Chapter 4

CONDUCTING THE SURVEY

The following discussion assumes the reader is familiar with the basic assumptions and underlying concepts of Wyoming's aerial line transect procedures for estimating pronghorn abundance. This chapter outlines the duties of the pilot and observers, and presumes the survey has already been designed. The plane will be operating under a restricted category according to Federal Aviation Administration regulations because the strut markers are attached to the outside of the plane. Therefore, the pilot and observers are the only essential crew members and should be the only persons on board.

RESPONSIBILITIES

Both the pilot and observers have specific duties during the survey. For both, *safety is a major responsibility*. Each member of the survey crew should be properly trained to perform the following duties prior to participating in the survey. The specialized aircraft equipment recommended for these surveys allows observers to maintain their attention on observing and minimizes the time required for pilots to enter data.

Observers: Because the line transect procedures require a great deal of concentration, *do not try to perform extra tasks* like recording sex and age composition or mapping locations of other features such as raptor nests. Observers are responsible for the following tasks:

- be trained in the proper observation procedures and criteria,
- prepare the flight plan and initiate flight-following (The position and heading of the plane will be monitored periodically during the survey so that officials will know where to initiate a search should the plane turn up missing),
- be familiar with the survey layout and design (area or strata boundaries, transect headings, sample sizes, etc.),
- keep track of times (survey time, ferry time, take-offs, landings, etc.),
- follow correct observation protocols,
- report observations (distance band, cluster size) accurately when the plane is perpendicular to the animal's position (in some instances, observers may have to record data on a tape recorder),
- report to the pilot any hazards seen, and
- decide if a survey should be stopped because of poor viewing conditions, hazards, or inattentive observers.

Pilots: The pilot's main responsibilities involve the following:

- fly the designed survey safely (proper height AGL, straight lines, proper groundspeed, etc.),
- record data (transect start- and end-points, GPS positions of observations, height AGL, distance band, cluster size, etc.),

- report the plane's location and heading periodically during flight-following (latitude and longitude, direction of travel), and
- continually monitor equipment.

PRE-FLIGHT PROCEDURES

The survey crew needs to *have equipment and materials ready prior to the survey*, go over the survey design, initiate the flight following process, and check out equipment on the plane. A preflight checklist can be found in Appendix II. The following topics should be addressed.

Safety

Several safety-related issues need to be covered prior to the survey:

- **Observers are required to wear fire-resistant (nomex) flight suits:** Helmets are optional (for fixed-wing line transect surveys) because some observers cannot get their heads in the proper observation position while wearing helmets.
- **Flight-following**: The survey must comply with the Wyoming Game and Fish Department's flight-following policy. Some of the critical elements of the flight following procedures include:
  1. Filing a flight plan with SALECS (Wyoming's State Agency Law Enforcement Communications System: 1-800-442-2767) describing :
     (a) the type of survey (line transect),
     (b) area (herd, hunt areas, nearest town, etc.),
     (c) survey layout (transect orientation, line spacing, initial line, etc.),
     e.g., flying North-South transects 3 minutes apart in the Iron Mountain Herd in Hunt Areas 39 and 40, starting at 105 degrees 40 minutes, working to the west, south of the Laramie River, etc.
     (d) aircraft description (make, model, colors, and tail (N) number),
     (e) pilot name and flight service,
     (f) observers or the names of the SOBs (that's "souls on board" - not what you were thinking!),
     (g) GF call number used for reporting,
     (h) frequency of reporting,
     e.g., 20 or 30 minute intervals
     (I) primary and alternate repeater towers,
     e.g., Laramie and Hanna Towers
     (j) expected duration of flight,
     (l) estimated starting time,
     (m) airport, and
     (n) any contingency plans (in case you go to another area because of conditions).
  2. Notifying the flight officer (usually the wildlife management coordinator) of the flight plan.
- **Pre-flight review:** The pilot should review emergency procedures with observers in the event of an emergency including the location and use of emergency radios, ELTs, and fire extinguishers; fuel and electrical switches; emergency equipment, and other safety information.

- **Weather briefing:** The pilot should obtain up-to-date weather forecasts about expected flying conditions. Weather should be discussed in terms of flight safety and how it will affect survey results.

Survey layout

Observers should *review the survey layout with the pilot*, including the following:

1. transect line orientation and spacing,
2. survey area boundaries and landmarks,
3. starting point,
4. the need for practice while ferrying to the start of the survey (with novice observers),
5. expected duration of the survey,
6. desired sample size (number of clusters),
7. potential hazards in the survey area (e.g., terrain, prevailing winds, light conditions, powerlines, radio towers, restricted air space),
8. sensitive areas (subdivisions, irate landowners, sensitive wildlife areas, etc.).
9. alternate survey areas in the event the survey is completed sooner than expected or conditions are not suitable in the primary area.

Other Issues

Observers should *bring a list of transect lines, a map of the survey area and boundaries, a tape recorder with spare tapes and batteries or a notepad* to record data in the event of a computer or instrument malfunction. Appendix II contains some helpful forms. Bring along emergency equipment like a jacket, some water and a charged portable radio in case the plane must set down out in the field.

Prior to taking-off, observers should *check the strut marker system* to make sure the dowels are aligned properly (i.e., parallel to the long axis of the fuselage).

The pilot should check aircraft instruments and the onboard computer for data acquisition to make sure these are functioning. The *computer should be initialized* with the correct date, herd name, hunt or survey areas, and other pertinent information.

The survey crew should make contingencies in case the GPS, radar altimeter or computer fail during the survey. These issues are discussed later in this chapter.

OBSERVER SURVEY PROCEDURES

This section describes how observers should conduct their duties during the actual survey, provides criteria to be used in assigning observations to distance bands, and discusses ways to handle some common problems. Participants should keep in mind that *you want good data and not necessarily more data. Follow the procedures correctly*. Remember that the sampling object is a cluster of pronghorn and not individual pronghorn (although a cluster can be made up of one animal). The surveys are planned for a target number of clusters of an expected average size.

While line transect surveys can be conducted under poorer counting conditions than trend counts, it is best to conduct surveys under conditions that improve visibility of pronghorn. The more steeply detectability declines as a function of distance from the plane, the harder it is to fit a reasonable correction to the observed data and variances tend to be larger. If you do not encounter the target sample size of clusters, you may need to increase the number of lines flown.

Recording Data

Although the pilot will generally be entering data during the survey, one of the observers should also record general information related to the survey. A data form (Appendix II) or notepad may be used as a last resort. A tape recorder is recommended. Tape recorders have the advantage of allowing an observer to continue looking out the plane while recording data. However, the observer should periodically check to make sure the tape recorder is working properly. Bring extra batteries and blank tapes.

General data to be recorded at the start of the survey include the date, area, weather conditions, observers, pilot, plane, and airport. Also record the time the plane took-off, started the survey, ended the survey, and landed. The times and locations of any breaks should also be recorded.

Tracking The Survey

Observers should *have a copy of the transect layout in the plane* including the area, line headings, transect spacing, and where the previous session left off. A data sheet for this can be found in Appendix II. Contingencies should be made in the event that conditions preclude surveying in the planned area but other areas could be flown. *Check off each transect as it is completed.* If you notice the plane deviating drastically from the planned heading or from an approximately straight line, ask the pilot to check the heading and get back on course if necessary. If sample size appears to be low, initiate flying supplemental lines. These contingency lines should be drawn up with the original survey design. Sometimes it is helpful to check that observers are watching the line by having each tally up the number of clusters seen in the A band (see Appendix II). Over the long run, both observers should see about the same number in A even though they may differ in search pattern, experience and visual acuity. This helps focus attention to the first band where all clusters should be detected.

