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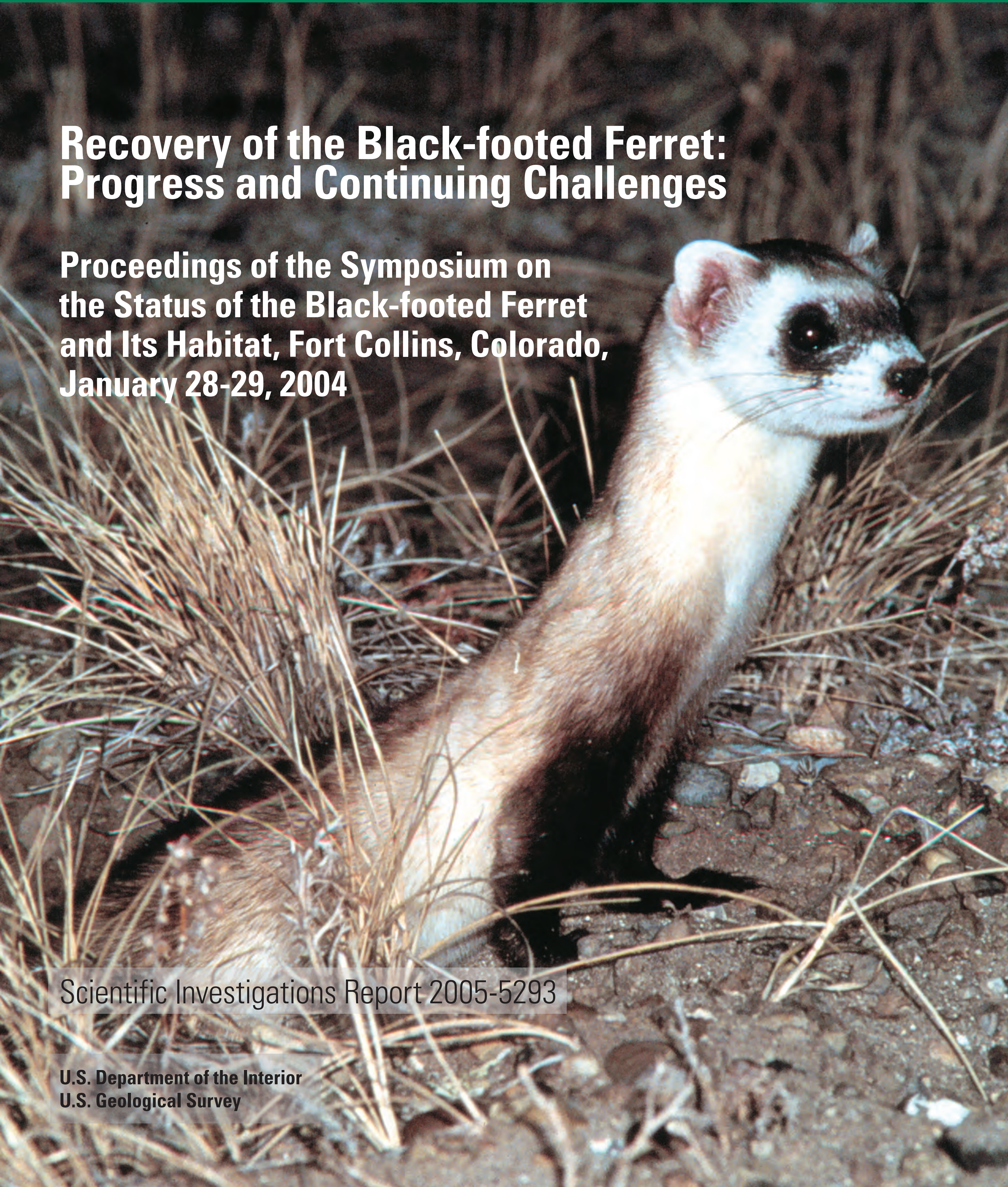

Recovery of the Black-footed Ferret: Progress and Continuing Challenges

Proceedings of the Symposium on the Status of the Black-footed Ferret and Its Habitat, Fort Collins, Colorado, January 28-29, 2004

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Monitoring Black-footed Ferrets During Reestablishment of Free-ranging Populations: Discussion of Alternative Methods and Recommended Minimum Standards

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Abstract

Although the monitoring of black-footed ferret (*Mustela nigripes*) populations following reintroductions has not been haphazard, several ferret recovery groups since 1994 have recommended development of uniform standards prescribing minimum methods, intensities, and frequencies of monitoring that would provide data on population size, mortality rates, and recruitment. Such standards would promote comparability of data among sites, document expectations for those who will attempt to establish new populations, and allow the U.S. Fish and Wildlife Service and other responsible groups to better assess progress made toward achieving recovery objectives. Our recommendations are based on methods that have been successfully used to monitor natural and reintroduced populations of ferrets and are an attempt to balance needs and costs. We suggest a combination of marking ferrets with passive integrated transponder (PIT) tags and annual spotlight searches coupled with automated transponder readers to individually identify survivors. Unmarked ferrets should be captured and implanted with PIT tags whenever possible. These and other methods are detailed. Circumstances that may dictate other methods or more intensive monitoring (e.g., high rates of loss or low recruitment) also are discussed.

Keywords: anesthesia, black-footed ferret, monitor, *Mustela nigripes*, snow tracking, spotlight, transponder, trap

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Introduction

The need to prescribe standards for monitoring black-footed ferrets (*Mustela nigripes*) at reintroduction sites has become apparent to the U.S. Fish and Wildlife Service (FWS) and members of the Black-footed Ferret Interstate Coordinating Committee (ICC), who discussed formulating standards at the ICC annual meetings of 1994 and 1995. That need was reaffirmed as an action item in an American Zoo and Aquarium Association program review (Hutchins and others, 1996) and at the Black-footed Ferret Conservation Subcommittee (of the Black-footed Ferret Recovery Implementation Team) meeting of 2001. Standards are needed in order to (1) accurately assess progress toward recovery goals, (2) clearly define monitoring expectations for future sites for black-footed ferret reintroduction, (3) provide guidance regarding methods and associated limitations, (4) assure FWS that participants provide consistent feedback on progress, and (5) make limited data comparable for broad-scale interpretations.

The need for standards does not imply that monitoring is presently haphazard. Indeed, several groups releasing black-footed ferrets have used similar strategies, most commonly spotlighting, to evaluate ferret status and trends; however, standardizing would increase the opportunity for comparisons among sites, years, and other variables of interest. Our suggestions are an attempt to balance needs and cost. Our goal was to prescribe methods that maximize applicability of the most basic data but would not preclude any group from participation because of cost. Reviews of monitoring efforts during the early years of ferret reintroductions in Wyoming, Montana, South Dakota, Arizona, Utah, Colorado, and Mexico revealed strengths and weaknesses that influenced our recommendations. This prescription defines minimum levels of monitoring, but we encourage all working groups to consider using more intensive monitoring efforts, when applicable, to help address questions of importance to recovery goals.

We are not suggesting procedures for so-called clearances (U.S. Fish and Wildlife Service, 1988) related to section 7 of the Endangered Species Act, although some of the techniques we discuss are useful for those purposes. We do not exhaustively analyze or describe methods beyond the minimum prescription (e.g., radio telemetry) but provide references for more information on those topics. We describe monitoring of black-footed ferrets only; monitoring of prairie dog populations, associated species, and diseases at reintroduction sites is also important, but such topics are beyond the scope of this paper.

