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AN AERIAL SURVEY TECHNIQUE FOR NORTHERN BIG GAME

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INTRODUCTION

The use of aerial surveys in determining the populations, herd composition, and annual increment of big game animals has become increasingly important in wildlife management. Pioneer work in the development of aerial survey techniques was done by Saugstad (1942) in North Dakota. Other workers have introduced modifications to fit their field conditions. Morse (1946) surveyed moose and deer in Minnesota; Hunter (1945), and Riordan (1948) described technqiues for surveying game in mountainous country; and Sumner (1948) surveyed Dall sheep ranges in Alaska. The use of aerial photographs in wildlife management has been well reviewed by Leedy (1948).

Early uses of aircraft by the Department of Northern Affairs and National Resources were in counts of the bison in Wood Buffalo National Park by the Royal Canadian Air Force in 1931, and of musk-oxen in the Thelon Game Sanctuary by Clarke (1940), in 1936. In the latter case Clarke took advantage of an air search for a lost aircraft to observe game on systematic transects.

It was soon realized that aerial survey was the only practical means of obtaining big game population data in the vast regions of northern Canada. It was used extensively during the preliminary barren-ground caribou investigation in 1948 and 1949 (Banfield, 1954). Since that time mammalogists of the Canadian Wildlife Service have flown approximately 2,000 hours on aerial survey work in northern Canada. Northern species studied by the authors include: moose (*Alces alces*), barren-ground caribou (*Rangifer arcticus*), white sheep (*Ovis dalli*), mountain goat (*Oreamnos* americanus), musk-oxen (Ovibos moschatus), wolf (Canis lupus), and Atlantic walrus (Odobenus rosmarus). Fuller (1950) has previously reported an aerial survey of northern bison (Bison bison).

During our aerial survey work several innovations have been attempted. We have developed a technique which seems to be well adapted to northern conditions. A report on this work forms the basis for this paper.

FACTORS TO BE CONSIDERED IN AERIAL SURVEYS

The characteristics of aircraft best suited for aerial survey work have been well described by Crissey (1949), and Riordan (op. cit.). In order to cover great distances in northern regions it has been found necessary to use heavy aircraft with longer ranges than those of the aircraft generally used in the United States. It is desirable to have a range of five or more hours flying time. Frost shields on the windows are often needed to provide clear vision under winter conditions. It is necessary to carry a good deal of emergency gear. The types of aircraft found most useful for our work include: Cessna 180, De Haviland Beaver, and Noorduyn Norseman. It is also important that a window may be opened to permit the taking of aerial photographs.

The maps most commonly used in northern aerial survey work in Canada are the National Topographic Series, Department of Mines and Technical Surveys, scale eight miles to one inch (1:506,880). These maps are based upon aerial photographs and are available for the whole of Canada. Some areas on them are still relatively blank but most of them present topographic detail. A few units have elevation contours; most give spot elevations.

Generally speaking the best time to undertake aerial surveys is the winter. At that season big game species are concentrated in restricted areas of suitable range. The game is clearly visible against the background of snow and finds little cover among the bare, deciduous trees.

The tracks of various species can frequently be distinguished from the air. Wolf tracks tend to be in straight lines, but those of herbivores meander. Fresh tracks are often sighted before any animals have been observed, and may be used as a guide in locating them. Old trails, feeding holes, and beds in the snow provide proof that the area was previously occupied.

Most of our experience has been gained in working with the barren-ground caribou, which is gregarious and migratory in its habits. The population of this species is not continuous over the whole range, but the herds tend to occupy discrete ranges.

We have found that the best period for caribou surveys is in March and April. At that time the herds are migrating from the winter ranges in closely packed columns and have a tendency to travel on frozen lakes and rivers. This makes it comparatively easy to count them. The hours of daylight are lengthening in that season, and thus there is a fairly long day for flying. Also, the region which the caribou occupy is generally in the polar air mass, and clear, dry, cold weather can usually be counted on. Visibility is good, and "bumpless" flying conditions, desirable for safety in low level flying, may be expected.