Watching for Hazards

Although observers will typically be watching a relatively small area during the surveys, be on the look-out for hazardous flying conditions (high winds, downdrafts, military and other low-level air traffic, eagles, powerlines, towers and other features). *Advise the pilot of any hazards* you see and report their position with respect to the plane using "clock directions" as shown in Figure 4.1 (e.g., "9 O'clock " is directly left. "12 O'clock" is directly ahead, etc.). Pilots usually appreciate help in locating hazards.

As the plane approaches hills, ridges and other terrain, it may have to climb to get over these features. If the plane is high enough, you will see more of the landscape behind the feature as you

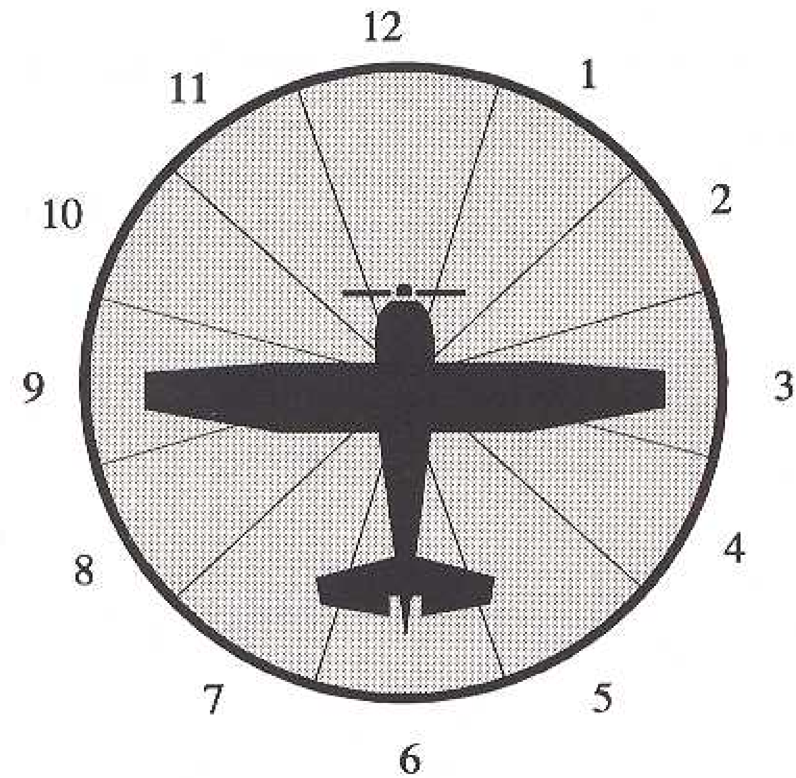


Figure 4.1. "Clock" directions used to describe the position of objects relative to the airplane (see text).

get closer. If this is not the case, ask the pilot if he sees the landscape feature. In some situations, the plane may have to break the line, circle to climb, and then resume the line.

Searching For Pronghorn

How you search for pronghorn is one of the biggest differences between aerial line transect surveys and more traditional techniques like strip transects or quadrats. It is extremely important to *follow the correct procedures* for searching, counting pronghorn, and assigning observations to distance bands. Remember to *emphasize watching for animals closer to the plane*. Observers who tend to look out toward the middle to outer distance bands will miss pronghorn on and near the line. The resulting histogram of detection distances will be peaked away from the line, violating the primary assumption of line transect sampling that all animals on the line are seen. The following items should help observers to maximize their chances of meeting the basic line transect assumptions.

Position: The strut and window markings on the plane are used to assign observations to distance bands when the plane is perpendicular to the cluster's initial position. While scanning, observers can be in a more relaxed position. You do not need to hold your head in a fixed position during the entire survey. *The only time that observers must align their heads in a prescribed position is when assigning groups to distance bands.*

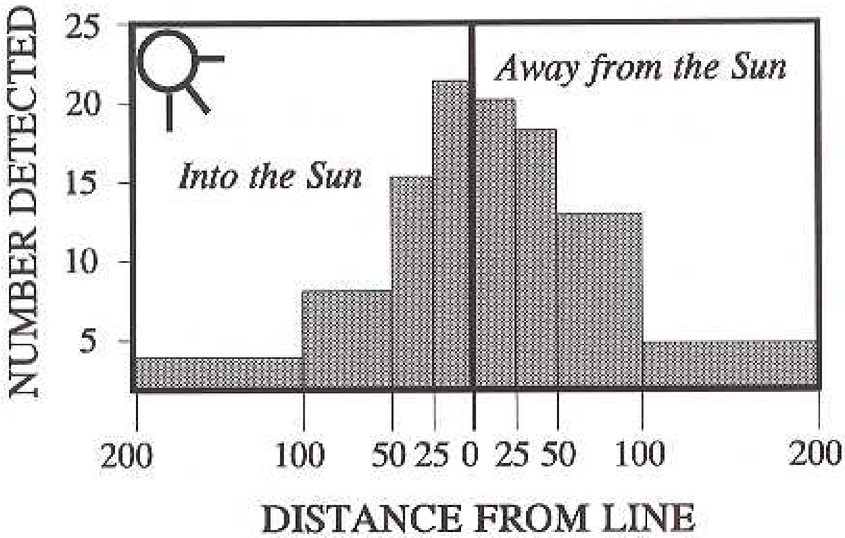
Scanning For Pronghorn: Observers should *concentrate on scanning ahead and back along the line and within the "A" and "B" bands*. If several clusters are seen at the same approximate location, *you can ignore the clusters that are farther out* to make sure you don't miss animals on or near the line. Do not spend much time scanning the horizon or the outer edge of the "D" band. It's okay to periodically look out at the outer distance bands after you are sure you haven't missed any on the line, but don't scan out there too long. Keep searching inward. *Watch for pronghorn moving ahead* or running under the plane. Do not try to classify pronghorn during these surveys.

Late in the survey, observers may find themselves having difficulty concentrating on the line and searching the strip for pronghorn. This problem also occurs on long transect lines (>25 miles) and in low density areas where pronghorn are not seen for long stretches. Watch out for this happening. If you find you cannot refocus your attention, then it is time to take a break.

Poor Viewing Conditions: Periodically, you will encounter conditions that make it harder to see pronghorn. Such conditions include looking into the sun (Fig. 4.2), backlighting, low contrast, complex backgrounds, shadows from clouds or ridges, flying higher than planned, and complex backgrounds. Under these circumstances, *concentrate more intently on searching along and close to the line* to be sure you don't miss any pronghorn.

Groundspeed: The plane is normally flown as fast as possible as long as observers do not fail to detect animals on and near the line. Groundspeeds can exceed 100 mph. In low density areas, this speed seems to be okay. If the plane seems to be going too fast (i.e., you just notice pronghorn as you go by them), ask the pilot to slow down to a safe speed that is more comfortable for viewing.

A



B

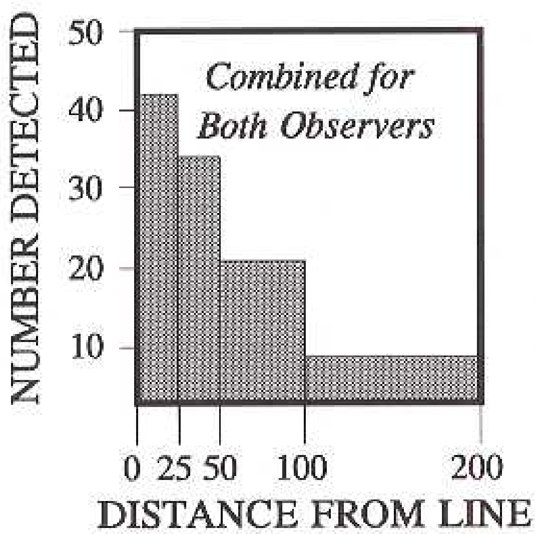


Figure 4.2. Histograms illustrating the influence of looking into versus away from the sun on detection (A), and the effects of pooling observers with different detection rates (B). Detectability usually declines more steeply for observers looking into the sun (A). Pooling both histograms in (A) results in the histogram in (B). Pooling is reasonable as long as animals on and near the line are detected.

