COYOTE ABUNDANCE, FOOD HABITS, AND REPRODUCTION
AT THE ROCKY MOUNTAIN ARSENAL NATIONAL WILDLIFE REFUGE
2005

U.S. Department of the Interior
U.S. Fish and Wildlife Service
Rocky Mountain Arsenal NWR
Commerce City, Colorado

Project Lead:
Noelle Ronan
Rocky Mountain Arsenal NWR
Bldg. 120
Commerce City, CO 80022
(303) 289-0908
Noelle_Ronan@fws.gov

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Project Summary

Coyotes are the top predator at the Rocky Mountain Arsenal NWR (RMA). A previous study provided density estimates of coyotes using RMA (Hein 1992). Since then, only limited updated coyote abundance information exists and there is no documentation of diet and reproduction. This 2005 study will estimate the abundance of coyotes that breed, forage, and travel on RMA, describe the seasonal food habits of coyotes, and estimate the number of coyote dens and litter sizes to provide an indication of reproductive success at RMA.

Introduction and Project Need

Estimates of wildlife population parameters are needed for informed management decisions, particularly when managing wildlife and habitat in remnant patches surrounded by significant urban development. The coyote population at RMA is of interest, in part, because the coyote is a primary predator and scavenger and has a potentially important influence on other wildlife such as small mammals and deer. The relationship between predator and prey can not be fully assessed without adequate estimates of population densities (Pyrah 1984) and other population demographics. This study will provide a current abundance estimate, document seasonal food habits and predominant prey items, and provide an indication of reproductive success of coyotes, which will help elucidate predator/prey relationships at RMA.

Coyote depredation on deer has been a popular topic of interest and investigation (Truett 1979). A study was initiated in 2004 to investigate the possible factors influencing a recent trend of low mule deer and whitetail deer recruitment at RMA. Using radio telemetry, high fawn mortality (approx. 75%) was documented (USFWS, unpubl. data). While the causes of fawn mortality are varied and often difficult to determine, field observations suggest that over predation of fawns by coyotes may be one contributing factor to low recruitment. An estimate of population size at one point in time is of limited value when concerned with questions regarding status (Lancia et al. 2004). Deer populations have been surveyed at RMA for many years, providing status and trend information. Deer population trends may be difficult to interpret without adequate data on predator abundance. Hein (1992) found that coyote density at RMA was high (0.71/km$^2$) relative to similar studies (Camenzind 1978, Pyrah 1984), however no updated estimate exists.
Current coyote density may not be comparable to the previous estimate due to changes in prey availability. Animal populations fluctuate irregularly in response to natural limitation factors. Food supplies have been shown to be the predominant restraint on coyote populations (Connolly 1978) through death of individuals and reduced reproduction. For example, jackrabbits are a significant food source for coyotes in some areas and coyote population changes have been correlated with associated jackrabbit population changes (Johnson and Hansen 1979). Furthermore, coyote diet fluctuates with season and prey availability (Johnson and Hansen 1979, Henke and Knowlton 1995, Andrews and Boggess 1978). The food habits and predominant prey of coyotes at RMA have not been studied. Collecting this information may indicate coyote population response to population changes of their dominant prey. Additionally, habitat conditions at RMA have been hypothesized to contribute to reduced deer recruitment; lack of cover may predispose fawns to greater predation through increased susceptibility. Determining coyote food habits would provide information on the percent of coyote diet constituting deer and can be compared to similar studies.

Objectives

1) Estimate relative abundance of resident and transient coyotes at RMA using scat deposition rates. Given sufficient volunteer assistance, estimate absolute density using distance sampling techniques.
2) Describe the seasonal food habits of coyotes by identifying mammal hair, skeletal remains, and other materials in scats collected on road transects.
3) Provide reproductive success information by locating coyote den sites using howling surveys and estimating litter sizes using standardized den observations.

