unit during the course of one day. If that is not possible, at least 10 km of trail should be traversed. If there are no roads, cover the area on skis as thoroughly as possible. Start the survey at the portion of the sample unit with the most likely habitat for the target species or where there have been unconfirmed sightings. If on skis, cover the sample unit proceeding from the most suitable to least suitable habitat and conclude the search after one day, regardless of distance traveled provided it exceeds 10 km. Traveling all roads in the sample unit in one day should not be difficult if snowmobile(s) are used. When tracking at bait stations is the chosen method, a protocol similar to that for 35-mm cameras should be used. A minimum of two bait sites, at least 1.0 mile apart, should be chosen per 4-mi^2 square sample unit.

Survey Duration

Searching for rare carnivores is expensive. While some duplication of effort is necessary to minimize the possibility of overlooking an occupied area, detection surveys should be designed to reduce the costs of collecting more information than is necessary. To minimize these costs we advocate that surveys be conducted in each sample unit until either the target species is detected *or* a reasonable amount of effort is expended (see

Chapters 3, 4, and 5 for minimum survey durations). The survey of a sample unit is terminated when the intended target species is (are) detected. Although multiple detections can be of value in some circumstances (e.g., when detection sites are used to assess habitat use), they are of little use when individuals cannot be reliably identified and when the objective is to determine the distribution of a species within an administrative area.

Sample Unit Distribution

Regional Surveys

Regional Surveys are designed to determine the distribution of MFLW within an administrative area and are not motivated by the need to verify the presence of a species on a project area. For this reason, the objectives of the survey are determined by the information needs of the land manager. The region within which information on the distribution of target species is desired should be delineated and divided into 4-mi^2 sample units. All sample units should eventually be surveyed, and the number that can be surveyed each year will depend on funding and the detection method chosen. Many different schedules can be envisioned; we suggest one of the three following options (*fig. 4a-c*):

(1) *Stratify by expectation of success.* Use the same logic for determining where to allocate survey effort within the region that is applied to the sample unit: choose the areas to survey first where the expectation of success is greatest (northeast and southwest regions in *fig. 4a*).

(2) *Proceed in a single direction.* Proceed across the administrative area in a consistent pattern or direction, surveying as many sample units as possible each year.

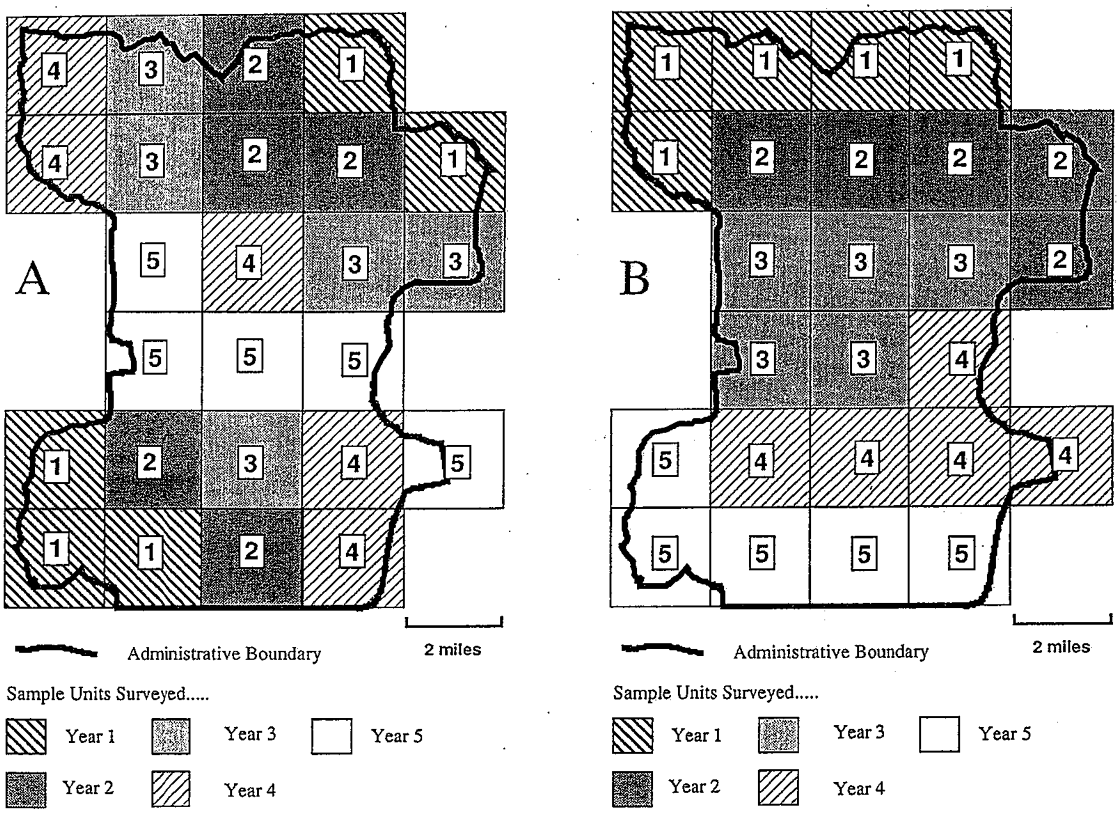
(3) *Systematic surveys.* Each year, distribute the number of sample units for which you have funding or personnel to survey evenly across the administrative area. Survey the same number of new sample units each successive year until all the sample units have been surveyed.

Hypothetical results of surveys conducted in any one of these ways is presented in *fig. 5*.

Project Surveys

A Project Survey is conducted prior to a proposed management activity (e.g., timber harvest, recreational development). Projects vary in size, but are typically small relative to the size of the home ranges of the species considered here (with the possible exception of marten). With small projects, surveys conducted only within the boundaries of the project have a poorer chance of detecting a member of a resident population than surveys in larger areas. If a target species is not detected during a survey, that should not be interpreted to mean that the species does not use the area at some other time or that it does not occur immediately adjacent to the project. As good as our detection methods appear, their efficiencies have not been adequately tested. This uncertainty demands a conservative approach. It is important to determine use on adjacent areas because this should be considered in evaluating a project's indirect and cumulative effects on habitat suitability. For these reasons we recommend that every project be centered on a *minimum* survey area equivalent to the size of a township (36 mi^2) (e.g., *fig. 6*).

The 36-mi^2 area should be delineated and divided into nine, 4-mi^2 sample units. Each 4-mi^2 sample unit should be surveyed as described above for Regional Surveys until either the maximum effort recommended for the method has been expended or the target species has been detected. It is important to emphasize, however, that a detection



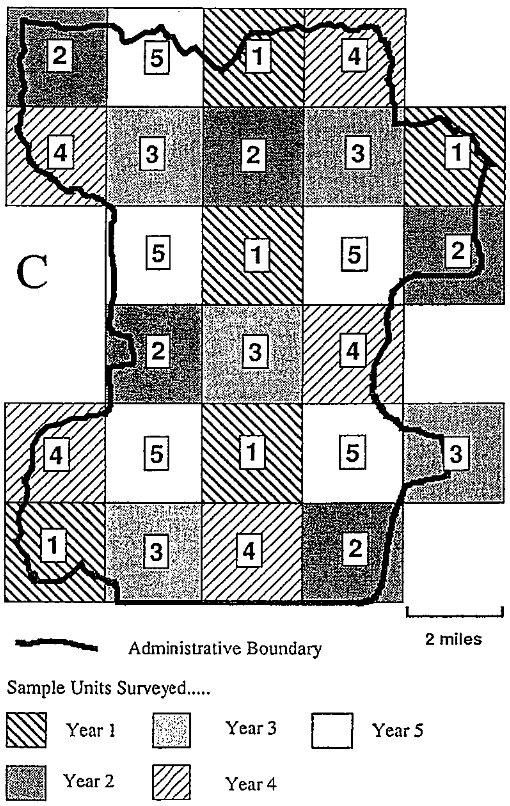


Figure 4—Three hypothetical options for scheduling a Regional Survey of a 100-mi² administrative area that includes 25 sample units. Stratification by (A) expectation of success, (B) directional coverage, and (C) systematic coverage.

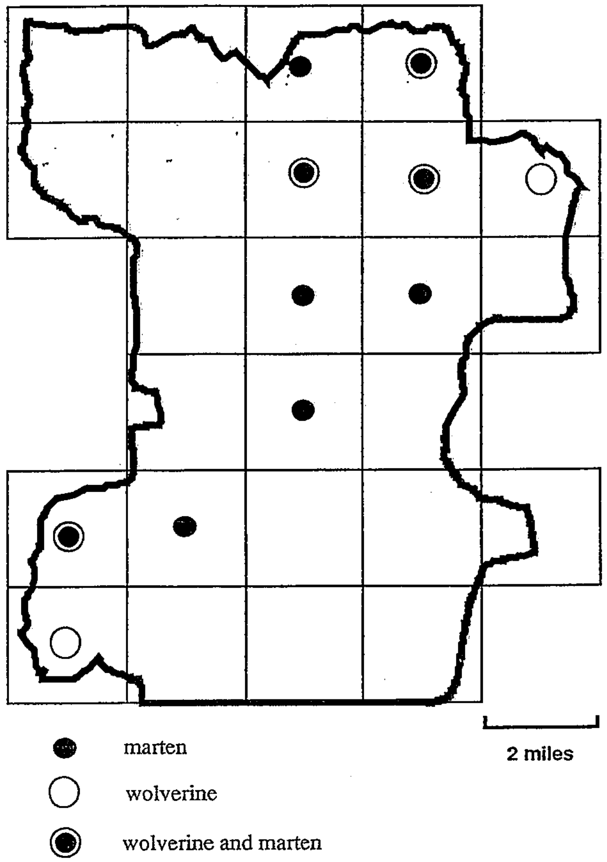


Figure 5—Hypothetical results of the completed surveys on a 100-mi² study area. Each sample unit is reported as either occupied or not occupied after the survey is complete, regardless of the number of detections that have occurred.

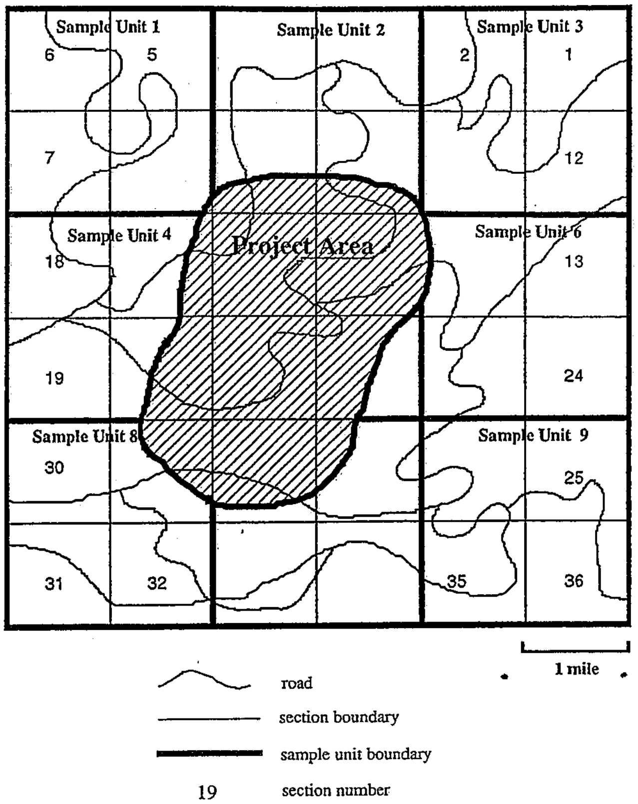


Figure 6—Schematic representation of a simulated survey area for a proposed project (e.g., timber sale, recreational development). The approximately 4,000-acre project area is centered on a township-sized (36-mi²) area that is composed of nine, 4-mi² sample units (see also *figs. 1-3*).

in one of the nine sample units should not trigger the termination of survey efforts on all nine sample units. Each of the nine sample units should be surveyed until either a species is detected or the maximum effort is expended.

Several options for survey schedules exist, but we suggest that the sample units that include the project area be surveyed first and, based on resources available, the sampling sequence thereafter proceed from sample units nearest the project to those furthest from the project boundary.

Photographic Bait Stations

Thomas E. Kucera,[1] Art M. Soukkala,[2] and William J. Zielinski[3]

Introduction

There are a variety of systems in use that employ a camera at a bait station to detect wildlife. We will describe three that are widely used and with which we are most familiar. They can be divided into two major categories according to the type of camera used. The first employs automatic, 35-mm cameras and can be further divided into two types that differ by the mechanism that triggers them. We will refer to these types as "single sensor" (Kucera and Barrett 1993, 1995) and "dual sensor" (Mace and others 1994). The second major category is a line-triggered system that uses a manual, 110-size camera (e.g., Jones and Raphael 1993). We provide data on equipment costs and discuss the relative merits of the various systems in a later section of this chapter.

Remote-camera systems are currently available from several manufacturers (e.g., Cam-Trakker, 1050 Industrial Drive, Watkinsville, GA 30677; Compu-Tech Systems, P.O. Box 6615, Bend, OR 97708-6615; Deerfinder, 1706 Western Ave., Green Bay, WI 54303; also see Bull and others 1992, Laurance and Grant 1994, Major and Gowing 1994, Danielson and others 1995).[4] All employ somewhat different configurations and have different advantages and disadvantages. The cameras used in these systems also change as camera models are discontinued by manufacturers and new ones are introduced. Thus, the systems we describe in this document may differ from what is available in the future, and the reader who wishes to use remote photography to detect wildlife may need to modify specific procedures as appropriate for the equipment in hand. As remote-camera technology advances, it is likely that additional designs will continue to be developed.

Description of Devices

Single-Sensor Camera System

The single-sensor system that we will describe here is the Trailmaster TM1500 (Goodson and Associates, Inc., 10614 Widmer, Lenexa, KS, 66215, 1-800-544-5415), which consists of an infrared transmitter and receiver, used with the TM35-1, an automatic, 35-mm camera (*fig. 1*). The camera is triggered when an infrared beam is broken; such an occurrence is termed an "event." The transmitter emits a cone of infrared pulses. Because the receiver has an area of sensitivity of about 1 cm in diameter, the effective beam diameter is about 1 cm, thus requiring precise placement to intercept the target animal. The transmitter and receiver may be placed as far as 30 m apart. Their alignment is facilitated by a sighting groove on the receiver and a red light that flashes during the setup procedure to indicate that the beam is being received; this light stops flashing when the system is in data-collection mode.

The receiver also is an event recorder that stores the date, time, event number, and whether a picture is taken each time the beam is broken. A maximum of 1000 events can be stored. The sensitivity of the trigger—that is, the length of time the beam must be broken or, more accurately, the number of infrared pulses that must be blocked to register as an event—can be adjusted by the user from 0.05 to 1.5 seconds. The time

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[4]The use of trade or firm names in this publication is for reader information and does not imply endorsement of any product or service by the U.S. Department of Agriculture.

after a photograph is taken until the next can be taken (the "camera delay") also is set by the user, from 0.1 to 98 minutes. If the beam is broken during the camera delay, events are still recorded and stored. The transmitter and receiver are each powered by four alkaline C-cells, which last approximately 30 days of continuous field operation. Both units come with nylon straps about 70 cm long for attachment to trees.

The most recent (November 1995) Trailmaster configuration employs an Olympus Infinity Mini DLX camera; earlier models used a Yashica AW Mini or an Olympus Infinity Twin. These camera changes were dictated by the availability of the models from the manufacturer; users of the equipment must become familiar with the operations of the particular camera they have. The components of the different systems, such as receivers and cables, are not interchangeable and should not be mixed up. The camera is modified to be triggered by an electrical pulse from the Trailmaster receiver. A quartz clock in the camera allows display of date and time on the photograph. The camera connects to the receiver with an 8-m wire, providing flexibility in the placement of the camera. Several cameras can be triggered simultaneously with the use of an optional multi-camera trigger. The flash can be operated automatically as required by available light, in fill-in flash mode so that the flash operates with every frame, or the flash can be turned off. With 100-ASA film, the flash illuminates to about 3.5–6 m, depending on the camera model; with 400-ASA film, this distance is doubled. Infrared film also may be used with an infrared filter over the flash. Slave flashes, triggered by the flash of the camera, can be used to extend the area illuminated.

Figure 1—Single-sensor equipment. From left to right: transmitter, receiver, and camera. Above the camera is the metal shield that protects it. Immediately below the camera is a ball-and-socket head bolted to a metal L-bracket for attachment to a tree; below that is the "tree-pod" that comes with the system. The camera is attached to the receiver with an 8-m wire.

The Olympus Infinity Mini DLX in the newest Trailmaster configuration can use either one 3-v lithium or two AA alkaline batteries. In normal use, the lithium battery will operate through about 14 rolls of 36-exposure film, and the alkaline batteries about 10, assuming flash on half the exposures. At a bait station, because the camera is constantly on and the flash is charged, the battery may last only 30 days. The quartz clock is operated by the camera battery. The capacitor that charges the flash in the Olympus Infinity Twin camera used in earlier models drains after 2-4 days if no photograph is taken. Thus, if the camera is not triggered, or is not reset by closing and opening the lens hood during this time, the flash may fail to operate the first time the camera is triggered. This does not happen with the Yashica, which keeps the flash charged at all times. However, the batteries in the Yashica must be changed more frequently. The Olympus Infinity Twin uses two 3-v lithium batteries, which will last through approximately 20 rolls of 36-exposure film, assuming the flash operates on half the frames. The Yashica camera uses 2 AA batteries, which last approximately 2 weeks. The quartz clock is operated by a separate 3-v lithium battery that will last 3 years.

The system comes with a 10-cm, collapsible, plastic tripod with a threaded ball-and-socket head that screws into the bottom of the camera. A metal bracket shields the top and back of the camera and prevents birds from pecking the controls while allowing access to the viewfinder; the metal bracket also provides some protection for the lens from rain or snow if the camera is operated in landscape format. The tripod is designed to be placed on a flat surface, or when collapsed, attached to a small tree or branch by a Velcro strap. The attachment of the camera to a tree or other support can be greatly improved by using a more substantial ball-and-socket head purchased at a photographic supply store (the Bogen model 3009 works well), attaching this to a metal "L"-bracket with a bolt, and fixing the bracket to a tree with lag bolts (*fig. 1*). This is a much more secure and convenient alternative.

The entire system weighs about 2 kg with batteries, and can be transported in a 25- × 20- × 10-cm box. It is weatherproof and operates in rain and snow. We tested low-temperature operation of an early model using the Olympus Infinity Twin in a freezer, and it performed consistently at −17 °C for 2 weeks and at −7 °C for 2 more weeks.

Also available from the manufacturer (Goodson and Associates) is a device that allows electronic collection of data (date and time of all events, and which events triggered the camera) in the field for later transfer to a personal computer; the data can also be transferred directly from the receiver to a personal computer. The collector is particularly useful when you check several stations in a day by reducing the time you spend recording data at each station. The software package required for downloading from either the receiver or collector provides output in the form of text (event number, date, time, and frame number) and a graph showing events by day and time in a 3-dimensional bar chart. Trailmaster also makes a battery-operated printer that produces a hard copy of the event data in the field.

Dual-Sensor Camera System

The dual-sensor remote camera system consists of an automatic 35-mm camera modified to be triggered by a microwave motion and a passive infrared heat sensor (Mace and others 1994; *figs. 2A, 2B*). Dual-sensor systems are made by Compu-Tech, Trailmaster, and Tim Manley (524 Eckleberry, Columbia Falls, MT, 59912, 406-892-0802). Although the Trailmaster TM500 dual sensor (*fig. 3*) has recently been field-tested and proved reliable and lightweight (K. Foresman, pers. comm.), we will describe the use of the equipment from the last source, sometimes referred to as the "Manley" camera. These three systems share many similarities. If you are using a dual-sensor system from another manufacturer, the procedures described below will need to be altered as required by the

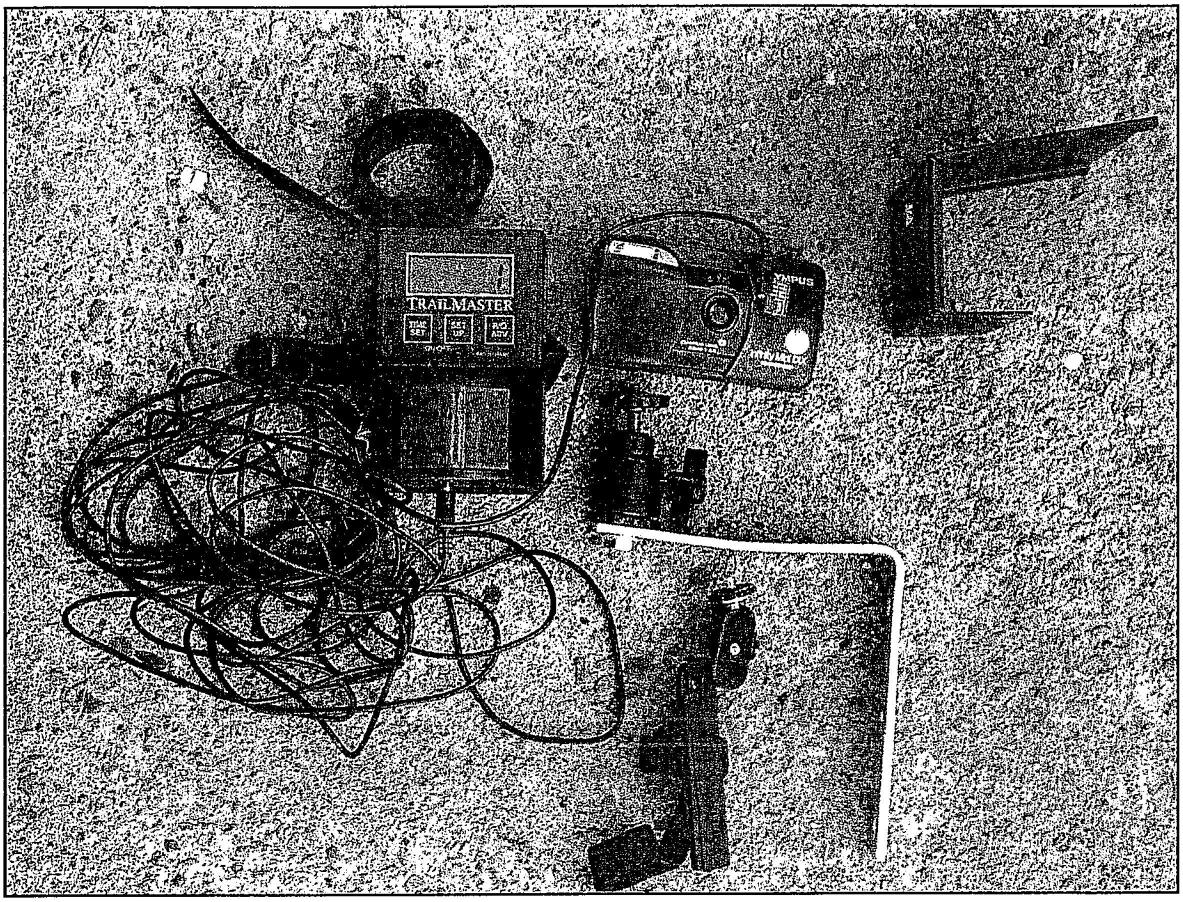

Figure 3—The Trailmaster TM500 dual-sensor camera system. From left to right: dual-sensor unit, camera, and metal camera shield. Immediately below the camera is a ball-and-socket head bolted to a metal L-bracket for attachment to a tree; below that is the "tree-pod" that comes with the system. The camera is attached to the receiver with an 8-m wire.

particular system employed. Again, because of the availability of particular camera models from the manufacturers, specific designs of the system are likely to change.

