Alaska Department of Fish and Game
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Brown Bear Line Transect Technique Development

Earl F. Becker

Research Performance Report
1 July 1999–30 June 2000
Federal Aid in Wildlife Restoration
Grant W-27-3, Study 4.30

This is a progress report on continuing research. Information may be refined at a later date.

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RESEARCH PERFORMANCE REPORT

STATE: Alaska **STUDY:** 4.30

COOPERATORS: Pham X. Quang, University of Alaska; Jerry Belant, Kyran Kunkel, Susan Huse, National Park Service; Becky Strauch, Alaska Department of Fish and Game

GRANT: W–27–3

STUDY TITLE: Brown Bear Line Transect Technique Development

JOB TITLES:
1. Transect selection
2. Upgrade data collection program
3. Refine covariates
4. Test variability of location marking
5. Population estimate (A-Lake Clark, B-Talkeetna)

AUTHOR: Earl F. Becker

PERIOD: 1 July 1999–30 June 2000

SUMMARY

Susan Huse wrote an ArcInfo program for the initial selection of transects. Becky Strauch made extensive modifications to the program to deal with transect delineation problems near study area borders and in flat sections of the study area. Becky Strauch used Geolink software to write project-specific data entry screens for in-flight recording of the line transect and bear-sighting data.

Analysis of previous data indicated problems with measuring the impact of both habitat on bear sightability and topography on the quality of the search. Habitat primarily affects bear detection by the amount of cover provided. To quantify the effect of cover on bear detection, we estimated percent cover within a 10-meter radius of the bear. Cover was estimated to the nearest 10% with the aid of cover diagrams. We obtained a GPS (Global Positioning Satellite) location for the most distant location the observer searched. From this data we could obtain the search distance (distance from the transect) used to quantify the impact of topography on bear detection.

We did not test the variability of the GPS units because we are about to switch from using military GPS's to commercial units. We will perform this test in the upcoming field season. The bear line transect data is electronically captured and requires extensive editing in order to be analyzed. Due to time constraints and the lengthy process of editing the data, a bear population estimate for the Northern Game Management Unit 9B study area has not yet been completed. The population estimate will be reported in next year's report. An additional year of data is needed in the Unit 13E Plus (Unit 13E and the northern sections of Units 16A and B) study area and will be collected next year.

***Key words*:** black bear, brown bear, density estimation, double-count data, line transect, *Ursus americanus, Ursus arctos*.

CONTENTS

BACKGROUND

Aerial surveys of wildlife populations are often the quickest and most cost-effective way to determine and monitor the population status of wildlife species. In order to obtain valid population estimates with aerial surveys, the problem of visibility bias (Caughley 1974, Pollock and Kendall 1987) must be overcome. Visibility bias occurs when an animal that is available to be seen goes undetected by the observers. This differs from availability bias that occurs when an undetected animal was "unavailable" to be seen, usually due to environmental conditions (Pollock and Kendall 1987). Examples of unavailability bias in aerial surveys include animals in dens, under very thick canopy (e.g., rainforest canopy) and underwater (marine mammals). Valid population estimates also require an estimate of the sampling variance and a valid sample design to correctly expand the estimator into unsampled areas.

Numerous methods have employed mathematical models to correct the visibility bias of aerial survey data. Gasaway et al. (1986) used an aerial resurvey estimator to estimate moose (*Alces alces*) population size. Aerial sightability models (Steinhorst and Samuel 1989) have been developed for elk (*Cervus elaphus*) (Samuel et al. 1987) and moose (Anderson and Lindzey 1996). Mark and resight estimators applied to aerial survey data have been used to estimate population size for white-tailed deer (*Odocoileus virginianus*) (Rice and Harder 1977), mule deer (*O. hemionus*) (Bartmann et al. 1987), mountain sheep (*Ovis canadensis*) (Neal et al. 1993), moose (Bowden and Kufeld 1995), coyotes (*Canis latrans*) (Hein and Andelt 1995), brown bears (*Ursus arctos*) (Arnason et al 1991, Miller et al. 1997), and black bears (*U. americanus*) (Miller et al. 1997). Double-count data, specialized mark-recapture data, collected from aircraft have been used to generate a population estimate of white-tailed deer (Cook and Jacobson 1979), feral horses (*Equus caballus*) and donkeys (*E. Asinus*) (Graham and Bell 1989). Line transect theory (Pollock 1978, Burnham et al. 1980, Buckland et al. 1993) has been extended to allow the apex of the detection function to shift off the transect line (Quang and Lancott 1991). This is a more realistic model for aerial transects since the transect line is obscured by the flight path of the aircraft. Aerial line transect surveys have been used to estimate pronghorn (*Antilocapra americana*) (Johnson et al. 1991), Pacific and common loons (*Gavia pacifica* and *G. immer*) (Quang and Lancott 1991), and caribou (*Rangifer tarandus granti*) (Drummer et al. 1990).

