Chapter 2

QUALITY CONTROL

This chapter describes some of the steps needed to maintain the high degree of quality control required for aerial line transect surveys using the Wyoming Technique. Users should be familiar with the basic concepts of this approach and the assumptions underlying the technique as described in the previous chapter. The following sections discuss some of the basic principles involved in training participants, conditions influencing survey results, and considerations in selecting and outfitting aircraft. There are considerably more aspects to aerial line transect sampling than are presented here. Each pronghorn population will have special characteristics that should be considered in the design of specific surveys. Factors such as population status, density, distribution, desired sensitivity (e.g., precision), habitat characteristics, and prevailing winds should be considered in the survey design. Nonbiological factors such as aircraft availability, manpower, budgets, and weather may also impose constraints on surveys.

Aerial line transect surveys require considerably more care in the physical set-up of the aircraft, the design of the survey, survey procedures, and data analysis than were typically performed with traditional strip transects and other related aerial survey techniques. However, properly conducted strip transect surveys require about as much effort. It is important for participants in aerial line transect surveys to appreciate the need for a great deal of quality control with these procedures. Training of observers and pilots is essential (Laake et al. 1997). The Wyoming Technique is not bullet-proof. Poor results have been obtained in some herds because personnel did not follow proper procedures, care was not taken in setting up planes, and/or data were not recorded accurately. Users should review the following basic considerations before conducting a survey.

Training

The demands of the Wyoming Technique require all participants to be trained in their specific tasks and responsibilities, including pilots. Participants must conduct themselves differently than they would in other types of aerial wildlife surveys. It is best if persons with substantial experience using this aerial line transect technique assist new participants before and during surveys, and with analysis and interpretation. Ideally, experienced biologists should fly with new observers or pilots to help answer any questions that come up during the survey and to make sure the survey is being conducted properly.

The Wyoming Game and Fish Department, with the assistance of the Wyoming Cooperative Fish and Wildlife Research Unit, prepared a number of training aids to help familiarize new participants with line transect surveys prior to gaining actual experience in the air. These materials are also helpful for refreshing participants in their duties since most biologists conduct line transect surveys about once each year. The original *Guidelines* (Johnson and Lindzey 1990) and this manual were intended to provide some basic background on the steps needed to set-up and conduct a survey. A short video, *Estimating Pronghorn Numbers with Line Transects*, described

some of the basic steps outlined in Johnson and Lindzey (1990). Although partly outdated, this video is still helpful in showing participants and other interested persons the general aspects of how the surveys are conducted and analyzed.

Experience is one of the best ways to learn the technique. I strongly recommend flying practice transects be prior to conducting an the actual survey. Practice is important because the technique requires participants to be familiar and proficient with procedures. Because of limited budgets, flying special "practice" surveys may not always be feasible. However, opportunity exists to practice while ferrying to the survey area, or taking a short detour into an adjacent area before starting the survey. Observers should practice placing objects in distance bands, ask questions about the technique, understand contingencies for problems, and practice reporting information in the proper sequence. Pilots should practice maintaining the plane along a straight heading at the proper height AGL using the radar altimeter and GPS. Pilots can also practice entering data. These "shake-down" runs also help make sure equipment and personnel are functioning properly before starting the survey.

Observers: Persons who will participate as observers should review the basic assumptions and procedures outlined in this manual. First-time observers may find that watching the video helps. Novice line-transect observers and persons experienced in conducting other aerial surveys tend to look farther out instead of scanning along the line. The natural tendency is to look out toward the horizon. Unfortunately, pronghorn will be missed at those distances. That is okay with line transect sampling. However, observers will fail to detect animals on the line if they are looking farther out. It is extremely important to follow the procedures to make sure you don't miss animals in the first band. With practice, observers generally develop the discipline (and comfort) to watch the line. Observers should limit survey sessions to 2-3 hours at a time.

Observers should not try to do too much. Avoid attempting to record sex and age composition of pronghorn clusters, counting nontarget species, mapping, or performing other activities that divert attention away from the main objective of the survey.