Objectives

To monitor is to watch, observe, or check, especially for a real purpose (*Webster's New Collegiate Dictionary*). Monitoring is needed to accomplish the following objectives:

- assess progress toward site-specific population establishment and make attendant decisions related to the need to continue to release captive-bred animals and numbers that should be released,
- detect serious problems or catastrophic population declines (e.g., due to diseases) that might be remediated,
- assess recovery at the national level, and
- test hypotheses regarding methods involved in establishing self-sustaining ferret populations (e.g., rearing, release, translocation, disease prevention, ferret searches, predation reduction).

Specifically, monitoring may provide data to (1) estimate population size, composition, and rates of natality and mortality; (2) assess genetic representation within a population; (3) identify causes of mortality; (4) document spatial distribution of ferrets including dispersal and habitat use; and (5) assess condition of ferrets, exposure to diseases, and parasite loads.

Types of Data: Balancing Needs and Costs

Useful minimum monitoring levels must produce information that identifies whether or not there are serious problems and allows assessment of progress toward local and national recovery goals (the first three objectives listed above). If losses of ferrets are low during initial releases, and if later populations appear to be self-sustaining, then monitoring can be maintained at these minimum levels. If problems are evident (e.g., excessive losses of ferrets), then we suggest increased levels of monitoring to identify their causes. The alternatives are site abandonment or sustained augmentation of ferrets. Abandonment does not contribute to our understanding and may result in repeated mistakes. Sustained augmentation seems inefficient but may, in the end, be needed at some sites.

The fourth listed objective of monitoring relates to experimentation and hypothesis testing to better understand the ecology of ferrets and improve reintroduction strategies, thereby enhancing the prospect for successful species recovery. This objective may necessitate monitoring that is different and sometimes more intensive than the minimum levels prescribed below. This learning objective is sufficiently important to programmatic decisions that it may at times take precedence over other objectives. Needs vary by site and year; further discussion of this objective is beyond the scope of this paper.

Minimum data needed to accomplish the first three objectives are estimates of population size, survival rates, and annual recruitment. A critical review of the last four decades of black-footed ferret monitoring, however, reveals that there never have been estimates of these attributes that were free of known biases. Recently, we have qualified these estimates as “minimums,” recognizing that not all ferrets will be found (Biggins and others, 1998). Moreover, “survival” rates should really be termed “retention” rates, where failure to retain ferrets at a reintroduction site can be due to emigration or mortality. Retention rates are likely biased downward because of undetected ferrets, but actual survival rates could be higher than retention rates if dispersal away from the reintroduction sites occurred without concurrent mortality. Population size, survival, recruitment, and associated variances can be estimated with closed form models or iterative numerical optimization if unbiased surveys are repeated over short time spans (Otis and others, 1978; White and others, 1982), and even more analytical tools are available if those multiple surveys done in short spans are replicated again over longer spans (robust designs: Kendall and others, 1995; Hines and others, 2003; program MARK: White and Burnham, 1999). The increased effort in repeated surveys is obvious, but avoiding bias caused by observer familiarity gained during previous surveys calls for additional constraints, problematic logistics, and even greater costs. Thus, we believe that the effort required could not be sustained over multiple reintroduction sites and years; the 24-year history of rather intensive monitoring of black-footed ferrets provides ample evidence regarding how much can be accomplished with available resources. Realistically, the tactics that have been used over the past 10 years are likely to remain the ones used to monitor black-footed ferret populations in the future, and the measures of population size, survival, and recruitment obtained by those monitoring methods (described below) will have to serve as indices to population attributes.

Although those indices (e.g., population size) are biased, they are nearly always based on complete coverage of respective reintroduction sites during spotlight surveys. Thus, issues of spatial sampling are not relevant. Although coverage may be complete, the counts are not a census because all ferrets are not found. We do not regard this bias as a fatal flaw, in part because it is unlikely to be large and in part because the counts can be adjusted for effort, providing indices that are particularly useful in a comparative sense (e.g., comparisons among groups and years within sites). Diminishing cumulative detections of unique ferrets over several days of spotlight searches (discussed below) provide reassuring evidence that large numbers of ferrets usually do not remain undetected during spotlight surveys. The standardization of search methods suggested below also will enhance comparability of data sets.

Data Collection Methods

Relatively few techniques have proven effective to “watch, observe, and check” black-footed ferrets; each method has its advantages, disadvantages, limitations, and risks. The methods currently used are snow tracking, spotlighting, capture-mark-recapture, and radio telemetry, but each can be utilized at varying levels of intensity and can be coupled with other strategies to increase the quality and quantity of data. Indeed, use of multiple methods allows cross-checking and verification of data.

Snow Tracking

Snow tracking involves searching from the ground or aircraft to locate tracks and other sign (especially diggings) of black-footed ferrets. Individual ferrets can sometimes be identified based on geographic location of tracks and origin and terminus points. Counts can be cumulative, giving an estimate of ferret numbers, provided that snow conditions remain optimal for at least several days. The strategy involves searching along ground transects (Richardson and others, 1987) or aerial flight lines (Biggins and Engeman, 1986; Miller and Biggins, 1988) until tracks or diggings are encountered. Track sets then are individually followed from origin to terminus to determine individuality and gather accessory information on movement pattern (use of space, but only crudely related to time) and to opportunistically collect scat for diet information. Broad-scale searches for tracks have revealed the presence of ferrets on prairie dog colonies that would not otherwise have been monitored. Absence of tracks, however, does not prove absence of ferrets because ferrets may remain inactive for many days following a snowstorm.

Snow tracking is least likely to adversely impact ferrets, requires little specialized equipment, and is relatively inexpensive. The principal disadvantage is weather dependency; although snow is common in the northern and western portion of the ferret’s original range, good tracking conditions occur only sporadically. Best results are attained when snow cover is continuous and undisturbed for several days. Warm sunny spells can cause patchiness, and winds can quickly erase evidence. Prairie dog (*Cynomys* spp.) tracks cause confusion during searches from the air and ground and may obliterate ferret tracks; however, white-tailed prairie dogs (*C. leucurus*) and Gunnison’s prairie dogs (*C. gunnisoni*) routinely hibernate, and black-tailed prairie dogs (*C. ludovicianus*) also may enter torpor (Lehmer and others, 2001), allowing effective midwinter ferret searches during prolonged spells of calm, cold weather following accumulations of snow. A team of searchers must respond immediately when favorable conditions develop. Each site should have a snow-tracking plan targeting priority areas for searches so that implementation can be rapid and efficient. Identification of mustelid tracks is not always straightforward; long-tailed weasel (*Mustela frenata*) tracks cause potential confusion (Miller and Biggins, 1988). Individual identities of ferrets can be ascertained if they have been marked with passive integrated transponder (PIT) tags (see subsection on Capture, Handling, and Marking). If ferrets are not individually identified, conservative time and space separation criteria should be used (see subsection on Minimum Level of Monitoring) to determine the minimum number of different ferrets present because ferrets can move long distances each night and because several ferrets can reside in close proximity.

Spotlighting

Spotlighting has been the universal technique for finding black-footed ferrets (Campbell and others, 1985). Prairie dog colonies are scanned at night with high-intensity spotlights by individuals on foot or in vehicles (e.g., all-terrain vehicles or trucks). Recently, most spotlighting has been conducted by using continuous illumination while the observer moves slowly (10 km/h), but earlier workers, searching on relatively small prairie dog colonies, preferred a systematic schedule of intermittent illumination from a fixed location (Henderson and others, 1969; Fortenbery, 1972). Standardization to the extent possible is very important because variation in the manner of implementation can lead to erratic results, but standardization must be balanced with site-specific needs.