Aerial line transect sampling is limited to flat terrain because flying linear transects in hilly and mountainous terrain causes the airplane's height above ground to constantly shift. This shifting changes sightability and eliminates the possibility of using strut marks (Johnson et al. 1991) to record sightings into distance classes. Quang and Becker (1999) have developed a procedure for collecting line transect data in mountainous terrain by flying contour transects. The transects follow elevational contours for a fixed length.

Sightability among animals can vary markedly, resulting in the need for the use of covariates to adjust for differences in their detection probabilities. Methods to incorporate differences in animal sightability have been developed for mark-recapture estimators (White et al. 1982, Pollock et al. 1984), line transect models (Drummer and McDonald 1987, Borchers et al. 1998, Ramsey 1987, Quang and Becker 1996), and sightability models (Steinhorst and Samuel 1989).

The disadvantage of using line transect models on aerially collected data sets is that they require the generally unrealistic assumption of perfect detection of all animals at the distance associated with the apex of the detection function. Recently, double-count and line transect models have been combined to form an improved population estimator (Borchers et al. 1998, Manley et al. 1996, Alpizar-Jara and Pollock 1996, and Quang and Becker 1999). Double-count data simultaneously collected with the line transect information are used to estimate the probability of detection (≤1) at the apex and thus avoid this assumption. Quang and Becker (1999) developed a joint likelihood model, which combines line transect and double-count data to obtain a population estimate. The assumption of independent sightings between the observers is critical for this technique. Laake (1999) showed that restricting the use of the double-count data to estimate sightability at the apex relaxes the independence assumption to only bear sightings at the apex need be independent.

Becker and Quang (in revision; see Appendix) have developed a sequential likelihood model, which uses the double-count data only to estimate parameters associated with sightability at the apex. These parameters are used to adjust the initial line transect estimated to obtain the population estimate. Their sequential line transect, double-count model is implemented by first fitting the data to a line transect model with covariates. Next, the double-count data are used to estimate the probability of detection at the apex.

Development of a line transect model incorporating double-count data to estimate brown bear population size has been a collaborative effort between ADF&G (Earl Becker) and the Department of Mathematics, University of Alaska, Fairbanks (Dr. Pham Quang).

STUDY AREA

Line transect data for brown bears were collected in a high-density study area on Kodiak Island (Barnes and Smith 1995). The next step in developing this technique to estimate brown bear population size was to obtain data from moderate- and low-density study areas. We also wished to use larger study areas to highlight the utility of the technique to collect data on a scale that was relevant to managing these populations.

The northern half of Unit 9B (Northern 9B Study Area) was chosen to be the medium-density study area. Since the area also contains a sizable black bear population, we also collected data on black bears at very little additional cost to obtain their population estimate. The elevation ranges from towering snow-covered mountains (6122 feet) of the Alaska Range to Lake Clark (754 feet). The habitat consists of glaciers, snow, barren rock, high-alpine habitat, alder shrub communities, black spruce forest, aspen forest, and sedge meadows. Due to high winds, which frequent the area, there is a lot of downed timber.

The low-density study area consisted of Unit 13E and the northern sections of Units 16A and B (13E Plus Study Area). Since the area also contains a sizable black bear population, we also collected data on black bears at little additional cost to obtain their population estimate. The elevation ranges from towering snow-covered mountains (17400 feet) of the Alaska Range to Lake Clark (254 feet). The habitat consists of glaciers, snow, barren rock, high-alpine habitat, alder shrub communities, black spruce forests, birch forests, mixed spruce-birch forests, and sedge meadows.