In normal operations, both the microwave sensor that detects motion and the passive infrared (PIR) sensor that detects changes in ambient temperature are triggered simultaneously and operate the camera. If either sensor malfunctions (e.g., the microwave sensor loses its signal, or if ambient temperature approaches the body temperature of a target animal), the other sensor will take priority and will work like a single-sensor system. Both sensors send out a field to approximately 11 m. The camera is triggered when an animal enters the field, which can be restricted to several meters wide by obstructing the PIR sensor window. The sensors draw 35 mA from the 12-v gel cell (golf-cart type), deep-cycle battery used to power the system. This rechargeable battery should last for 20 days between charges.

Early versions of this system used an Olympus Infinity Jr. camera, modified to be triggered by an electrical pulse from the sensor. The camera focuses from 0.7 m to infinity; the flash illuminates to 4.5 m with 100-ASA film and 9 m with 400-ASA film. The flash can be operated automatically as required by available light, continuously on every picture in fill-in mode, or the flash can be turned off. The capacitor that charges the flash drains after 3-4 days if no picture is taken. Thus, if the camera is not triggered or is not reset by closing and opening the lens hood, the flash may fail to operate the first time the camera is triggered. The camera is powered by a 3-v lithium battery that will last through 20 rolls of 36-exposure film, assuming the flash operates on approximately half the pictures. However, because the light meter is on continuously while the remote camera is operating, the camera battery may last only 1-2 weeks depending on how many rolls of film are exposed, how many flash pictures were taken, and the ambient temperature. The camera is equipped with a quartz clock that allows displays of date and time on each photograph; the clock is powered by a 3-v lithium battery that will last several years.

The entire system is housed in a weatherproof 15- × 30- × 19-cm metal ammunition box that will withstand moderate abuse (e.g., from a bear) without being damaged. An external switch allows the system to be turned on and off without opening the box. The box can be modified to allow it to be locked shut and cabled to a tree to discourage theft and vandalism. The system comes with a mounting bracket and lag bolts for attachment to a tree. Total weight is approximately 13.6 kg including the 12-v battery.

Line-Triggered Camera System

This is an inexpensive, remotely triggered system, assembled by the user, that employs a 110-size camera (*fig. 4*). We have the most experience with the Concord 110 EF and CEF with internal, electronic flash (a distributor can be contacted by calling 908-499-8280), but similar models may be satisfactory. It is essential that the camera have an internal flash; "flash bars" and "flash cubes" have a high failure rate in the field. Each camera should be identified with a unique number engraved or written on the body with permanent marker.

The system is composed of the camera, a wooden mounting stake, a cover from a plastic gallon milk jug, an external battery pack, and the trigger mechanism. The mounting stake is a 1- × 3- × 36-inch post topped with a 0.05- × 2.75- × 5.0-inch wooden platform (*figs. 5, 6*). The platform should be firmly screwed to the top of the post because this is the surface on which the camera is attached. Avoid using plywood for the platform.

The camera can be adequately weather-sealed for most conditions by putting a strip of electrical tape over the trigger release and a second strip over the flash switch area (*be sure the switch is ON*). However, in rainy conditions, the camera should be covered with

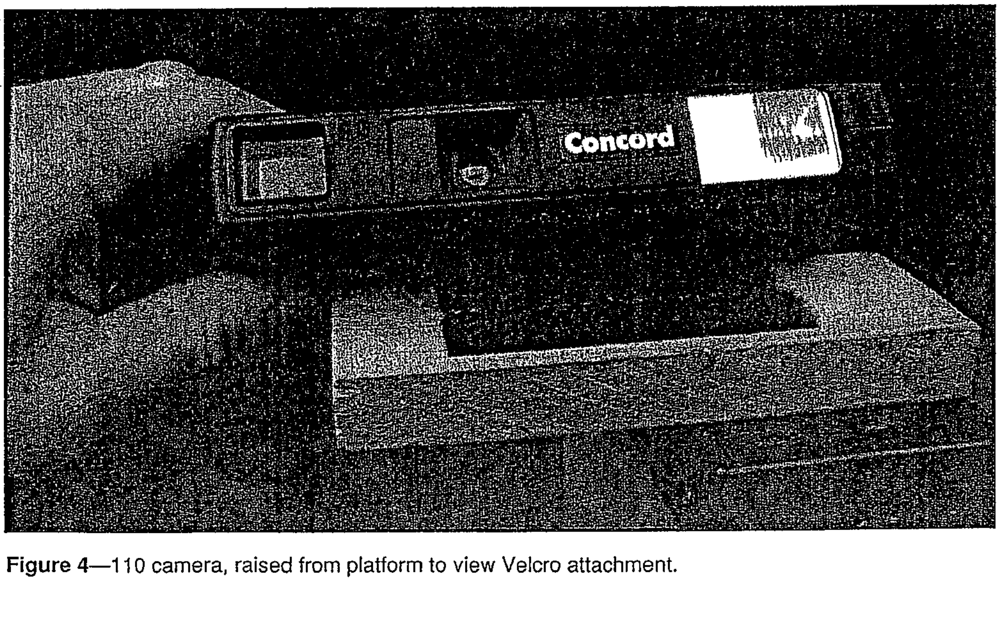

Figure 4—110 camera, raised from platform to view Velcro attachment.

half of a 1-gallon milk jug (*fig. 5*). Staple Velcro to the milk jug and to the vertical surface of the platform board to hold the jug in place. Position the Velcro pads to avoid obstructing the nylon leader that comprises the trigger mechanism (see below) as it exits the camera. Camouflage the jug with dark green or brown spray paint to reduce the chance of its discovery by passers-by.

Unlike previous versions in which a coat-hanger-wire mechanism triggered the shutter (Fowler and Golightly 1993, Jones and Raphael 1993), the design presented here employs a line from the bait that connects directly with the shutter mechanism *inside* the camera (L. Chow, pers. comm.). Familiarize yourself with how the 110 camera works by opening the rear of the camera and watching inside while tripping the shutter and operating the film-advance mechanism several times. Look for a flat, triangular lever that snaps backwards when you trip the shutter. This is the internal shutter release. Trip the shutter to disengage the internal shutter release from the toothed gear. Drill a small hole (using a #68 or #70 gauge drill bit) in the underside of the camera, approximately 2 mm from the rear edge of the camera. Position and angle the hole so it is just behind the internal shutter release. Make a loop in a 12- to 15-inch length of a 2-lb test nylon fishing leader. Fold and pass the loop through the hole and, using forceps, hook it over the internal shutter release. Secure the loop by knotting it outside the camera an inch or two from the hole; a knot inside the camera may prevent the shutter release from operating properly.

Because the factory-suggested batteries for the camera are insufficient to provide energy for more than a few days, additional power must be provided. Build an auxiliary battery unit that will house two size D batteries (*fig. 6*). House the batteries in a standard, open, plastic battery pack, available at electronics stores. The D-cell unit should be connected to the battery terminals in the camera by stereo wire that is soldered from the battery pack to the contacts in the camera battery compartment; if wires are provided with the battery pack, use them. The Concord 110 requires very little modification to solder the wires to the battery terminals in the camera's battery compartment. After soldering the wires, cut a small hole in the camera's battery compartment door to allow entry of the wire from the auxiliary battery unit. Seal this hole with silicone. The battery compartments of other camera brands (e.g., Vivitar and Focal) require that some of the plastic body be cut away to access the internal battery terminals. Attach the battery pack to the bottom of the platform board with short screws or rubber bands; Velcro is inadequate to support the weight of the batteries.

Baits and Lures

Recommendations:

With the 35-mm systems, we recommend using road-killed deer, fish, or a combination of the two. The amount used should be as large as possible, up to a whole deer carcass, but at least 5 kg. With the line-triggered system, chicken wings are the recommended bait. Also use a commercial lure and, especially for surveys for lynx, a visual attractant (e.g., hanging bird wing, large feather, or piece of aluminum).

Mustelids

Wolverines, fishers, and martens are opportunistic hunters, and the great diversity in their diets reflects this (Banci 1989, Hash 1987, Martin 1994). In addition to taking live prey, they frequently scavenge in winter and can be attracted to carcasses of ungulates (Hornocker and Hash 1981; Pittaway 1978, 1983). Thus, road-killed deer (*Odocoileus* sp.) are probably one of the most readily available baits to attract these species to 35-

mm camera stations. However, because it is illegal to handle or transport road-killed deer without appropriate permission, coordination with the state game agency is necessary before handling and transporting them.

In many areas, road-killed deer are available seasonally; this may require planning in order to have bait for the field season. Storing deer can be a challenge; a large freezer such as at fish hatcheries or cold box at some National Forest System ranger districts often is necessary. The bigger the bait the better, but handling whole deer carcasses can be difficult. An important requirement is that the bait be large enough to remain attractive until it is scheduled to be replaced. We recommend a piece of road-killed deer weighing at least 5 kg. One approach to increase the convenience of storage and transport of bait is to quarter deer when fresh and freeze the pieces in individual plastic bags. The frozen packages can be transported when needed, eliminating the need to cut up frozen carcasses. Another attractant being experimented with is cow blood, frozen in gallon milk jugs, from a slaughterhouse. Putting an anticoagulant in the blood will keep it in a liquid state. At the camera station, perforate the jug to allow the scent to escape and suspend the jug from a cable, approximately 3.5 m above the ground.

Commercially available trapper lures such as skunk scent may be valuable to attract the mustelids, and we recommend that they be tried and evaluated in conjunction with the bait. Two sources of such lures are the M & M Fur Company, P.O. Box 15, Bridgewater, SD 57319 (605-729-2535) and Minnesota Trapline Products, 6699 156th Ave. NW, Pennock, MN 56279 (612-599-4176). Standard predator-survey disks containing fatty acids can be obtained from the Pocatello Supply Depot, 238 East Dillon St., Pocatello, ID 83201. In several areas of California, fish emulsion sold as fertilizer in garden-supply stores and used in conjunction with deer carrion has been used to attract fishers and martens. Brands vary in the strength of their odor. Mixing vegetable oil or glycerin with the fish emulsion may retard evaporation and thus extend the attractiveness of the scent.

Lynx

Lynx rely heavily on a single prey species, the snowshoe hare (*Lepus americanus*), although they do take other small mammals, birds, and carrion, particularly when hares are rare (Hatler 1989). This requires somewhat different strategies in attempts to detect them. The typical set used to trap lynx employs a scented lure (e.g., commercially available skunk scent and some catnip) in addition to a visual attractant or "flasher" such as a grouse wing, a turkey primary feather, or an aluminum pie plate on a string above the trap (Baker and Dwyer 1987, Geary 1984, Young 1958). Once attracted to the general area by the scent, the animal sees the object moving in the wind and comes to investigate it. A similar arrangement could be used to attract lynx into the beam of the single-sensor, or within the range of the dual-sensor camera. Scents are probably best purchased from a commercial supplier. A set employing carrion, a scent, and a bird wing conceivably could attract any of the four target species.

Survey Seasons

Recommendations:

35-mm systems: Conduct surveys in winter. Bears are least active during winter, and the dual-sensor cameras operate best in cool temperatures.

Line-triggered system: Conduct one survey in the spring, shortly after snowmelt, and if the target species is not detected, conduct another in the fall. The line-triggered camera system works best in snow-free conditions.

Survey Duration

Recommendations:

35-mm systems: Operate each station until either the target species is detected *or* a minimum of 28 days have elapsed.

Line-triggered system: Stations should be set for a minimum of 12 nights and checked every other day for at least six visits (excluding setup) *or* until the target species is detected. If the target species is not detected during the first 12-day session, run a second session during the alternate season (either spring or fall) for at least 12 days *or* until the target species is detected.

Allow extra days to achieve the recommended duration if the camera becomes inoperative.

Because the objective of the survey is to determine whether the target species is present in a sample unit, effort need not be expended beyond the detection of the target species. The minimum duration that a 35-mm camera station should operate without detecting a target species is 28 days. We based this minimum effort on data on "latency to first detection" of wolverines and American martens. Using dual-sensor systems, J. Copeland (pers. comm.) detected wolverines at six stations with a mean latency of 38 days; the median latency was 17 days. Mean latency to first detection at dual sensor cameras in Montana was 13.5, 9.0, and 13.0 days for martens, fishers, and wolverines, respectively (Foresman and Pearson 1995). Kucera[5] detected American martens at 25 single-sensor stations after a mean of 7.9 days and a median of 5 days.

[5] Unpublished data on file at the Department of Environmental Science, Policy, and Management, University of California, Berkeley, CA.

We set the minimum effort when using line-triggered cameras at 12 nights in response to several sources of information on the latency to first detection for marten and fishers. In reviewing the results of 207 surveys that used either track plates or line-triggered cameras, Zielinski and others (1995) found that the mean (SD) latency to first detection for surveys that had from 6 to 12 stations was 4.2 (2.4) and 3.7 (2.6) days for fisher and marten, respectively. This estimate is biased downward, however, because it included only those surveys that detected a target species before the survey was concluded. Raphael and Barrett (1984) suggested that 8 days were sufficient to achieve high detection probabilities when measuring carnivore diversity at a site. Jones and Raphael (1991), however, discovered that 60 percent (3 of 5) of first detections during marten surveys occurred after day 8 but before day 11. They concluded that surveys should run more than 11 days. Fowler and Golightly (1993) suggested a 22-day survey duration, but this was with the intention of using track-plate visits to monitor population change. Because the objectives of detection surveys are different, and because the statistical merits of their approach have not been adequately addressed, 22 days is probably excessive for detection.

Because visits by lynx and wolverines to line-triggered camera stations have not yet been recorded, there are no data on which to base recommendations for survey duration. Until appropriate data are collected to suggest otherwise, we believe that the 12-day duration, twice per year if necessary, is sufficient effort.

Preparations for the Field

Defining the Survey Area

Recommendations:

Conduct surveys in 4-mi^2 sample units, as described in Chapter 2.

Chapter 2 discusses the two types of survey, Regional Distribution and Project Level. The investigator should decide which type is appropriate for the planned work and outline the survey area on a map. In both types of survey, we recommend the use of separate, 4-mi^2 sample units as the basis of the survey. For a Regional Distribution survey, the region of interest should be defined on a map, and the 4-mi^2 sample units located as suggested in Chapter 2. A Project Level survey will include a 36-mi^2 area, with nine sample units, centered on the project.

Station Number and Distribution

Recommendations:

35-mm systems: Use a minimum of two cameras in each sample unit, no closer than 1 mile apart, at the sites of the most appropriate habitat or where unconfirmed sightings have occurred.

Line-triggered system: Use a minimum of six camera stations in each sample unit. Arrange stations in a grid, distributed at intervals of about 0.5 mile, at the site in the sample unit with the most appropriate habitat or where unconfirmed sightings have occurred (see Chapter 2, *fig. 2*).

Within each sample unit, place the detection devices (minimum of two 35-mm or six line-trigger cameras) where a detection is most likely. This could be in an area thought to have the most suitable habitat or near an area of previous reports of occurrence or likely travel routes, as discussed in Chapter 2. However, in doing so, try to maintain the inter-station spacings recommended above.

Two 35-mm cameras are an adequate minimum density per sample unit because they can operate longer for the same personnel costs than the line-triggered cameras, and the larger baits used should attract target individuals from a greater distance. The number of line-triggered cameras in a survey can influence its success (Zielinski and others, 1995). Although the data are too few to estimate the optimum station number, it seems reasonable to have detection stations that sample at least 10 percent of the area in the sample unit for the survey duration. Six stations provide at least 12.5 percent coverage of the sample unit if they are arrayed as a rectangle and one assumes that a target individual will be detected if it travels within the area created by joining the perimeter stations. Of course more stations will provide a greater assurance in detecting occupants, but more than 12 stations (covering 1.5-mi^2; 37.5 percent of the area) would probably be excessive.

If there is no reason to place the line-triggered camera stations either at the most suitable habitat or where previous sightings occurred, array the stations as a grid in the center of the sample unit. Wherever the grid is placed, adjust its shape to accommodate road access in the vicinity. If the sample unit is roadless, pack the materials into the area.

In the Field

Before you go out, become familiar with the operation of the device you are using. Practice with it so that you are comfortable with its operation. When using the single-sensor system we describe, understand its commands, know how to program it, read out the event data, clear it, change batteries, and know where in the manual to look for instructions for a particular topic you need help on. This is *much* more easily done in the warmth of home or office than in the field.

In the field, do not go alone, especially during winter. Tell someone where you are going and when you will return, and what to do if you do not return by a certain time. Be aware of the weather forecast, have appropriate gear, and expect the worst. Remember that ease of access can change drastically as snow conditions change. Be sure you have all the necessary equipment; a list is provided below (Equipment List).

The major considerations for establishing stations in the field are maximizing the probability that they will be found by the target animal species and minimizing the likelihood that the station will be found by people. Mark the station permanently with a metal tag or stake, and precisely describe its location. If possible, use a Global

Positioning System to determine the location. This will allow future study efforts to replicate your work.

Winter Safety

Surveys using 35-mm cameras will be conducted primarily during winter when potentially hazardous conditions frequently exist. It is the responsibility of the supervisor to evaluate potential hazards in the survey area and to obtain proper training for all personnel before they go into the field. Field biologists often assume they know how to get along in the outdoors. Surveying for rare species during winter may test those assumptions; being a field biologist does not guarantee competence to conduct fieldwork in winter.

Job descriptions and training for field technicians should stress winter field skills including skiing, snowshoeing, snowmobiling, camping, and avalanche training. Proper winter equipment must be provided to each field person. Employees should be trained by in-house experts or at one of several established winter training schools. Lists of winter camping and avalanche training schools are provided in Chapter 5 under Safety Concerns. Two excellent references on avalanches are by Armstrong and Williams (1986) and Daffern (1992). Selected references on winter outdoor skills include Forgey (1991), Gorman (1991), Halfpenny and Ozanne (1989), Pozos and Born (1982), Schimelpfenig and Lindsey (1991), Weiss (1988), Wilkerson and others (1986), Wilkerson (1992), and Wilkinson (1992).

Handling Bait

Uncooked meat baits are a potential source of *Salmonella* bacteria, so meat should be wrapped in plastic and frozen until the day it is used. Contact with either fresh or old bait should be minimized. Plastic bags can be used as gloves to reduce contact, and for smaller pieces of bait, kitchen tongs can be used. Carry soap, water, and disposable wipes so that you can wash your hands thoroughly after handling bait. Careful attention to cleanliness will make the risk of contamination from rotting meat, including chicken, negligible (J. Sheneman, pers. comm.). The risk of poisoning the target species with rotting meat baits is very low, as most target species regularly consume carrion.

Station Setup

Single Sensor

A soft-sided cooler bag is convenient for carrying the Trailmaster and provides some protection. Be sure that the receiver is programmed for the correct date and time, for pulses = 10 (**-P 10**), and for camera delay = 2.0 (**cd 2.0**). These are initial recommendations; change them if you have reason. For example, make the trigger more sensitive (fewer pulses) if bait is being taken but no events recorded, or increase the camera delay if a non-target animal such as a squirrel is shooting up a lot of film. Make sure that the receiver is programmed to activate the camera (see the Trailmaster manual, p. 12). A short summary of Trailmaster commands is presented in *appendix B.*

Load film into the camera. Print film of 100 ASA works well, is relatively inexpensive, and can produce enlargements of acceptable quality. Using a small, blunt tool, synchronize the date and time on the camera display with the receiver, and set the display to show the date (day number) and time, not month or year or other configuration. With the Olympus Infinity Twin, be sure that the horizontal bar over the minutes digits is showing, which indicates that the information will appear on the film.