Compared to snow tracking, spotlighting gives much more accurate temporal data to accompany spatial data. The eyes of ferrets reflect an emerald green shine, but other animals, such as badgers (*Taxidea taxus*), coyotes (*Canis latrans*), weasels (*Mustela* spp.), deer (*Odocoileus* spp.), and pronghorns (*Antilocapra americana*), can cause confusion. Interorbital distance, distance from ground, and behaviors help distinguish ferrets from some other mammals, but distances can be deceiving at night, and experience is necessary for reliable and efficient identification. Coyotes tend to briefly look at the spotlight, run a short distance, stop, and then look at the spotlight again. Weasels dart about much more quickly than ferrets and have a more subdued eyeshine. Swift foxes (*Vulpes velox*) run with a rigid gait, so the eyeshine does not undulate, then may stop and briefly lay close to the ground. When ferrets are moving, their eyeshine tends to bounce because of their bounding gait. Deer and pronghorns have much larger eyes and tend to be bedded down at night in groups; their eyeshine rises when they stand up.

Reported detection rates range from 1.4–102.6 hours per black-footed ferret sighting and up to nearly 264 hours per unique ferret located (table 1) for surveys of reintroduced and wild populations. Sighting rates are influenced by ferret density, but topography, vegetation, and varying behaviors of the animals (e.g., because of weather, season, origin of stock, rearing method) may also contribute to variation in sightability

Table 1. Examples of search efforts expended for locating black-footed ferrets (*Mustela nigripes*) with spotlights.

Location	Time	Source	Hours	Number of hours/ ferret sighting	Number of hours/unique ferret sighting
Southwest South Dakota	1966–67	Hillman (1968)	462.0	4.0	
Meeteetse, Wyo.	Summer 1983	Forrest and others (1988)	260.0		3.0
	Summer 1984	Forrest and others (1988)	554.0		4.3
	Summer 1985	Forrest and others (1988)	647.0		11.2
Shirley Basin, Wyo.	October 1991	Hnilicka and Luce (1992)	121.5		12.2
	November 1991	Hnilicka and Luce (1992)	258.5		28.7
	Summer 1992	Hnilicka and Luce (1993)	1,256.1	35.9	125.6
	November 1992	Hnilicka and Luce (1993)	925.1	17.5	51.4
	Summer 1993	Luce and others (1994)	675.8		35.6
	October 1993	Luce and others (1994)	1,244.7		52.0
	Summer 1994	Staley and Luce (1995)	570.7		95.1
	October 1994	Staley and Luce (1995)	591.3	34.8	118.3
C.M. Russell NWR, Mont.	1994–96	Stoneberg (1996)	952.7	3.1	5.9
Conata Basin/Badlands, S. Dak.	Fall 1994	Plumb and Marinari (1996)	247.5	7.7	35.4
	Summer 1995	Plumb and Marinari (1996)	600.4	26.1	66.7
Conata Basin, S. Dak.	September 16–23, 2002	T. Livieri (unpub. data)	462.0	1.4	3.1
Aubrey Valley, Ariz.	June–December 2002	Winstead and others (2003)	1,847.0	102.6	263.9
Aubrey Valley, Ariz.	June–November 2003	Hoss and others (2004)	2,014.0	69.4	83.9

(Marinari, 1992). The probability of detecting an individual free-ranging ferret with spotlights has not been estimated for any set of conditions. Cumulative counts over time, however, have been plotted and may generically illustrate probability of detection during short time spans, assuming no mortality occurs. Data from the Meeteetse, Wyo., population of ferrets on white-tailed prairie dog habitat suggest that about 82 percent of the cumulative total number of ferrets had been counted after four nights of spotlight searches (Forrest and others, 1988). Similar data from spotlighting in 17 black-tailed prairie dog colonies in the Conata Basin of South Dakota (T. Livieri, unpub. data, 2002) resulted in a steeper curve, with 92 percent of the cumulative total counted after three nights and 98.5 percent counted after four nights (fig. 1). For the South Dakota data set, the cumulative proportion of ferrets counted also increased as a function of cumulative time spent spotlighting adjusted by area covered during the search (fig. 2). Although most ferrets appear to be found during diligent searches, individuals can be elusive. In Utah, a female remained undetected for 24 months (three surveys) (B. Zwetzig, oral commun., 2004); in Arizona, two females were not located for 27 months (Hoss and others, 2004); and an adult male in South Dakota was first relocated 40 months after release (W. Perry, oral commun., 1998).

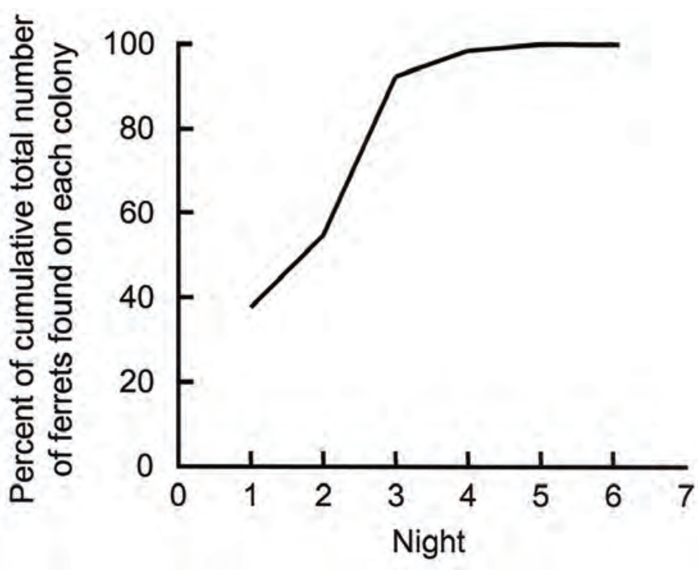

Figure 1. Black-footed ferrets (*Mustela nigripes*) encountered per night during spotlight searches on 17 black-tailed prairie dog (*Cynomys ludovicianus*) colonies, September 16-22, 2002, in Conata Basin, S. Dak.

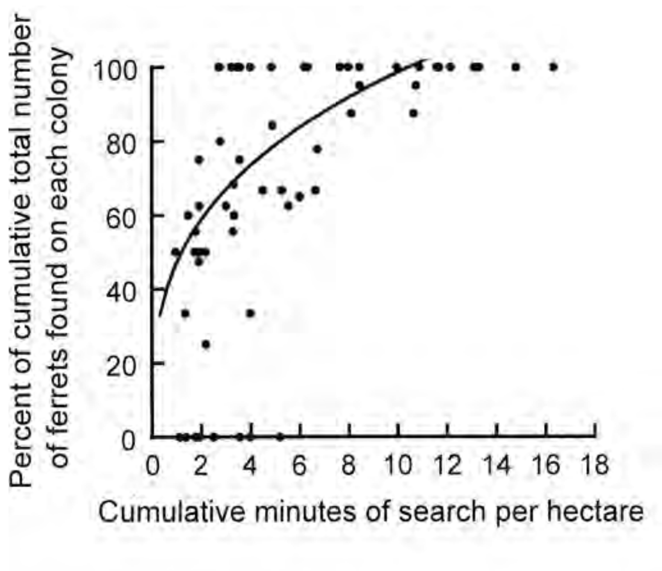

Figure 2. Black-footed ferrets (*Mustela nigripes*) encountered per minute per hectare during spotlight searches on 17 black-tailed prairie dog (*Cynomys ludovicianus*) colonies, September 16-22, 2002, in Conata Basin, S. Dak. An exponential curve was fitted to data.