OBJECTIVES

The objectives of this study can be classified as increasing survey efficiency, increasing data quality, and obtaining population estimates. Survey efficiency was increased by automating the transect selection process with a computer program. Efficiency and data quality were increased by the use of a specialized data program that linked GPS data to the desired data attributes, such as the location of sighted bears and the start and endpoints of the transect. This program was also used to record data on the bear sightings. We further enhanced data quality by using more standardized methods to assess percent cover around the bear and by measuring a maximum sighting distance at locations where bears were observed. Assessment of the accuracy of the military GPS units (PLUGGERS) was not done this year because we are going to be replacing the PLUGGERS with commercial units. We initially used the PLUGGERS to avoid errors due to “selective availability” that the military adds to the GPS location data. The decision by the federal government to turn selective availability off will allow us to upgrade to commercial units and not suffer errors due to white noise added by the military. Population estimates for both brown and black bears in the northern Unit 9B study area will be in next year’s report. Population estimates for both brown and black bears in the Unit 13E Plus study area will be in the final report.

METHODS

Collection of bear distance data begins with randomly selecting transects to be flown. In the past this was a manual, personnel-intensive process that crudely marked the transect location onto survey maps. Susan Huse, National Park Service, wrote the initial transect selection program. Becky Strauch (ADF&G) made modifications to deal with keeping the transects within the study area boundaries, the resulting program is called AdfgBearTrans. Safe flight of the aircraft demands that transects follow elevational contours. The computer program selects a random point within the study area, determines its elevation, interpolates that elevational contour, and using the selected point as the midpoint of the transect, draws a transect of the specified length. This method will not work in areas of very little elevational relief. Instead, we delineate such areas and use a random point to mark the midpoint and pick a random angle. Boundary problems are handled by shifting the midpoint toward the center to fit in the whole transect. If this does not work, a random angle is used to delineate the location of the missing transect segment; only angles that allow the missing segment to be drawn within the study area are allowed. Becky Strauch wrote this computer code as an enhancement to AdfgBearTrans.

All the data were collected electronically using onboard laptop computers. GPS location data for the survey aircraft was recorded using Geolink software. Becky Strauch programmed the software to act as a data-entry screen. Data included transect identification, date, pilot-observer team, and transect locations taken every second. We recorded additional information on these data points, such as the start-transect, off-transect, resume-transect, and end-transect locations. When a bear group was observed, its location was marked by going off transect, overflying the bear and obtaining its GPS location by hitting a special bear location key. This labeled that point in the GPS data stream as the location point and brought up a data-entry screen to record information about the bear sighting. This information included bear species, group size, group activity, the amount of vegetative cover around the bear group, and the observer (pilot and/or backseat observer) of the bear group. We enhanced data quality by obtaining an accurate measure of the area near each observed bear being searched. This was accomplished using another special key to mark the extent of the search pattern when a bear was observed. This location was recorded by hitting another special key when the plane overflew that location. All marking flights were flown parallel to the transect unless it was unsafe.

Previous data sets did not show any relationship between type of cover and distance from the transect. An examination of that data indicated that a percent cover that could block the bear from view might be more important than the type of cover. Data quality was improved by developing digitized cover diagrams of bears in 10, 20, 30, to 80% cover and requiring the observers to consult the diagram before classifying the cover to the closest 10% around the bear group. Cover percentage was calculated by a pixel count of vegetation in the diagram; all the percentage diagrams are accurate to within 0.5%. This idea has been used for the construction of sightability models (Steinhorst and Samuel 1989). Following Steinhorst and Samuel (1989), we also used a 10-meter radius around the bear.

The independence assumption associated with the double-count data was enhanced by the use of curtains and a light system. A curtain partitions the aircraft in half so that pilot head movement does not alert the backseat observer to the pilot's finding a bear. A light system is used to signal and verify the sighting of a bear or potential bear group. When an observer sees a potential bear group, he or she turns on a light normally concealed but available. Once the plane has passed the potential bear, the observer seeing the bear is ready to announce the potential sighting. First he or she examines the other observer's light. If it is not on, the other observer has either not seen the bear group or has seen something but is so unsure of a sighting that the plane does not go off transect and circle that location. If the light is on, the other observer has also seen the group. This method ensures independent double-count data.