For mustelids, an ideal site has three trees, 15-30 cm in diameter and 3-10 m apart, lined up in a north-south direction with the middle tree slightly (15 cm) offset, and a

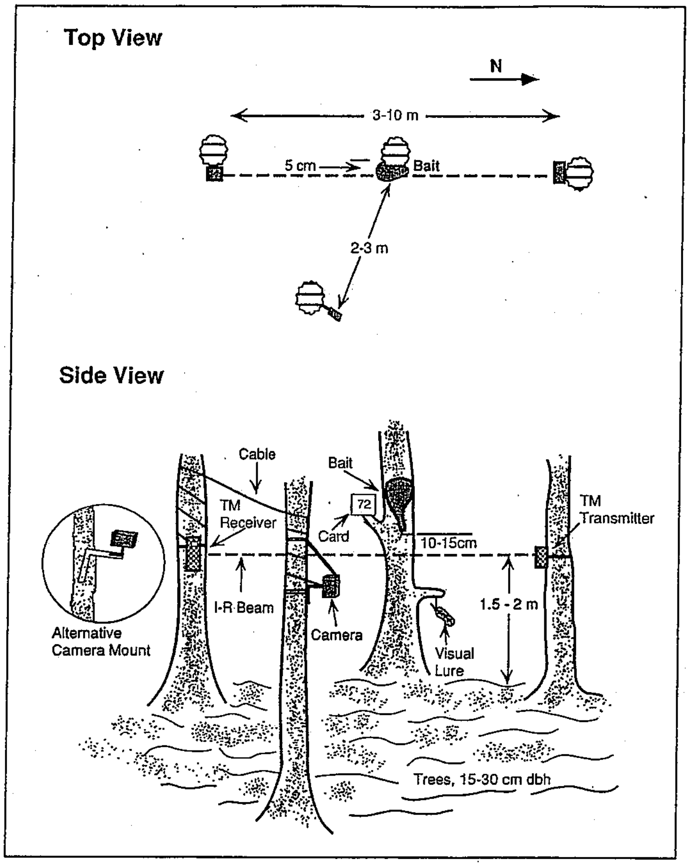

Figure 7—Schematic configuration of a single-sensor camera station.

fourth tree or a branch 2-3 m from the middle tree with a good view of it (*figs. 7, 8*). The transmitter will be in the middle of the trunk of the northernmost tree facing south, and the receiver will be on the east side of the trunk of the southernmost tree with the receiving window pointing north. This orientation is important to prevent solar infrared radiation from reaching the receiver and causing false events to be recorded. The bait will be on the middle tree, and the camera will be on the fourth tree. As an alternative, the camera can be above the receiver on the same tree. The beam should pass within 5 cm of the middle tree about 1.5-2 m above the ground. With some practice, you can easily identify the appropriate configuration of trees. Do not use trees that will move in the wind, and trim any branches that could blow into the beam or block the camera.

It is best to have one person handle the bait and another the equipment, so that no odors from the bait get on the equipment. Hang the bait along the trunk of the middle tree so that it is at least 2 m above the ground to prevent canids from reaching it. In areas of heavy snowfall, you may need to adjust the height of the bait to accommodate changing levels of snow. Attaching the bait to the tree with wire will prevent loss of the bait if the string or rope is chewed. Trim lower branches to guide animals to the bait through the beam and to eliminate perches for birds and squirrels in the beam. Add any scent as appropriate to attract animals to break the beam.

Position the transmitter on the northern tree and receiver on the southern tree so that the infrared beam passes 10-15 cm below the bait on the middle tree and about 5 cm from the tree, so that any animal climbing the tree to get the bait must pass through the beam. Look down the sighting groove on the receiver, and aim it *precisely* at the transmitter window; this is important for getting the best performance. When the approximate positions of the transmitter and receiver are established (using the receiver in setup mode with its flashing red light), tighten the receiver strap and check the alignment again.

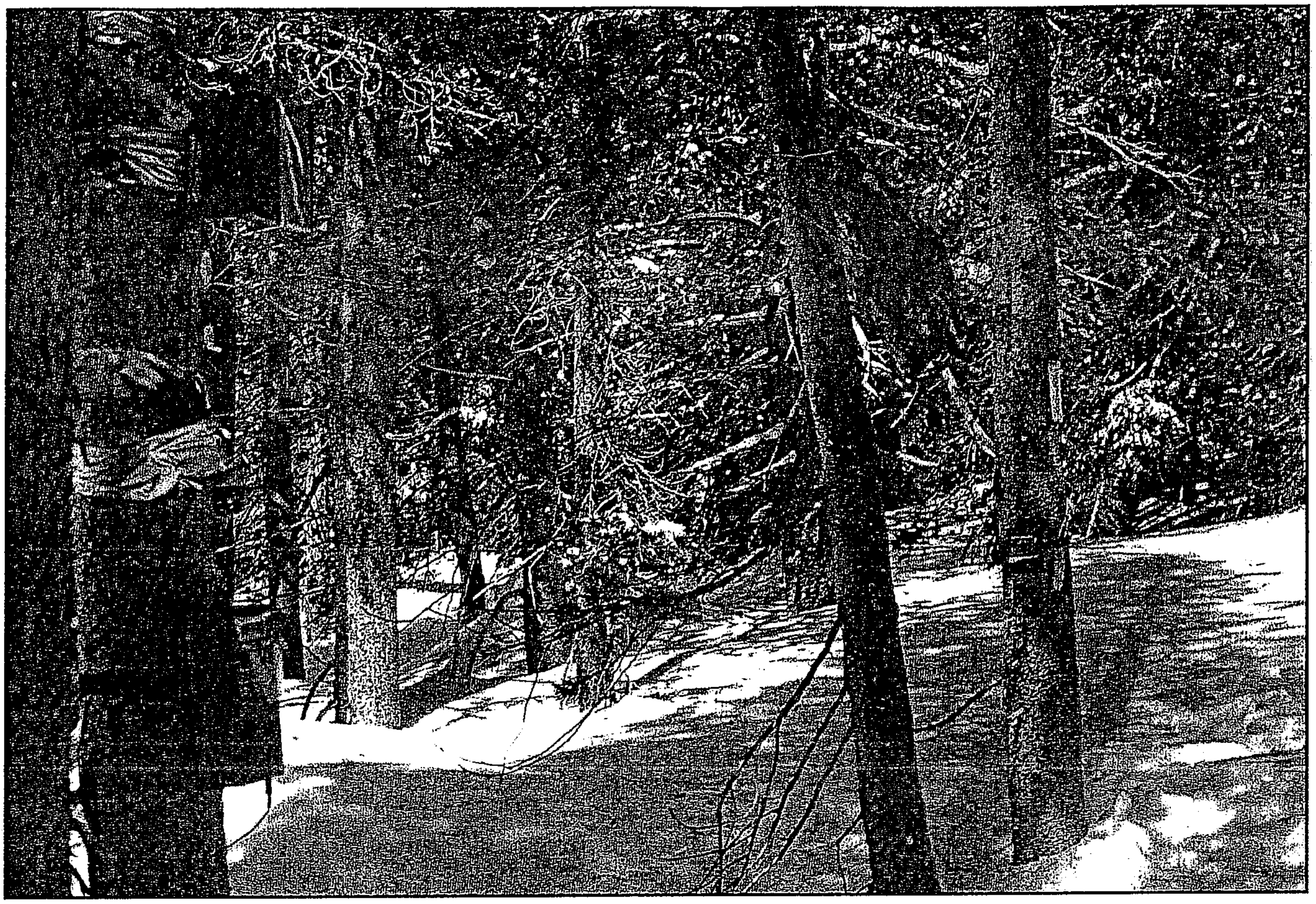

Figure 8—Single-sensor station. Camera and receiver on tree on left, bait (deer leg) on central tree, and transmitter on tree on right.

Loosen the transmitter strap and tilt the transmitter up and down and side to side, watching when the red light on the receiver stops flashing. This is to determine where the central portion of the infrared beam is; fasten the transmitter so that this central portion of the beam hits the receiver. Check the position of the beam relative to the tree and bait by passing your hand through the beam to simulate an animal coming to the bait and watching when the red light on the receiver goes out, showing that the beam is broken. Remember, after 4 minutes the receiver automatically leaves the setup mode and the red light stops flashing. Again, sight down the groove in the receiver; adjust it so that it points directly at the transmitting window and tighten the strap, pushing the points on the back of the receiver into the tree so that the unit is firmly positioned. Visually check the transmitter to determine that the central portion of the beam is directed at the receiver, and adjust it if necessary.

If you are using the collapsible tripod supplied with the Trailmaster, attach the camera to it with the metal bracket shielding the top of the camera. Set the flash mode for **FILL-IN**, so that the flash operates on every exposure, and make sure that the self timer and continuous mode are off. Attach the camera and tree-pod to a tree or large branch about 2-3 m from the bait, with an unobstructed view centered on where you expect the animal to be. Position the camera so that the automatic focus frame in the viewfinder is on the target and not a distant background. The tree-pod should be collapsed; use duct tape to attach it to the tree. Tighten the attachment of the tree-pod to the camera, make a final alignment of the camera to the target, and tighten the ball and socket; this should be done with pliers to achieve a secure connection, but be careful not to strip the threads. A length of duct tape from the camera shield up to the tree helps prevent the camera from tipping down when weighted with snow. As a more secure alternative, attach an L-shaped metal bracket to the tree with lag bolts to provide an attachment for a more substantial ball-and-socket head such as the Bogen 3009 (*figs. 1, 7*).

Run the camera cable from the receiver to the camera, winding it several times around the trees on which the camera and receiver are placed, so that any tugging on the cable (from snow, animals, you falling down) pulls on the tree and not the equipment. Be aware that the cables are specific for the model camera used and are not interchangeable. Be sure you are using the correct one. Run the cable at least 2 m off the ground so that animals and most people pass below it. Do not plug the cable into the camera yet. Trim any branches that could be in the field of view or interrupt the beam when weighted with snow or that could lift into the field of view as snow melts. Attach a blue, 3 x 5 card with the station's identification number written in large letters with a waterproof, wide-tipped marking pen to the tree in the field of view. The card provides a scale for measurement of animals in photos and a record of location. Avoid white cards, which often are overexposed and difficult to read on the photo. Attach a laminated card with the following message to a nearby tree, positioning it out of view except when close to the set:

> This is part of an important wildlife study being conducted by ____________________ . Please do not touch. It is an automatic camera that will take a picture of an animal as it comes to the bait, and will not harm the animal. If you have any questions, please contact ______________________________ .
> Thank you.

Finally, when you think all is ready, plug the cable into the camera and receiver, being sure the cable is plugged in correctly. Reset the event recorder to zero, run your hand through the beam where you expect the animal to be, and be sure a picture is taken and an event recorded. If they are not, check the programming of the receiver (p. 12 in the Trailmaster manual), the camera cable, or the alignment of the beam. Make sure everything is right, and remember the 2-minute camera delay: a picture will not be taken for 2 minutes after the last picture is taken. If necessary, reset the receiver to zero and try again.

Record in your field notebook the number of photographs taken during set-up, the final event number on the receiver, and the date and time of your test photo departure. This will be important information when you return to check the camera. A sketch of the set on the Survey Record form (*appendix A* and in pocket inside back cover) will help identify what configuration works and what does not. Be generous in taking field notes; these will be used in the future to reconstruct what happened, and to analyze what went wrong and right. Use flagging tape to mark the way to the site if necessary, but do not flag the site itself, to lessen the chance of its being found by people.

Dual Sensor

We will describe a station configuration that we have used with the Manley system. If you are using the Trailmaster TM500 or another dual-sensor system, modify the station as the equipment and reason dictate. Before going out, familiarize yourself with the camera and the other components of the system and how they work. The camera will operate without film so the system can be assembled in the office to make sure all components are working properly. Set the camera so that the day, number, and time are displayed and will be printed on each picture. Make sure you have all the equipment on the list provided at the end of the chapter.

An ideal site for the dual-sensor station is the intersection of several game trails. However, if deer densities are high, setting over game trails may produce too many pictures of non-target animals. Choose a site in a sheltered area, if possible, that will be shaded for most of the day. The camera unit produces the best pictures if it faces north. An area along the trail with three trees in a triangle will work best (*figs. 9, 10, 11*). The tree at a southern point serves to support the camera and should be 3.5-5.5 m from the target point. The two other trees support the cable holding the bait and should allow the bait to be at least 3 m from any tree trunk and hang over the trail or target point. Because the Manley dual-sensor camera operates as long as a warm, moving object is in its sensor field, the bait must be inaccessible. An animal should be attracted to the station but leave shortly because it cannot reach and feed on the bait. The Trailmaster TM500 requires setting a camera delay, which avoids exposing all the film in a short time.

Suspend the bait on 1/8-inch cable between the bait trees at least 3.5 m off the ground. Use 10-m cable pieces with looped ends that will allow the cables to be hooked together to reach the appropriate length. Using a climbing belt and either removable tree steps or climbing spurs, attach one end of the cable to one tree. Then climb the other tree, wrap the cable around it as many times as needed, and anchor the cable with a nail through the looped end. Remember to place the cable high enough so the bottom of the bait will be at least 3.5 m off the ground. The bait can be suspended by attaching a rigid wire hook to the bait, roping it up to the cable, and using a pole to push it out along the cable until it hangs over the appropriate target point. If you are using heavy baits, they can be suspended using a pulley system. Attach a pulley to the cable so that when it is strung, the pulley will hang over the target point. Before suspending the cable, tie a rope to the bait (using burlap sacks to contain the bait will help) and put the rope through the pulley. Suspend the cable, keeping in mind that the pulley plus a short length of rope will cause the bait to hang lower. The bait can then be pulled up and the rope tied off to a tree. Attach a laminated card with the following message to a nearby tree, positioning it out of view except when close to the set:

> This is part of an important wildlife study being conducted by ____________________. Please do not touch. It is an automatic camera that will take a picture of an animal as it comes to the bait, and will not harm the animal. If you have any questions, please contact ______________________.
> Thank you.

Climb the camera tree and mount the camera at a location where it is no more than 3-4 m from the target point and sufficiently high in the tree to reduce its accessibility to people and animals (between 3-4 m). By pointing the camera slightly down to the target point, the sensor field will be shortened so that an animal will not trigger the camera before it is close enough to be illuminated by the flash. Secure the camera to the tree using the mounting bracket and lag bolts. Mount the bracket at the approximate angle and direction needed to have the camera point directly to the target point. The camera angle can be adjusted slightly after it is mounted in the tree.

To test that the sensor field is appropriate for the site, position the unit and turn it on without film in the camera. With one person in the camera tree, the other person should walk into the target area from different directions to determine where the sensors first trigger the camera. Adjust the sensor field by blocking part of the sensor with the magnetic strips provided so that the camera is triggered only when the person is near the target point and toward the center of the picture.

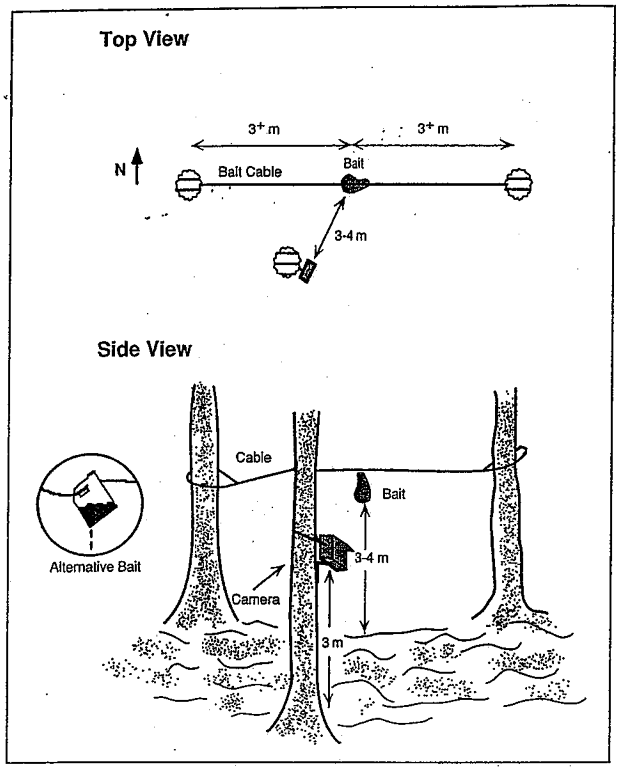

Figure 9—Schematic configuration of a dual-sensor camera station. Meat is used as an attractant, but blood baits can also be used.

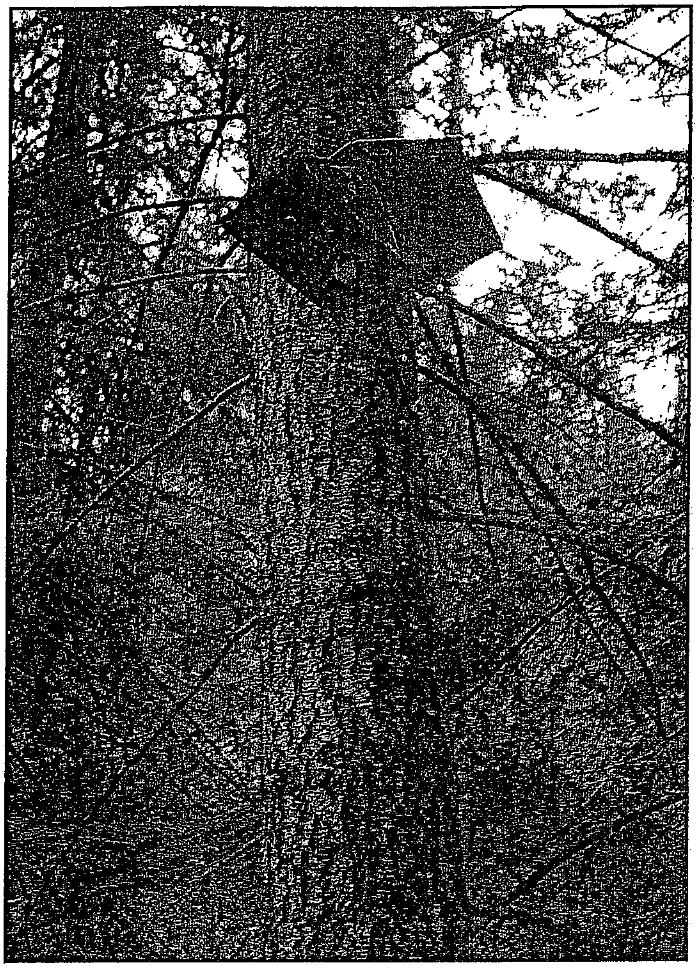

Figure 10—Dual-sensor camera in position.

When the test is complete, load film in the camera and climb down the tree. With a black marker, write the station number on the back of a data sheet. Walk into the sensor field and trigger a single picture so that the station number will be identified in the photograph. Record in your field notebook the number of pictures taken during set-up, and the date and time of your departure from the site. A sketch of the site on the Survey Record form (*Appendix A* and in pocket inside back cover) including directions and approximate distances will help in evaluating the effectiveness of different configurations. Leave the site without walking through the sensor field. Write a short description of how to get to the site (a dot on an orthophoto-quad, topographic map, or aerial photo is extremely helpful), and flag the way to the site if necessary, but do not flag the site itself to lessen the chance of its being found by people.

Line Trigger

These stations are most easily established with two people, one setting up the mounting stake and camera and the other preparing the bait. If only one person is available, the camera portion should be assembled and in place before bait is handled to avoid transferring scent to the camera unit (Jones and Raphael 1993). Avoid putting stations in direct sunlight; light can penetrate these cameras. Remove vegetation so that the camera has an unobstructed view of the bait and the monofilament line is not obstructed (*figs. 5, 6*). Dig a hole about 6 inches deep for the mounting stake, put the bottom of the stake in it, and tap the soil around its base firmly to secure it. Rocks can be used for additional support or to help adjust the angle of the stake.

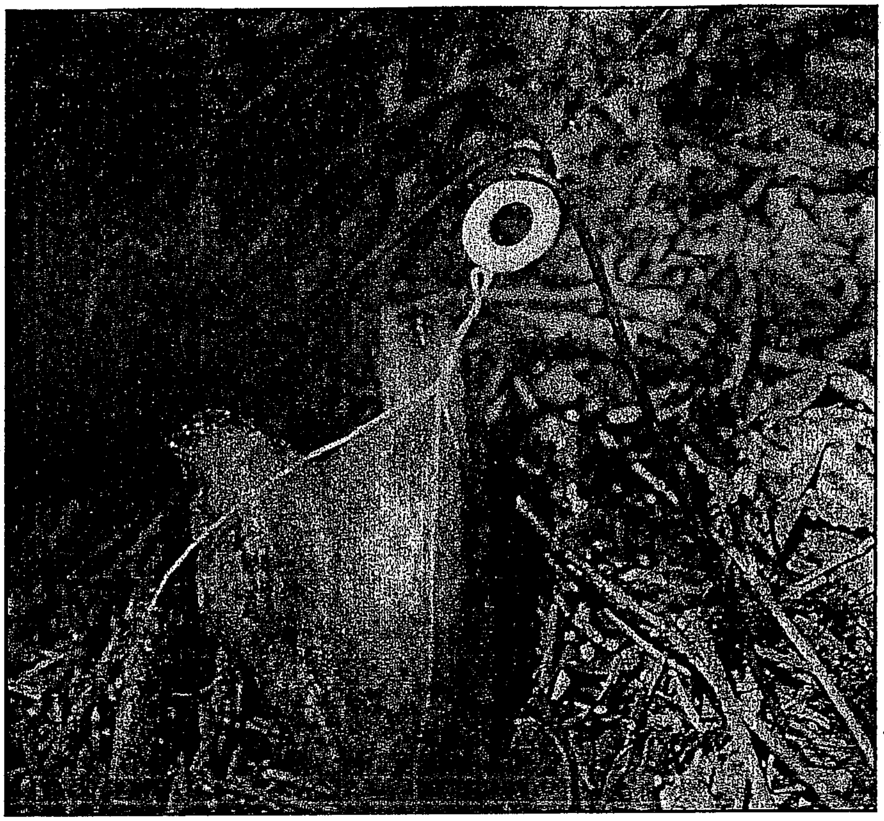

Figure 12—Bait attachment to ground wire, line-triggered camera system.

> This is part of an important wildlife study being conducted by ________________. Please do not touch. It is an automatic camera that will take a picture of an animal as it comes to the bait, and will not harm the animal. If you have any questions, please contact ________________________.
> Thank you.

When you consider the camera "set" in the field, take one or two test shots, holding a label card (a piece of 8 × 8-inch paper with the camera number, date, and station number indicated in large print) in view of the camera. Record in your field notes the number of test shots and the exposure number on which the camera is set when you leave, and then transfer this and other general information onto the Line-Triggered Camera Results form (*appendix A* and in pocket inside back cover).