Table 2. Percent of the cumulative total number of black-footed ferrets (*Mustela nigripes*) counted during 1999–2002 at Conata Basin, S. Dak.

	Cumulative counts				
	1999	**2000**	**2001**	**2002**	**Mean**
			Males		
July–August	71.4	70.0	85.2	65.4	73.0
September	92.9	76.7	92.6	96.2	89.6
October	92.9	93.3	100.0	100.0	96.6
November	100.0	96.7	100.0	100.0	99.2
December–on	100.0	100.0	100.0	100.0	100.0
			Females		
July–August	93.9	92.9	88.3	94.1	92.3
September	100.0	100.0	95.0	100.0	98.8
October	100.0	100.0	100.0	100.0	100.0
November	100.0	100.0	100.0	100.0	100.0
December–on	100.0	100.0	100.0	100.0	100.0

Cumulative total spotlight counts of ferrets continue to increase over time spans of months, but in these longer spans it is not reasonable to assume that the estimates are unaffected by losses of animals. For a 4-year data set from South Dakota (T. Livieri, unpub. data, 1999–2002; data from those colonies that were repeatedly searched each month), monthly detection rates for males appeared to be lower than rates for females (table 2). Assuming a constant monthly survival rate of 0.9763 (annual survival of 75 percent), the increasing cumulative monthly counts in table 2 can be approximated by (constant) monthly spotlight detection rates of 0.722 for males and 0.918 for females. These estimates need refinement but seem to reflect differences in ability to detect adult males and adult females with spotlight searches.

Spotlighting can alter behaviors of black-footed ferrets. Responses to the lights seem to vary among individual ferrets. Some ferrets may avoid the light by decreasing aboveground activity, and others may attempt to escape through increased movements (Campbell and others, 1985). Spotlights emitting white light probably should not be used for prolonged observations of a ferret (Campbell and others, 1985). More equipment (e.g., spotlights, backpack units, batteries) is needed for spotlighting than for snow tracking. Similar to snow tracking, located ferrets can be identified with remote transponder readers or through capture.

Capture, Handling, and Marking

Whether ferrets are located by spotlighting or snow tracking, identification of each individual may enable (1) cumulative minimum counts of animals while positively avoiding double counting, (2) an overview of dispersal movements, (3) tests of hypotheses regarding comparisons between treatments (e.g., rearing conditions, sex, site, habitat use, release method; Biggins and others, 1998), and (4) assessment of likely matrilineal relationships within populations (Biggins and Godbey, 2003). With some monitoring designs, marking also may allow (1) use of mark-recapture methods for population estimation (Otis and others, 1978; White and others, 1982; White and Burnham, 1999; Rivest and Daigle, 2004), (2) use of survival estimators (Lebreton and others, 1992), and (3) estimation of age-specific mortality rates.

Successful methods for marking ferrets are passive integrated transponder (PIT) implants (Fagerstone and Johns, 1987) and ear tattoos (Fagerstone and others, 1985). Tattoos are usually identifiable only on ferrets that are in hand and sometimes become illegible or disappear entirely. Less commonly, transponders have ceased functioning or have been lost from the ferrets. Passive integrated transponder tags are relatively inexpensive and easy to install and have become the preferred technique for marking ferrets. Two transponders should be implanted, one on the posterior part of the head and the second dorsally between the hips. After a ferret has been located by spotlighting or snow tracking, its transponders can be identified with an automated reader that is left at the occupied burrow (Stoneberg, 1996) (fig. 3), or the ferret can be captured and identified with a hand-held reader.

If an attempt at automated transponder reading fails, capture can be used as a backup. Capture involves additional stress on animals (Thorne and others, 1985) but provides an

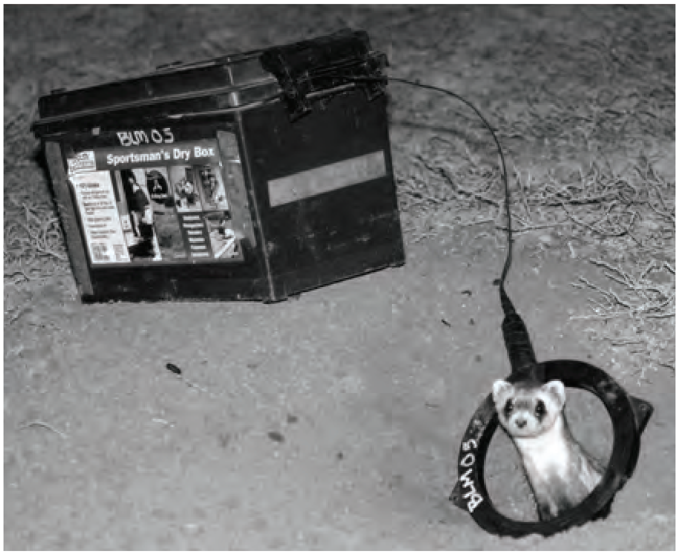

Figure 3. Automated passive integrated transponder readers in waterproof boxes may be left at burrows occupied by black-footed ferrets (*Mustela nigripes*). Transponder numbers will be recorded as the ferret passes near (or through) the loop antenna placed to encircle the burrow entrance.

opportunity to assess condition and take samples of blood, parasites, etc. These samples could prove invaluable in disease evaluations and for genetic studies. Traps (see fig. A1 in appendix) must be in good working order. It is exasperating to find a malfunctioning trap at the end of an extended attempt to capture an animal. If a burrow system is thought to have multiple openings, openings lacking traps may be plugged with rocks, wood, or plastic cups (44 oz). When trapping is finished, all traps must be retrieved, and all burrows must be unplugged.

Dye marking captured ferrets can prevent double counting during a survey and helps identify ferrets already captured during a trapping session. Dye can be applied to captured animals without use of anesthetics. Effective dyes include Nyanzol D (Hoogland, 1995) and hair dyes. Dyes, however, are temporary compared to transponders, lasting at best until the next molt; PIT tags should be used whenever possible, whether or not fur is dyed.

Anesthesia is necessary for many of the procedures mentioned above. Anesthetics used in the field on black-footed ferrets have included ketamine, a ketamine-medetomidine mixture (reversed with atipamezole) (Kreeger and others, 1998), telazol, and isoflurane. Gas anesthesia (including isoflurane) requires a relatively bulky and complicated apparatus, including an induction chamber, vaporizer, mask, oxygen bottle, and connecting tubes. Isoflurane, however, allows a highly controllable level of anesthesia and maintenance of much higher blood oxygen concentrations (Gaynor and others, 1997).

Field technicians who need to capture and handle black-footed ferrets must complete a certification course. Presence of a veterinarian is beneficial when using anesthetics and handling ferrets. Ferrets should not be released until fully recovered from anesthesia, which may take hours with some injectable anesthetics.

Radio Telemetry

Radio telemetry has been used on black-footed ferrets since 1981 (Biggins and others, 1985, 1986). Telemetry has distinct advantages; animals are individually identifiable from remote locations with minimal human disturbance, behaviors can be monitored remotely (e.g., movements, home ranges, activity cycles, dispersal), fates can be identified, additional methods of survival analysis are available (Heisey and Fuller, 1985; Pollock and others, 1989), causes of mortality can be identified, and habitat use can be objectively assessed (White and Garrott, 1990). Disadvantages include the expense and impact of placing transmitter packages on or in the animals. Ferrets are assumed to be influenced by a transmitter, whether external or implanted; the effect can vary from trivial to devastating. Discussions about whether or not to use radio telemetry should focus on the degree of suspected impact weighed against potential gains in knowledge. Neck abrasions have been caused by collars, and premature collar loss has been common. The currently recommended collar is made of wool and degrades within several weeks to months (Biggins, Godbey, Miller, and Hanebury, this volume).