Methods

Estimating Abundance

We will estimate relative abundance of coyotes on RMA by determining the scat deposition rate along approx. 1.0 mile segments of unimproved and infrequently traveled roads during seasonal time periods (Henke and Knowlton 1995; Fig. 1). Scat counts will be conducted every 2 weeks, which will correspond with sample collection for analysis of food habits (see below). The number of scat piles will be the sample unit, and field guides (Rezendes 1992, Halfpenny 1998) will be used to correctly identify coyote scat. Road transects will be traveled by truck at slow speeds (~20 mph). Because failure to detect scats causes bias, transects will be traveled twice in the same day, once in each direction. An index of coyote relative abundance will be calculated as the number of scats/mile/day. Due to seasonal changes in scat abundance resulting from differences in the amount and type of prey consumed, comparisons will not be made across seasons (Henke and Knowlton 1995). Also, Universal Transverse Mercator (UTM) locations of scats will be recorded and plotted to provide an indication of areas of habitual use for marking by coyotes.

Methods such as scat deposition rates, scent stations and den counts provide relative indices of abundance (Henke and Knowlton 1995). These are often less costly, more logistically feasible and repeatable, and are sufficient to answer the question, but they may be difficult to interpret and are not comparable to other studies/methods. Mark-recapture methods provide reliable population estimates and are often used to determine coyote population density but are prohibitively costly. Distance sampling is another method that provides an absolute density estimate (Buckland et al. 2001). Distance sampling would provide a comparable estimate to Hein’s (1992) mark-recapture estimate. Results from a pilot survey in December 2004 of coyote...
observations on RMA showed that an abundance estimate using distance sampling would be feasible, given sufficient survey effort. We will conduct a distance sampling survey only if the volunteer time available would allow for reasonably precise estimates. See Appendix 1 for a more detailed discussion and evaluation of this method.

Food Habits

To examine seasonal food habits, we will collect scat every 2 weeks along unimproved, infrequently traveled roads (Gese et al. 1988; Fig. 1) from February to September/October. Roads that are heavily traveled, paved, and/or located in the Central Remediation Area are excluded because either vehicle traffic would negatively influence scat persistence, or conditions would be unsafe. Approximately 50 miles of road will be surveyed. Road segments will be cleared of all scat prior to collection of samples for analysis. Scats deposited from November 1 to March 31 represent a winter diet, April 1 to May 31 represents a spring diet, June 1 to August 31 represent a summer diet, and September 1 to October 31 represent a fall diet (Johnson and Hansen 1979).

Scats will be placed in a paper bag and air dried for 2-3 months, crumbled, and analyzed by hand for prey remains (Gese et al. 1988). Skeletal (Roest 1991, Jones and Manning 1992) and hair (Moore et al. 1974) keys will be used to identify prey remains. Prey items will be recorded as frequency of occurrence and as an estimated volume of prey; volumes represent relative amounts consumed and will total 100% (Gese et al. 1988).

Reproduction

To locate den sites, we will conduct 2-3 standardized howling surveys along RMA roads in mid-May/June, when pups are nursing (Andelt and Gipson 1979) and still at a den site (Andrews and Boggess 1978). We will broadcast recorded coyote howls or human imitations of howls to elicit responses from wild coyotes (Henke and Knowlton 1995). Surveys will be conducted from dusk through late evening, when the response rate tends to be higher. Survey stations will be placed approx. every 2.5 miles (Henke and Knowlton 1995) along roads. Because pups frequently respond to survey calls, den sites can be found after obtaining triangulation data on responding coyotes (Eric Gese, pers. comm.). Pups become mobile and move to temporary dens sites by 3-4 weeks of age (Andrews and Boggess 1978), therefore areas identified by triangulation will be searched on foot the following day (or shortly thereafter) to locate dens. Transient coyotes typically do not respond to sounds that normally elicit a response (Henke and Knowlton 1995), therefore vocalizations should represent resident coyotes.