Checking the Stations

Recommendations:

35-mm systems: Check the station four times at 7-day intervals so that it is operating 28 days *or* until the target species is detected. Allow extra days to achieve the minimum survey period if the station becomes inoperative. Pay particular attention to tracks in the snow near the station every time you check it.

Line-triggered system: Stations should be set for a minimum of 12 nights and checked every other day for at least six visits (excluding setup) *or* until the target species is detected. If the target species is not detected during the first 12-day session, run a second session during the alternate season (either spring or fall) for

12 days *or* until the target species is detected. Allow extra days to achieve the minimum survey period if the station becomes inoperative.

Single Sensor

The station should be checked at weekly intervals to ensure that it is working and that a non-target animal such as a squirrel has not immediately found it and used all the film. Weekly checks are also necessary to check the camera batteries which can discharge rapidly during cold winter conditions (Foresman and Pearson 1995). The station should be checked at least four times at weekly intervals, so that it is operating for 28 days.

Before you leave to check a station, be sure you have new bait and replacement film and batteries, Camera Results form (see *appendix A,* and in pocket inside back cover), contact cleaner and brush, and equipment for recording tracks in snow (see Chapter 5). Be familiar with the tracking material in Chapter 5. This is important. J. Copeland (pers. comm.) detected wolverine visits to photographic bait stations more frequently by tracks in snow than by photographs. Do not go alone, do check the weather, and bring appropriate gear. A list of equipment is provided below.

When you approach the set, look for and identify, describe, measure, photograph, and collect, as appropriate, tracks, scat, or any other sign of what may have been there. Note whether the bait is still present, whether it has been consumed, etc. Has the tree been scratched up, or have any string or wires been chewed or broken? Record these observations on the 35-mm Camera Results form (*appendix A,* and in pocket inside back cover).

Press R/O ADV to cycle through the "events" (i.e., interruptions of the beam). Record on the Camera Results form the date, event number, and time of only those events that caused a photograph to be taken (i.e., those that show a period between the first and second digit locations on the receiver's display; see "Displays" section of the Trailmaster manual). If you miss something, cycle through the data again.

After recording the event data you will know how many frames were exposed. Replace the film if half or more of the frames were shot, or if you suspect from tracks or other sign that a target species has been at the set. To rewind a roll of film before its end, press the rewind button on the bottom of the camera gently with a ball-point pen. Immediately upon removing the film, write the station code and date on it with a marking pen, and put it into a film canister to keep it dry. Check the three electrodes on the camera cable for corrosion, and clean them if necessary.

With the Yashica camera, replace the two AA batteries after 1–2 weeks in the field. Avoid getting moisture or any other contamination in the battery or film compartments, or on the rubber seals; remove any moisture with a cotton-tipped swab. The Olympus cameras have a battery display on the LCD panel when the lens cover is opened. A solid battery figure indicates that the batteries are good; an outline of a battery, either flashing or on continuously, means that the batteries must be changed. Replace them with one (Infinity Mini DLX) or two (Infinity Twin) "DL123A" or "CR123A" lithium batteries. With the Infinity Mini DLX, check the day and time display to be sure it is still correct after changing the battery.

The batteries in the Trailmaster transmitter and receiver will last for 30 days in the field. When the batteries in the transmitter are low, the red indicator light on its base will immediately come on and quickly turn off when the unit is turned off; the light will stay on, or will not flash, when the unit is turned on. The receiver has a **L o b** ("low on batteries") display and will not record events if the batteries are low. If the batteries have been in use more than 20 days, or if either the transmitter or receiver indicates low batteries, replace the batteries in both units with four new alkaline C-cells. Do this over a jacket or cloth to avoid losing the tiny hex screws or wrench when you drop them into the snow or forest litter. Always replace batteries in both units at the same time. Before replacing the backs of the transmitter and receiver, make sure the rubber-gasket seals are seated in the groove, and that there is no moisture or other contamination on them.

If you are going to keep the station in place, replace and align the transmitter, receiver, and camera as necessary. Clean the camera lens with lens tissue and fluid if it is dirty. Clear the events from the receiver. Take a test photo to determine that all is operating correctly, and record the frame and event numbers left on the units when you leave.

If you find that a bear, coyote, or gray fox (*Urocyon cinereoargenteus*) has found the station and has been frequently returning, move the station at least 0.5 miles from the first location. If smaller animals such as birds or squirrels are triggering the camera, move the beam farther below the bait or out from the tree so that smaller-bodied animals do not break it. Check to see that no branches that may serve as perches remain near the beam.

Dual Sensor

Stations should be checked 4 times at weekly intervals. When checking a station, have all the gear necessary to establish one, including extra film and batteries. A spare camera unit or two will allow you to replace faulty ones if necessary. Bring equipment for recording tracks (see Chapter 5). Be familiar with the tracking material in Chapter 5. This is important. J. Copeland (pers. comm.) detected wolverine visits to photographic bait stations more frequently by tracks in snow than by photographs.

When you approach the set, look for and identify, describe, measure, photograph and collect, as appropriate, any tracks, scat, or other sign of which animals may have been to the station. Has the bait or scent been disturbed? Has the bait tree or camera tree been climbed? Record these observations on the Camera Results form (*appendix A* and in pocket inside back cover).

Enter the sensor field with the station sign, and trigger a single picture. Climb the camera tree, turn the unit off, and open the box. Record the frame that the camera is on. If the roll is more than half exposed, or if you suspect that a target species has visited the station, remove the film. Using a digital pocket battery tester, test both the 12-v battery and camera battery, and change them if they are low (this will depend on how long the unit has been out and when you plan to visit the site again). Remember, new, fully charged batteries will probably need recharging after 20 days, so you will probably need to replace the batteries after 1–2 weeks. Put new film in the camera if needed, check the batteries, hook the unit up, and turn it on just before you climb down the tree. Enter the sensor field with a sign indicating the station number and date, and expose a single picture. Leave the site without again entering the sensor field.

Line Trigger

When checking the camera, first determine whether the film can be advanced. If so, a photograph has been taken since the last visit. Record this and other information on a copy of the Line-Triggered Camera Results form (*appendix A* and in pocket inside back cover). Examine the camera unit, and note whether the camera is functional. Reasons for non-functional cameras include the thread being chewed through, the monofilament line obstructed or broken, and misattachment of the trigger line. To verify that the unit is functional, take a test photograph at every visit. To save processing costs, take this test shot with your hand blocking the lens so that no print will be developed from this exposure. Replace the bait at every visit. Initially, replace the film after one or two exposures (excluding test shots). Once the crew is familiar with the operation of the camera and the area appears safe from vandalism and persistent bear damage, the film can be left in the camera longer. If the film is to be removed, make certain to advance it to the end of the roll before removing the cartridge. Failure to do so will result in the overexposure of the last few photographs and loss of data. Before leaving the station, make sure to advance film to the next exposure. If necessary, take additional test shots with the lens blocked to test the camera operation. Other general suggestions for checking line-triggered cameras are outlined in Jones and Raphael (1993).

Developing Film

When you remove exposed film from a camera, label it with the station number and date so that it will not be confused with other rolls. Fine-tipped, indelible markers work best. Often the least expensive developing is provided by large discount or drug stores, which typically make two prints of each exposure. Record the camera number, station number, and time period over which the film was exposed on the processing envelope *and* on the receipt. When using 110 film, if a custom-processing laboratory is available, have a contact sheet printed first. Review each frame on the sheet, and if possible, request that only those photographs that contain animal subjects be printed at full size. If custom processing is not available, and the budget is especially tight, have the negatives developed first and then select for printing only those frames that, when examined under a lens, contain an animal subject. However, there is a danger of missing something important if just the negatives are examined.

Label the back of each photograph with the species, date, and station. This same information should be entered on the Camera Results form. Archive all photographs in protective plastic covers. Examples of prints from 35-mm and 110 camera systems are presented in *appendix C*.

Data Management

We recommend three forms for data: Survey Record, Camera Results (different for 35-mm and line-triggered systems), and Species Detection form (*appendix A* and in pocket inside back cover). In wet areas or during snowy seasons, we strongly recommend using indelible ink and photocopies of the data sheets made on waterproof paper. All forms should be stored with photographs in a 3-ring binder as a permanent, complete record of what was done, where, when, by whom, and what the results were. Record all species detected. Your survey efforts can contribute to understanding the distributions of a variety of species in addition to MFLW.

Survey Record Form

This form contains information on each survey's location and details on its configuration. It is important to identify the legal description *and* the Universal Transverse Mercator (UTM) coordinates at each station. Collectively, these forms become a record of all the surveys conducted in the administrative area, regardless of their outcome.

Camera Results Form

Single and Dual Sensor

When checking stations using either the single-sensor system or the Trailmaster dual sensor, fill in the Date, Event, Number, and Time columns in the field as you cycle through the Readout/Advance mode. Record data only for those events associated with a picture, which is indicated by the decimal point between the first and second digits on the receiver's display. Fill in the Contents section after the film is developed, noting any species present.

When checking the stations using the dual-sensor system made by Manley, record in the comments section the number of frames exposed. When the film is developed, record the Date, Time, and Contents of each exposure by examining the prints. Ignore the Event column.

In a 3-ring binder, store the data sheets, negatives, and prints by sample unit and station. Put the negatives and prints in plastic sleeves made for storing film.

Line Trigger

Use this form when establishing and checking the line-triggered camera stations. Use a separate sheet for each day, and record information for each camera visit whether an exposure was taken or not. Record the station number, the camera number, and the exposure number (at both your arrival and your departure from the station) at each visit. Record the visit number (0 for setup, and 1-6 for station visits) and the number of nights since the last visit (should be two in most cases). Note also whether a photo was taken since the last visit and the number of test shots taken at each check. The species recorded will be determined after the film is processed, so that space will remain blank until later. Remember, do not terminate effort on the sample unit until the film is developed and you are certain the target species was photographed.

Species Detection Form

When a survey is successful at detecting marten, fisher, lynx, or wolverine, complete the Species Detection form, which characterizes successful surveys and is used for all methods (camera, track-plate, snow-track). Complete one form for each species detected. Submit one copy to the state Natural Heritage office (addresses provided in Chapter 1), and archive a copy at the office of the agency that manages the land where the survey was conducted. Most Natural Heritage databases record only positive results from detection surveys.

Comparisons of Camera Systems

The perfect remote camera system is yet to be developed. In this section we discuss some of the strengths and weaknesses of each of the camera systems described to allow investigators to decide which may be most appropriate for their circumstances.

The first major difference between 35-mm and line-triggered systems is in the cost of the equipment. The 35-mm systems cost $500-$600, and the line-triggered systems less than $25. This substantial difference in initial price, however, may be mitigated by differences in labor involved in the construction of the equipment and the frequency of checking the stations. The 35-mm systems require virtually no assembly upon receipt from the manufacturer. The line-triggered system must be built by the user. Because the 35-mm systems can shoot an entire 36-exposure roll of film, they may be left in the field longer without being checked than the line-triggered systems, which can take only one picture and then must be rebaited and reset. However, damage or loss from vandalism, theft, or bears is more serious with the 35-mm systems than with the line-triggered system. Both of the 35-mm systems can be more readily used in severe weather, especially winter, than the line-triggered cameras.

Another difference between the two types of camera system is the triggers. The 35-mm systems use infrared (single sensor) or infrared and microwave (dual sensor) triggers, which require only that an animal be near the bait to be photographed. In contrast, animals must physically pull the bait to be photographed by the line-triggered system. In addition, the sensitivity of the triggers on several of the 35-mm systems is adjustable, and the film displays the date and time. The line-triggered camera lacks these features. Jones and Raphael (1991) found that half of all photos taken by line-triggered cameras did not record a subject and that 65 percent of these problems were due to failure of the disposable ("flip") flash. However, the 110 camera recommended here has an internal flash that rarely fails.

Track Plates

William J. Zielinski[1]

Introduction

A carbon-sooted aluminum track surface has been used in a variety of ways to detect mammalian carnivores. The method was developed first to monitor rodent abundance (Mayer 1957) and was adapted for use with carnivores by Barrett (1983) to survey for American martens. This application enclosed an aluminum plate in a plywood box ("cubby") that was attached to the side of a tree. Bait was placed near the back of the box. Track impressions were "negatives," in that they were created when an animal's foot removed soot and revealed the underlying plate surface. A record of the track was created by transferring the track image to transparent tape by pressing the tape onto the track and lifting the tape. The method was also adapted for more general use by placing a larger (162.8 × 81.4 × 0.06-cm) unenclosed plate on the ground with bait attached to the center (Barrett 1983, Raphael and Barrett 1984, Raphael 1988). Marten and fisher were detected using this method, but neither wolverine or lynx has been detected at these stations (M. Raphael, pers. comm.).

In 1991 the technique was significantly improved with the addition of a surface capable of collecting a positive track impression (Fowler and Golightly 1991). A slightly tacky, white paper (commercially available Con-Tact[2] paper used to line cabinets and drawers) was placed across the distal end of a rectangular sheet of sooted aluminum. The plate was inserted into a plywood box to protect it from moisture and debris, and the box was scaled to a size that would permit the entrance of marten and fisher (30.0 × 26.7 × 81.3 cm). The soot that adhered to an animal's foot as it entered the box was transferred to the white paper when the animal walked to the rear of the box. The positive track impression, often transferred in great detail, was cut out from the paper and stored in a clear acetate envelope. The clarity of tracks is sufficient to distinguish the previously confusing male marten and female fisher tracks using discriminant function analyses (Zielinski and Truex 1995).

I will describe the use of two types of sooted aluminum plates. The first is the enclosed plate system that records tracks on white paper. This device has been effective at detecting marten and fisher (Fowler and Golightly 1991; Zielinski and others 1995) and was the detection device recommended in the original USDA Forest Service protocol for detecting these two species in Region 5, California (Zielinski 1992). The second device is the larger, unenclosed plate without the track-receptive paper (Barrett 1983, Raphael and Barrett 1984). Despite this shortcoming, this is the only adequately field-tested track-plate method that is capable of detecting all four species, although neither lynx nor wolverine has been detected. However, it is more likely that they would be detected on the uncovered track plate than on a plate in a relatively small box.

A logical combination of the two approaches is to enclose the large plate, partially covered with Con-Tact paper, in a large box. However, boxes larger than that recommended in the Forest Service, Region 5 protocol have not received much testing. Large plywood boxes (35.6 × 38.1 × 78.7 cm) and even larger cardboard boxes (61.0 × 61.0 × 86.4 cm) were used in a modest pilot test in northern Idaho, where all four species were thought to occur, but each box detected only marten (A. Dohmen, pers. comm.). A 40.6 x 30.5 x 81.3-cm version was used in a study of the mammalian

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[2]The use of trade or firm names in this publication is for reader information and does not imply endorsement by the U.S. Department of Agriculture of any product or service.

carnivores associated with the Sacramento River in California (J. Souza, pers. comm.), but none of our four species of interest occurs at that location.

Description of Devices

Track-Plate Box

This device is composed of a carbon-blackened aluminum plate (20 × 76.2 × 0.1 cm) partially covered with white contact paper that is enclosed in a plywood box with the inside dimensions 25.4 × 25.4 × 81.3 cm (*figs. 1, 2*). Bait is placed at the back of the box, beyond the Con-Tact paper. The box described here is designed to be placed on the ground. Somewhat smaller boxes have been attached to the boles of trees (Barrett 1983, Martin 1987), presumably to dissuade visits by non-target species. However, this assumption has not been tested, and because arboreal plates require more time to install and are more expensive than terrestrial boxes, they will not be described in detail here. Those interested in attaching boxes to trees should consult the references cited above.

The aluminum plate should be about 1 mm thick (0.063 gauge). Thicker material has no advantage and is heavier. Aluminum can usually be acquired as flat stock from a

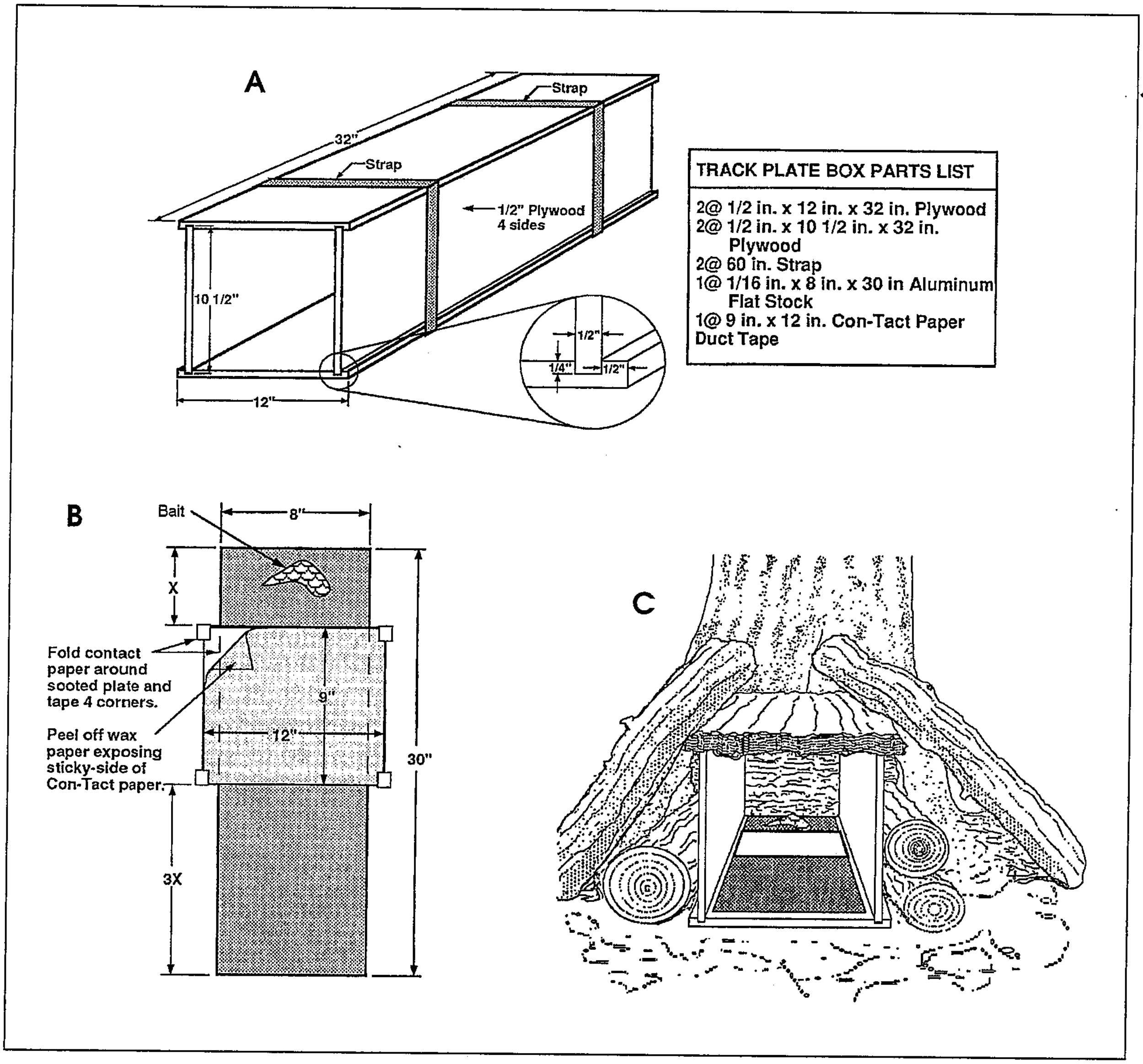


Figure 1—Schematic drawings of a track-plate box station and its components: A) wooden, plywood track box, B) sooted aluminum plate with Con-Tact paper, C) established station in field. (Based on original figure in Fowler and Golightly 1993).

sheet metal shop, but some biologists have received donated aluminum from newspaper publishers (e.g., J. Souza, pers. comm.). The preferred method for applying soot is with acetylene gas from a welding torch. Carbon production is maximized by covering the oxygen intake on the nozzle with duct tape. Alternatively, the soot can be applied from a burning kerosene-dipped wand. Suspend the plates horizontally above the ground between sawhorses (or some similar support), and soot them from below as the soot rises. Soot the plates outdoors in a well-ventilated area. A water source should be available at all times to prevent spread of fire. A half-mask respirator and safety glasses are recommended to minimize inhalation of the soot (see Safety Concerns). If the respirator is not available, wear a dust mask to block large particulates. Soot should cover the plate evenly and lightly; do not oversoot, as excessive soot may produce a poor quality track on the paper. The area of the plate that will be covered with the paper need not be sooted. When learning the process, test that the soot is sufficient by transferring some from the plate to a piece of Con-Tact paper with your finger.

Carpenter's chalk, dissolved and applied in isopropyl alcohol, has also been used as a tracking medium (G. Fellers, pers. comm.; Orloff and others 1993). In the best circumstances, under completely dry conditions, the results can approach the quality of those from a carbon-sooted plate (Orloff and others 1993; W. Zielinski, pers. observ.). However, track quality can be quite poor under even moderately damp conditions, so the use of chalk is not recommended to detect the forest carnivores considered here.

After the plate is sooted, wrap a 31- × 23-cm piece of Con-Tact paper, with sticky side up and backing intact, around the plate, and tape it to the back of the plate using pieces of duct tape. Align the paper so it is slightly rear of the center of the plate but with about 9 cm of exposed plate beyond it where the bait is placed (*fig. 1B*). To save time, prepare the pieces of Con-Tact paper and duct tape in advance. Keep the protective backing on the paper until the plate is placed in the field for use, and then peel it off.

The box is constructed of four pieces of 1/2-inch, medium-grade plywood (*fig. 1A*). The back of the box is open to facilitate construction and transportation and to minimize cost. The top and bottom pieces should have two, approximately $^1/_2$-inch grooves running the length of their inside surfaces into which the two side pieces can be slid or gently hammered. Use no hardware to assemble the box. Rope, strips of tire tubes (often

Figure 2—Track-plate box station in the field. Note how the back of the box is against the base of a tree and how the box is covered with debris to stabilize and camouflage it.

available at no cost from local tire dealers), or plastic banding (applied with a commercial banding tool) can be used to hold the sides together. Cotton clothesline works well and biodegrades if left in the field. Heavy woody debris, placed over the box in the field, will strengthen it further.