Compared to spotlighting and snow tracking, radio telemetry on black-footed ferrets is expensive and relatively difficult to master. Use of radio triangulation during ferret reintroductions has concentrated on intensive but short-term (30–60 days postrelease) data collection to compare behaviors of animals and document their fates (Biggins and others, 1999: Biggins, Godbey, Livieri, and others, this volume). Less labor-intensive, automated signal detection was used in releases of ferrets in South Dakota and Montana with emphasis on determining fates of ferrets, but interpretation of data was problematic. Because of the large commitment of time and funds and the possibility of adverse impacts on ferrets carrying transmitters, we regard radio telemetry as a specialized tool that should not be considered for routine monitoring of black-footed ferrets (Biggins, Godbey, Miller, and Hanebury, this volume).

Alternative Techniques

Other techniques that have been used in attempts to locate ferrets include scent dogs (Reindl, 2004); scent attractants coupled with remote cameras or transponder readers; implantable radio transmitters; long-range transponders; night vision equipment, such as light amplifiers and infrared detectors; and track plates. To date, these techniques have not proved widely applicable under field conditions, but they may become more useful in the future.

Recommended Standards

Minimum Level of Monitoring

Under the present circumstances and state of technology, we recommend marking all ferrets, including as many wild-born individuals as possible, with two transponder chips; spotlighting to locate black-footed ferrets; and identifying all ferrets located by using combinations of remote transponder readers and capture. Dye marking in addition to PIT tagging can allow the searchers to bypass ferrets, avoiding the need to set a reader or capture the animals to find out if they have already been PIT tagged. Failure to read the PIT tag each time a ferret is located, however, may preclude more rigorous assessments of population attributes and ferret movements. Exactly how these tools are deployed depends on the phase of reintroduction and the objectives for monitoring.

For sites where ferrets are released in fall, we recommend a minimum of two spotlighting periods, the first beginning 30 days after the final release (if there were several, closely spaced, sequential releases) and the second, postreproductive survey beginning in August of the following year. An existing ferret population that has not received additional releases of ferrets during the previous 12 months may be monitored with an August survey only. A prebreeding survey in March–April is highly desirable (for both recently released and established populations) but is not considered a requirement. If possible, ferret searches should be conducted during bright moonlight. Preliminary analyses for Siberian polecats (*M. eversmannii*) and black-footed ferrets suggest that radio-tagged individuals of both species were more active during bright nights (full moon) than during dark nights (new moon); when the moon was partially illuminated, they were more active during the part of the night when moonlight was present than when it was absent (Biggins, 2000).

Clark and others (1984) suggested methods for locating ferrets, and the FWS later recommended criteria for black-footed ferret surveys to clear prairie dog towns for development activities, application of toxicants, or other actions that might be detrimental to an existing population of black-footed ferrets (U.S. Fish and Wildlife Service, 1988). Because the guidelines were developed from techniques used at Meeteetse to monitor a wild population, some aspects are applicable to the standards proposed here for monitoring released ferrets. The basic recommendations of the survey guidelines are reiterated below, and each of these is followed by suggested modifications (if any) applicable to the minimum standards for monitoring reintroduced ferret populations.

1. When monitoring existing populations, surveys should be conducted between August 1 and September 30. This is the period when young ferrets have become sufficiently active above ground that they can be captured for marking, and it is normally prior to dispersal so that litters are usually separately identifiable. Adult males seem to be less detectable than adult females during this period (table 2).

2. Prairie dog towns should be continuously surveyed between dusk and dawn on each of three to five consecutive nights to ensure systematic coverage and increased opportunity to discover black-footed ferrets. A ferret can stay inactive for days (Biggins and others, 1986; Richardson and others, 1987), presumably depending on weather and its food supply. We suggest adding more nights (if necessary) until no (or few) new ferrets are found. If scheduling dictates that spotlighting cannot be continuous from dusk until dawn, then gaps in coverage should be rotated among nights so that no time period is neglected.

3. Detection depends on the ferret being above ground and facing the observer at the time the spotlight is directed toward it. Pass the spotlight across the landscape, and follow with a sweep back across the same path. A ferret looking away from the light during the first pass may become curious and turn toward the light on the second pass. Large prairie dog towns should be divided into tracts, and each tract should be systematically and repeatedly searched. Each searcher should concentrate on an area that ensures at least one pass every 30–60 minutes. Rough terrain, dense vegetation, and lack of road access may dictate small tracts to result in effective coverage. On occasion, the objective may be only to document presence or absence of ferrets on colonies, in which case tracts could be large (up to 800 ha). The area should be as small as practical to increase the opportunity for detection. In some cases backpack spotlighting may be necessary (e.g., if vehicle access is impossible or legally restricted). If searches are done on foot, then each person should concentrate on about 130 ha or less. Boundaries of tracts should be well marked to keep searchers oriented at night.

4. Observations on each prairie dog town or tract searched should begin at a different geographic point on each successive night to maximize the chance of intercepting a black-footed ferret during its nighttime activities, the patterns of which tend to be somewhat animal specific and repetitive. Even within a night, searchers should consider varying their search patterns while ensuring even coverage (e.g., alternate traveling north-south and east-west).

5. Previous guidelines suggested that survey crews consist of one vehicle and two observers equipped with two spotlights of 200,000–300,000 candle power. Teams searching for ferrets in areas with known populations have used a wider variety of equipment and organizational strategies. Single searchers on foot, in trucks, and with all-terrain vehicles (ATVs) have been effective, and other types of spotlight equipment also have been used. Because relative efficiency of various strategies is somewhat site dependent, we propose no limits. Use equipment that is suitable for the weather, terrain, and personnel.

Additional specifications include the following:

1. It is better to search each site entirely within a short time span by using a large number of searchers than to use few people over a long time span. The long-span, low-intensity method leads to problems in specifying the time interval for which the estimate is relevant (e.g., for estimating survival) and increases potential for confusion in counting individuals that are not recaptured or otherwise identified (e.g., double counting or missing ferrets that moved).

2. Use a systematic sampling scheme giving uniform coverage to the entire area, even though higher densities of burrows may be present in some areas than others. Resist the temptation to repeatedly return to places where ferrets have been seen. Some of the fringe areas of prairie dog colonies may have the largest populations of prairie dogs, and intuitive perceptions of habitat quality are not always reliable. Provide markers to assist with relocating ferrets and orienting the surveyor.

3. Diligently attempt to identify all ferrets. If a transponder cannot be read remotely, then try to capture the ferret. If some members of the team are more adept at capture than others, then consider using them as a dedicated "capture" crew whose job is to capture and identify ferrets rather than search for them. Occasionally, individual ferrets can be identified by unique physical characteristics that can be distinguished after capture or, even more uncommonly, without capture. Acceptable examples we have seen include deep scars, missing portions of ears, and missing toes. We do not consider differences in coloration and individual mask patterns to be sufficiently reliable for individual identification.