In addition to being familiar with the observation technique, observers should be trained in aspects of flight safety, including the Department's flight following policy; be familiar with circumstances that warrant interrupting a survey (e.g., poor survey conditions, fatigue, safety, etc.); and be familiar with the transect layout in case circumstances warrant flying areas out of the sequence planned.

Pilots: Although pilots are not employees of the Wyoming Game and Fish Department, they too need specific training in conducting line transect surveys using the accepted procedures. Pilots should also be familiar with the assumptions of the technique and survey procedures. It is extremely important to conduct surveys accurately and safely. The technique requires the use of specialized equipment (e.g., radar altimeter, computer, GPS) while flying the plane. Pilots should be proficient at operating this equipment while safely flying the plane along the prescribed transects. Experience shows this can be done using the current set-up. Pilots should practice using the equipment and flight procedures before conducting a line transect survey. They should also check on observers to see if they are surveying properly.

Analysts and Designers: Usually, persons designing surveys will also be analyzing them, but not always. Persons involved in the design and analysis of the survey should be familiar with the assumptions, survey procedures and special considerations about designing and analyzing surveys as discussed later in this manual and elsewhere (Buckland et al. 1993, Laake et al. 1996). It is extremely valuable for these persons to have actual experience as observers on line transect surveys in order to better understand the manner in which surveys are conducted and to be aware of potential problems that may need to be addressed in the analysis.

Survey Conditions

Properly conducted, line transect procedures tend to be more robust to problems affecting observability of pronghorn than many other aerial survey techniques. However, care should be taken in the type of conditions under which surveys are performed. Although the technique allows detectability to decline with distance under varying conditions, efforts should be made to conduct the survey under the best conditions possible. Conducting surveys during poor conditions may result in poor estimates. Sample size and the shape of the histogram of observed distances can have a profound effect on the accuracy and precision of the estimate. Ultimately, it will be up to someone responsible for the survey to decide if conditions are acceptable to continue. Usually unacceptable survey conditions occur prior to conditions becoming unsafe to fly the survey. External factors such as wind, storms, clouds, time-of-day, light angle and intensity, and background may affect the quality of the survey. Internal factors of the observers and pilots such as fatigue, motion sickness and emotional status can also have a profound influence on meeting the assumptions required of the technique.

Sometimes surveys may have to be carried out under less than optimal conditions. Deciding when to stop depends upon the line length needed to finish that line or segment and whether or not animals on the line are not being detected. Observers should be alert for signs that animals on the line are going undetected. You are probably missing pronghorn if you only notice them after the plane has passed by. You may also be missing animals on the line if you are seeing few clusters in areas where you know densities are high. Observers should check with each other to see if they feel they are observing pronghorn adequately.

Wind: Wind can influence the safety and reliability of surveys. Surveying may become hazardous on the leeward side of mountains, foothills and ridges due to strong downdrafts and turbulence. Turbulence and strong winds are common in Wyoming's airspace. Areas prone to those conditions should be surveyed during calm periods, often the first thing in the morning. Observers and pilots tend to be distracted from the survey when excessive turbulence is encountered. Under such conditions, a survey should be stopped. Sometimes, other parts of the survey area may be okay to fly. The survey can be resumed in the area when conditions improve.

Strong winds may cause the plane to crab (turn sideways like a weather vane). Surveys should be stopped when noticeable crabbing occurs. Under those circumstances, observers on the downwind side of the plane may not be able to watch for pronghorn coming up and potential exists for both observers to count the same cluster. An estimate of the angle that the longitudinal

axis of the plane deviates from the transect orientation would be needed to correct distances because the markers on the plane no longer define perpendicular distances from the transect line.

Strong winds may also affect the ground speed of the plane. Tailwinds can cause the plane to travel too fast for observers to see animals on the line and more may be missed away from the line, reducing sample sizes. Conversely, the plane may go so slow flying into the wind that observers are less attentive. This can be a problem in low density areas.

Weather: Late spring and early summer storms are common, particularly during afternoon surveys. These storms may bring strong turbulence, lightning, hail, and clouds that reduce the light intensity. In some cases, the survey can continue in other parts of the survey area away from a weather cell. Other times, it will be best to return to the airport and pick up where you left off when conditions are favorable.