Early morning and late afternoon are good times to observe animals feeding. Caribou frequently bed down on snow-covered lakes on sunny afternoons, and they are easily counted from the air at these times.

Unfavourable weather conditions such as strong winds and snowstorms may force big game to take shelter in forests and thus become harder to see from the air.

FLIGHT PATTERNS

The flight track patterns used vary considerably depending on type of job, type of terrain, and species under study. Consideration should be given to the sampling adequacy of the census strips. If population data are required for areas of limited extent, or areas with definite boundaries such as game sanctuaries, then the flight tracks are laid out in a systematic grid to provide adequate coverage. Unfortunately in aerial surveys of large wilderness areas the economic considerations may restrict the coverage.

In other investigations data are sought on big game populations over vast areas. Here different techniques are needed for the sake of economy. In our caribou surveys reconnaissance flights are made over the range to find areas occupied by herds. When a herd is discovered, the range is quartered to delimit the length and width of the occupied area at the time of the survey.

Moose are difficult animals to census because it is hard to see them from the air in their coniferous forest habitat. Moose populations may be concentrated in favourable winter ranges such as old brulés and river bottoms. The aerial census of moose has been described by Edwards (1952), and DeVos and Armstrong (1954). Flook found that moose census data have greatest use in the determination of trends. Transect routes should be established over favourable winter ranges. These routes may be flown annually under comparable conditions and estimates of moose per square mile obtained. A comparison of the data over the years may be used to provide an estimate of the population trend. Coupled with kill statistics this data may give close estimates of populations, as demonstrated by Riordan (op. cit.).

A special technique is required for the aerial survey of white sheep and mountain goats. These species inhabit discontinuous winter habitats. It is necessary to plan a flight path to cover the occupied ranges of known bands. In this case census consists of enumerating local bands on their winter slopes.

Big game animals are more easily observed on the tundra. This makes it advantageous to try to cover the caribou migration about the time the animals are leaving the timber-line in spring. Musk-oxen, which inhabit the tundra, introduce their own particular problems. When stationary, they are easily confused with rocks. When they run, they bunch up so closely that it is very difficult to count them or identify calves. Because of our present lack of information on winter ranges, musk-oxen are more easily censused in summer when most of the population is concentrated in a few known lake, river, and coastal areas to browse on willows and birch. Here, however, tall shrubs may hide the animals when bedded down.

The altitudes at which the surveys are flown depend upon a number of factors. Generally our work is done between 200 and 1,000 feet above the ground. Within this range the higher altitudes are satisfactory for surveying the larger species and for over tundra and water. Survey of moose in forested areas requires low elevations. Eye strain, an important factor to be considered on prolonged flights, is eased considerably at an elevation of 1,000 feet.

The walrus is a marine animal, leaving no tracks to trace its movements by. As it is gregarious and occupies a discontinuous habitat, random sampling cannot be used in obtaining population estimates.

Taking advantage of its habit of hauling out on off-shore islands and peninsulas, Loughrey made ground counts of herds during his investigation of the Atlantic walrus in 1952-54. It was found that the most representative counts were obtained in July, when all age and sex classes are present. At this time the bulls spend much time on land. Cows with calves or yearlings normally stayed on shore when the water was rough. The period from mid-morning to mid-afternoon appeared to be the best for accurate counting, as the walrus fed in the sea in the early morning and late afternoon.

During the ground work, Loughrey collected information for an aerial survey, which would make it possible to census all known hauling-out grounds within a radius of 100 to 200 miles within a few hours. Observation and careful questioning of the Eskimos provided information on the locations where the walrus were known to haul out year after year. These locations can often be spotted at a considerable distance by the darker colour resulting from the deposit of excrement and the accumulation of hair in crevices. It was also found desirable to ascertain the location of the pack ice. The walrus leave the land for the ice when it comes close to the hauling-out grounds, and spread out over a wide area where they are difficult to census.

