Distance Sampling to Estimate Abundance of Biological Populations:
Protocol for Distance Sampling Surveys of Coyotes
at the Rocky Mountain Arsenal NWR

A Brief Overview of the Method

Many population studies require estimates of density (D) or population size (N) and distance sampling can be an effective method to estimate these parameters. 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. Distance sampling is a class of methods to estimate density and the theory includes 2 main approaches: line transects or points. We will be using **line transects** to estimate the density of coyotes at RMA. For this method, a set of randomly placed lines are established and distances are measured to objects detected by traveling the line (Fig. 1). An observer travels along a transect line and records the perpendicular distances (**or the distance and sighting angles**) of all objects (i.e. coyotes) visible from the line (Fig. 2). The theory allows for the fact that many objects will go undetected. Also, detectability of objects decreases with increasing distance from the transect line (Fig. 3). 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, pack size). We will be recording clusters of animals (i.e. number of coyotes in a group).

Unbiased estimates of density can be obtained from distance data if certain assumptions are met. There are **3 main important assumptions** of this method that must be met for the method to be valid. The assumptions include:

1) objects directly on the line are always detected
2) objects are detected at their original location, prior to movement in response to the observer
3) distances and angles are measured correctly

Assumption 1 requires observers to remain alert and aware at all times. Assumption 2 requires that observers remember to record data at the point of first seeing an animal. If the animal is moving, the observer must make a mental note of where the animal was when it was first seen. Assumption 3 requires that observers are trained and comfortable with measuring distances (in our case, a laser rangefinder) and angles (a compass).

Observer variability or bias is well known. Interest in the survey, training, experience, and vision and hearing acuity are some reasons why observers vary. For this reason, we will focus on training and rotate observers among survey routes to ensure that everyone has an opportunity to survey all areas. It also helps to have consistency in who is doing the surveys.

Figure 1. Line transect sampling approach, with a randomly placed line of length x. Six objects were detected with distances of $x_1 - x_6$. This shows perpendicular distance measurements.

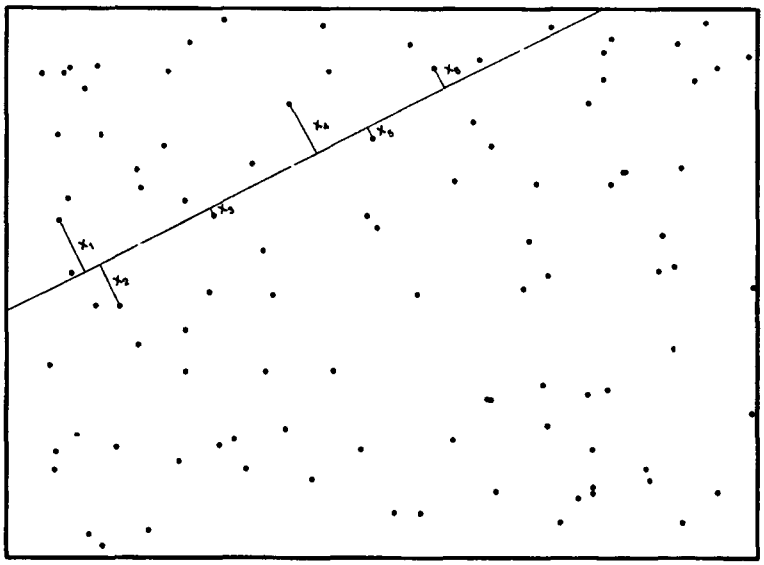


Figure 2. Basic measurements that are taken in line transect sampling. **Sighting distances** (r) and **sighting angles** (θ) are measured from the point the observer firsts sees the object. Recording sighting angles (rather than perpendicular distances as depicted in Figure 1) is often more realistic when working with animals that are likely to be moving in response to the observer.