Clouds: Ideally, surveys should be conducted on clear days whenever possible. However, cloudiness does not necessarily dictate that a survey should be stopped. How high the cloud ceiling is may determine whether it is safe to fly. A weather forecast may indicate whether clouds are expected to clear out or increase. On occasion, early morning fog may develop along rivers and other low-lying areas following a rain. Surveys in those areas may have to be postponed until the fog lifts. Low lying clouds may also form in the foothills, precluding flights in those areas until the clouds rise.

Patchy cloud cover is common in the afternoon during late spring and summer. In and of itself, this condition does not necessarily require the survey to be stopped. It all depends on the quality of the light in the shadows. As long as you feel you aren't missing animals on the line, then the survey can probably continue. Depending on the size and distribution of the clouds, light may have too much contrast for one's eyes to accommodate when going in and out of the shadows.

In some cases of continuous, thin cloud cover, the light may still be adequate for continuing the survey. Sometimes visibility is as good with less intense light because of the reduction in glare from strong sunlight.

Time-of-day: Although line transects can generally be flown during most daylight hours, early-to-mid-mornings and mid-afternoon to early evenings seem to be better. During those periods the sun angle tends to illuminate animals more conspicuously on the side of the plane away from the sun, yielding a flatter detection curve. Weather conditions are usually more favorable than mid-day and early afternoon. Pronghorn tend to be more active and dispersed in the morning. During mid-day, pronghorn tend to bunch up and bed down so you may encounter fewer clusters during that period. During morning and late afternoon surveys, visibility will be poorer on the side of the plane looking into the sun. That is okay as long as animals on the line are not missed. While the observer looking into the sun may see fewer clusters, both observers should see about the same in the first distance band over the long run. Line transect sampling is robust to pooling different detection curves (see Buckland et al. 1993).

In some parts of Wyoming with lots of topography (e.g., canyons, rims, draws), shadows can become a problem when flying shortly after sun-up or close to sun-down.

Background: Although pronghorn occupy relatively open habitats, not all are seen within the areas surveyed. The ability to detect pronghorn depends in part upon how much contrast there is between the animals and the habitat. Ideally, surveys are conducted during late spring and early summer during peak green-up. In spring of some years, dry conditions persist and there isn't much contrast. Some parts of the state contain a lot of bare ground, rocks, and other features that make it harder to spot pronghorn from the air. Under these conditions, observers must concentrate along the line to make sure that animals on the line are seen. Occasional spring snow storms may cover the ground with a uniform snow cover. In some cases, this may improve visibility. In many situations, the snow cover is not uniform, making it harder to detect animals. In most instances, it may be worthwhile to wait a day or two to let the snow melt and allow animals to redistribute themselves.

Fatigue: Unlike conventional aerial surveys, line transect sampling requires a great deal of concentration in order to observe animals. Objects appear to go by faster because observers tend to be looking down rather than out toward the horizon. These factors contribute to observer fatigue. As a result, observers may start missing animals on the line before they recognize the problem. In low density areas, observers may also become mesmerized and forget to concentrate on searching the ground for pronghorn. Some observers who take motion sickness remedies may become drowsy during long surveys. Pilots can also become fatigued since this technique requires them to actively maintain the plane on line at the desired height AGL as well as input data. Refer to the section below about the duration of surveys. Survey crews should take a minimum of two hours rest between survey flights.

Duration of surveys: The duration of survey flights should be limited to about two to three hours at a time. Although many observers feel they can continue to survey effectively for four hours or more, the likelihood that they are observing effectively is greatly reduced. If surveys must be continued, the plane should go back and pick up a fresh set of observers.

Motion sickness: Some observers tend to become airsick during line transect surveys. Prior to the flight, observers should avoid factors that promote airsickness (e.g., improper diet, alcohol, not getting enough rest). In flight, observers should avoid rapidly moving their eyes or getting too hot. 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.