A lighter-weight alternative for protecting the track plate uses thin plastic sheets (L. Chow, pers. comm.). The plastic is bent into a half cylinder and the edges are placed inside a raised lip on each of the outer edges of a galvanized steel base (28.0 × 76.0 × 0.1 cm with a 1.0-cm raised lip along the sides) and are kept in place by a combination of the force acting to straighten the plastic and liberal use of duct tape (*figs. 3, 4*). Alternatively, holes can be drilled through the raised lip of the steel base and through the plastic at corresponding locations so that sheet-metal screws can be used to secure the canopy (Foresman and Pearson 1995). Although one large piece of plastic is sufficient, two smaller pieces (each 40.5 × 70.5 × 0.2-cm) can fit in a backpack more easily. At the station location, each piece is bent, positioned in the base, and then taped

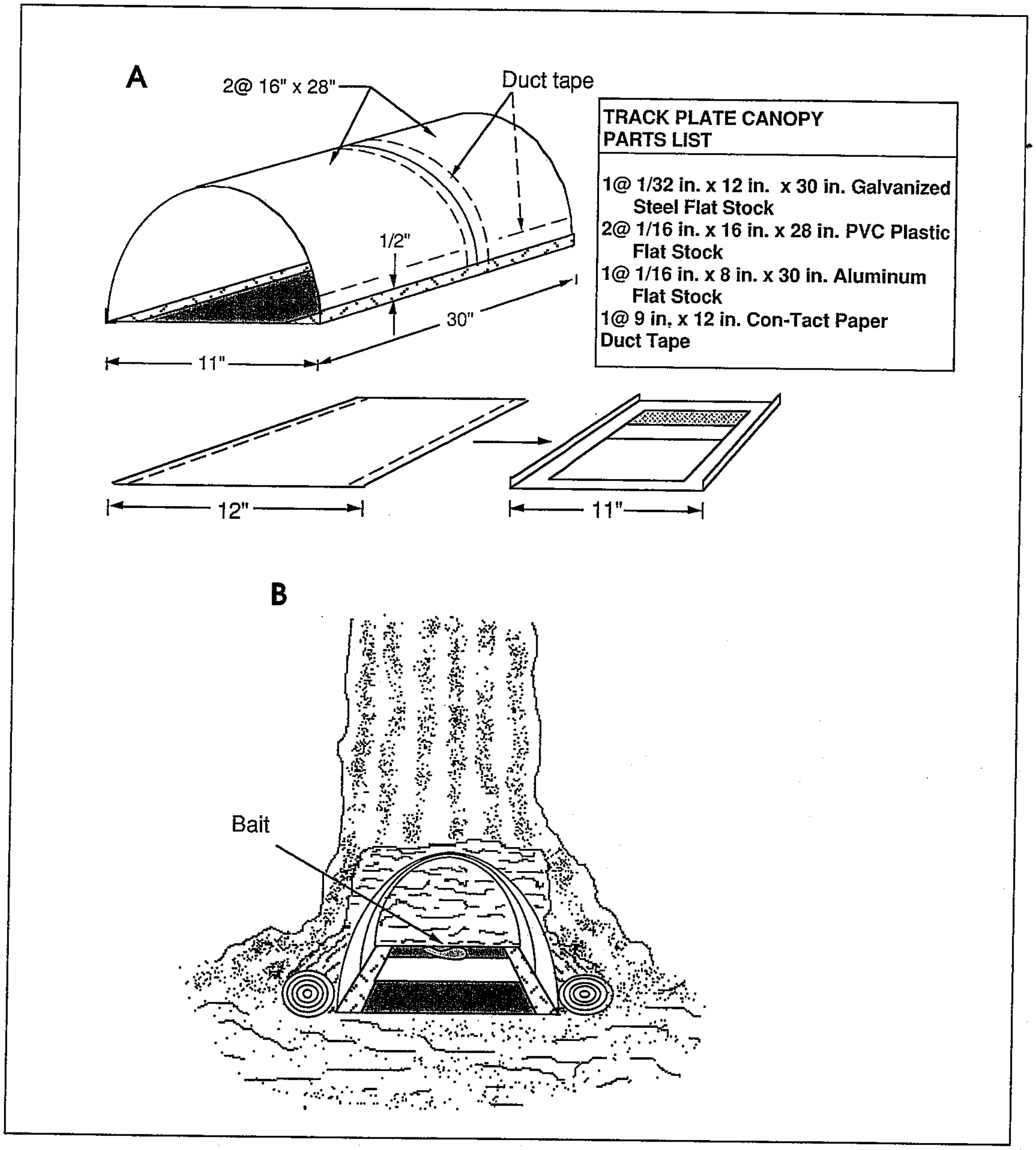


Figure 3—Schematic drawing of a plastic canopy-covered track plate and its components: A) dimensions and construction of the unit, B) established station in the field.

together where they overlap. The sooted aluminum plate with Con-Tact paper is placed on the galvanized base. Track-plate stations with this type of protection have successfully detected marten and fisher. The materials for this design weigh somewhat less than the plywood box, but the structure is much less sturdy. The roof is very flexible and cannot support woody debris that might be used to strengthen and camouflage it. The entire enclosure appears to move more readily when an animal enters it than does the plywood box. In addition, the plate may be less protected from moisture than when the absorbent plywood box is used.

There are several means by which the sooted plates can be transported in the field. For storage in a vehicle, a travel case should be constructed that can accommodate field-ready track plates (sooted, with Con-Tact paper and backing attached) (*fig. 5*). This can

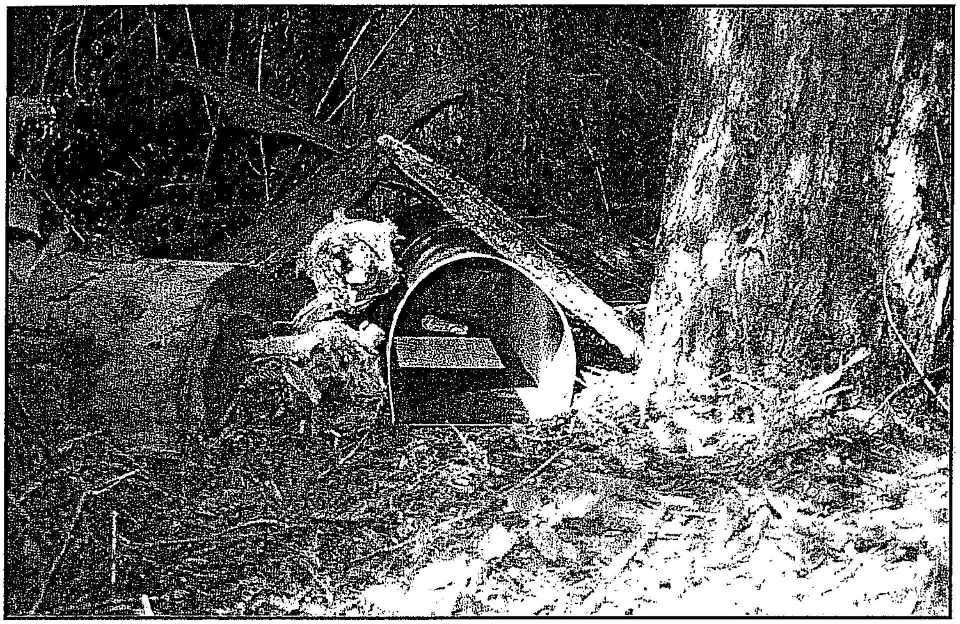


Figure 4—Plastic canopy-covered track plate in the field. Note how the back is against the base of a tree and how the unit is stabilized with bark and logs.

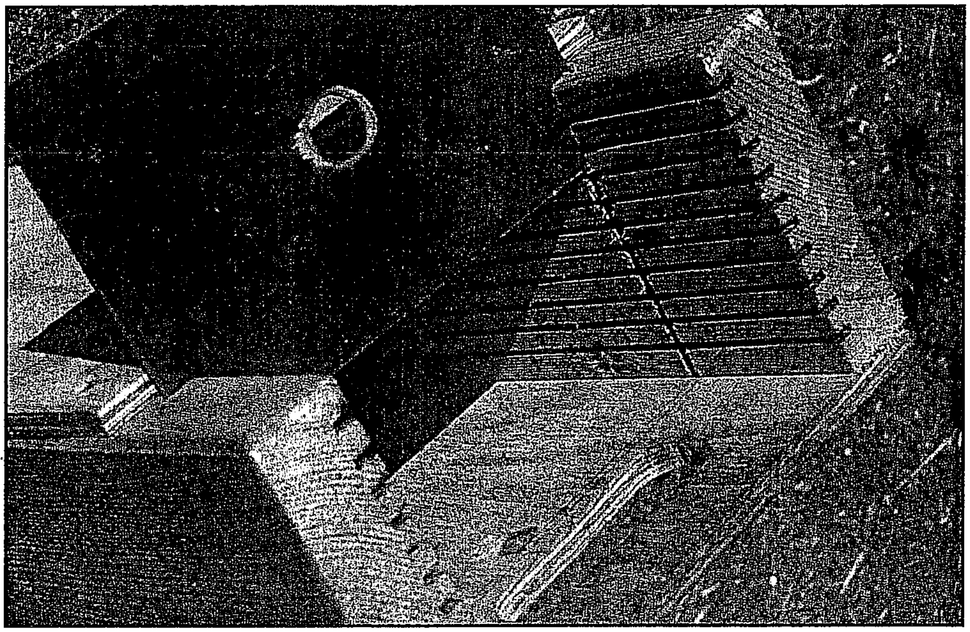


Figure 5—Example of track-plate carrying case designed to be transported in a vehicle.

be a sturdy wood or plastic box with parallel grooves cut on the inside surface of two sides into which the plates can slide. Grooves separated by at least 1/2 inch will keep plates apart during travel, and a box lid will prevent dust from settling on the plates. To protect individual plates from being marred while you walk from the vehicle to the station location, cover the sooted plate(s) with an unsooted one and bind them together tightly with duct tape or welding clips. Alternatively, holes can be drilled in diagonal corners of each plate; a bolt and wing-nut can secure a number of plates firmly together. Nothing need be placed between the plates, provided each Con-Tact paper has its protective cover in place and plates are stacked front to back. This procedure is particularly useful when multiple plates must be back-packed into a roadless area.

Unenclosed Track Plate

This device is an uncovered, carbon-blackened aluminum plate made of the same material described above and sooted in the same fashion. The plate is actually composed of two plates (40.0 × 80.0 × 0.1 cm each), placed side-by-side, to create an 80.0 × 80.0 cm surface (*figs. 6, 7*). Because this method does not involve the use of a white track-receptive surface, it is important that the soot be applied lightly enough so that the feet of visiting animals remove it all and expose the underlying plate. Bait is placed in the center of the two plates.

To prevent the sooted surfaces from rubbing together, carry the plates in wooden boxes bolted to pack boards. Flat, army surplus pack boards made of particle board are the best. The lightest boxes are made of 0.25-inch plywood on the front, back, and the bottom; sides and hinged top are made of 0.5-inch plywood. One box, 41.5 cm long and 135 cm deep, will hold six sets of plates. Cut six slots, 5 mm wide and 5 mm deep, spaced about 12 mm apart, into the interior surfaces of the box. Fit the sheets into the slots back to back. A larger and sturdier box of the same general design that can be carried in a vehicle will be helpful in transporting many plates at once.

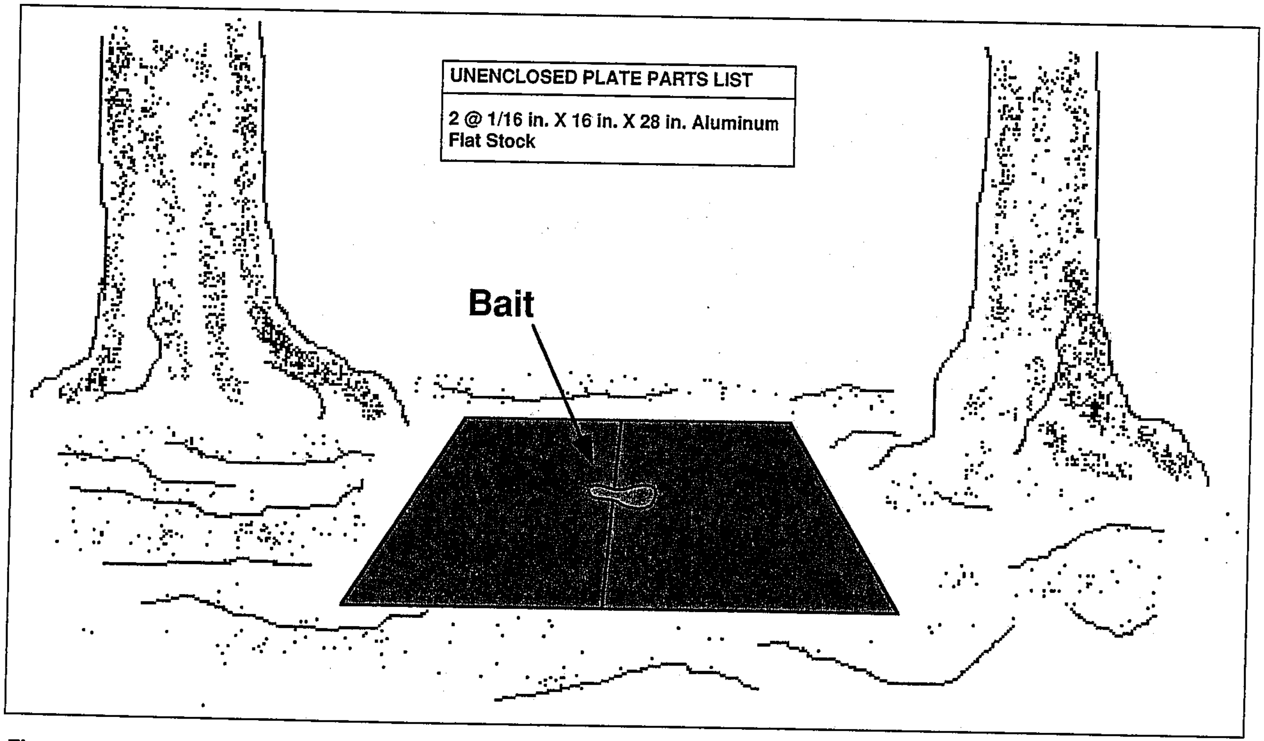


Figure 6—Schematic drawing of an unenclosed track plate and its components.

Baits and Lures

Recommendation: Chicken is the recommended bait. Also use a commercial lure and a visual attractant (e.g. hanging bird wing, large feather, or piece of aluminum foil).

In tests with captive fishers, chicken and tuna were equally attractive, but in the field, chicken elicited significantly more detections of a variety of carnivores, including martens (Fowler and Golightly 1993). Chicken is used exclusively for bait in the original USDA Forest Service, Region 5 protocol (Zielinski 1992) because it is readily available, relatively inexpensive, of a convenient size for use in the boxes, and poses no greater risk of microbial disease than other meats if hands are washed after use (see Safety Concerns). However, other baits have successfully attracted fisher (e.g., fresh fish, deer carrion) and marten (e.g., fresh fish, deer, beef bones, jam). Laymon and others (1993) found that jam did not increase visits to detection stations, and Jones and Raphael (1991) suggested that martens prefer chicken bait without the addition of jam. There is no consensus as to the relative effectiveness of different bait combinations. The unenclosed plates have typically been used with a perforated can of tuna cat food in the center and the excess juices distributed on surrounding vegetation. However, alternative baits were not tested. In the box or canopy-enclosed plate, place the bait behind the paper; with the unenclosed plate, place bait at the union of the two plates (*figs. 1, 3, 6*).

Commercially available trapper lures such as skunk scent may be useful attractants, and we recommend that they be used in addition to chicken bait. Sources for these lures include M & M Fur Company, P.O. Box 15, Bridgewater, SD, 57319-0015, (605-729-2535), and Minnesota Trapline Products, 6699 156th Ave. NW, Pennock, MN 56279, (612-599-4176). Fish emulsion, sold as fertilizer in garden-supply stores, can also be an effective lure, especially when mixed with vegetable oil to retard evaporation.

Visual attractants (e.g., suspended bird wings, aluminum pie tins) are frequently used by commercial trappers, but their effectiveness at increasing detections has received only one modest test, in which they did not increase detections of "carnivores" (a group of species that included marten but excluded lynx, wolverines, and fishers; Laymon and others 1993). This is insufficient evidence to discourage their use, especially in light of their reputed value by trappers (Young 1958, Geary 1984, R. Aiton, pers. comm.). Whenever possible, use a visual attractant, and use it consistently. Suspend either a dried wing, feather, or aluminum foil about 2 m above the ground within 5 m of the station.

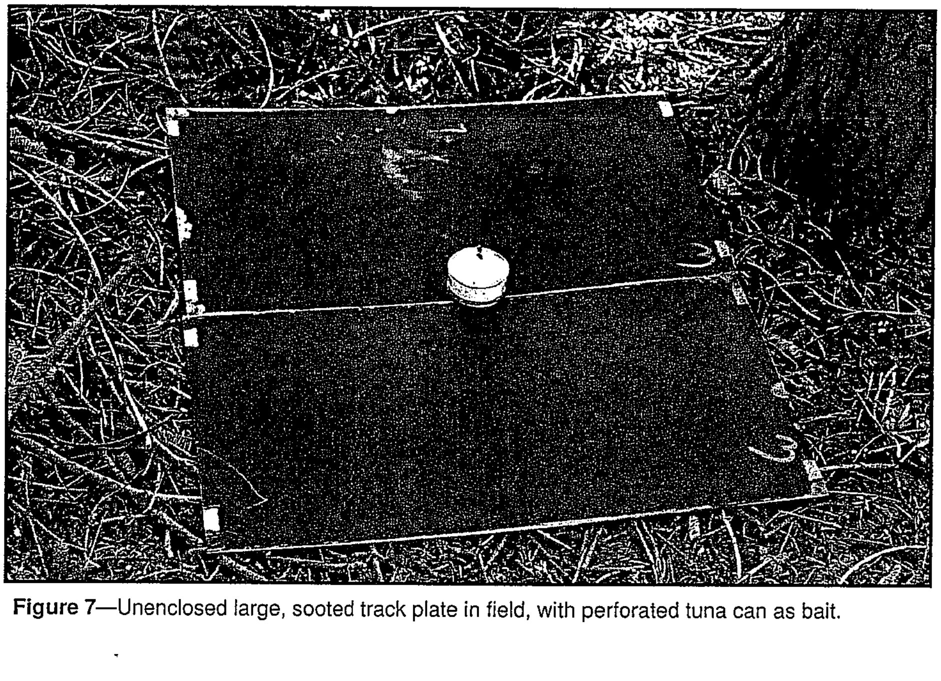


Figure 7—Unenclosed large, sooted track plate in field, with perforated tuna can as bait.

Survey Seasons

Recommendation: Conduct two surveys per year per sample unit, one in spring and one in fall. However, do not conduct the second survey if the target species is detected during the first.

Because both the enclosed and unenclosed plates are placed on the ground where they could quickly be covered with snow, and because of the increased costs of operation, avoid conducting surveys during winter. However, because the target species may be more easily detected during the winter when food may be less available, conduct surveys as soon after snowmelt in the spring and (if necessary) as late as possible in the fall.

Survey Duration

Recommendation: Stations should be set for a minimum of 12 nights and checked every other day for a total of at least six visits (excluding setup). Discontinue the survey when the target species is detected even if this occurs before 12 nights have elapsed. If the target species is not detected during the first 12-day session, run a second session at the same station locations during the alternate season (either spring or fall) for a minimum of 12 days.

Because the objective of the survey is to determine whether a sample unit is occupied, effort need not be expended beyond the detection of the target species. However, the minimum effort without detection is set at 12 nights in response to a number of sources of information on the "latency to first detection" for marten and fishers. In reviewing the results of 207 track-plate and line-trigger camera surveys, Zielinski and others (1995) found that the mean (SD) latency to first detection for surveys that had from 6 to 12 stations ($n = 50$) was 4.2 (2.4) and 3.7 (2.6) days for fisher and marten, respectively. This estimate is biased downward, however, because it included only those surveys that detected a target species before the surveys were concluded. Raphael and Barrett (1984) recommended that 8 days were sufficient to achieve high detection probabilities when measuring mammalian carnivore diversity at a site. Jones and Raphael (1991), however, discovered that 60 percent (3 of 5) of first detections during marten surveys in Washington occurred after day 8 but before day 11. They concluded that surveys should run more than 11 days. Foresman and Pearson (1995) detected marten after a mean of 3.3 days and 2.3 days at enclosed and open plates, respectively; fishers were detected after a mean of 5.3 days at enclosed track plates. Fowler and Golightly (1993) suggest a 22-day survey duration, but this is with the goal of increasing the number of detections to the point where a statistical decline in detections will be discernible at a subsequent sample. Because the objective of detection surveys is to detect presence only, and because the statistical merit of using number of detections as an index has not been adequately addressed, the 22-day survey duration is probably excessive.

Because lynx and wolverine have not yet been detected on track plates, there are no data on which to base recommendations on survey duration. Until data are collected to suggest otherwise, the 12-day duration, twice per year if necessary, is considered sufficient effort.

Preparations for the Field

Defining the Survey Area

Recommendation: Conduct surveys in 4-mi^2 sample units, as described in Chapter 2, "Definition and Distribution of Sample Units."

The survey approach will be different depending on whether the survey is a "Regional Survey" or a "Project Survey" (see Chapter 2). In each case, however, we recommend the use of separate 4-mi^2 sample units as the basis of the survey. Conduct surveys on as many sample units concurrently as time, personnel and funds permit. If it is a Regional Survey, choose one of the scheduling options suggested in Chapter 2; if it is a Project Survey, focus your attention first on the sample units within the project area.