To estimate litter sizes, den site observations will be conducted. We will conduct 2-5 observations on consecutive days following the location of a site. Observations will be a minimum of 1 hour, will be made using binoculars and a spotting scope, and will be from a vehicle, when possible. Methods will be adapted based on predominant den conditions and the behavior/tolerance of pups. Early postnatal mortality is 10-15%, which is a source of error associated with litter counts at dens (Kennelly 1978). Thus, our estimated litter sizes will represent the number of pups recruited into the population (irrespective of first year mortality) rather than an actual birth rate.
Equipment, Staffing, and Project Timeline

**Equipment & Staffing**
- FWS Project Lead (part-time field assistance)
- Volunteers (2-4)
- Trucks (2)
- Paper bags for scat collection
- Binoculars, spotting scopes, tripod, and window mount (2 each)
- Compasses (2-4)
- GPS unit (2)
- Megaphone with CD player (2)
- Microscope for hair sample identification
- Mammal hair identification key
- Laser rangefinder (2-4)

**Project Timeline**
- Feb. 2005: remove scat from road transects prior to collecting samples for analysis
- Feb. – Sept. 2005: collect scats from road transects for seasonal food habits analysis and relative abundance index calculation
- May - June 2005: conduct howling surveys and area searches to locate den sites, conduct den observations to estimate litter sizes
- April 2005: if sufficient volunteer help available, conduct distance sampling survey to estimate density
- Summer – Fall 2005: ongoing scat sample analysis

**References**


Figure 1. Designated road transects for coyote scat collection for analysis of seasonal food habits and determination of relative abundance at the Rocky Mountain Arsenal National Wildlife Refuge, Colorado. Roads not designated as transects are heavily traveled, paved, and/or located within the Central Remediation Area.
Appendix 1.

For line transects using distance sampling, an observer travels along a transect line and records the perpendicular distances (or the distance and sighting angles) of all animals visible from the line. The detection function is the central concept in distance sampling. This method relies on modeling the probability of detecting an animal as a function of perpendicular distance (y), and the detection function g(y). Buckland et al. (2001) is the standard reference and provides a detailed description of the method. Program Distance (Laake et al. 1998) is the software package used for data analysis and has been shown to perform well under many situations (Schwarz and Sebery 1999). This method has a wide range of applications. The objects of interest may be animals or inanimate objects such as nests or sign. The objects may be recorded as individual sightings or as clusters (i.e. flock size). The main assumptions of this method include: 1) objects directly on the line are always detected; 2) objects are detected at their original location and; 3) distances and angles are measured correctly.

Given sufficient field support, we will use distance sampling to estimate coyote densities. A single cluster or group of coyotes will represent one sample. We will use compasses and laser rangefinders (i.e. Bushnell YardagePro 1000) to record sighting angles and distances of coyotes detected from the transect. To ensure that the field techniques meet the critical assumptions, a few days will be spent training volunteers. The major section line roads will be the transect routes, which make up a systematic grid. Typically, transects must be randomly placed and roads are not good transects because they are not representative of the study area, resulting in a biased sample. RMA roads are systematic and provide uniform coverage of the area. Also, though coyotes use roads to mark territories, they likely are not being drawn to the roads (i.e. there is no specific attractant such as garbage or a stream that follows the road which would draw in coyotes). Thus, in this situation roads may provide an adequate and feasible survey route. Transects will be surveyed by 2 teams for a minimum of 5 consecutive days during the spring. Surveys will be from sunrise to approx. 10 am, when coyote activity is higher (Andelt and Gipson 1979). Surveys will be repeated and data pooled to obtain a sufficient sample size for density estimation. Because detection probability differs among habitats, we may stratify RMA by major habitat type: woodland-prairie in the southern portion and prairie in the northern portion.

To assess the feasibility of distance sampling for RMA coyotes, we conducted a small pilot survey in December 2004. This allowed us to determine the average encounter rate (n₀/L₀), and estimate the line length (L) and sample size (n) necessary for a given level of precision. The coefficient of variation (CV) is used to measure model precision; values <10% indicate good precision (Buckland et al. 2001). An average of 16 coyotes was detected in 77 miles of survey transects. Let n₀=16 coyotes detected and L₀= 77 miles surveyed.

To calculate the expected line length (L) and sample size (n) needed for a 10% CV (where b = a stable variance estimate, D-hat = estimate of density):

\[ L = \frac{b}{\text{CV}^2 \text{(D-hat)}} \left( \frac{L₀}{n₀} \right) \]

\[ L = \frac{3}{(0.1)^2} \left( \frac{77}{16} \right) = 1443 \text{ miles} \]

\[ n = \frac{L₀}{n₀} \left( \frac{L}{n} \right) \]

\[ n = \left( \frac{77}{16} \right) \left( \frac{1443}{n} \right) \]
n = 299

Thus, for a 10% CV, we could expect a sample size of 299 coyotes seen in 1443 miles surveyed.