Motion sickness is a common affliction for many participants in aerial surveys. Even persons who do not normally become affected during most low-level surveys are more prone to air sickness during line transects because observers must concentrate searching on the ground near the plane. Observers who become queasy during surveys tend to lose concentration on the task at hand (that may not be all they lose!). 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. Do not wait to become ill before dealing with motion sickness.

Time-of-year: The best time of year for conducting line transect surveys for pronghorn in Wyoming is generally from late May through mid June which coincides with green-up and fawning. At this time of year, pronghorn tend to be maximally dispersed into smaller clusters. Although smaller clusters are harder to see than larger ones, there are more clusters out there to be observed for a given amount of survey effort (length of transects surveyed). The time window for conducting aerial line transects for pronghorns is wider than for conventional trend counts. Line transects have been flown from late April through August in Wyoming. Estimates must be compared for comparable times of the biological year (e.g., late May surveys for the end of the biological year, August surveys for preseason, etc.).

Accuracy

The Wyoming Technique is a quality control intensive method. Users should recognize potential sources of errors, attempt to minimize their impact, and acknowledge that some errors cannot be eliminated. Errors can come from several sources:

- measurement errors in marking the struts and windows to define the proper distance bands,
- errors in assigning observations to distance bands due to observer alignment, procedure, or position of the plane,
- errors in estimating cluster sizes,
- errors due to deviation from the planned survey design (e.g., line lengths, height AGL, etc.),
- violations of assumptions (missing animals on the line, evasive movements, etc.),
- species misidentification,
- equipment failures (e.g., radar altimeter, GPS, onboard computer)
- recording and transcription errors
- "pilot" error,
- inadequate survey design,
- lost data,
- errors in analyses, and
- random sources.

Persons conducting and analyzing aerial line transects should use extreme care to make sure the technique is used as accurately as possible.

Oversight

Review and constructive criticism of survey designs and analyses are helpful ways to improve pronghorn surveys and maintain professional credibility. Many of the problems biologists in Wyoming have experienced with aerial line transect surveys relate to incorrect application of the technique, data input errors, or analysis errors (Guenzel 1994). Oversight can help prevent such errors from proliferating, may suggest improvements to the technique, or may help to better define survey limitations. Persons conducting surveys in new areas or using the technique for the first time would benefit from the advice of experienced personnel. Objective feedback is an important component of any quality control process.

AIRCRAFT REQUIREMENTS AND SET-UP

Certain procedures and equipment are needed to properly conduct aerial line transect surveys using the Wyoming Technique. The following describes the basic requirements for type of aircraft, avionics and other equipment, pilot qualifications, and distance reference marks on the plane. A detailed description of the procedures for marking aircraft for aerial line transect surveys is beyond the scope of this manual. Interested persons should contact the author for details on those procedures.

Aircraft Suitability

The Wyoming Technique is designed to be used from certain types of fixed-wing aircraft. Although line transect surveys can be conducted from helicopters, use of those types of aircraft is not described in this manual. Helicopters are more expensive to charter. Distances must often be estimated (see White at al. 1989, Firchow et al. 1990, Pojar et al. 1995, van Hensbergen et al. 1996) or measured by going off line and recording GPS positions because of problems setting up accurate distance references analogous to the strut marker system described here.

Certain types of fixed-wing airplanes can be used in aerial line transect surveys of pronghorn. These planes should have the following characteristics:

1. a single-engine, high-wing aircraft that affords good visibility,
2. strut-braced wings that allow perpendicular distance markers to be attached,
3. capable of safely flying low and slow, but powerful enough to climb over powerlines, towers, hills and other major terrain features;
4. able to accommodate special equipment as described below, and
5. accommodates a pilot and two observers (one observer in some cases).