Station Number and Distribution

Recommendation: Use a minimum of six track-plate stations in each sample unit. Distribute them as a grid, with 0.5-mile intervals, in the area of the sample unit with the most appropriate habitat or where unconfirmed sightings have occurred (see Chapter 2, *fig*. 2).

Detection success increases with an increase in number of stations in the survey (Zielinski and others 1995). Although the data are too few to determine the point of diminishing returns on station number, it seems reasonable to have stations that collectively sample at least 0.5 mi^2 (12.5 percent) of the unit, especially if they are placed in the most appropriate habitat. Six stations provide at least this much coverage if one assumes that a target individual will be detected if it travels within the rectangle created by joining the perimeter stations. Additional stations will provide a greater assurance of detecting occupants, but more than 12 stations (covering 1.5 mi^2, 37.5 percent of the area) would probably be excessive.

If habitat is homogeneous throughout the 4-mi^2 sample unit and there are no previous sightings, center the grid in the middle of the sample unit. If roads are available, the shape of the grid can be adjusted to accommodate road access, but maintain the recommended inter-station distances. If the sample unit is roadless, the track-plate materials will need to be backpacked into the survey area.

Before conducting on-site reconnaissance, study aerial photographs and topographic maps of the sample unit(s) to be surveyed. Station locations should be assigned on maps or photos before conducting any field work.

In the Field

Station Location

First conduct reconnaissance to verify the existence and location of roads and trails that will be used to access the stations. Locate each station at least 50 m perpendicular to the road; placement of stations closer to roads may reduce their attractiveness to target species and increase visibility to people. When possible, mark the station locations with flagging and metal tape or rebar, and identify them using Global Positioning Satellite (GPS) technology. These locations may need to be revisited during a second survey. In roadless areas, record the compass bearings, elevation (using an altimeter), and distances between landmarks used for orientation so others can find the stations with ease.

Station Setup

Set out all the detection stations you plan to check during the survey before baiting them. Because the original location and establishment of the stations will require more time than checking them, it is best to bait them after all have been established. For reference, if there are six stations per sample unit, an experienced 2-person crew can set up about 18 track-plate stations per day; 24 if there are 12 stations per sample unit. Additional time is required for roadless sample units. No more stations should be established than can be checked every other day by available personnel. However, because stations are checked once every 2 days, only half the stations need to be checked on any one day. If this is difficult, then additional crews should be hired, or the number of sample units surveyed during that particular period should be reduced (see Chapter 2 for recommendations on how to survey multiple sample units).

Track-Plate Box

Assemble the box, and place it on level ground so it will not move when entered. Place the baited end of the box against the base of a tree, rock, or log to discourage entry from the rear (*figs. 1C*, *2*). Cover the box with heavy debris (e.g., limbs, bark) to secure it in place and to hide it from passers-by. Remove the protective cover from the Con-Tact paper, and insert the sooted plate in the box. Mark a flag near the box with the station number. Place the bait on the plate behind the Con-Tact paper, using kitchen tongs to minimize contact with meat. Wash hands thoroughly after handling chicken, or wear gloves to prevent contact.

Unenclosed Track Plate

At each station, clear and level an area of about one square meter. A small, folding shovel is a useful digging tool. Place the sooted plates side-by-side onto the cleared spot in a manner that will provide a stable surface for animals to step on. Attach the bait with wire to the center of the sheets. At a conspicuous location, attach the following laminated message to a tree:

> This is part of an important wildlife study being conducted by ______________________. Please do not touch. The sooted aluminum plate will record the tracks of animals. It will not harm or entrap them. If you have any questions, please contact
> ______________________________________.
> Thank you.

Checking the Stations

Recommendation: Check the stations every 2 days, including weekends, for a minimum of six checks (12 days). Replace the plates as necessary, either when the soot becomes ineffective (test with finger) or when the tracks of non-target species occupy more than 20 percent of the plate. Rebait at every visit (at least six times), and remove old bait from the station area. Apply lure at least twice during the survey period.

The day a station is baited is Day 0, and the subsequent visits should occur on Days 2, 4, 6, 8, 10, and 12. If there are too many sample units for all stations to be checked on one day, then half of the stations should be run on alternate days. If using the alternate day method, the minimum survey period will be 13 rather than 12 days. If rain or snow renders the stations ineffective (especially common for the unenclosed plates), add additional days to the survey period to compensate for the days during which visits could not be detected.

Survey crews should be familiar with the tracks of potential target species. The track guide of Taylor and Raphael (1988) describes the tracks of species that commonly occur on track plates in the Pacific Northwest, but their key is only for tracks directly on the aluminum plate. Examples of marten and fisher tracks on Con-Tact paper are provided in *appendix A*. Although the tracks of male marten and female fisher can overlap in size (Taylor and Raphael 1988), they can be easily distinguished by using the discriminant function developed by Zielinski and Truex (1995) (*appendix B*). Unfortunately, the tracks of wolverine and lynx on plates or paper have not been described. It is extremely helpful to build a library of life-sized examples of tracks of the common carnivores in the area. These can be used to identify most species quickly.

As the stations are checked, complete the Track Plate Results form (*appendix C*). Make an entry on this form every time a station is checked, regardless of the results. If tracks of the target species are on the paper, cover it with one of the original protective

Safety Concerns

Sooting the Plates

The use of acetylene to soot plates can expose the operator to carbon monoxide and acetone. Soot the plates outdoors where there is adequate ventilation and where the risk of fire is low. A "Half-Mask Respirator" with organic vapor filter and goggles is recommended. At a minimum, a dust mask should be worn to exclude large particulates. Always receive training in the use of the welding equipment (tank and torch) from an experienced technician. A "Job Hazard Analysis" for sooting plates is available upon request from Bill Zielinski (Redwood Sciences Laboratory, USDA Forest Service, 1700 Bayview Dr., Arcata, CA 95521).

Handling Bait

Uncooked chicken and many other meat baits are a potential source of *Salmonella* bacteria. Contact with both fresh and old bait should be minimized. Chicken pieces should either be individually wrapped in sandwich bags and frozen until the day they are used or be handled using kitchen tongs. Carry soap and water or disposable wipes so that you can wash your hands thoroughly before meals. Careful attention to cleanliness will make the risk of contamination from chicken negligible (Dr. J. Sheneman, pers. comm.). The risk of poisoning the target species with rotting meat baits is also negligible, as most target species regularly consume carrion.

Comparison of Track-Plate Methods

The methods recommended here have not been compared in the same study. However, it is generally agreed that the enclosed-plate method is superior to the open plate because it is protected from moisture and debris, the white surface collects positive track impressions with fine detail, and the track can be easily collected and stored with minimum loss of information. Furthermore, the unenclosed plates require larger and more unwieldy aluminum plates than the enclosed box because an animal is not directed over the plate from a single direction. However, in a recent study where plastic-canopy enclosed plates were alternated with unenclosed plates the latter received first detections by marten earlier than the former (Foresman and Pearson 1995). These authors suggest that some animals man be more reluctant to enter an enclosed area than to walk across an open plate. This conclusion is premature, however, until the unenclosed plate is compared with the *wooden box*-enclosed plate, which is sturdier and can be reinforced with logs and sticks in the field more easily than the plastic canopy version (K. Schmidt, pers. comm.).

Wolverine and lynx will probably step on the unenclosed plate more readily than the plate enclosed in the relatively small box described here. Thus, unenclosed plates should be used when sooted track plates are the chosen device for the detection of wolverine or lynx. Continued experimentation with the use of large (greater than 30.0 × 26.7 × 81.3 cm) boxes is encouraged for the detection of these species. When either wolverine or lynx are the target species, stations with plates enclosed in large boxes should be interspersed with unenclosed-plate stations, or both types of stations should be placed at the same location. This is the only way we will discover whether the larger target species will be successfully detected on box-enclosed plates. A potential advantage of the plastic canopy design is that the enclosure size could be increased to accommodate lynx and wolverine without the additional weight that would be incurred by enlarging the plywood box.

sheets, and return the plate to the field station. Record the station number and date on the paper and the plate as they are removed from the box (a fingernail can etch these numbers in untracked soot on the plate). Remove the paper from the plate, and cut away the untracked portion of the paper. Record the date, sample unit number, and station number on the paper, and place it in a clear 8 1/2- by 11-inch document protector with perforations for a 3-ring binder. To collect and preserve tracks from the sooted portion of plates, place a wide strip of clear tape over each print. Press the tape on the print with a burnishing tool (the tip of a capped pen will usually do). Carefully peel away the tape, and transfer it onto a sheet of heavy white paper. Practice this procedure on tracks of non-target species before lifting those of potential target species.

Data Management

We recommend three forms for data: Survey Record, Track-Plate Results, and Species Detection form (*appendix C* and in the pocket inside the back cover). We strongly recommend using indelible ink and photocopies of the data sheets (especially the Track-Plate Results form) made on waterproof paper. All forms should be stored in a 3-ring binder as a permanent record of the survey.

Survey Record Form

The Survey Record form contains information on the survey location and its configuration. It is important to identify the legal description *and* the Universal Transverse Mercator (UTM) coordinates at each unit. Collectively, these forms become a record of all the surveys conducted in the administrative area, regardless of their outcome.

Track-Plate Results Form

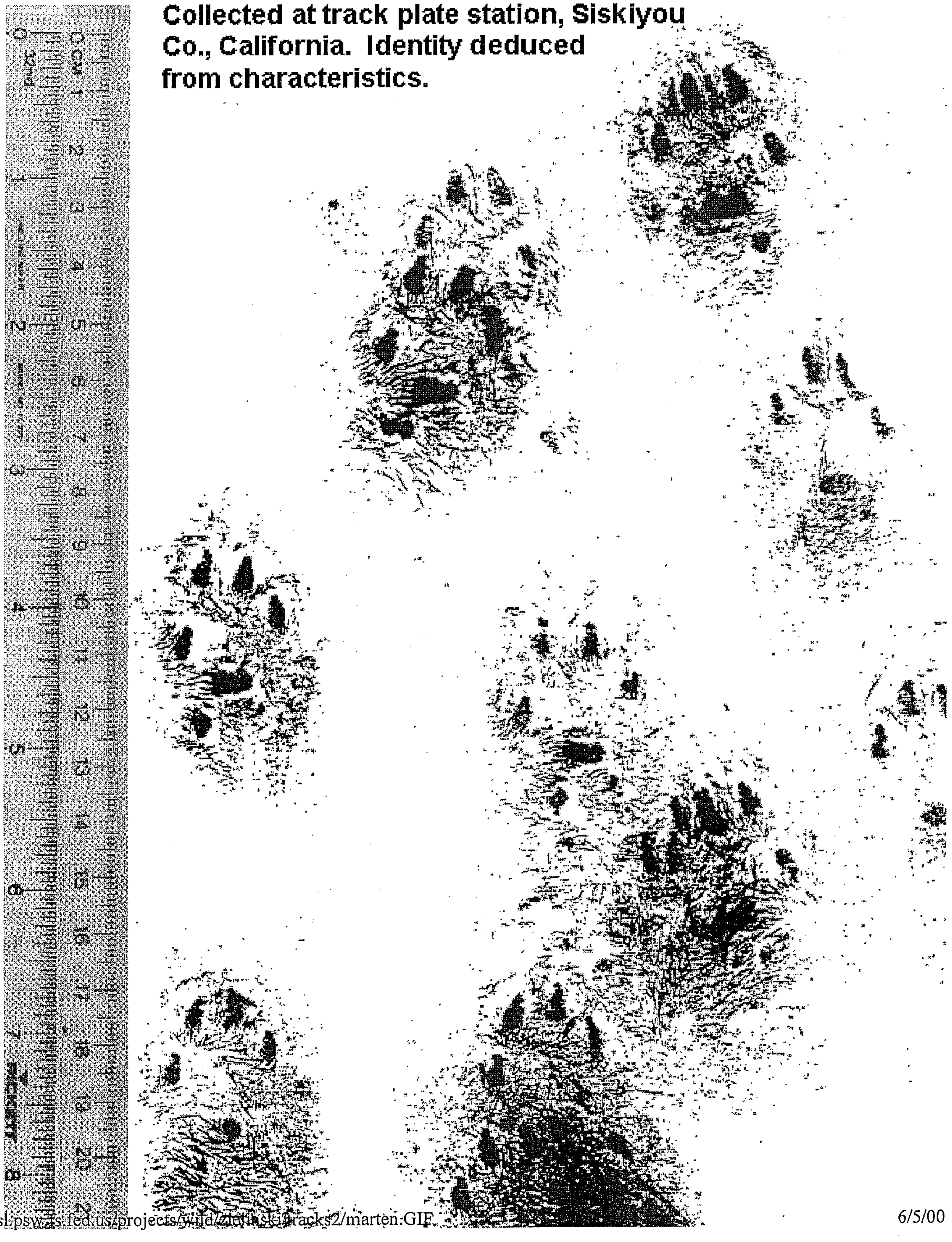
Use one copy of the Track-Plate Results form for each day in the field. Record information from each track plate station, whether there were tracks on the plate or not. Note the station number, the visit number (1-6), the nights since last visit (should usually be two), whether there were tracks of target species and which ones, the identity of tracks of other species of interest, and general comments. Remember that Visit 1 occurs after the second night the station has been set up; the set-up visit can be referred to as Visit 0. If you are uncertain about the identity of tracks, use track reference materials (especially Taylor and Raphael, 1988), the examples provided in *appendix A*, and the discriminant function in *appendix B* to assist in the identification, *and* ask a biologist who is experienced with tracks to confirm your identification. Tracks from Con-Tact paper can be easily photocopied and sent by FAX to qualified biologists. Make certain to record the season, date, a code for weather since the last visit, and the location of the survey on each copy of the data form. Completed forms and survey maps should be archived at the local administrative office (e.g., Forest Service Ranger District), and a duplicate set should be filed at a second location of your choice.

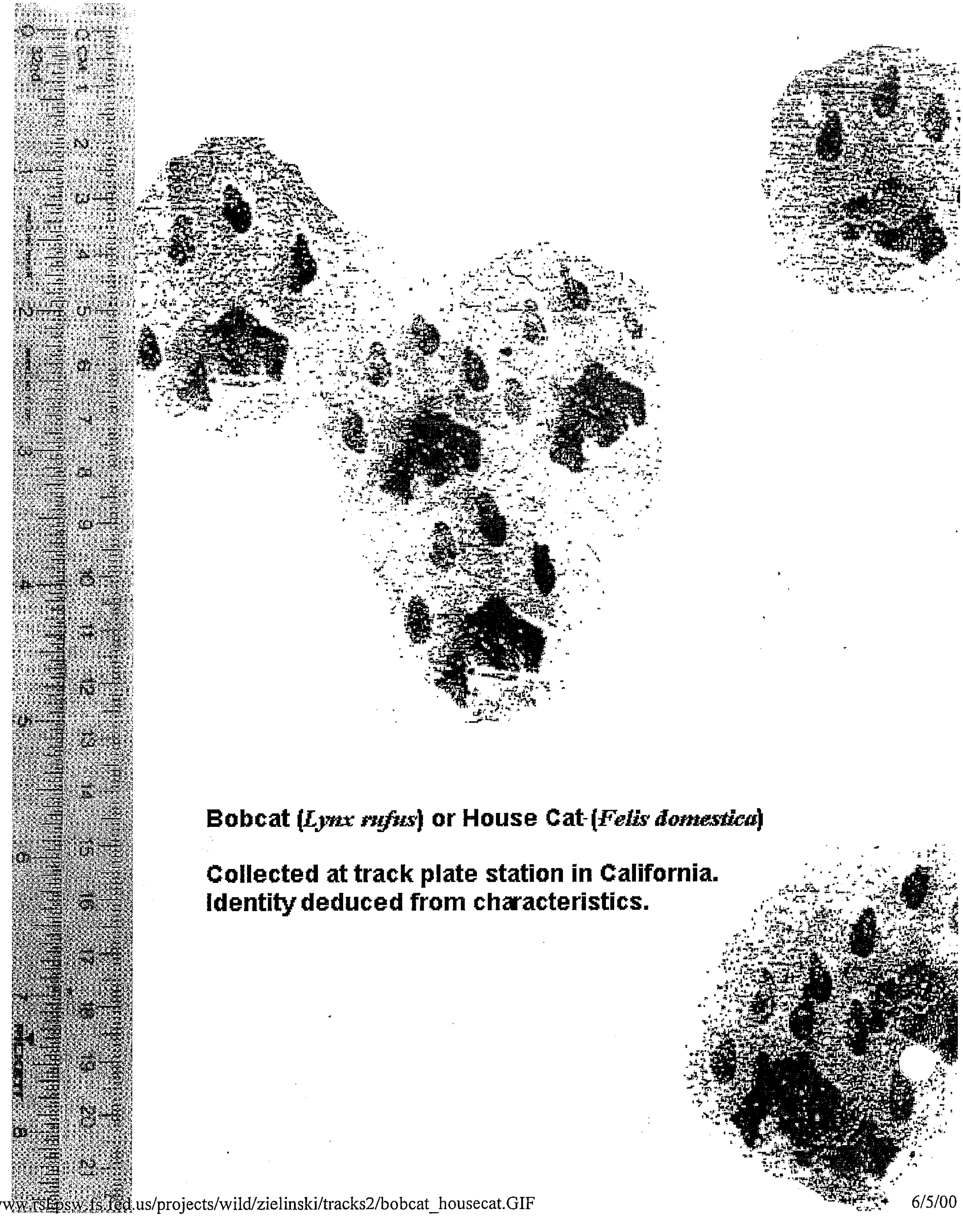
Species Detection Form

When a survey is successful at detecting lynx, wolverine, fisher, or marten, complete the Species Detection form, submit one copy to the state Natural Heritage office, and archive a copy at the administrative office of the agency that manages the land where the survey was conducted. Most Natural Heritage databases record only positive results from detection surveys. Complete one form for each species detected. This standardized form characterizes successful surveys for marten, fisher, lynx, and wolverine and is used for all methods (camera, track plate, snow track).

American marten (*Martes americana*)

Collected at track plate station, Siskiyou Co., California. Identity deduced from characteristics.





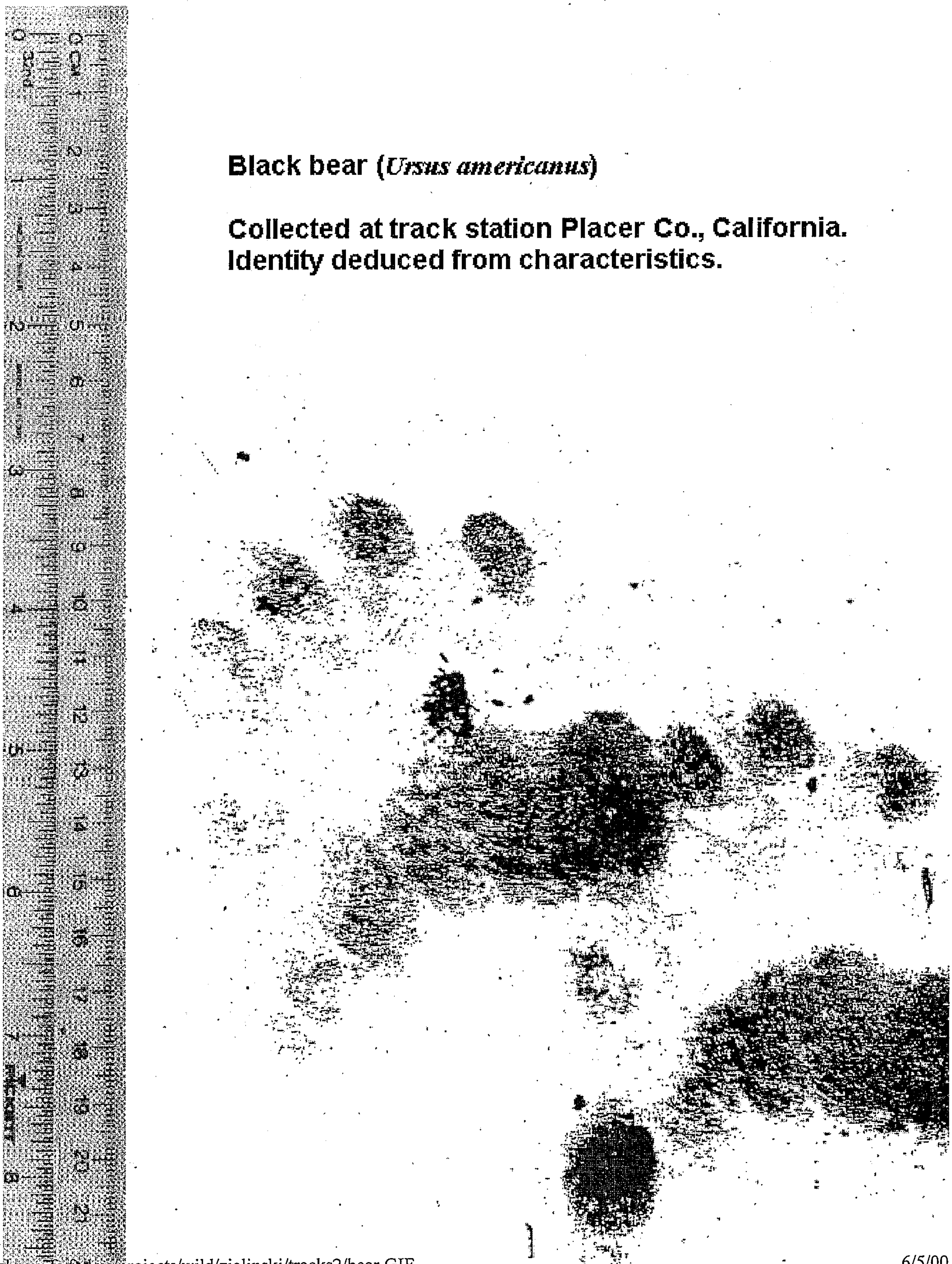
Bobcat (*Lynx rufus*) or House Cat (*Felis domestica*)