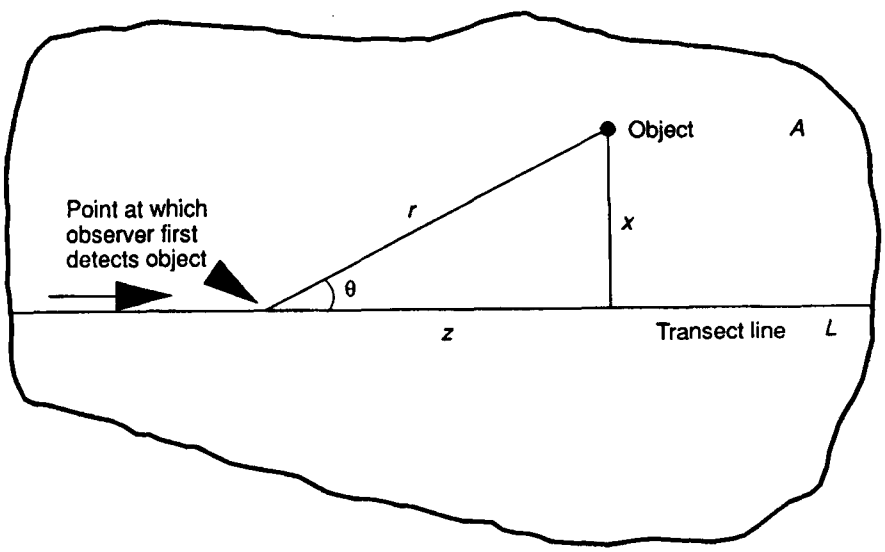
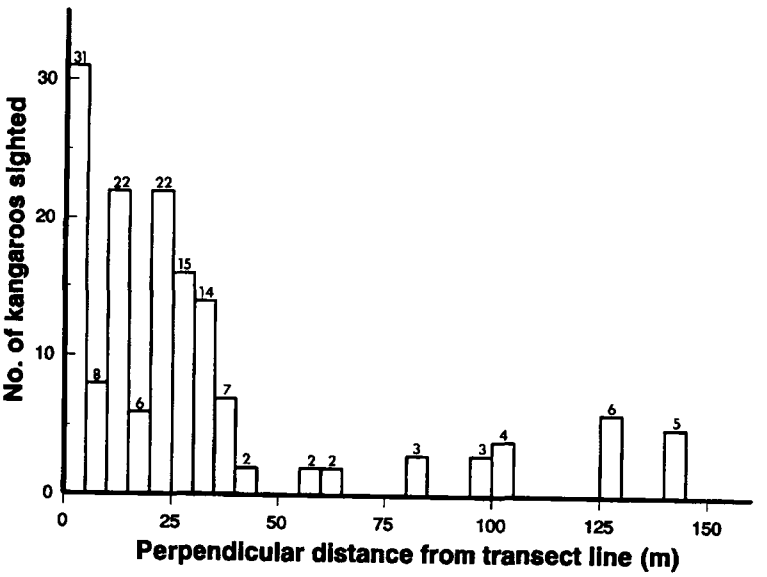


Figure 3. An example histogram showing the distance of objects sighted from the transect line. This shows how the probability of detecting an object decreases with increasing distance from the transect line.



Distance Sampling Field Protocol: Coyote Density Survey

1) We will conduct driving surveys along the major section line roads at RMA. These will be the transect routes, which make up a systematic grid and include approximately 56 miles of road (Fig. 4). 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.
2) To ensure that the field techniques meet the critical assumptions, observers will be trained to use a compass and rangefinder, and to estimate distances on their own prior to conducting the survey.
3) Fill out the header of the data form before starting the survey (i.e. date, observers, weather, start time, route area).
4) Transects will be surveyed by 2 teams driving in separate trucks each day for a minimum of 7 nearly-consecutive days in April. Each team will consist of 2 observers.
5) The study area will be divided in half, with each team surveying one half of the survey routes. Teams will alternate surveying route portions each day, which will help account for observer bias.
6) Surveys will be started in the early morning (7-8 am) and will be conducted until all routes have been driven (until approx. noon).

7) Surveys will be driven at speeds of approx. 10-20 mph.
8) A transect will be surveyed from start to finish before the next transect is begun. For example, survey all of transect 4 before starting transect 5.
9) When a coyote or group of coyotes is sighted, observers will immediately stop the truck and record the following data:
    a. **The Sighting Distance**- the observer will use the laser rangefinder to get the distance. The observer should verify that the distance obtained from the laser rangefinder makes sense. Sometimes the laser is not reflecting off the correct object and the distance will then be wrong. Observers should have a general idea of how to judge distances themselves. If sighting on a group of coyotes, take the distance measurement from the center of the group.
    b. **The Bearing**- the observer will **get out of the truck** and get the sighting angle with a compass. **It is important to get out of the truck** because the truck's metal parts affect the compass and will give wrong bearings. If sighting on a group of coyotes, take the bearing from the center of the group.
    c. **The Group Size**- Record the number of coyotes seen, even if it is just 1 individual.
    d. **The Transect Number**- record the designated transect number that is noted on the field map you were given.

Weather is always a concern when conducting wildlife surveys. We will not survey in weather that will negatively influence our ability to see the animals or that may severely influence their behavior such that they are not out traveling or hunting. Surveys will be cancelled in the event of snow, rain, or extreme high winds (i.e. ~30 mph or greater).

Though it's a common occurrence to see coyotes at RMA, each team can expect to see about 4 or fewer individuals in a day so don't be surprised if you have few sightings each day. This is the reason why we will be repeating the surveys; sufficient sample size is critical. It is possible that we may need to increase the number of survey days to meet sample size requirements (i.e. minimum of 80 observations of groups of coyotes, preferably about 200).

Figure 4. Map of the survey transect roads to estimate density of coyotes at RMA.