The hauling-out areas located were marked on the pilot's map, and a flight course was laid out to cover all of them as economically as possible.

The walrus has poor eyesight but appears to react strongly to the noise of low-flying aircraft. The best counts were obtained at 1,000 to 1,500 feet elevation. At these altitudes it was often possible to make a second run before the walrus took to the water. Small herds seemed to take alarm more quickly than large ones.

Considerable experience in ground work is necessary with this species to give the observer confidence and competence before he attempts to estimate from the air closely-packed herds which may number 1,000 or more. Aerial photographs, as yet untried, should provide a check on visual estimates. The use of telephoto pictures should permit age and sex group segregation, which was impossible visually.

We have found that aircraft at moderate heights do not generally alarm moose, caribou, and musk-oxen which seldom take alarm until they hear the propeller tip noise as the aircraft passes. Often one has the first glimpse of a moose as it jumps from its bed directly opposite the wings of the aircraft.

Sumner (1948) and Edwards (1954) have tested the accuracy of aerial surveys by ground checks. Both report that aerial counts are about 20 per cent low. Our field experience tends to confirm this figure.

Figures have been given on the cost of aerial census in the United States. Morse (op. cit.) reported a cost of $1.09 per square mile in Minnesota. Saugstad (op. cit.) reported a cost of 60 cents per square mile. Costs in northern Canada are greater than this because aircraft hire is much more expensive in remote areas. Our survey work in the Northwest Territories costs in the order of $4.00 per square mile for aircraft hire alone.

DETERMINATION OF TRANSECT WIDTH

One of the basic problems in aerial census is the determination of the width of the transect. In the preliminary caribou survey in 1948-1949, Banfield, (op. cit.) developed a system to estimate transect widths. He plotted the flight course on the map. From time to time he also plotted the locations of the caribou seen farthest from the aircraft. Since the caribou were generally on frozen lakes, it was an easy matter to pin-point them. Later the average transect width was determined from the individual measurements. This system had the advantage that the altitude of the aircraft was not required for the calculation. One of the disadvantages was that some areas surveyed had not been adequately mapped. It was impossible to plot observations when flying over these blank areas.

Caribou and musk-oxen in open country are often visible from the air for distances which allow transect widths far greater than in forest. Accurate estimation of sighting distance is difficult or impossible through map reading because water margins do not stand out sharply at low altitudes except in areas of rugged topography. Kelsall has often checked sighting distances by turning the aircraft to point directly at animals seen. The distance is computed from the known airspeed and the time required to fly between the point of sighting and the point of sight. This technique has value when it is not possible to measure the distance mechanically.

As another aid to visual estimation of strip widths in open country, sighting tests have been conducted with groups of caribou whose position could be accurately plotted on one mile to the inch flight maps. It was found that bands of caribou could be seen and recognized at distances up to 3 miles at altitudes from 500 to 1,500 feet, but that individuals and small groups could easily be missed at 1½ miles. Accurate counts could only be secured at distances under 1½ miles and conditions for using the maximum possible sighting distance are rarely found.

After much experimentation it was decided to adopt the system which uses an angle of sight to determine transect width, as originally described by Saugstad (op. cit.) and recently used by Edwards (1952). In this method the observations are limited to a definite field, whose outer margin is marked by guides - one on the observer's window and another on the strut of the aircraft. This marks an arbitrarily chosen maximum angle of sight. The transect width is calculated from the tangent of the fixed angle and a fixed altitude.

We have found that this system has several disadvantages. When aircraft hire is expensive and big game sparsely distributed, it goes against the grain to neglect observations beyond the arbitrary angle. It is difficult to find the angle where efficiency in observing big game drops off. This varies with altitude, terrain, visibility, and species. Also it is often difficult to fly at a constant altitude.