Given that logistical restrictions would prohibit this level of effort, we can calculate the expected level of precision (CV) given a more reasonable level of effort. This helps us assess whether the survey is worth doing (i.e. if the CV is too large, then the information obtained may not be very useful). The number of miles that would be surveyed per day is 60. Assuming that 5 consecutive survey days are reasonable, we have 300 miles of survey possible.

\[
\text{cv}(D\text{-hat}) = \left( \frac{b}{L(n_0 / L_0)} \right)^{1/2}
\]

\[
\text{cv} = \left( \frac{3}{300} \times \frac{16}{77} \right)^{1/2}
\]

\[
\text{cv} = 0.22 \text{ or } 22\% \text{ CV}
\]

Therefore, given 5 survey days with 300 miles surveyed, and an encounter rate consistent with our pilot survey, we could expect a CV of 22%. This variation is high, thus increasing the survey days would provide a more informative estimate.
PLANNING
NOTES
TITLE: Ecological Aspects of Predatory Mammals at Rocky Mountain Arsenal.

RESPONSIBILITY: 1) Management

INTRODUCTION

In a cooperative agreement between the Service and Colorado State University, a field study emphasizing ecological aspects of coyotes (Canis latrans) and badgers (Taxidea taxus) was initiated in May, 1990. Aspects of the study were: (1) to estimate the abundance of coyotes at the Arsenal, and (2) to evaluate the effectiveness of Canine Lure Operative Devices (CLODs).

METHODS

Abundance Estimation

Coyote abundance was estimated via visual surveys of marked and unmarked coyotes (Lincoln-Peterson Index/Mark-Resight) from December, 1990 - January, 1991. A total of 20 coyotes were captured on the Arsenal with padded leghold traps (Linhart et al. 1986) equipped with tranquilizer tabs (Balser 1965). Each captured coyote was fitted with a colored collar supporting a radiotransmitter, and tagged with a colored ear tag prior to release at the trap site.

Visual surveys of marked and unmarked coyotes were conducted for 2 to 3 hour periods following sunrise on 15 snow-covered mornings to aid visibility. Surveys were done along section roads. Routes were alternated from north-south to east-west regularly. Identification of marked and unmarked individuals was aided by a spotting scope and/or binoculars. A scanning radiotelemetry receiver with a vehicle-mounted dual 4-element null-peak antenna system was used to verify transmitted coyotes. Field data were entered into program NOREMARK to ascertain an abundance estimate.

CLODs

The effectiveness of CLODs for delivering ingestible substances to coyotes was tested by using a solution of syrup/powdered sugar (Marsh et al. 1982) and biological markers, including iophenoxic acid (10 mg) (Larson et al. 1981, Knowlton et al. 1987) and tetracycline hydrochloride (100 mg) (Johnston et al. 1987). A detailed description of the field technique employed is provided in Appendix E.
RESULTS AND DISCUSSION

Coyote Abundance

Preliminary analysis indicates that coyote abundance at the Arsenal during December 1990 - January 1991 was approximately 58 individuals (final results forthcoming in a Colorado State University Master's thesis). It should be recognized that even though the Arsenal is completely encompassed by a 3.25 m chain-linked fence, coyote abundance does fluctuate as a result of emigration and immigration. Coyotes equipped with radiotransmitters were frequently located both on-post and off-post (Eric Hein, pers. comm., December 1991). One collared individual was recovered approximately 20 km northwest of the Arsenal following a vehicle collision.

CLODs

Results from the CLODs experiment are presented in Appendix E.

LITERATURE CITED


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CLODs

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LITERATURE CITED


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Coyote Abundance and Food Habits 2005:
Scat Sample Collection Routes
Rocky Mountain Arsenal NWR

Scat Collection Routes
RMA Section Roads
First Creek

Shrubs
Lakes

Desired # of Transects to Sample:
10 North
10 South

21 North
20 South

TOTALS TO SHOWN