4. If individual ferrets are not identifiable, then we recommend a conservative approach to classifying them as separate individuals. Unless snow allows absolute separation of track sets, ferrets can be classified as separate individuals only if it was nearly impossible for an animal to have moved between the two locations during the time interval between sightings. For sightings separated by <500 m, the sightings must be simultaneous (fig. 4). For sightings separated by longer distances, we assumed a maximum speed of 6 km/h for a ferret, decreasing in a nonlinear manner with increasing distance. This maximum has been used to screen radio-telemetry data for errors (Breck and Biggins, 1997). We reduced the maximum speed to a low of 0.694 km/h with a separation of 50 km because the maximum documented movement of a ferret in a 3-day period was about 50 km (Biggins and others, 1999). Two sightings with distance and time separations that plot above the curves of figure 4 can be assumed to be separate individuals. This approach mandates substantial evidence for inclusion of animals into a population count. To avoid underestimation of population size for unmarked populations, a larger survey crew will be

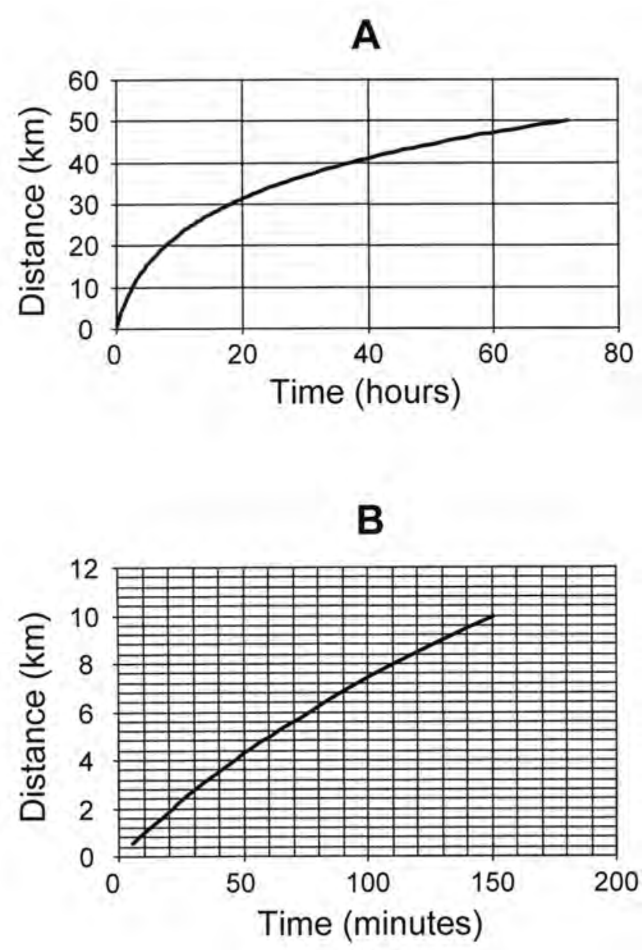

Figure 4. Minimum separations of distance and time needed to classify two sightings of black-footed ferrets (*Mustela nigripes*) as different individuals. Plot B is the lower portion of the curve in plot A, rescaled to provide better resolution. Separations of two sightings plotting above the curves can be considered separate individuals (e.g., two sightings 4 km apart separated by 30 minutes).

necessary (to increase the probability of simultaneous sightings of ferrets living in close proximity to each other).

5. A brief meeting should occur the morning following each spotlight search session to discuss results from the previous night. One important purpose is to assess the number of unique individuals that are likely represented by ferrets seen but not identified (using the criteria of 4 immediately above).

6. Use a standardized form with a map on the reverse side. Record all nonspotlighting periods (e.g., rest breaks) on the form, sketch ferret locations on the map, and place a marked flag at each ferret location. Use Global Positioning System (GPS) equipment to obtain coordinates of ferret locations, and record these coordinates on the data form (see appendix for examples of forms and checklists). Once coordinates and other necessary data have been collected, remove all flags.

7. Ferrets should be double marked before release with two PIT tags (anterior and posterior). At present, incompatibility among manufacturers requires that the ferret program adopt a single system. The tags and readers currently used in the ferret program are made by AVID® Microchip I.D. Systems (Folsom, La.). Transponder technology is developing rapidly, and other systems may be practical in the future.

8. Unmarked ferrets that are wild caught should be marked or re-marked if they have lost previous markings. Field anesthesia by a veterinarian or certified individual is necessary.

9. An annual report to the FWS should include a table listing all ferrets identified in monitoring surveys. Ideally, the table should be in a commonly used computer spreadsheet. For each ferret, the following accessory information should be provided:

   a. Studbook number and field identification number (telemetry number, site-specific wild-born animal number, PIT tag number, etc.)

   b. Sex

   c. Method of identification

   d. Date(s) of capture or identification

   e. Location(s) of capture or identification (Universal Transverse Mercator [UTM] coordinates from GPS receiver; include datum and grid zone)

   f. Observer(s)

   g. Date of original release (if applicable)

   h. Specimens taken (blood, fecal, parasites, etc.)

   i. Other data taken (weight, measurements, etc.)

   j. If previously unmarked wild-born kit, identify litter size and associated dam.

10. A standard release form (see appendix), filled out for each ferret released, should also be forwarded to the Black-footed Ferret Recovery Program Coordinator. As in 9 above, the forms can be tabulated and forwarded in spreadsheet form on a magnetic disk (see Plumb and Marinari [1996] for an example table).

Recommended Precautions—Legality, Human Safety, and Animal Safety

1. If using all-terrain vehicles (ATVs), heavy batteries used to power spotlights can change weight distribution and make the vehicles unstable.

2. Riders of ATVs should be certified if required by the employer. Night operation and use of a spotlight increase the difficulty. Special training should be provided on ATV safety and night use. Use appropriate protective gear and clothing.

3. Obtain all permits and notify appropriate authorities regarding timing and location of spotlighting activity. Spotlighting is prohibited or regulated in some States. A Federal endangered species permit will be required.

4. Listen to weather reports and be familiar with local conditions. Weather can change rapidly, and impending changes may not be obvious at night. Hazards include lightning, dangerously large hail, tornadoes, and disorientation at night, especially in snowstorms. These phenomena are not imaginary; spotlight searchers have had close calls with all of them.

5. Searchers should be fully familiar with their assigned areas, which may require a visit during daylight. A compass or personal GPS unit may allow a technician to avoid becoming lost during thick fog or heavy snowfall. Searchers should work in pairs when there is a threat of adverse weather.

6. The survey crew should be as well equipped as possible with two-way radios. For safety and efficiency, it is especially important to maintain frequent communication with individuals working in remote areas.

7. Landowners must agree (preferably in writing) to the activities being conducted on or around their properties and should be kept well informed of progress.

8. Respect property, whether public or private. Avoid rutting muddy roads, and follow applicable rules and procedures for off-road driving with ATVs or larger vehicles. If you inadvertently damage property (e.g., gates, fences, cattle guards), make any needed repairs or arrange to have them done.

9. Spotlights are disruptive, so minimize the observation time with intense white light. After locating a ferret, it should be observed in the periphery of the light beam, using the least illumination possible to maintain contact for necessary follow-up activities (e.g., transponder reading, trapping). Avoid repeated harassment of the same animal.

10. When trapping, do not separate a mother from her kits for extended periods. Although unusual circumstances may dictate either more lenient or more restrictive limits, we suggest limiting such separations to <24 hours during late July–September. Separations should be much shorter if it becomes necessary to trap an adult female (that has young kits) earlier in the season. Remember that a burrow blocked by a trap can separate the dam from her kits even if no ferrets are caught. Traps should be checked at least once per hour by approaching the trap and looking all the way into it. Closed traps should not be left in burrows (ferrets have been inadvertently caught in closed traps). Badgers and other predators can kill an entrapped ferret, and severe weather can cause hyperthermia or hypothermia.