A typical survey starts with the observer powering up the laptop computer and the PLUGGER GPS and opening the Geolink software. Prior to takeoff, we ensure that the GPS is inputting GPS location data into the laptop via a data cord. Next, the date, transect identification, and pilot and observer names would be inputted. The transect identification is entered; a special keystroke marks the location at the start of the transect. In order to obtain good double-count data, both observers look out of the same side of the plane (usually the uphill side). When a bear group or potential bear group is sighted and then announced, a keystroke is used to mark the off-transect location in the GPS data stream. Once it determined that a bear has been seen, its location is marked in an overflight, parallel to the transect line if possible, and a keystroke is used to mark the bears location in the GPS data. Covariate information is recorded in the computer and on backup data sheets. These data include bear species, group size, group type (boar, subadult, female with yearling cubs, female with cubs of the year), activity at the time of spotting (bedded, sitting, standing, feeding, walking, running), percent cover around the bear, percent snow around the bear, and the observer who saw the bear (pilot, backseat observer, or both). Next, an overflight is made to record the location of the farthest location that was actively searched. After the data have been collected, the aircraft resumes the transect at a point just prior to the location it had gone "off-transect"; the location that the transect resumes is tagged in the GPS data with a special computer keystroke. A stopwatch is used to track both the amount of time spent flying "on-transect" and the average air speed, used to determine when the plane has reached the end of the transect. A typical transect flight, including off-transect and bear-marking flights, is given in figure 1.

GIS software is used to determine transect length, based on the start, stop, resume, and end transect locations. Distance from the transect to the bear group is obtained by a GIS program that computes the shortest distance between the transect and the bear location. Transect locations that occur after the plane has gone off-transect to look and mark the bear are not allowed in this calculation. A histogram of bear distances is computed and a cut-off point used to trim the sporadic long distances from the data (Buckland et al. 1993); this distance is called *w*. From previous fieldwork, we know that the blind strip of a Super Cub at 100 m above the ground is about 25 m. The area surveyed by the transect is determined as a union of right angle translates (Quang and Becker 1997) of distance *w* (Fig. 2), minus the union of right angle translates of distance 25 m. The population estimate obtained by the line transect model is for this area. The density estimate for the entire study area is the density of the randomly placed transects. The double-count data is used to a sightability adjustment applied to the line-transect density estimate.

Using the above methodology, bear data collection, for the northern 9B study area, was actually started 1-year before the initiation of this Federal Aid project. Rather than use unsure expert opinion to set the upper limit of the contour transects, we used 914.4 meters (3000 ft.), which was higher than the elevations being discussed. After 5-days of surveying in 1999, we used the elevations of the transects on which bears were observed to set the elevational limit to future contour transects. All transects above that elevation were dropped from the analysis.

RESULTS

Survey efficiency and data quality were greatly enhanced during this reporting period. The transect selection programs saved substantial time. It also allowed computer-generated maps that included the transects, which is a huge improvement over previous efforts. The new data-entry programs have allowed automated GIS programs to start the transect cleanup process which is the first step in obtaining transect length. Data quality has improved by using standardized vegetative cover sheets and collecting location data that allow us to obtain an estimate of the amount of habitat being searched during observations of bear groups.

Using the data from the first 5 days of the 1999 field season in northern GMU 9B, we constructed a data set of the elevations of the transects from which bears were observed. Stem and leaf plots of these data (Fig. 3) indicate that bears are rarely observed on transects above 823 meters (2700 ft.). Therefore, we restricted future transects in this study area to be below 823 meters. Only transects of elevational contours below 823 meters will be used for the population estimate because bear habitat will be defined to be below 823 meters.

During the 1999 season, we flew 757 transects (approximately 440 25-km and 317 30-km transects) and observed 96 brown and 135 black bear groups in the Northern Unit 9B study area. During the 2000 season, we flew 478 30-km transects and observed 70 brown and 84 black bear groups in the Northern 9B study area. In the 13E Plus study area, we flew 478 35-km transects and observed 79 brown and 256 black bear groups.

DISCUSSION

This project should continue for 1 more field season and data analysis into the winter of 2001–2002. During the winter of 2000–2001, the Northern 9B bear data will be analyzed to obtain population estimates.