Conversely, you can ask the pilot to speed up if you feel you can watch adequately without missing animals on the line. *It is okay for the groundspeed to vary during the survey*. Occasionally, strong head- and tailwinds will limit the pilot's ability to adjust the speed over the ground. If the plane is going too fast with a tailwind, then you may have to postpone the rest of the survey until the winds are more suitable. Typically, acceptable groundspeeds range from 80 to 120 mph.

"Counting" Pronghorn

The following sections describe how to count pronghorn during line transect surveys. *You cannot simply count the number of pronghorn you see*. Pronghorn are "counted" in a multiphase process. You first observe the cluster at its initial position noting that point on the ground (the animals may run from that spot). You count the number of animals in that cluster. When the plane is perpendicular to the cluster's initial position, you assign that observation to a perpendicular distance band by aligning the window and strut markings on the plane. You need to correctly follow the procedures as explained below.

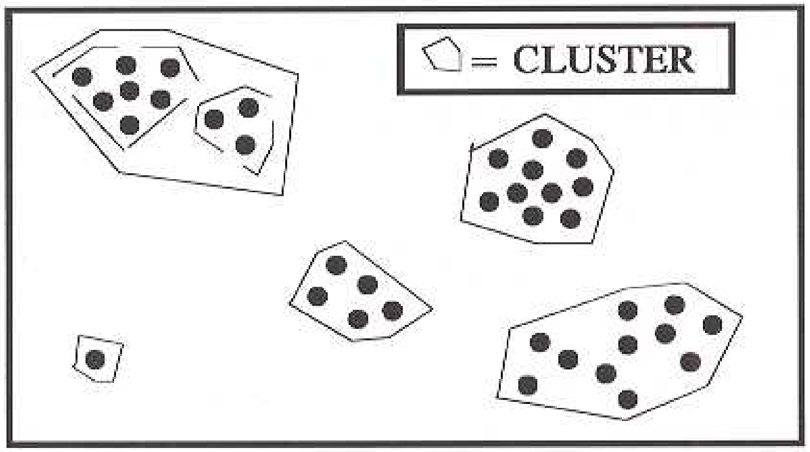
Observing Clusters

In aerial line transect sampling for pronghorn, we count the number of individuals observed, but we must record them as individual observations by cluster (or "group") and distance band. This is necessary to address the influence of cluster size on detectability. The following criteria and discussion should help observers be consistent in the manner in which they "count" pronghorn.

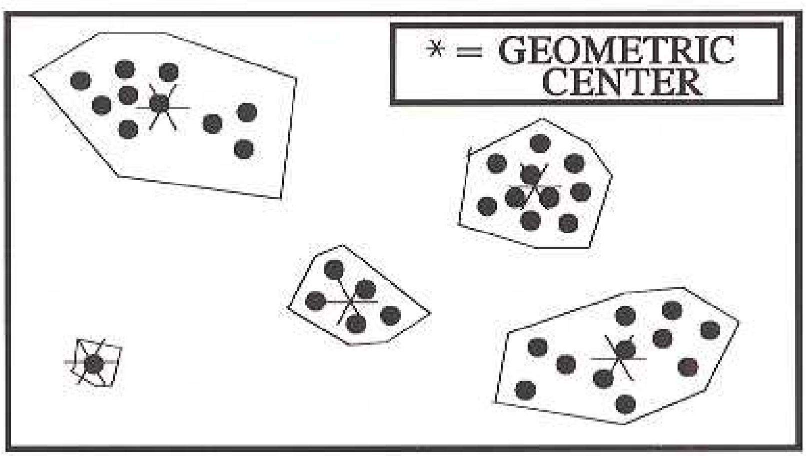
Defining A Cluster: It is extremely important to *count animals in individual clusters*. A cluster may be one or more animals. You must be able to decide fairly rapidly whether an association of more than one pronghorn is a single cluster or more than one. The following criteria should help (refer to Fig. 4.3A). If you saw a pronghorn because of its association with other pronghorn, then it is part of the same cluster. If you would have seen the animal(s) regardless of its(their) proximity to another cluster, then you have two different clusters. The basic idea is that we normally see pronghorn in clusters rather than as individuals. We record pronghorn by clusters seen because sightings are not independent and the size of the cluster has some influence on your chances of seeing it at a certain distance out from the plane.

You must record clusters separately. *Do not add clusters together*, even if they are in the same distance band at approximately the same location along the line.

Initial Cluster Position: When you first see a cluster, *visually estimate the geometric center of the cluster on the ground before the pronghorn move away* (see Fig. 4.3B). You should *note that spot on the ground*. You will assign this to a distance band when you are perpendicular to that position using procedures below. As the plane approaches that position, count the number of pronghorn in the cluster. The animals may move but that is okay. Continue to watch for more pronghorn.



A



B

Figure 4.3. Criteria for defining clusters and identifying the center of the cluster's initial position. Clusters are considered distinct if the sighting of each is independent (A). The cluster's initial position is defined as the location of it's weighted geometric center as shown in (B). Refer to text for explanation.

Counting Pronghorn In Clusters: The counting of the number of pronghorn in individual clusters is fairly straightforward, with two notable exceptions: how you deal with large clusters seen in the outer distance bands, and whether or not you include fawns. These situations are described below:

1. Dealing With Size Bias and Large Clusters in the Outer Bands. Large clusters (>15) take more time to count and divert attention away from the line. Counting these may keep you from observing the line (you have to turn your head to count them all). At the time the survey is designed, *you must decide how you plan to correct for size bias* in the analysis (see the sections on Design and Analysis for more background). Observers need to know which way this will be handled in order to be consistent in collecting data during the survey. There are basically two common ways that this problem has been addressed in Wyoming pronghorn surveys:
    a. Use one of the bias correction algorithms in DISTANCE:
    If you plan to use one of DISTANCE's algorithms (e.g., size-bias regression), then you must count the animals in larger clusters out in the C and D bands. This is usually the preferred approach unless you are dealing with high densities and lots of large clusters.
    b. *Ad hoc* truncation in determining the mean cluster size:
    You can decide to calculate the mean cluster size using only observations in the A and B bands (e.g., within 50m of the line). These are presumed to be *less* biased (DISTANCE can handle this, too). If you see a large group out in the C or D bands, you can quickly estimate the size instead of counting it. That allows you to return attention back toward the line instead of taking your attention away from the line to count the cluster or breaking off the line. For some surveys, there can be some size bias within 50m, however.

    For either approach, you must count large clusters in the A and B bands. Occasionally, you may have to break off the line and circle to count these clusters. The pilot should note the position along the line and try to work the animals back toward the area that has already been surveyed while you count them. Extremely large clusters may have to be photographed for later counting, split into smaller clusters and then counted, or estimated. The pilot should resume the survey at the point where he broke off the line. Extremely large groups may require special treatment in the analysis or treated as outliers for the calculation of mean cluster size.

2. Fawns The time of year that you conduct the survey will dictate how to treat the counting of fawns. Most Wyoming surveys are conducted near the fawning period. You should *ignore any fawns-of-the year observed during May-June surveys* because most fawns are bedded away from does and can't be seen easily. The line transect estimate for those surveys would give an end-of-the-biological year population (just before fawns are born). Fawns can be counted in surveys flown later in the year (e.g., August) where they are as likely to be seen as older animals on and near the line (in some cases where that is not the case, a correction factor would need to be incorporated into the estimate).

Other Special Problems A few other problems in observing pronghorn deserve some discussion. Observers should be familiar with these circumstances and how to deal with them.