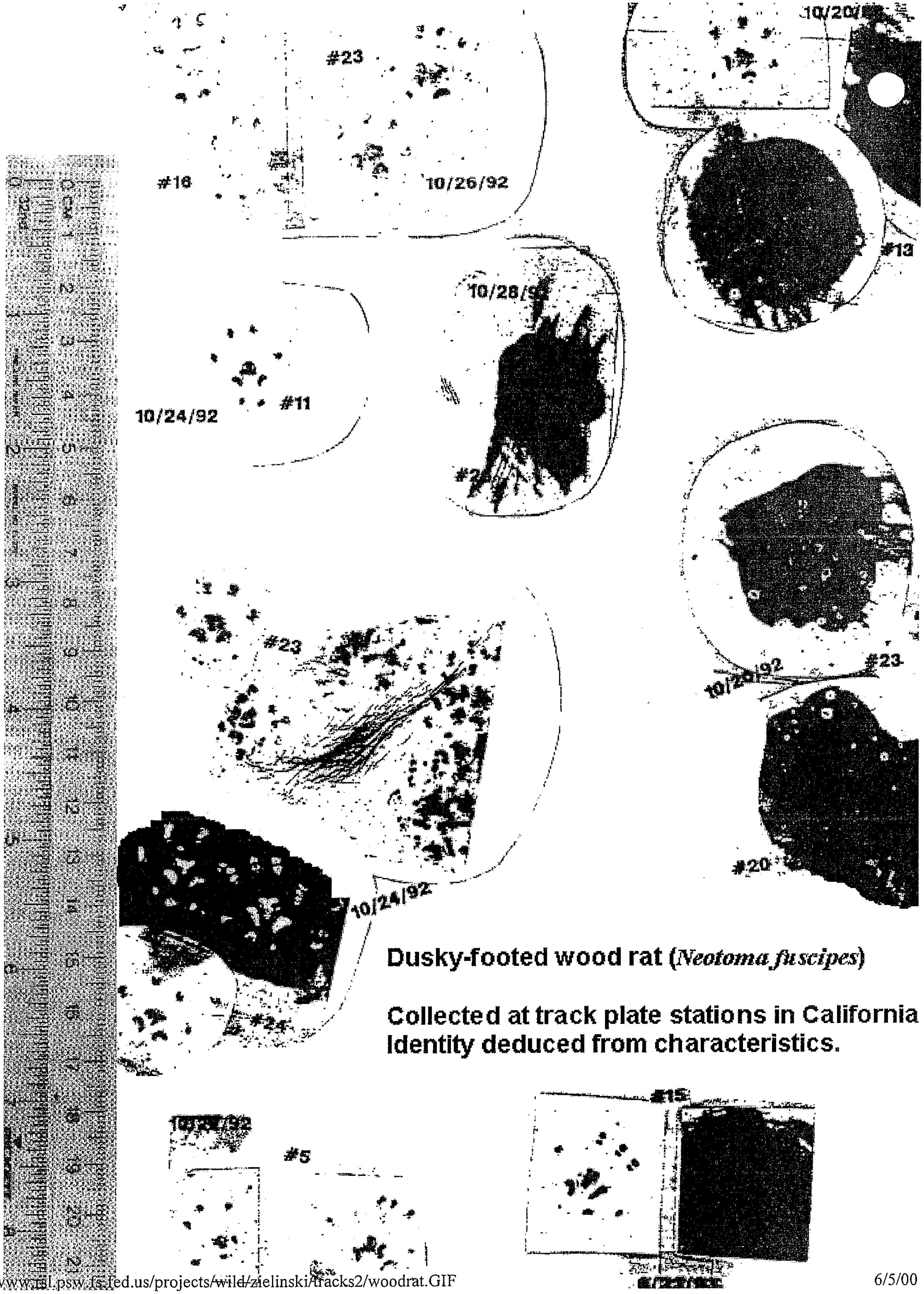
Collected at track plate station in California.
Identity deduced from characteristics.

http://www.rsl.psw.fs.fed.us/projects/wild/zielinski/tracks2/bobcat_housecat.GIF 6/5/00

Black bear (*Ursus americanus*)

Collected at track station Placer Co., California.
Identity deduced from characteristics.





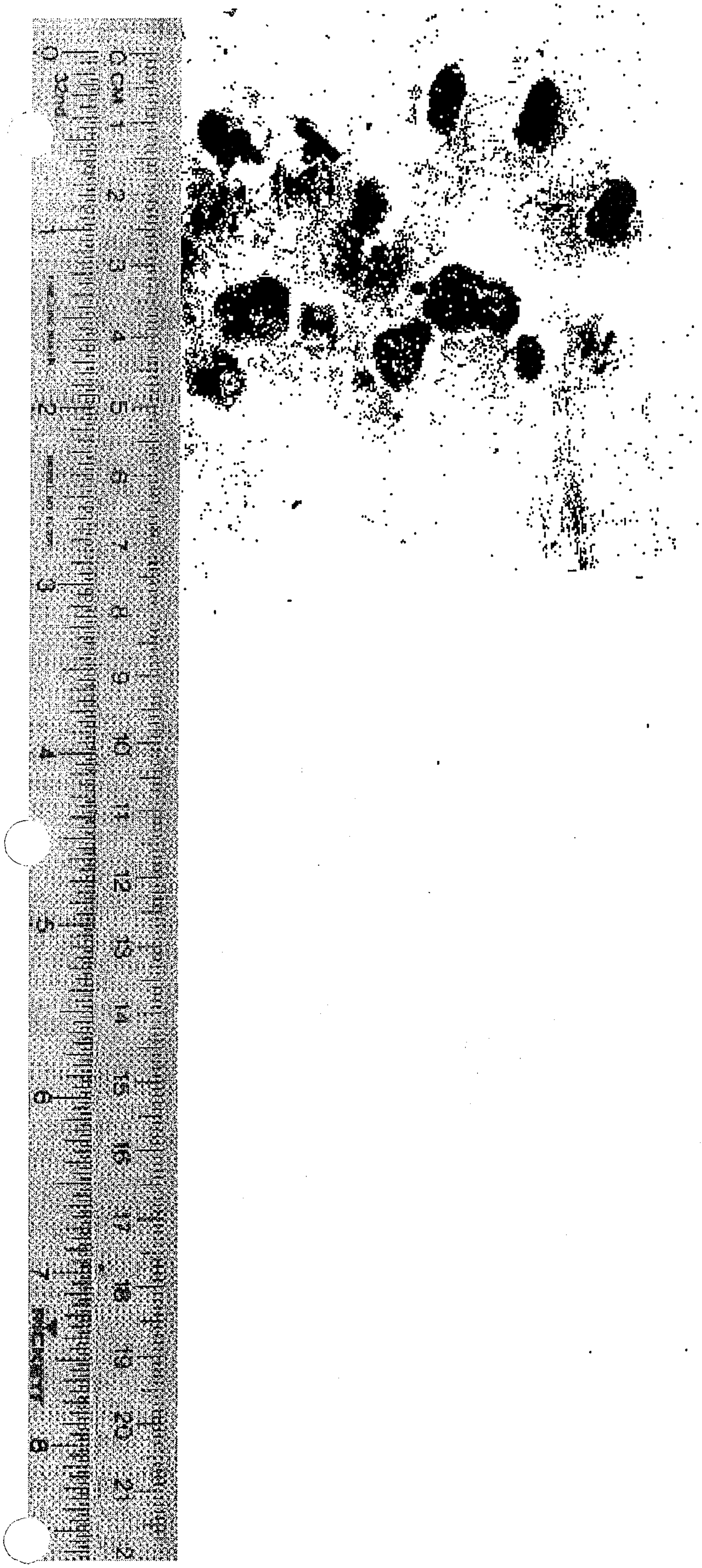
Dusky-footed wood rat (*Neotoma fuscipes*)

Collected at track plate stations in California
Identity deduced from characteristics.

http://www.rsl.psw.fs.fed.us/projects/wild/zielinski/tracks2/woodrat.GIF 6/5/00

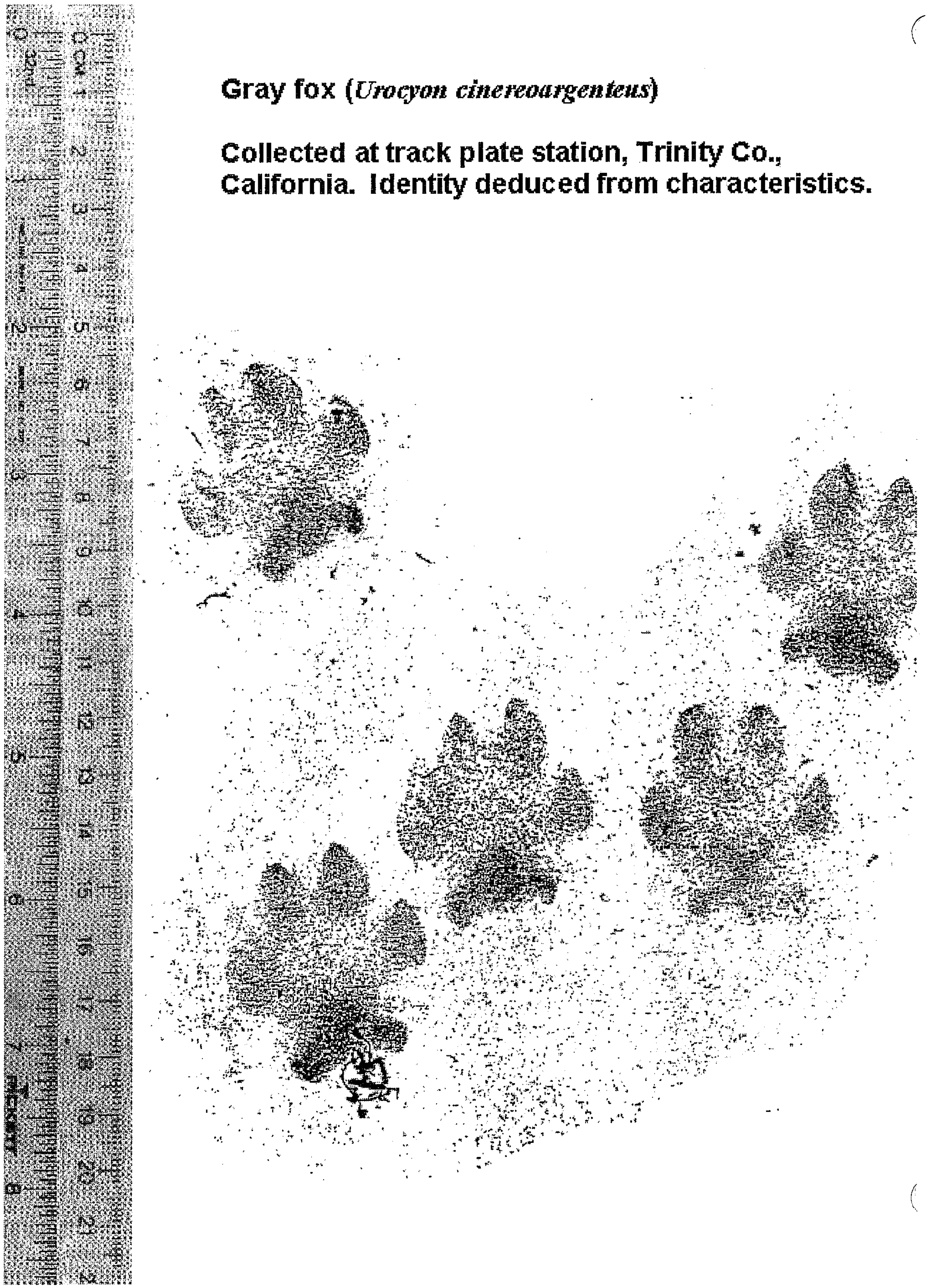
Fisher (*Martes pennanti*)

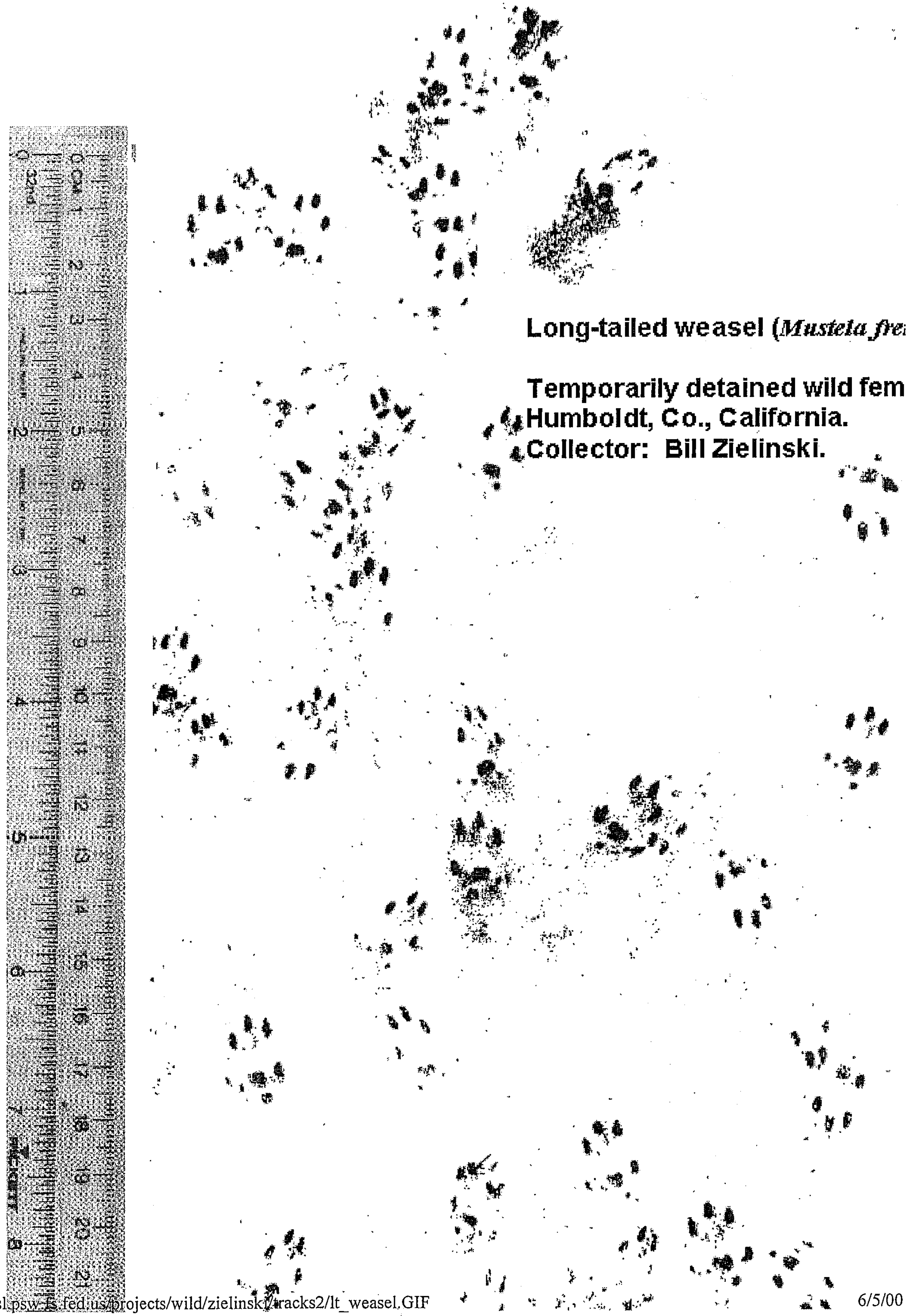
Temporarily detained wild male, Tulare Co., California. Collector: Rick Truex.



Gray fox (*Urocyon cinereoargenteus*)

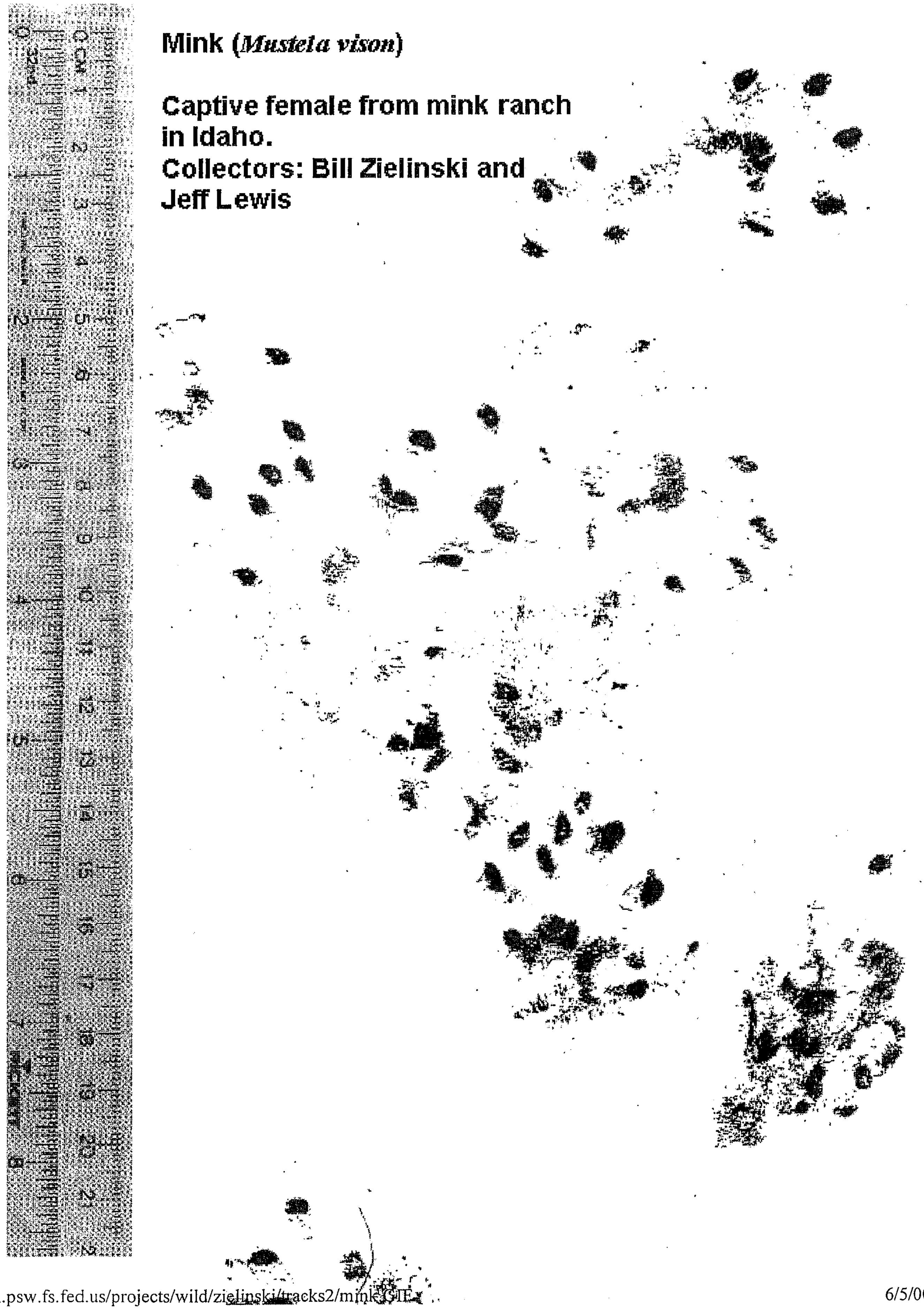
Collected at track plate station, Trinity Co., California. Identity deduced from characteristics.




Long-tailed weasel (*Mustela fre*
Temporarily detained wild fem
Humboldt, Co., California.
Collector: Bill Zielinski.