A correction should be made for the blind spot under the aircraft in many cases. This is needed if the observers are using only side windows. Even forward vision from the co-pilot's seat may not be adequate to cover this area if the aircraft flies in a nose-up attitude as the Norseman does.

We have found it preferable to record individual angles of sight to the animals observed, and use the data to calculate the transect width. A line is drawn on the observer's window with a grease-pencil. Using this reference line, markers are placed on the wing strut to indicate angles of

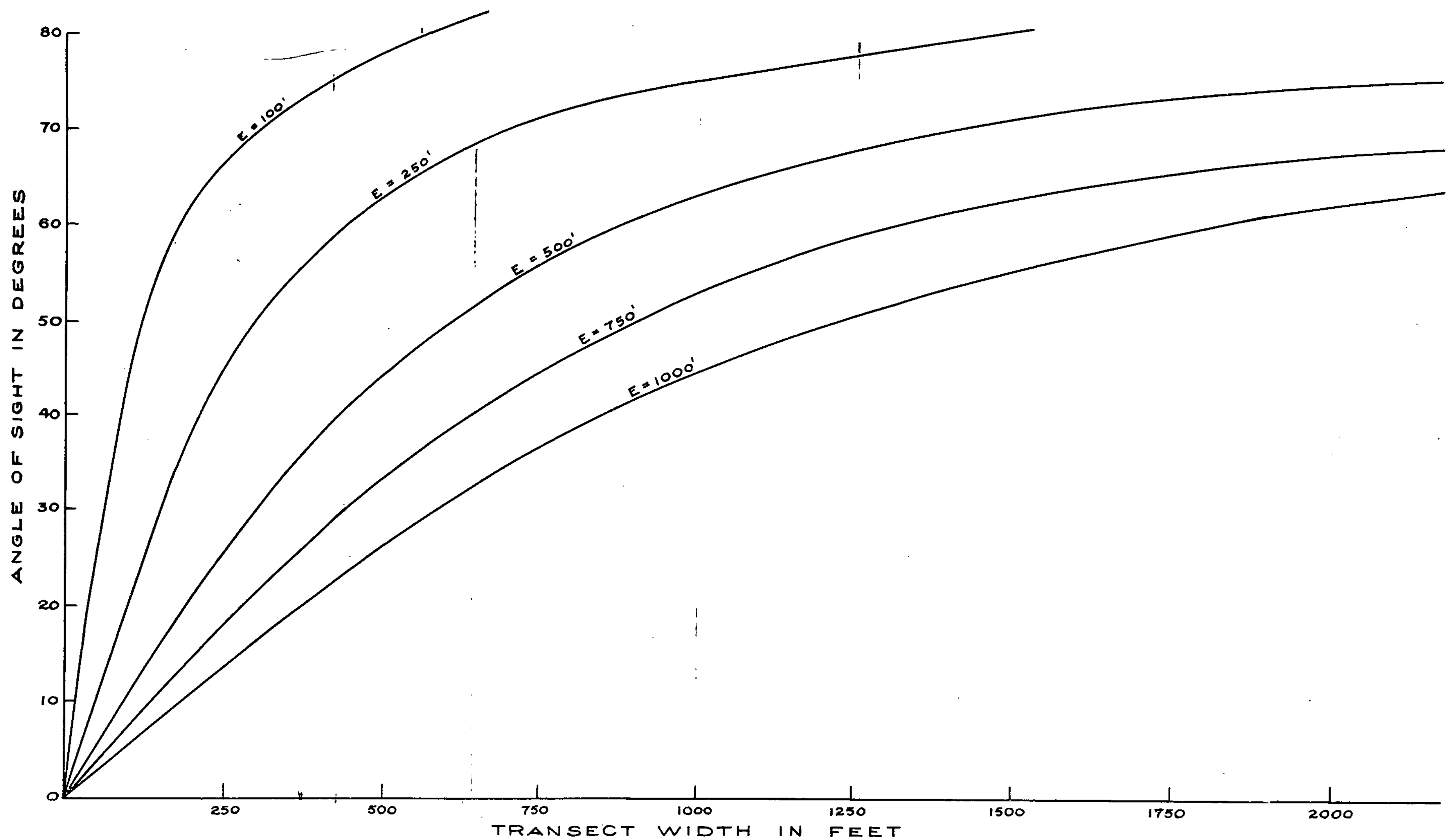

Figure 1. Transect widths for various angles of sight at five standard elevations: 100, 250, 500, 750 and 1,000 feet. Intermediate points may be estimated visually.

20, 30, 40, 50, and 60 degrees from the vertical by means of a protractor, Abney level or Brunton transit.

A graph has been prepared which gives ground distances for various angles of sight at several standard altitudes. These data are presented in Figure 1. The graph may be used to quickly obtain effective transect widths under different field conditions. If two observers are used, one on each side, the transect width is doubled in making the subsequent calculations.

Several fundamental considerations in aerial surveys are revealed by a study of this graph. The narrowness of the transect width which may be covered at low level is emphasized. For instance, at an elevation of 100 feet, an angle of sight of 80 degrees (nearly horizontal) covers a transect only 570 feet wide. In order to cover effectively a transect one-half mile wide it would be necessary to fly at an elevation of over 1,000 feet.

1/9 mile . impossible to count in 1/8 mile at 80° angle

It is also evident that at moderately low elevations a difference of a few degrees in sighting causes little change in a transect width. Therefore the recording of the angle of sight need only be approximate. It is advisable to restrict the observations to within an angle of approximately 70 degrees, for the transect width increases rapidly to infinity beyond this.

Another practical consideration is the speed of the aircraft at low altitudes. The ground sweeps by so quickly that the sector which may be scanned effectively is greatly restricted.

ANALYSIS OF AERIAL DATA

Field forms have been prepared to record the observations. Flight data recorded includes: flight number, date, time of take-off, base elevation on altimeter, weather conditions, topographical features, time of observation, altitude, angle of sight, number and class of big game observed, and number of photograph if one is taken.