- Movement: Observers should *watch for pronghorn moving in response to the plane*. *Scan ahead* to see if animals start running so you can *note their initial position before they move*. The pilot can also alert observers to pronghorn up ahead or those that may be crossing in front of the plane. Fortunately, pronghorn do not usually move before being detected (some even stay bedded) or they run parallel to the line (Johnson et al. 1991). Movement that is independent of the plane is not a problem (Buckland et al. 1993). Observers should advise each other if pronghorn run under the plane from one side to the other so that they aren't inadvertently counted by both observers.
- Animals in the blind area under the plane: *Do not count animals in the blind area* under the plane.
- Bedded animals: Bedded animals can be harder to see. Sometimes, bedded animals aren't detected until they stand up after the plane passes by them. *Scan along the line ahead and behind to watch for bedded animals*. Light angles may make them harder to see from some positions.
- Misidentification: Rocks, ant mounds, domestic sheep, and deer may be mistaken for pronghorn at some angles. *Make sure you count pronghorn and not other objects.*

Assigning Clusters To Distance Bands

One of the critical components of aerial line transect sampling is correctly assigning observations to perpendicular distance intervals. *Observers need to properly follow these procedures for assigning observations to distance bands*. Participants should understand the principles underlying the estimation of distances used in these surveys.

The Distance Reference System: The strut and window markings on the plane are essential to the correct use of this application of line transect sampling to aerial pronghorn surveys. That is why so much care must to be taken to properly mark the struts and windows of aircraft used in these surveys. The calculations are tedious.

The strut markings used on each aircraft for assigning observations to distance bands are calculated for a specific eye position. This eye position can vary from aircraft to aircraft and from front seat position to back seat position on the same plane. Therefore, do not use two observers (front and back) looking out the same side of the plane using the same set of strut markers. For planes accommodating two observers, each side of the plane should be marked differently.

Observers must align their eyes in precisely the proper eye position each time an observation is assigned to a distance. To do this, two marks were placed on the window of the plane to align with the strut markers defining the first distance band (Fig. 4.4) as described below. Using a single window mark or none at all will introduce errors (Fig. 4.5).

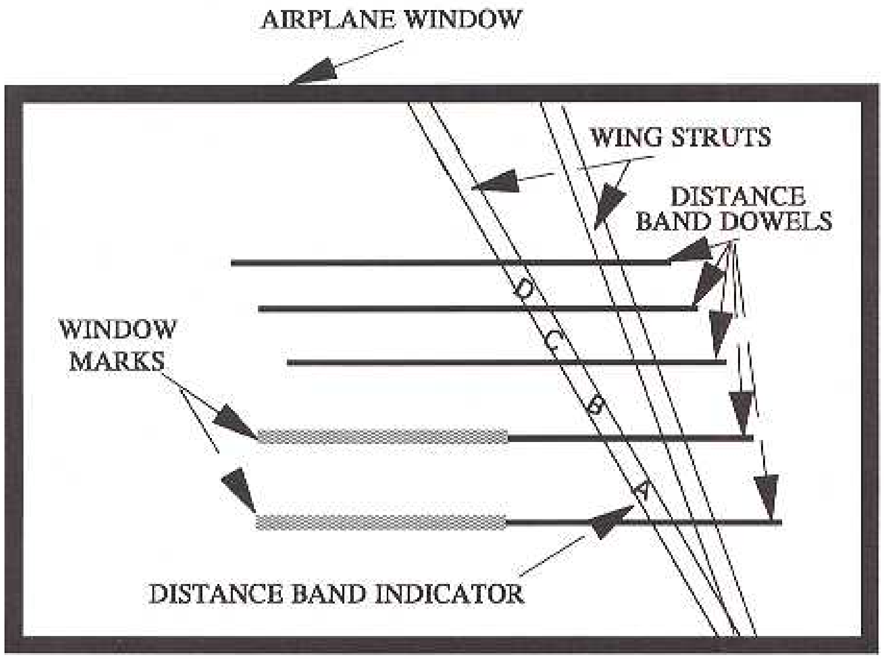


Figure 4.4. Observers should properly align their eyes with window and strut markers as illustrated prior to assigning observations to distance bands. That assures that the observer is assigning observations to distance bands from the correct position for which the plane was marked.

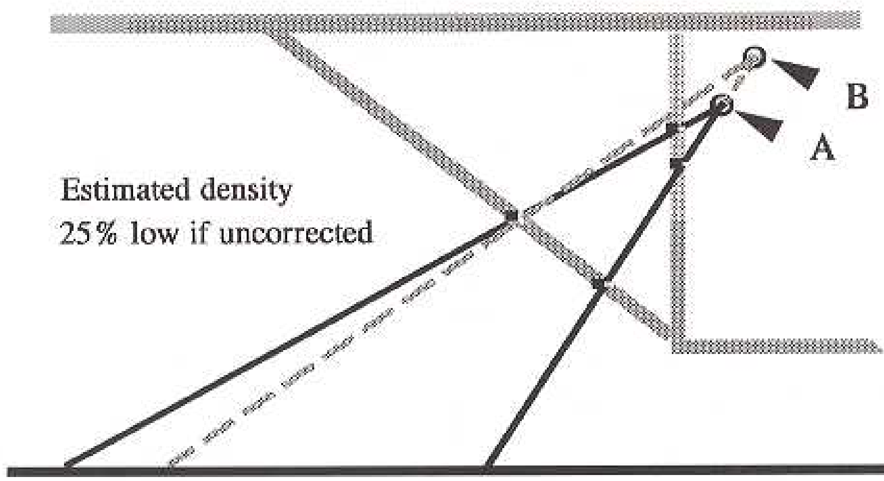


Figure 4.5. Aligning eye position with two window marks and their corresponding strut markers assures that the observer's eye is in the defined position for assigning observations to distance bands. Using only one window mark for alignment can lead to serious measurement errors as shown in this example.

These reference markings are one potential source of measurement error that should we try to minimize during surveys. Because the plane is marked for a specific height AGL (300 ft), the area on the ground defined by the markers varies as the height of the plane above the ground changes (Fig. 4.6). That is why a digital radar altimeter is necessary to measure the actual height AGL so that distances can later be corrected.

Determining The Correct Distance Band. When you see a cluster of pronghorn, follow these steps:

1. *Note the position on the ground where you first saw the cluster* (they may move off). The position is defined as the visually estimated geometric center of the cluster as defined above. If the animals run toward and under the plane, let the other observer know so that the cluster isn't counted again.
2. *Count the number of pronghorn in the cluster.* Use the conventions described above for dealing with large clusters and fawns.
3. *Get into the proper eye position* by aligning the window marks with the strut marks defining the A band (Fig. 4.4). On some planes, the observer in the back seat will have to mentally extrapolate the dowels to where they would be perpendicular.
4. *Note the distance band (A, B, C, or D) in which the spot on the ground where you initially saw the cluster (its geometric center) occurs when the plane is perpendicular to that location.* The wings should be level when you assign the cluster to a distance band. If the plane is rocking from side to side, try to interpolate for level flight. The bands will be labeled on the struts. Use the criteria below to determine whether a cluster is in or out of a particular distance band. Aircraft with forked or V-braced struts (e.g., Maules, SuperCubs) are the easiest to attach strut markers to and the dowels tend to stay in position. Planes with single braced wings (e.g., Cessnas) require special brackets to attach the distance markers. If the dowels vibrate, try to extrapolate to the center as if the dowels were stationary before assigning observations to distance bands.
5. *Announce the observation* in the intercom (see below), or record the observation on a tape recorder.

Determining Whether A Cluster Is In Or Out. A cluster is out and not counted if its geometric center at the spot you first observed it is beyond the outer distance marker (outer edge of D; outermost dowel) or between the plane and the line (inner edge of A; innermost dowel), i.e., in the blind area, as indicated in Figure 4.7. Although some animals in a cluster may be in and some may be out, go with where the majority are. It is too difficult to estimate how many of the animals in the cluster are in. When a cluster overlaps distance bands, use the same criteria to judge which band to assign it to.