Although individual aircraft vary in their equipment and capabilities, planes such as Cessna 185s, and Maules (M5, M6 and M7) have been successfully adapted for line transect surveys. Piper SuperCubs and Bellanca Scouts have also been used for line transect sampling with one observer, although room for extra instrumentation and computer hardware may be limited. Some aircraft may be too fast to fly safely at low speeds and heights AGL when pronghorn densities are too high to survey at usual speeds. For surveys of pronghorn at high elevations (i.e., density altitudes) and more than one observer, I do not recommend using less than a Cessna 182 (or similarly featured planes). Also, don't use planes with higher stall speeds (e.g., Cessna 206). Some aircraft may be fitted with STOL packages or other modifications that would improve their suitability. It's up to the individual in charge of the survey to be sure that the plane used is suitable for low level wildlife surveys of this type.

Special Equipment

Suitable aircraft (as described above) fitted with certain instruments and other equipment are preferred for aerial line transect surveys:

1. GPS linked to a computerized data acquisition system. The GPS allows for precise navigation of transect lines, and records line endpoints and positions for observations. I strongly advocate a computer-linked GPS system to instantaneously capture positions. LORAN-C navigation systems have been used, but should be calibrated with GPS to maintain accuracy.

2. Digital radar altimeter. Ideally, a digital radar altimeter linked to the computer system. The radar altimeter is extremely important for helping the pilot maintain the plane at the planned survey height AGL and allows heights AGL to be recorded for each observation. Those readings are used to correct distance data for actual survey height. Altitudes recorded from GPSs are unreliable for estimating survey height AGL. A digital radar altimeter is preferred over analog (dial)-style radar altimeters because it is difficult to record accurate heights AGL from dial units.

3. Data acquisition and storage system The computer system must be portable and capable of working while the plane is operating (e.g., banking, applying power, etc.) without interfering with other instrumentation. The interfacing of the GPS and radar altimeter allows data to be stored instantaneously. One commercially available computer system with its own GPS has been adapted for aerial line transect surveys (NavCap™ by Izee Labs, Prineville, OR). Without a data acquisition system, observational data and heights AGL must be manually recorded using tape recorders or other means and later matched to GPS waypoints. Data must be carefully recorded.

4. Properly marked airplane. Dowels must be accurately and safely attached to struts to define the prescribed distance bands when the plane is flown at the proper survey height. Windows must also be properly marked to define the precise eye position for each observer when they assign observations to distance bands.

This equipment is extremely important for maintaining quality control for aerial line transect surveys. Because the required equipment may not be available in some areas, some modifications may be necessary to conduct aerial line transect surveys. These may result in additional measurement errors. Users conducting surveys using these modifications should clearly understand the additional assumptions and limitations imposed. If there is no way to record height AGL for each observation, then pilots should fly as close to the desired survey height as possible. In some situations, heights may be recorded systematically or randomly to derive an average height AGL for use in analysis.

Air Charters

Several factors should be considered in selecting a flight service to conduct aerial line transect surveys using the Wyoming Technique. Ideally, the air service should already be set-up and experienced in conducting these aerial pronghorn surveys. Where that is not possible, the charter service should have a suitable plane that is properly equipped. The aircraft will have to be specifically measured and marked.

Users should also consider the qualifications and certifications of the pilot. The pilot should have extensive experience conducting low-level wildlife surveys, be proficient in the operation of GPSs

and other avionics, trained in line transect surveys, and be familiar with flight safety and flight following procedures.

Levels of Service

I've provided the following classification to help categorize aerial line transect capabilities. These presume that the plane is one of the acceptable types defined above. While Class 1 surveys are the ideal, acceptable results may be obtained using Class 2 and Class 3 surveys although additional assumptions may be required. I do not recommend conducting aerial line transect surveys using Class 4 or Class 5 equipped planes. Here are the class definitions:

Class 1: GPS linked to onboard computer or data acquisition system; digital radar altimeter (ideally linked to computer).

Class 2: GPS linked to onboard computer or data acquisition system; analog-type radar altimeter (needle dial).

Class 3: GPS not linked to computer or data acquisition system; data recorded by tape recorder or manually; radar altimeter.

Class 4: GPS or LORAN for navigation but no radar altimeter; may or may not be linked to computer or data acquisition system.

Class 5: No GPS, LORAN or radar altimeter.

Currently, two air charter services are experienced and provide Class 1 services for conducting aerial line transect surveys in Wyoming (Appendix I).