Care should be taken that the aircraft is on level keel when the angle of sight is recorded. This may be verified by glancing at the artificial horizon. If contours are not provided on the map in use, elevations may be obtained by landing and checking the altimeter.

The transect length is obtained by means of a map measure on the plotted route.

The distance of individual animals or groups from a point directly under the aircraft is then calculated as shown in Table 1. If the number of observations is small, full data should be used. If the number is large, a representative number can be used.

In order to ascertain the distances where efficiency in observing the animals drops off so that animals are missed, the data are re-tabulated according to the distances from the aircraft. An example is shown in Table 2. An arbitrary distance interval may be used to illustrate the grouping of the observations. This method resembles the Keller system for ground census.

It will be noted that most of the observations fall in the middle distance. Few animals are observed directly under the aircraft and beyond a certain point the number of observations drops off with increasing distance. It may be assumed that the animals were randomly distributed on the ground and that the flight track introduces no special bias. The grouping of observations indicates the efficiency with which the animals on the ground were observed and tallied. A scarcity of observations close to the plane indicates the blind spot and the falling off of observations with distance indicates decreasing efficiency in counting. The effective transect width is the distance between, where observation appears to be efficient. In the example shown in Table 2, the transect width chosen was 1,600 feet (from 400 feet to 2,000 feet).

Only those observations which fall in the accepted transect width are used. First the average number of animals observed per square mile may be calculated for the transect area. Population estimates for a larger area may be obtained when the per cent coverage of the area is known. In our caribou surveys herd areas are plotted on maps and then the number of square miles is calculated by planimeter or dot area grid.

Occasionally heavy local concentrations of caribou are observed in an otherwise sparsely distributed herd. In this case it is advisable to obtain an estimate of the concentration numbers by aerial photograph or count and add it to the systematic transect data. Care should be taken to delete the transect mileage across the concentration before calculating the remaining data.