In a few instances, the geometric center of the cluster will occur on the line, outer edge, or essentially straddle between two distance bands. In those cases, count every other one as in.

It may be tempting for observers to count pronghorn in the blind area. *Avoid using "Body English" to include clusters that are out.* Record the clusters as they occur. Some observers have a tendency to feel they are missing animals on the line because they see fewer clusters in the A band. Remember that the observations are scaled for distance. With the Wyoming Technique,

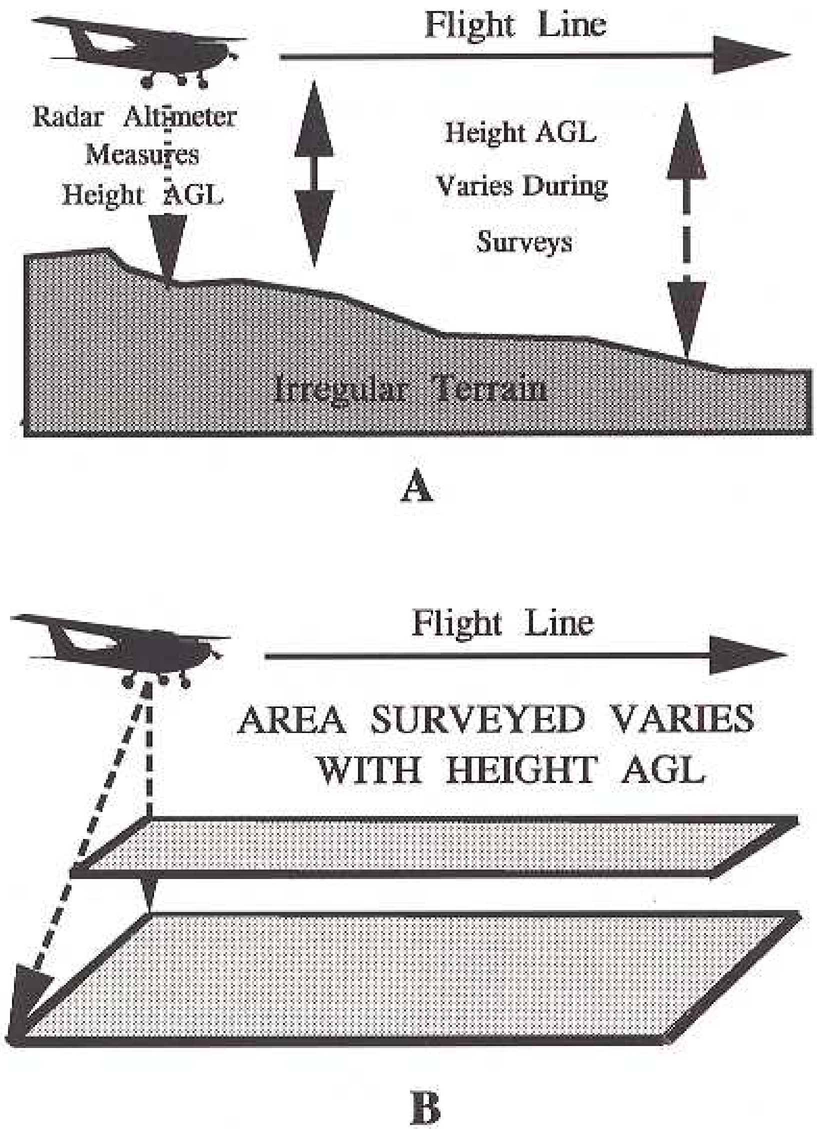


Figure 4.6. A radar altimeter measures the height AGL to adjust distances for terrain variations (A). The area on the ground defined by strut markers varies as height AGL varies from the planned survey height for which the struts were marked (B).

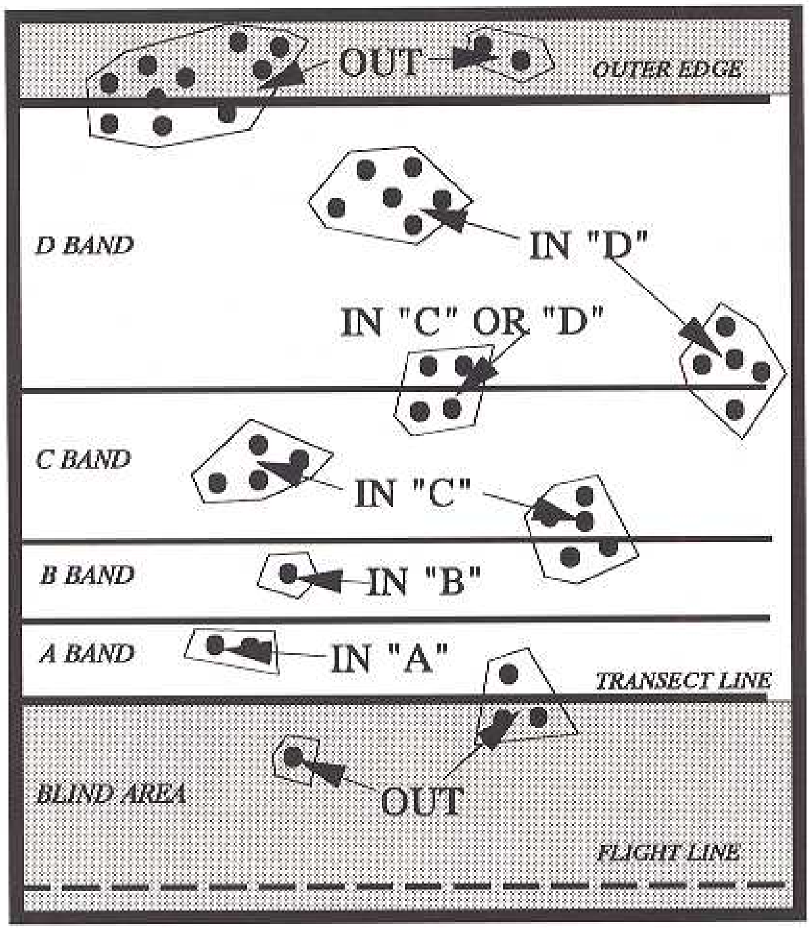


Figure 4.7. When perpendicular to the cluster's initial position, assign the cluster to the distance band in which its weighted geometric center occurred. The entire cluster is either in or out based upon where the majority of the pronghorn in the cluster were first sighted.

the C band covers twice the area as the A or B bands, and the D band has four times the area that the A or B band covers. You expect to get more observations in those larger bands. Relatively speaking, the A band tends to have a higher observed density than the outer bands.

Remember that *observations are not to be assigned to distance bands until the plane is perpendicular to the location on the ground where the pronghorn cluster was first sighted.* Figure 4.8 summarizes the criteria for properly assigning clusters to their correct distance bands. It shows: (1) properly aligning window and strut marks, (2) assigning clusters to distance bands based on the distance to their initial position, and (3) the number of animals in each cluster.

Reporting Observations for Data Entry

The pilot will enter all data so that observers can concentrate on observing. Observations are reported through the intercom. When you are perpendicular to where the cluster was initially spotted, say "Antelope." That lets the pilot know to capture the GPS position and enter the height AGL (if it is not done simultaneously). It allows the pilot to tab to the next input field. Next, list the distance band using the proper term ("Alpha" for A, "Bravo" for B, "Charley" for C and "Delta" (or "Dancer") for D). Then give the cluster size. The pilot should repeat your observation so you can make sure it was entered properly. Remember to speak clearly. Avoid unnecessary conversation to allow everyone to concentrate on their duties.

If you have more than one cluster at a location, try to relay them to the pilot in alphabetical order (e.g., alpha-1, bravo-3, charley-2, delta-6). If you see animals on your side of the plane at the same location after the other observer has announced a cluster, go ahead and report it if you can get it in sequence. You may have to circle until all data are entered if you encounter too many clusters at the same place.