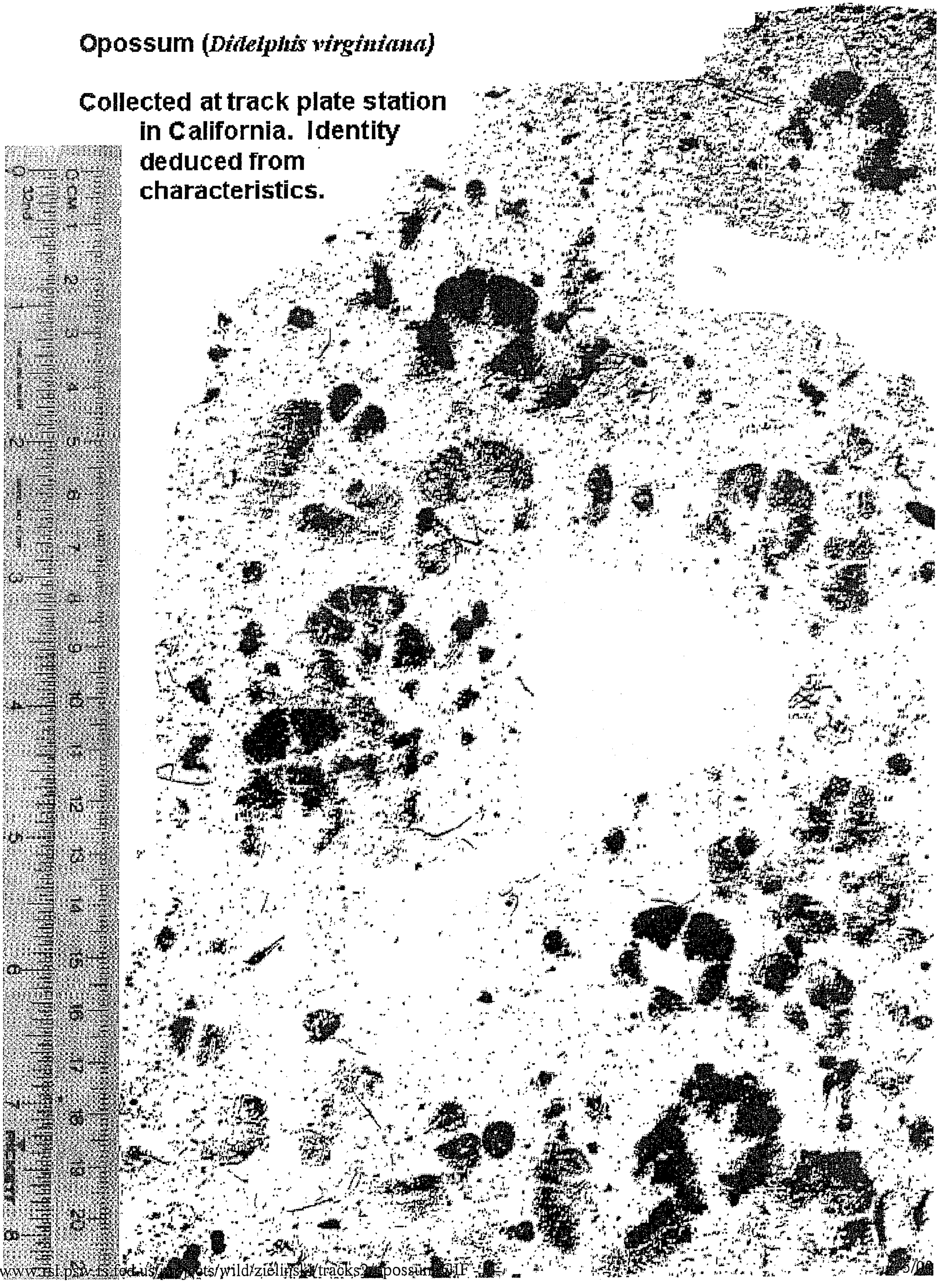
Mink (*Mustela vison*)

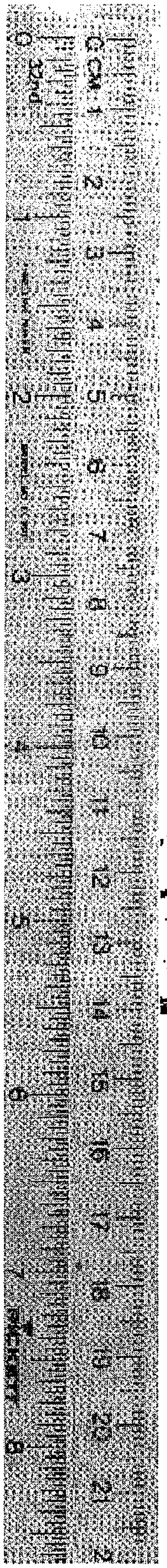
Captive female from mink ranch in Idaho.
Collectors: Bill Zielinski and Jeff Lewis



Opossum (*Didelphis virginiana*)

Collected at track plate station in California. Identity deduced from characteristics.

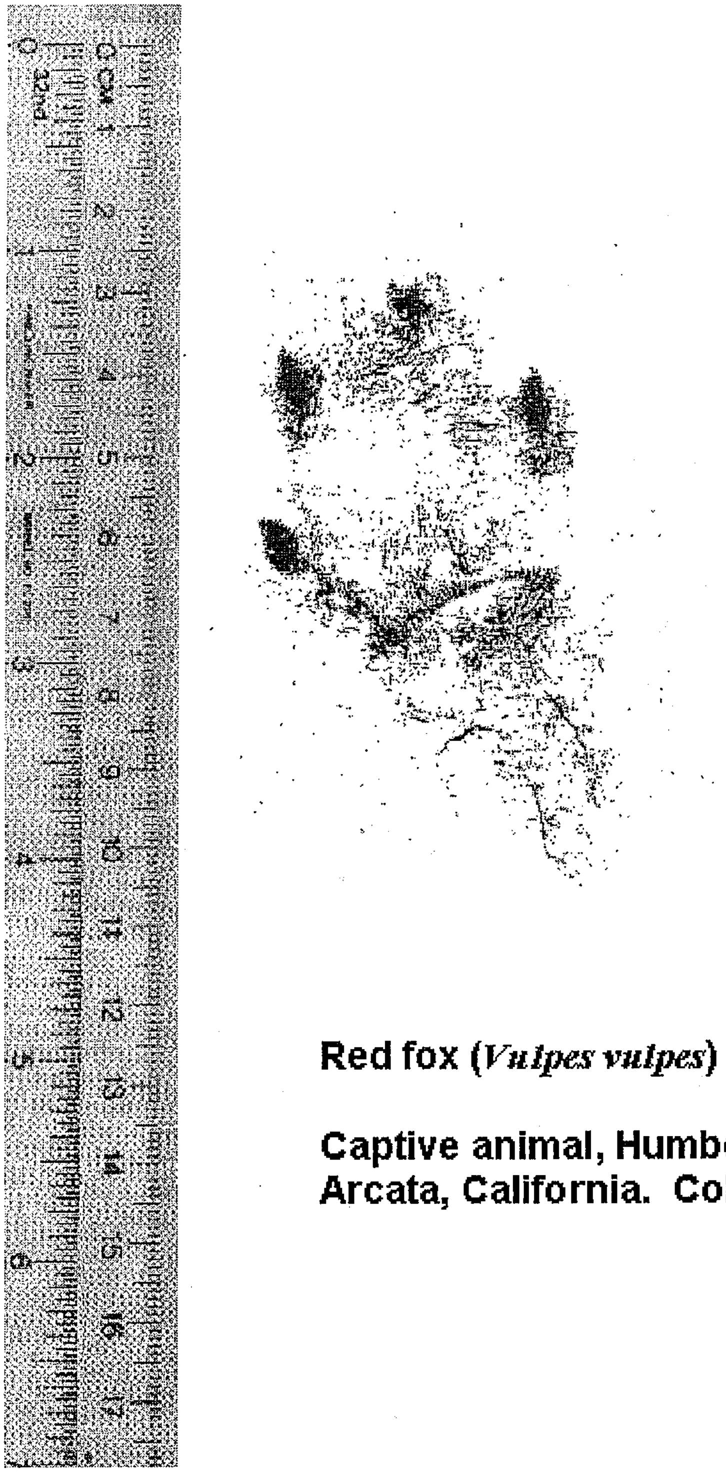




Raccoon (*Procyon lotor*)

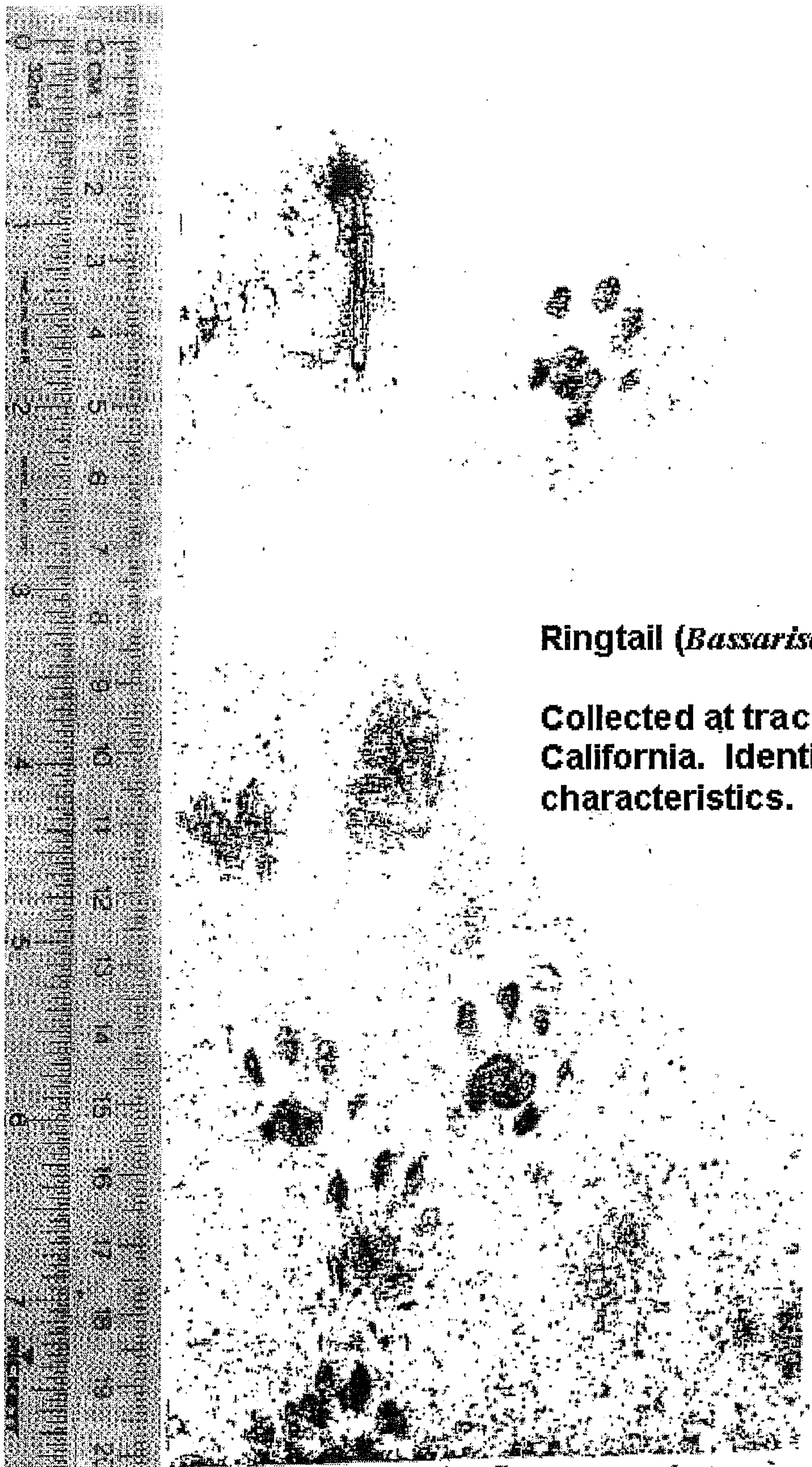
Collected at track plate station, Siskiyou Co., California.
Identity deduced from characteristics.

http://www.rsl.psw.fs.fed.us/projects/wild/zielinski/tracks2/raccoon2.GIF 6/5/00



Red fox (*Vulpes vulpes*)

**Captive animal, Humboldt State Universi
Arcata, California. Collector: Rick Golig**

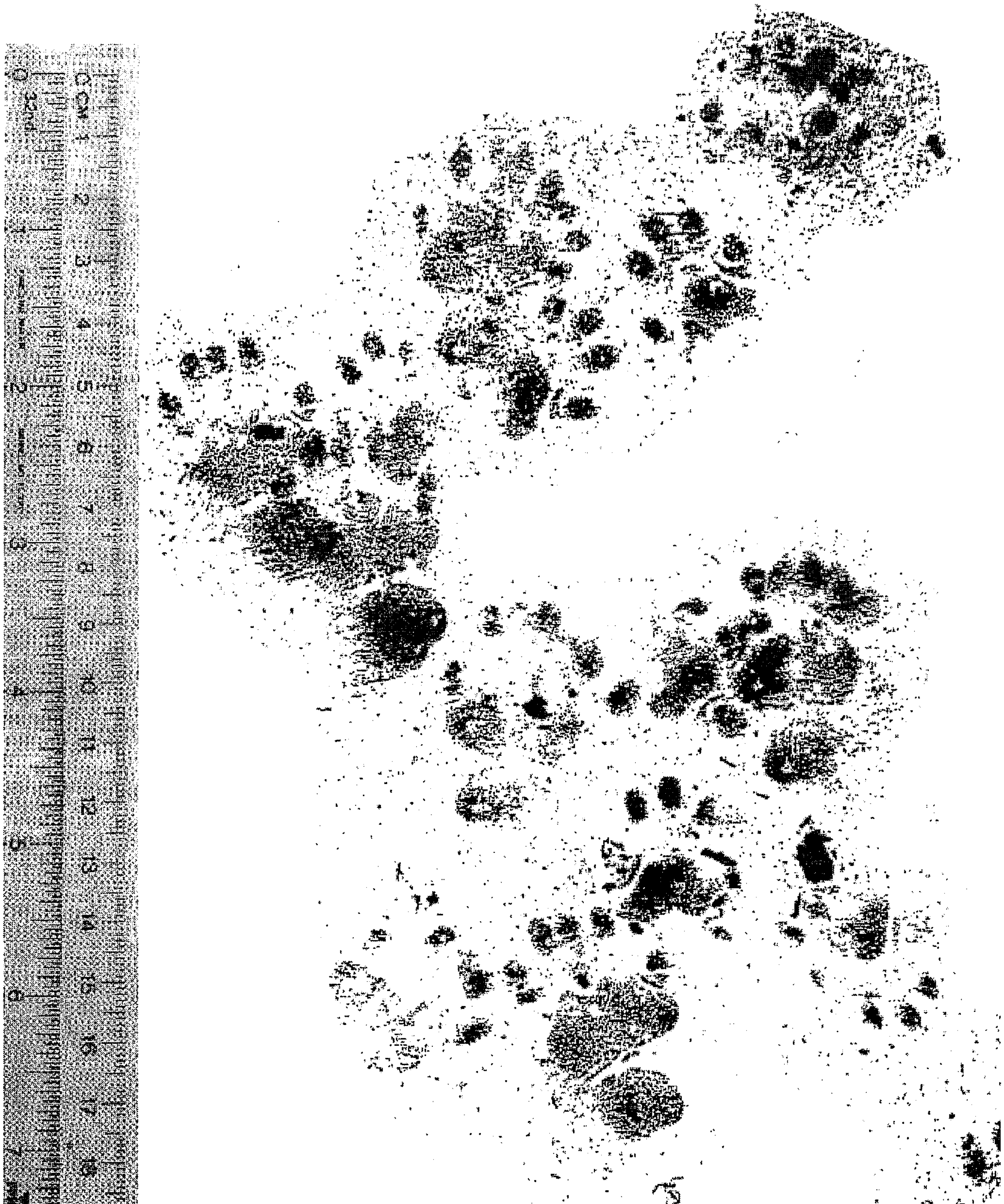


Ringtail (*Bassariscus astutus*)

Collected at track plate station i California. Identity deduced fro characteristics.

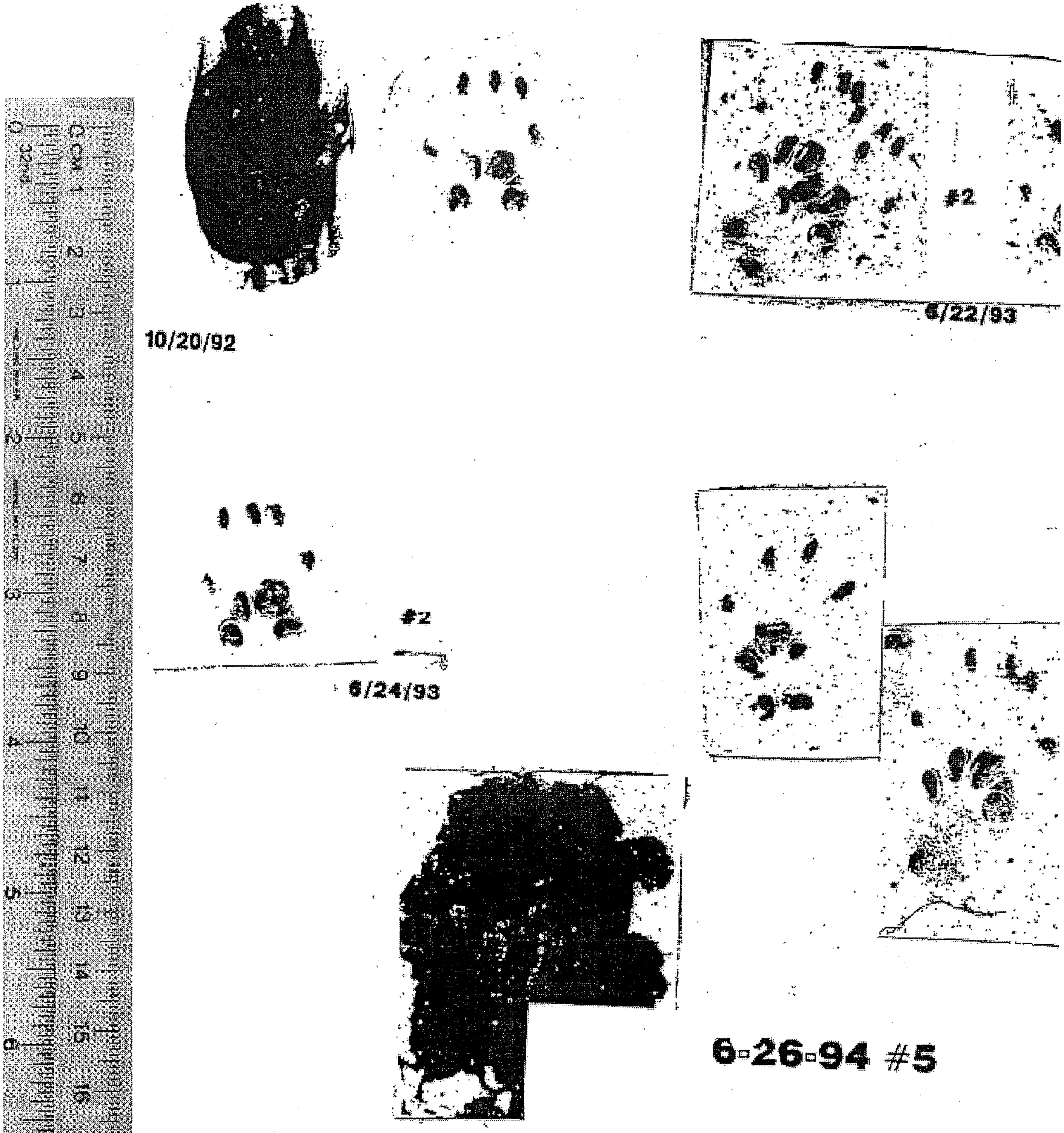
River otter (*Lutra canadensis*)

Captive male.
Collectors: Jeff Lewis and Dale Pedersen.



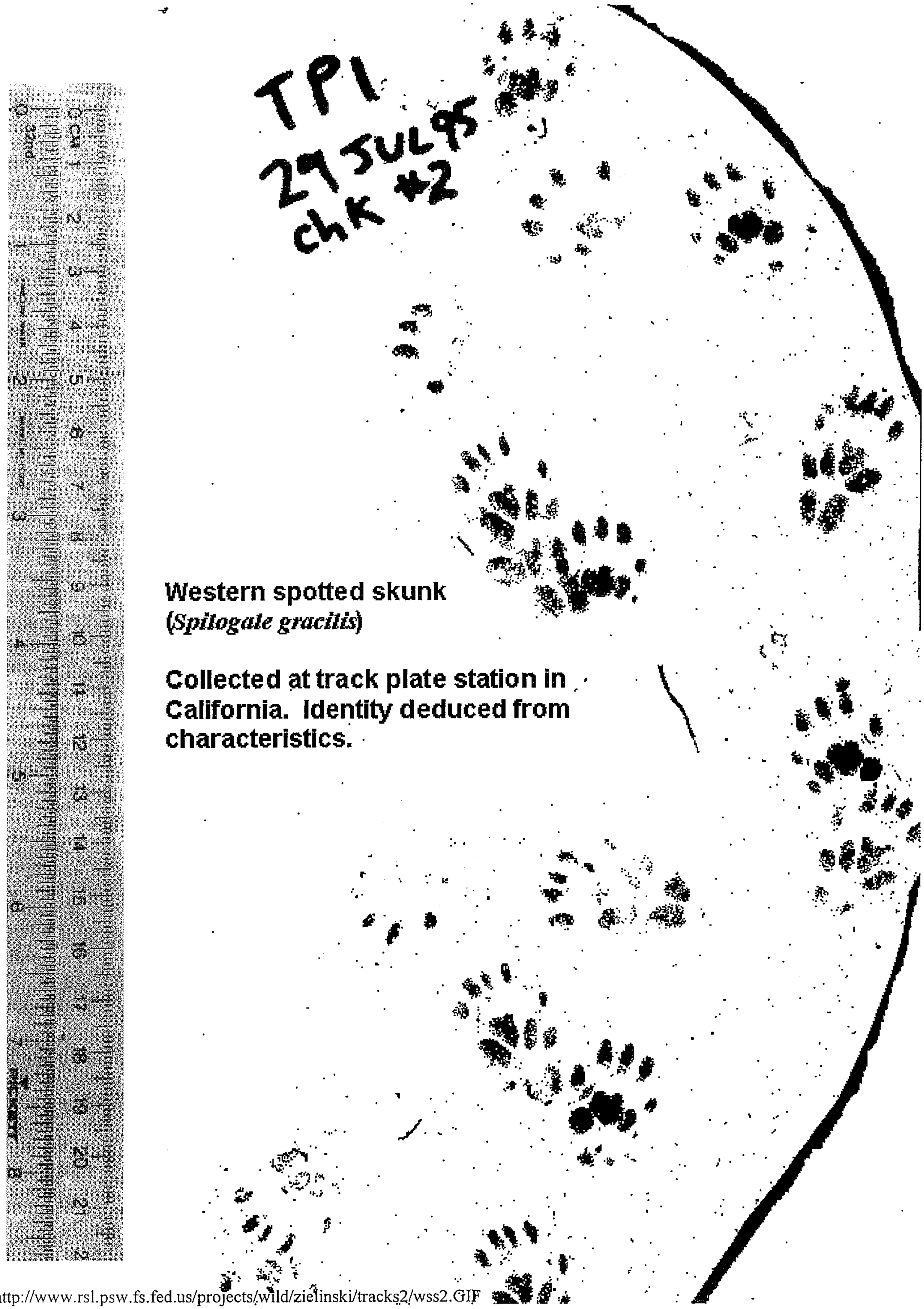
Striped skunk (*Mephitis mephitis*)

Collected at track plate station in California. Identity deduced from characteristics.



Western gray squirrel (*Sciurus griseus*)

Collected at track plate stations in California.
Identity deduced from characteristics.



Western spotted skunk
(Spilogale gracilis)

Collected at track plate station in California. Identity deduced from characteristics.