11. Use properly maintained traps. Traps that are poorly maintained or misused have injured ferrets. For example, ferrets have received abrasions and lacerations when forcing their way through gaps at the back door, even though the doors were secured with clips. We recommend clipping or otherwise fastening each corner of the back door. Check for treadle sensitivity, protruding wires, broken welds, and bent parts. Poorly maintained traps may increase the amount of time spent harassing an animal if repeated attempts become necessary to catch it. Wrapping traps in pieces of wool blanket or burlap helps protect a captured ferret from wind and cold and seems to create a more enticing tunnel that may facilitate capture and keep the animal calm after capture.

12. Ferrets usually should be released into the burrow where they were captured and during hours of darkness whenever possible. If necessary, a ferret may be held in a cool location until the following night. A portion of a prairie dog can be given to any ferret that must be captured for handling or marking to help mitigate the stress of the procedure. If presented at the time of release, ferrets often will take these offerings into the burrow. Prairie dog remains may attract badgers or other predators, so their use should be judicious and closely monitored. If your site is within the known range of plague, we suggest precautions to avoid inadvertently feeding plague-contaminated carcasses (use prairie dogs from plague-free zones or those that have been properly quarantined).

13. Contact the Black-footed Ferret Recovery Program Coordinator for latest developments regarding trapping and handling ferrets, and refer to Thorne and others (1985) for additional details.

The best training for monitoring black-footed ferrets is assisting in an effort that is already underway. Persons who will be responsible for monitoring at a new reintroduction site should participate in monitoring at an existing site well before the new project begins.

Expanding Beyond the Minimum Standards

1. Groups of ferrets may be released sequentially at a site throughout extended periods (60 days or more). Spotlight surveys have been conducted 30 days after the last release (Montana and South Dakota) and 30 days after the midpoint of extended releases (Wyoming). For releases over relatively long spans of time, a solution might be to conduct more than 1 survey at about 30 days postrelease, treating groups of animals as separate releases.

2. Prior estimates of survival of released ferrets using spotlighting data were treated as minimum survival because ferrets may have remained undetected during surveys. With several searches repeated over a short time span (e.g., 2 weeks) true survival rate or population size may be estimable. Separate estimates of the probability of detection and accompanying variation could be investigated with repeated sampling within short time spans. The assumption of no emigration or other losses is problematic, so each complete search should be carried out quickly (one to three nights) and repeated as often as expedient.

3. As conditions permit, snow tracking should be used to augment spotlighting. Data collected by snow tracking may not be directly comparable to spotlighting data. Because maximum comparability through standardization across sites and years is an important consideration, snow tracking may supplement spotlighting but cannot replace it. Ferret scats have been collected during snow tracking, providing additional opportunities for evaluations of food habits (Sheets and others, 1972; Campbell and others, 1987) and for molecular genetic assessments.

4. Telemetric monitoring will most likely provide con-

structive feedback for management decisions if used during the first release at a new site, at sites with high rates of ferret disappearance, during a dramatic population decline, or in studies designed to test hypotheses having wide-scale implications (see also Biggins, Godbey, Miller, and Hanebury, this volume). In the interest of avoiding additional burden to a dwindling population, it may be tempting to reduce monitoring intensity (and eliminate telemetry) at a time when information is most desperately needed. The information gained through detailed studies during a crisis may be critically important for future success at that site and for the recovery program in general. A "failure" may be recharacterized as a success if enough is learned to avoid repetition of the event at that same site or at other sites. As with snow tracking, use of radio telemetry does not eliminate the need for the spotlight surveys.

5. The addition of a spring spotlighting survey, conducted as described above for the fall and summer surveys, provides a useful assessment of overwinter survival and an estimate of the breeding population of ferrets. These surveys are often conducted in March or April (Matchett, 1997).

Other Issues—Duration of Monitoring Program, Altering the Intensity, Monitoring and Research

If the ferret population is not yet near estimated carrying capacity but its growth is as expected or above, the minimum monitoring strategy should be adequate. Because there will be a need to know when a population may require augmentation, and when a population is doing so well that it can be a source of animals for other populations, annual monitoring at these minimum levels should be conducted for each year that ferrets are released and at least 2 years following the final release. A ferret population may be surveyed in alternate years if it has a positive growth rate or remains stable because of birth of kits at the site for 2 years following the final release and if the site will not be serving as a source for translocations of ferrets. The most intensive monitoring should be planned for the first few years of releases at a site when there are many questions and no established record of success, with decreases in intensity during subsequent years. If population growth becomes slow or negative, intensive monitoring again is appropriate to identify the problem(s). Increased spotlighting and/or radio telemetry may be needed in some cases. Other types of monitoring (e.g., for diseases such as plague and distemper; prairie dog abundance and habitat quality) are also needed, and their results help define the relative need for ferret monitoring. The situation predictably will be dynamic, calling for flexibility in program management. If some working groups have insufficient resources to respond rapidly to changes, the leadership in the national program may need to recommend reallocation of resources (e.g., funds authorized under section 6 of the Endangered Species Act, different priorities for research support) to sites in response to shifting needs. Even the minimum monitoring standards proposed above may need modification if (1) the entire program becomes dramatically more or less successful than at present, (2) funding radically changes, (3) available habitat becomes fully occupied by ferrets, and (4) new technology makes more efficient techniques available. We strongly recommend close communication between working groups and national program managers during the process of formulating site-specific monitoring plans.

The suite of methods described for monitoring black-footed ferrets has been used for both research and management applications, but the distinction between the two purposes is poorly defined. Many ferret releases in the near future probably will have a blend of learning objectives (implying research with indirect benefits to long-term recovery) and population establishment objectives (implying management actions with direct, short-term benefits). A single monitoring program often contributes to both purposes. For example, snow tracking in 1982–86 at Meeteetse yielded winter population estimates for ferrets, helping to track the welfare of the population in the immediate sense, and gave information on movements of animals and other aspects of ecology (Richardson and others, 1987). Used during releases of ferrets, radio telemetry has allowed relocation of animals that dispersed into unsuitable habitat and has enabled documentation of heavy losses of ferrets to predation, information with important short-term management implications. In several cases, the primary purpose of radio telemetry was to test hypotheses of differential survival and behavior of groups of ferrets produced and released under varying conditions (Biggins and others, 1999). The minimum spotlighting standards recommended above emphasize the immediate need to assess population attributes. Addressing other objectives probably will require a more intensive strategy, expanded by adding other methods and/or increasing the amount of spotlighting (spatially or temporally).

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Appendix. Forms, Checklists, and Other Information that May Be Useful When Spotlighting, Capturing, and Handling Black-footed Ferrets

Spotlight Schedule/Assignments

Night of: ______________________________

Hours: ______________________________

Name	PDTs/route	Vehicle	No. of readers	Radio	Missing BFF/other

Black-footed Ferret (BFF) Survey Form

Mark sequential observation numbers on reverse-side map. Flag each location with BFF ID, date, and time for later GPS mapping.

Observer: ______________________________ Night of: ______________________________
(e.g., 3/19–20/98)

Transportation type: ______________________________

Prairie dog colony: (Sketch area searched on map on reverse side.)

Cloud cover: ______________________________ Moon phase: ______________________________

Snow cover %: ______________ Temp.: __________ Wind speed/direction: ______________

Comments: ____

____

Start and end time	Map and observation number	Time seen	BFF ID	Transponder number	Location	Time trap set/checked	Predators observed

Total search minutes: ______________

Black-footed Ferret Markings

ID	Sex	Date	Head transponder	Pelvis transponder	Dye	Location	CDV

Black-footed Ferret Handling Checklist

1. ___________Verify lack of transponder, other markings, and need to handle

2. ___________Date _________Time _________Sex _________ Age _________ ID

3. ___________Dam _________ Stud _________ Location and plot on map

4. ___________Trapper _________ Team

5. ___________Anesthetize at 3.0–4.0 ISO _________ Time

6. ___________DIAL ISOFLURANE TO 1.75, transfer to face mask _________ Time

7. ___________PATIENT NO.