If you have more than one cluster in the same distance band at about the same location, you will have to report them as separate observations (positions; e.g., Antelope-charley-1, Antelope charley-3). In the example shown in Figure 4.8, the observer would announce these as "Antelope - Alpha 2 - Alpha 7 - Delta 1" since those were the distance bands in which those clusters were initially sighted prior to moving.

Recording Observations When the Onboard Computer System Fails or is Not Available

You should take along a tape recorder (with extra batteries and blank tapes) as a back-up for data recording. In the event of a computer malfunction, you want to try to record the following minimum information:

- Line number, and bearing (e.g., 105 degrees 40 minutes north) for each transect.
- Start and stop location for each line (get the pilot to read you the GPS positions).
  For each location where pronghorn are observed within the strip, record:
- Height AGL (have the pilot read off the height AGL from the radar altimeter).

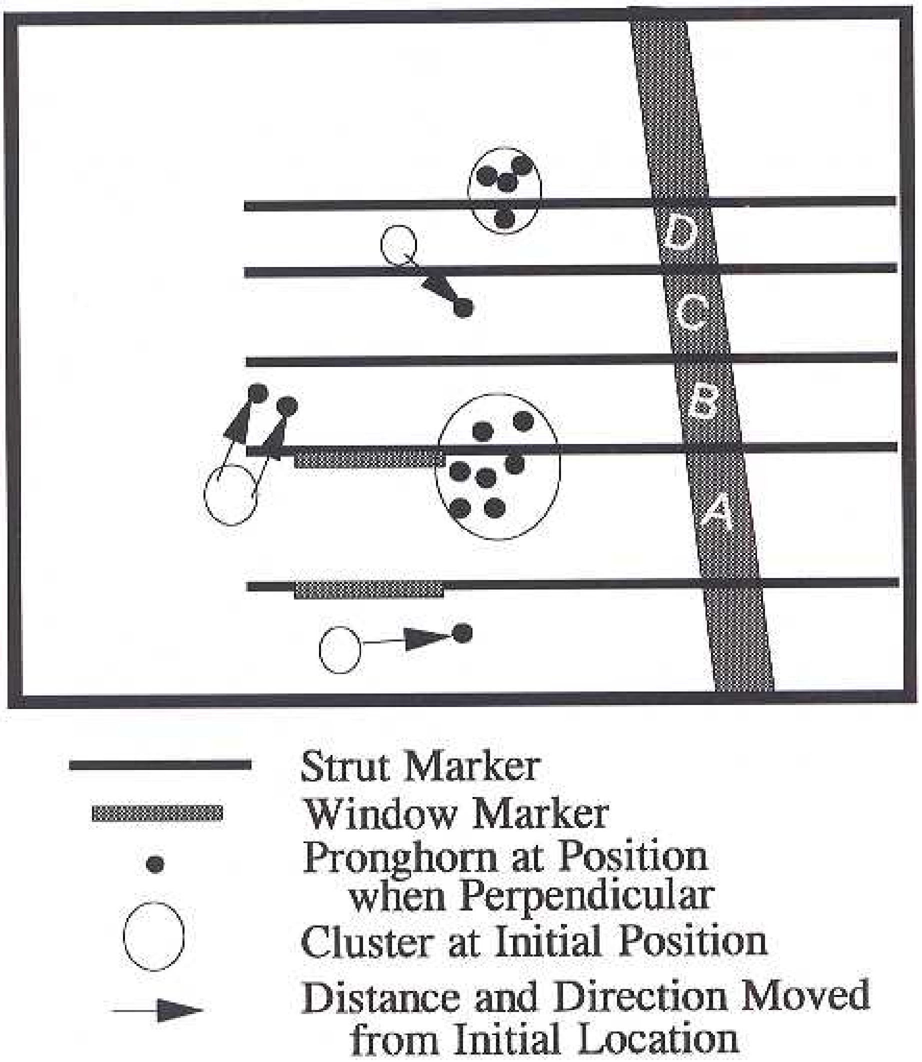


Figure 4.8. Hypothetical perpendicular view of five clusters when the strut and window marks are properly aligned. Note the initial position of the cluster's center. Assign the clusters to distance bands when perpendicular based on their initial positions. Count the number of pronghorn in each cluster and report the observation in the proper sequence. In this example, only three of the clusters are inside the strip.

- Distance band, and
- Cluster size for each cluster of pronghorn observed.

Ideally, it would be nice if you could get the GPS position for each observation but that may not be practical if the computer system is not working correctly. *Do not try to write down data on a pad while conducting the survey except as a last resort.* In the event the data acquisition system fails, it is best to stop the survey, return to the airport, and fix the problem (be sure to note where you left off so you can resume the survey at that location). If you have to write down the data, one of the observers should be reassigned as a recorder. The analysis would have to account for switching to one observer.

Special Circumstances

During some surveys, you may encounter circumstances that need special attention. Do not hesitate to ask the pilot to try and correct problems under his control. He'll let you know if he can't compensate. This discussion briefly reviews some of these conditions, how they affect the survey and how to deal with these circumstances if they occur during a survey.

Crabbing: Crabbing occurs when the plane is flying at an angle (e.g., sidewise) instead of straight ahead because of a strong cross-wind. The plane acts as a weather vane with the nose pointing into the wind. If it is very noticeable, you may want to stop the survey and finish that area later. With strong crabbing, the centerline is not parallel to the longitudinal axis of the plane so distance measurements would have to be adjusted for that angle. More importantly, the downwind observer may not be able to see pronghorn in their initial position or may count animals detected by the other observer.

Flying Excessively High: It is virtually impossible to maintain the plane at exactly the prescribed height AGL for the entire survey. In some cases, the terrain below will be too variable (e.g., canyons, foothills, ridges), or you may have to climb to get over an obstacle (e.g., powerline). If the plane gets too high, you may not be able to see animals on the line. In these situations, try to focus your search just on the area along the line. Do not look for pronghorn in the outer bands. Those observations are likely to fall outside the outer edge of the strip when adjusted for height.

Wings Not Level: The strut markers are designed to be used when the plane is in level flight. Try not to assign observations to distance bands until the wings are level. In some cases, this may not be possible. It may be okay to assign observations to distance bands when the plane is climbing or descending approximately parallel to the ground. Wait for the wings to straighten out if the plane is banking. In some cases, you may have to try to extrapolate the distance bands for level flight.

Too Many Pronghorn At Once: In high density areas, you may encounter too many clusters at once. The pilot may not be able to keep up with data entry. In those circumstances, you may need to break away from the line until the pilot gets caught up. In limited instances, you might be able to get away with having observers keep track of the observations until they are entered. The positions and altitudes for those may not be correct, however.

Flat Light: Occasionally, surveys have to be conducted under flatter light than desired. In those situations, really concentrate on the line so that you don't fail to detect pronghorn on and near the line. You might ask the pilot if he can slow the plane down to give you more time to scan. You should limit flying in flat light. It may be okay if you just have a small segment to finish, or will be coming out from under a cloud soon. You should *stop the survey if you feel you are missing animals on the line* . Even if you don't miss animals on the line, you will probably end up with a smaller sample size and a steeply decaying detection curve. Both of those conditions are undesirable.

Distractive Backgrounds: In some areas, the habitat characteristics make it more difficult to pick out pronghorn. Such conditions may occur in certain shrub types, rocky areas, and areas with patchy bare ground. When surveying these areas, concentrate on the A band. You will have to specifically look by rocks or patches to make sure you cover what is there.

Observer Comfort

Observers tend to concentrate better when they are comfortable. The seats of small aircraft can be uncomfortable during flights (resulting in a condition known as "cub butt"). Temperature extremes, turbulence, G-forces during turns, and eye strain are other potential sources of discomfort. Be sure to get adequate sleep the night before a survey. Limit fluid intake 1-2 hours prior to the survey. There are some steps that can be taken to minimize these distractions:

Resting: Observers should rest their eyes and stretch between transects. Look out toward the horizon, especially during banked turns. Minimize reading, writing or tallying between lines.