Table 1. **Calculation of distances of observed caribou from path of plane. Data from aerial survey of caribou in northern Quebec, April, 1954.**

Altitude feet	Ground Elevation feet	Height feet	Angle of Sight degrees	Transect Width feet
2,700	1,600	1,100	60	1,900
2,700	1,600	1,100	60	1,900
2,400	1,600	800	50	900
2,100	1,600	500	50	600
2,100	1,600	500	50	600
2,100	1,600	500	50	600
2,300	1,600	700	60	1,200
2,600	1,600	1,000	60	1,700
2,600	1,300	1,300	40	1,100

Table 2. **Calculation of transect width based upon data from aerial survey of caribou in northern Quebec, April, 1954.**

Distance from Flight Track Interval in feet	Number of Caribou Observations in Interval
0 - 200	1
200 - 400	0
400 - 600	5
600 - 800	6
800 - 1,000	3
1,000 - 1,200	7
1,200 - 1,400	3
1,400 - 1,600	4
1,600 - 1,800	5
1,800 - 2,000	6
2,000 - 2,200	0
2,200 - 2,400	1
2,400 - 2,600	1

SEGREGATED COUNTS

Valuable data on herd composition may be obtained from the air under favourable conditions. If the animals are distributed in small groups, age and sex classes may be counted on a multiple tally counter.

This type of work calls for familiarity with the age and sex groups on the ground. Advantage may be taken of the seasonal aspects of certain characteristics, for example, the presence or absence of antlers. Caribou with antlers in April and May are either cows or young bulls. Herds of cows and calves may be forced to string out. The aircraft may then fly along the flank and permit a calf count. Calves and yearlings may be distinguished from above by their short dorsal aspects.

Herd composition data, however, are best obtained from aerial photographs.

USE OF AERIAL PHOTOGRAPHS

We have made extensive use of aerial photography in our survey work in northern Canada. Low angle oblique photographs are taken of groups of animals. We have used the photographs later in the laboratory to determine the age and sex class composition of the herds. After field workers have become familiar with the appearance of the various classes on the ground, they can segregate them without too much difficulty in good photographs.

We use a Fairchild K20 4x5 inch aerial camera in our work. These cameras hold a roll of 50 negatives. The shutter is re-set and the film re-wound with one motion of a crank. The shutter is tripped by a trigger on the crank.

The photographs are studied under a binocular microscope or stereoscope in the laboratory and the animals segregated into classes: bulls, cows, yearlings, and calves, and recorded on multiple tally-counters.

Loughrey undertook a series of experimental counts at Churchill, Manitoba, in early 1954 to test the accuracy of segregated calf counts from aerial photographs. He found close agreement between these and counts obtained visually from the air and on the ground.

Large caribou herds have also been photographed to facilitate accurate counting. The photographs are placed under a glass slide ruled in a grid which aids in counting close groups. Photographs of small herds of known numbers may be used as checks in the visual estimate of numbers of gregarious species.

SUMMARY

Aerial survey has proved to be the only practical method of obtaining data on big game populations, herd composition, and annual increment in the wilderness areas of northern Canada. Different big game species require different handling of data. Caribou populations are best surveyed in early spring. Moose population data are best treated as trends. Caribou populations are best segregated into herds for study. White sheep and walrus may be censused as herds in discontinuous habitats. Musk-oxen are more easily counted in summer along the margins of lakes and rivers.

The following technique is best suited to varied northern conditions. Individual angles of sight to animals observed and altitude are recorded. The effective transect width may be obtained by grouping the distances to the animals in standard intervals. Outer and inner intervals may be discarded when the scarcity of records indicates low efficiency of observation.

Low oblique aerial photographs are used extensively to obtain segregation data, by examining them under binocular microscope or stereoscope in the laboratory.

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