Time	ISO	Oxygen	Pulse rate	% oxygen saturation	Respiration rate	Temperature

8. __________ Implant transponder chips HEAD _______________ PELVIS _______________
9. __________ Test transponder chips
10. __________ Collect hair and label envelope
11. __________ Collect blood and label VACUTAINER (cc) __________ NOBUTO (y/n) _______
12. __________ Give 1 cc, SC canine distemper vaccine. If recapture, booster given at 2 weeks
13. __________ Give penicillin injection (<1,000 g = 0.3 mL SC| >1,000 g = 0.4 mL SC)
14. __________ Apply dye mark: ADULT MALE = ---- WILD MALE = X OTHER
    ADULT FEMALE = | WILD FEMALE = 0
15. __________ Health inspection notes, read old tattoo, teeth, anomalies, etc.

16. __________ ISOFLURANE AND OXYGEN OFF
17. __________ Weigh
18. __________ Monitor recovery
19. __________ Disinfect/clean all equipment and surfaces, prepare for next animal

Dosages of Injectable Anesthetics for Black-footed Ferrets

KETAMINE/DIAZEPAM DOSAGES
premixed 10 mL KET (1,000 mg) with
2 mL DIAZEPAM (10 mg)

MEDETOMIDINE/KETAMINE
3.0 mg/kg KETAMINE + 0.075 mg/kg MEDETOMIDINE
Antagonize with 0.45 mg/kg; ATIPAMEZOLE after ≥30 min

Weight (g)	Light (20 mg/kg; cc)	Medium (25 mg/kg; cc)	T/T dose (30 mg/kg; cc)	Heavy (35 mg/kg; cc)	KET (cc)	MED (cc)	TOT (cc)	ATI (cc)
100	0.020	0.025	0.030	0.035	0.075	0.038	0.11	0.045
200	0.040	0.050	0.060	0.070	0.150	0.075	0.23	0.090
300	0.060	0.075	0.090	0.105	0.225	0.113	0.34	0.135
400	0.080	0.100	0.120	0.140	0.300	0.150	0.45	0.180
500	0.100	0.125	0.150	0.175	0.375	0.188	0.56	0.225
600	0.120	0.150	0.180	0.210	0.450	0.225	0.68	0.270
700	0.140	0.175	0.210	0.245	0.525	0.262	0.79	0.315
800	0.160	0.200	0.240	0.280	0.600	0.300	0.90	0.360
900	0.180	0.225	0.270	0.315	0.675	0.338	1.01	0.405
1,000	0.200	0.250	0.300	0.350	0.750	0.375	1.13	0.450
1,100	0.220	0.275	0.330	0.385	0.825	0.412	1.24	0.495
1,200	0.240	0.300	0.360	0.420	0.900	0.450	1.35	0.540
1,300	0.260	0.325	0.390	0.455	0.975	0.488	1.46	0.585
1,400	0.280	0.350	0.420	0.490	1.050	0.525	1.58	0.630
1,500	0.300	0.375	0.450	0.525	1.125	0.562	1.69	0.675

$$\text{DOSAGE} = \frac{\text{BODY WEIGHT * DOSE}}{\text{CONCENTRATION}}$$

MED/KET CONCENTRATIONS: KET = 4.0 mg/mL
MED = 0.2 mg/mL
ATI = 1.0 mg/mL

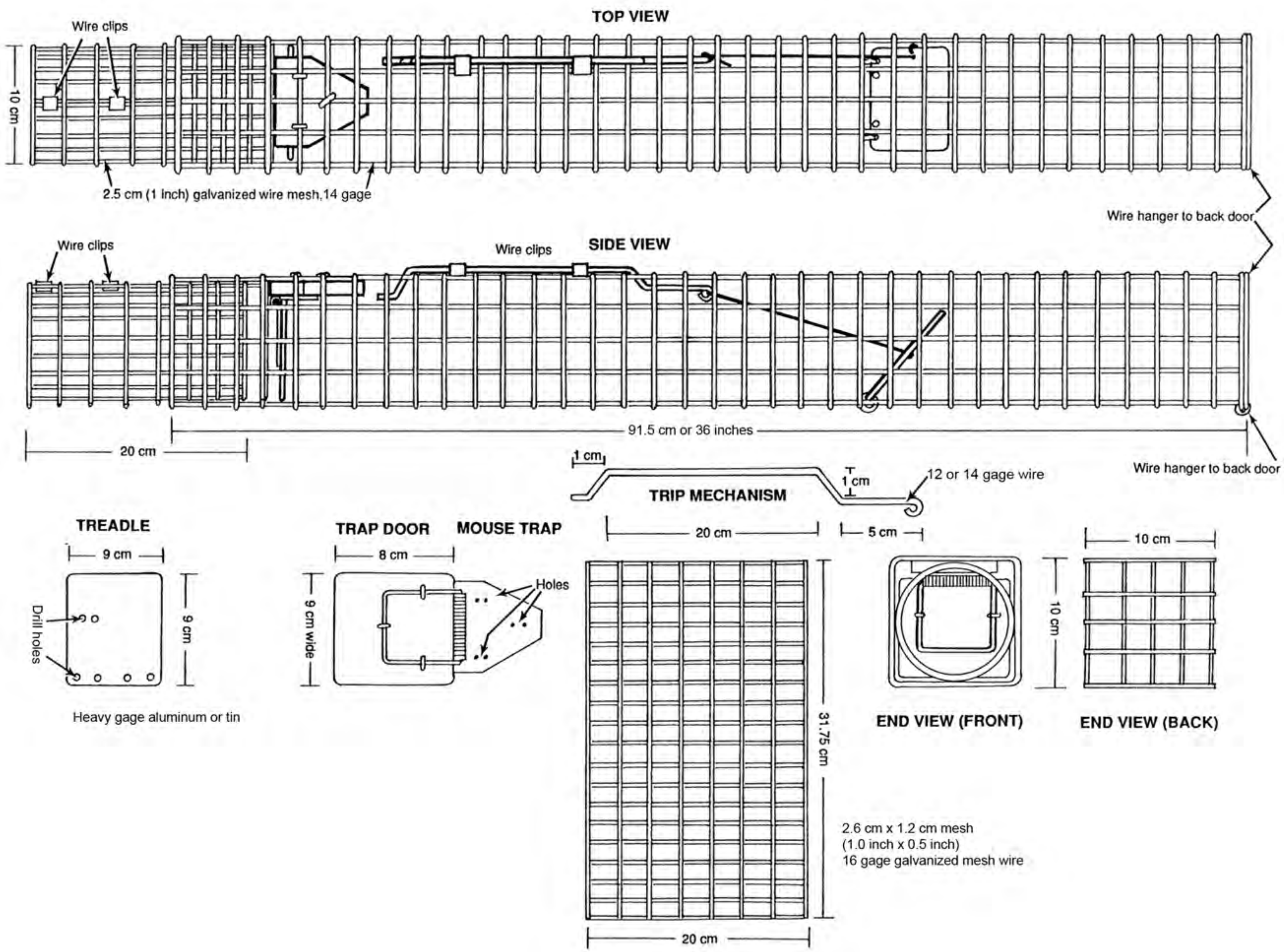

Figure A1. Design of a trap for black-footed ferrets (*Mustela nigripes*). This trap is a modification of the model described by Sheets (1972).