Position: Most aircraft used for line transect surveys accommodate two observers: one in the copilot seat and one in the back. For many observers, the front seat is more comfortable because it is closer to the plane's center-of-gravity, allows more head room, and affords more forward view. The back seat often has less head and leg room and observers cannot usually see as far ahead from that position. Observers can trade positions between flight sessions. Observers who are more prone to motion sickness may observe better if they occupy the front seat.

Posture: Aerial line transect surveys require that observers align themselves in a particular position each time they assign an observation to a distance band. That way, they are looking from the same place so that the markings on the plane define the correct distances on the ground. Depending upon one's stature, this may cause observers to sit in uncomfortable positions. For shorter observers, sitting on extra cushions helps them get into the proper position more comfortably.

Temperature: The cabin temperature should be maintained in a comfortable range during surveys. Observers may not survey well in extremes of heat or cold. For many persons, becoming too warm predisposes them to air sickness. Even when the cabin is at a generally comfortable temperature, observers on the sunny side of the plane may experience a personal greenhouse effect. Ambient temperatures can be quite warm during late May and June surveys. Observers may prefer to dress lightly under flightsuits when conducting surveys during warm weather. Avoid wearing clothes that are too tight. Make sure the flightsuit is adequately large and adjusted for your size. Adjusting the vents and windows to get a good supply of fresh air often helps. During cold periods, request that the pilot adjust the heat so that you stay comfortable.

Glare: In strong sunlight, glare can be a problem because of the substantial amount of bare ground common to pronghorn habitats. Glare tends to cause eye fatigue. Wearing a good pair of polarized sunglasses will provide some relief and improve contrast.

Fatigue Line transect surveys tend to fatigue observers and pilots more than trend counts. Normally, survey sessions should only run 2-3 hours at a time. Observers should take at least a 2 hour break between survey flights. It is best to rotate in fresh observers for consecutive flights. Surveys should be conducted when conditions are best for viewing (i.e., in the mornings and evenings when the sun is out).

In some cases, midday flights may be okay provided that observers feel they can see pronghorn clusters pretty well and densities are moderate to high so that you can still obtain a good sample size. Pronghorn tend to bed during midday and may occur in larger but fewer clusters. That may lower the sample size obtained.

Airsickness. Line transect procedures tend to make it easier for observers to become airsick. Prior to the flight, observers should avoid factors that promote airsickness (e.g., improper diet, alcohol, not getting enough rest, etc.). In flight, observers should avoid rapidly moving their eyes or getting too hot. Before becoming airsick, let the pilot know so he can break off a line so that you can look off to the horizon and get more comfortable. If you are prone to motion sickness and want to avoid the drowsiness and other side effects of Dramamine and related medications, you might try taking ginger root tablets. These are available in the "organic" vitamin sections of many pharmacies and some grocery stores. Be sure to take these before becoming ill. For some people, drinking ginger ale or ginger tea seems to help. Many persons who become airsick are much better off to "use" the airsickness bag rather than try to fight the nausea. Many can resume flying afterwards. Observers who are prone to motion sickness should only fly one survey session per day.

Landing: In some cases, it may be possible to have the pilot land the plane and allow a distressed observer to recover. This should be done if other efforts in the plane to overcome problems do not work. Be sure to record where the survey stopped so that you can go back and resume from there.

When To Stop A Survey

The main consideration for line transect surveys is not missing animals on or near the line. Aside from safety, it's time to stop the survey if light or other conditions such as mentioned above prevent you from meeting this assumption. Other conditions to stop include observers being too queasy to continue, drowsiness, observers becoming "hypnotized" (staring at the ground and forgetting to watch for pronghorn), or unsafe flying conditions. If winds are strong enough to cause noticeable crabbing (flying at an angle instead of head-on) or you encounter severe turbulence or thunderstorms, you should stop the survey or go to another area where these conditions don't occur.

Be sure to note the GPS location where you break off a survey if it is not an endpoint for an established line.

PILOT SURVEY PROCEDURES

Many important aspects of properly flying low-level wildlife surveys are beyond the scope of this manual. Potential users of aerial line transects should use pilots having considerable experience conducting precise, low-level pronghorn surveys. Ideally, they should have previous experience flying line transect surveys using these procedures with the recommended equipment..

This section of the manual outlines some of the many tasks pilots are expected to perform using the Wyoming Technique. Pilots should be familiar with these procedures and those required of observers during surveys. I strongly recommend pilots be proficient in the use of the data acquisition computer, GPS, and digital radar altimeter before flying actual surveys. Practice is probably as important for pilots as it is for new observers.

Pilots should recognize the critical need for quality control when carrying out line transect surveys. Although it may be tempting, pilots should not fly too many hours without a break. Both observers and pilots tend to tire sooner when conducting line transect surveys. Flying the plane while entering data is more demanding on pilots. However, the protocols and equipment used in the Wyoming Technique have allowed these surveys to be performed safely over 100 times in Wyoming since 1987.

Safety

The primary responsibility of the pilot is to fly the survey safely. The pilot should stop the survey at any time he/she feels conditions are unsafe. Usually survey conditions will deteriorate to the point that the survey must stop before flying conditions become too hazardous. However, unexpected conditions like wind shear and wake turbulence (e.g., from military training flights) may be encountered. Pilots should allow for adequate daylight to return to the airport following a survey session.

Flight-Following: Normally, *the pilot will be responsible for regularly updating the SALECS dispatcher with the plane's position* while flight-following during surveys. Usually, the pilot will relay the latitude and longitude of the plane's current position and the heading using the designated GF call number. He will also report any take-offs, landings, breaks or other changes in plans to SALECS. At the end of the flight, he can advise SALECS to terminate flight following for that survey.

Flying The Survey

One of the pilot's primary tasks is to fly the survey as closely as possible to the transect layout as designed. It is often helpful for the pilot to have a list of the transect headings, starting points and transect spacing. That allows the pilot to keep track of the survey's progress and look ahead for potential hazards along forthcoming transects (e.g., flying toward foothills with strong downdrafts, getting close to airports, etc.). Specific considerations for flying the survey are outlined below:

Straight transects: The pilot should *fly each transect line (or line segment) as straight as possible*. The technique assumes line lengths are fixed and not random variables. Try to keep the plane on line at all time. Do not intentionally fly off the line toward pronghorn to include them in the sample (or vice versa). Realizing that there will always be some "random" deviation from the line, GPS positions for pronghorn observations can be used to check on the straightness of the line and recalculate line lengths to approximate the actual area surveyed. One of the newer computer systems automatically records the plane's position throughout the survey. Those data can be used to estimate the actual length flown when available. Occasionally, the plane will have to deviate from the transect to avoid a hazard. Try to get back on line as quickly as possible without having to make abrupt maneuvers. Let the observers know prior to making a course change.

Designed Headings and Transect Spacing: In addition to being straight, the *transects should be flown as close as possible along the designated headings*. Try to *maintain the designed spacing* between transects so that you are less likely to encounter the same cluster of animals that was observed on a previous line.

The pilot should *announce the start and end of each transect* through the intercom. Say "on line" at the beginning and "end-of-line" at the end. If the start of the line is grossly off, go back and restart the line.

Tracking Progress: *Check off the transects as they are completed*. This will help keep track of the progress for the survey. You can also get a feel for how long it may take to finish the survey at the present rate by comparing the time it took to complete the number and length of transects flown to those remaining.

Designed Height AGL: To the extent practical, *try to maintain the plane as close to the designated survey height of 300 ft AGL.* Periodically look at the display on the radar altimeter (or computer monitor) and adjust the survey height accordingly. When flying over narrow canyons, obstacles, and irregular terrain, it will not always be possible to keep the plane at the target height. In those instances, the radar altimeter readings stored with each observation will help correct distance data. Try to be at the desired survey height as you reach the start of a new transect.

Groundspeed: As long as the plane can fly safely, *the groundspeed can vary during the survey*. Usually the survey will be flown in the 80 to 120 mph range. The groundspeed should be as fast as possible while allowing observers plenty of time to search the line and inner distance bands adequately. In low density areas, the survey can be flown closer to 120 mph. In high density areas or during poorer viewing conditions, slower speeds are preferable. With strong tail winds, you may not be able to slow the plane down sufficiently enough for observers to scan the transect adequately. Under those circumstances, you should probably stop the survey and resume it when conditions are better. Advise the observers whenever you are having trouble maintaining the plane at the proper survey speed.

Breaking Off Lines: On occasion, you may need to break off a line because of deteriorating conditions, hazards, allowing an observer to recover from airsickness, or to circle while catching up on data entry or to go back and count a cluster. Be sure to note and store that location so that you can resume the survey from that point.

Turns and Other Maneuvers: When turning to go to another transect, *announce the turn* to the observers *and gradually bank into the turn* so that they can anticipate the maneuver. They will be concentrating on watching the ground intently. Unexpected, sharp maneuvers tend to precipitate airsickness in some people. Where possible, advise observers prior to any course changes or sudden maneuvers.

Flight Attitude: Try to fly the survey with the wings level so that the distance markers are parallel to the ground. If an observer announces an observation when the plane is banking or not in level flight, try to level the plane as soon as possible so that they can assign the observation to the correct distance band. If the plane is climbing or descending at the same slope as the ground, then you only need to level the wings.

Dwellings, Corrals and Fences: Occasionally, the transect will take the plane directly over dwellings, livestock corrals or near range fences. Avoid flying directly over occupied houses. Try to avoid pushing livestock or wildlife into fences by climbing or detouring. Resume the survey on line at the proper survey height as soon as possible.

Special Circumstances

Pilots should be aware of certain flying conditions that can influence the quality of the survey. In some cases, the pilot may recognize problems before they become apparent to the observers. The pilot should advise observers any time such conditions are encountered during the survey and discuss whether or not to continue the survey. Some of these situations include the following:

Crabbing: When the plane starts to crab noticeably, advise the observers and see if the problem is significant enough to stop the survey.

Flying Excessively High: If circumstances warrant flying well above the prescribed height of 300 ft AGL, notify observers of the change in altitude so they can focus searching closer to the line. If the plane cannot be flown consistently at a reasonable survey height (e.g., <500 ft), the pilot should advise the observers and stop the survey.

Wings Not Level: The pilot should try to keep the wings relatively level and stable during the survey. When this becomes a problem, advise observers.

Winds: Strong cross-, head- and tail-winds can be problematic. Stop the survey if the plane cannot be flown straight along designed transects and at a reasonable speed for safety and proper observation.

Turbulence: Occasional to moderate turbulence can be expected on some surveys. The pilot should try to fly the plane as close to the specified design as possible (e.g., proper heading, survey height, and level wings) under those circumstances. Observers should advise the pilot if turbulence becomes too severe to maintain concentration and conduct the survey properly. The pilot should stop the survey if the plane cannot be flown precisely enough to complete the survey.

Data Entry

The pilot records survey data while safely flying the plane. Air services currently providing Class 1 line transect services for the Wyoming Game and Fish Department are properly equipped so the pilot can enter data into an onboard computer interfaced to the GPS (and digital radar altimeter on some planes). The computer system uses cursor keys and a numeric keypad for data entry. Data are displayed on a miniature monitor located on the dash or yoke so pilots can keep looking up while flying. Some data are captured instantaneously. This system allows observers to continuously scan for pronghorn. Observers are less likely to get airsick because they do not have to write or plot data.

Initialization: At the start of the survey, the pilot should initialize the data set with the herd name, hunt area(s), date, starting time, observers, pilot, weather conditions, and starting line.

Transects: The heading, start and stop times, and starting and ending positions should be recorded for each transect line. Note if the line had to be interrupted during the survey.

Observations: Each time an observer announces an observation, the pilot enters the following data through this sequence:

1. When the observer says "antelope" through the intercom when the plane is perpendicular to the pronghorn's initial position, *the pilot captures the GPS position and the radar altimeter reading.* The height AGL should be recorded to the nearest foot.

2. Next, when the observer gives the distance band(s) and cluster size(s), the *pilot repeats the observation(s)* over the intercom. If there is an error, the observer should correct it.

3. The *pilot then enters the distance band(s) and cluster size(s)* for the observation(s). *Do not add clusters in the same band together;* each observation must be stored separately.

End-of-Survey: The pilot enters the time and position for the end of the survey, and the time when the plane lands.

Checking on Observers

Part of the pilot's duties are to make sure that the observers are surveying okay. If an observer is silent for an extended period, the pilot should inquire if the observer is feeling okay and not asleep. If he notices that an observer is getting ill, he should break off the line until the observer has recuperated.

Contingencies for Handling Equipment Failures

Rarely, one of the components for capturing data will fail during a survey. The survey crew should have discussed contingencies in the pre-flight briefing. In most situations, it is best to halt the survey (note the position), return to the airport, and repair the system. The following describe things that can be done until the component can be repaired:

Data Acquisition System: A tape recorder should be available in case the data acquisition system fails. Observers can record their own observations on tape. The pilot should relay the radar altimeter reading. Obtaining locations for each position may be too cumbersome unless the pilot can store each as waypoints in the GPS and these positions can later be matched with the observations. At a minimum, transect endpoints and a few "random" positions along the line should be recorded.

GPS: Should the GPS fail and a back-up system like LORAN-C is not available, observers will have to try to map the transect endpoints and the flight path as well as possible. They can later determine line lengths from a map.

Radar Altimeter: If the radar altimeter fails, the pilot should try to maintain the plane as best as possible around the desired survey height. Occasional pressure altimeter readings taken over known landmarks or tied to GPS locations can be used to obtain a crude estimate of the average survey height. An estimate of height AGL can be calculated from the difference between these altitude readings and elevations of corresponding locations taken from a topographic map. Some interpolation of contours may be necessary. It will not be feasible to obtain these readings for all observations, however.

POST-SURVEY PROCEDURES

Upon completion of the survey, a number of tasks remain. Although the survey crew may be tired, the following items should be completed upon or soon after returning to the airport:

Closing Flight-Following

Flight following with SALECS should be closed. This is usually done by the pilot just before landing. The flight coordinator (i.e., wildlife management coordinator or designee) should be notified that the crew has completed the survey and safely returned.

Checking Data

Check on the data to make sure they were recorded. This can be done by reviewing the computer log files or tapes. You don't want to find out data are missing or there was a malfunction weeks after the survey was completed.

Tracking Flight Time and Costs

Keep track of the time and costs associated with each herd and hunt area including ferry time, survey time, and overnight charges.

Running Tally

It is most helpful to maintain a running tally of the following data to check on data quality, sample sizes, and adequacy of the survey design:

- number of clusters observed
- total animals counted
- total line length surveyed
- number of clusters observed by distance band

Some of this information may not be immediately available. However, these summaries can help identify potential problems with observers watching the line, and can help determine the need to fly additional transects or even reduce the current sampling effort. The observed mean cluster size and encounter rate can be helpful to other biologists planning surveys in adjacent areas.

Post Survey Briefing and Critique

Following the survey, the pilot and observers should review the survey and how they thought it went. Any problems should be documented and discussed, along with any suggested changes or improvements.

Coordination

Survey crews should keep in contact with observers for the next survey to let them know about scheduling, conditions, problems and any contingencies. Standby observers may need to be ready in case an observer for the previous flight is unable to go or continue. Be sure to let other observers know what areas have been covered, what areas are to be surveyed, and where to go if you can't continue with the area planned for that flight.