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Prepared by:

Earl F.Becker
Biometrician III

Submitted by:

Donald E. Spalinger
Research Coordinator

Approved by:

____
Wayne Regelin, Director
Division of Wildlife Conservation

____
Steven R. Peterson, Senior Staff Biologist
Division of Wildlife Conservation

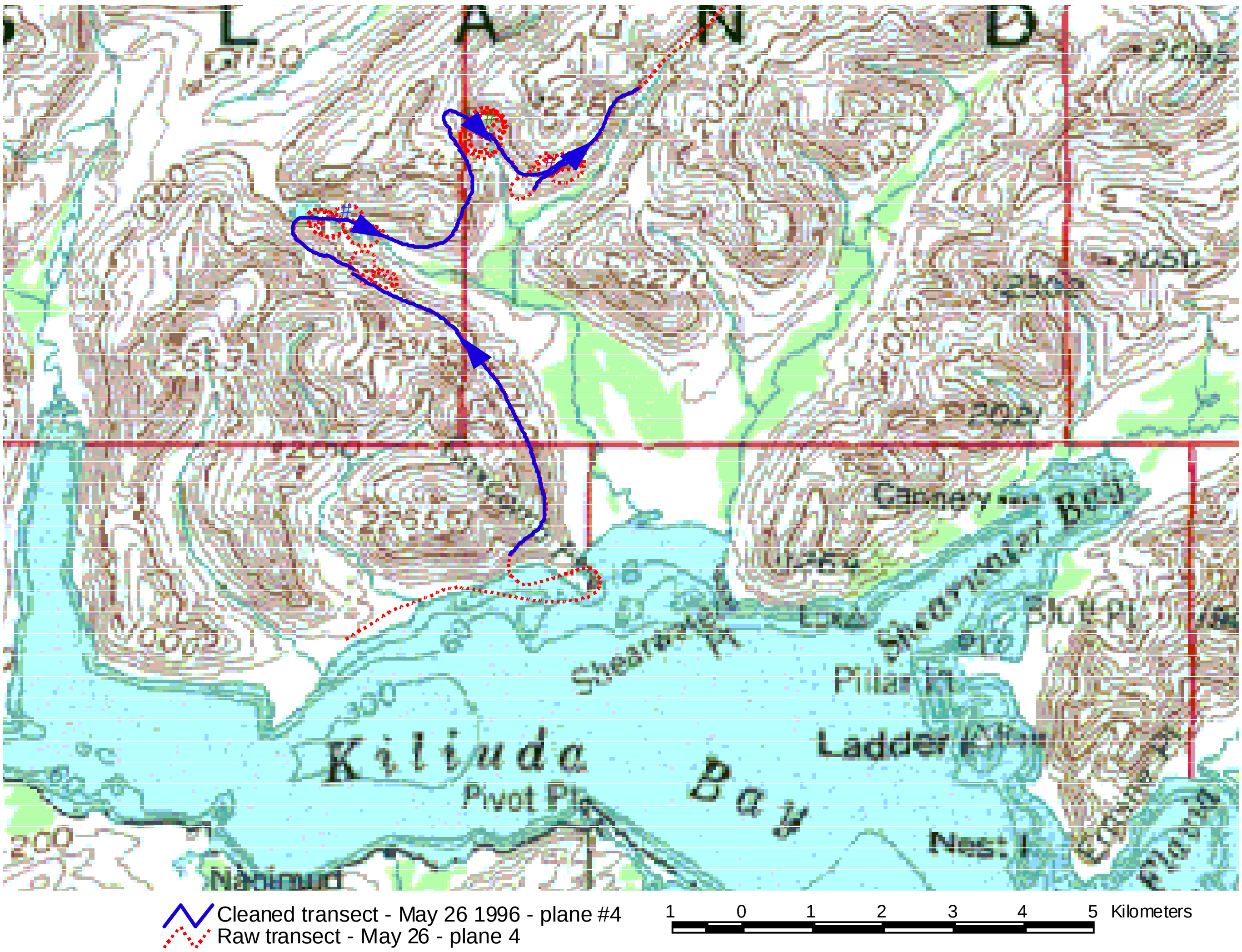

Figure 1. Survey flight path for a line transect in mountainous terrain along with marking flights for 3 bear groups.

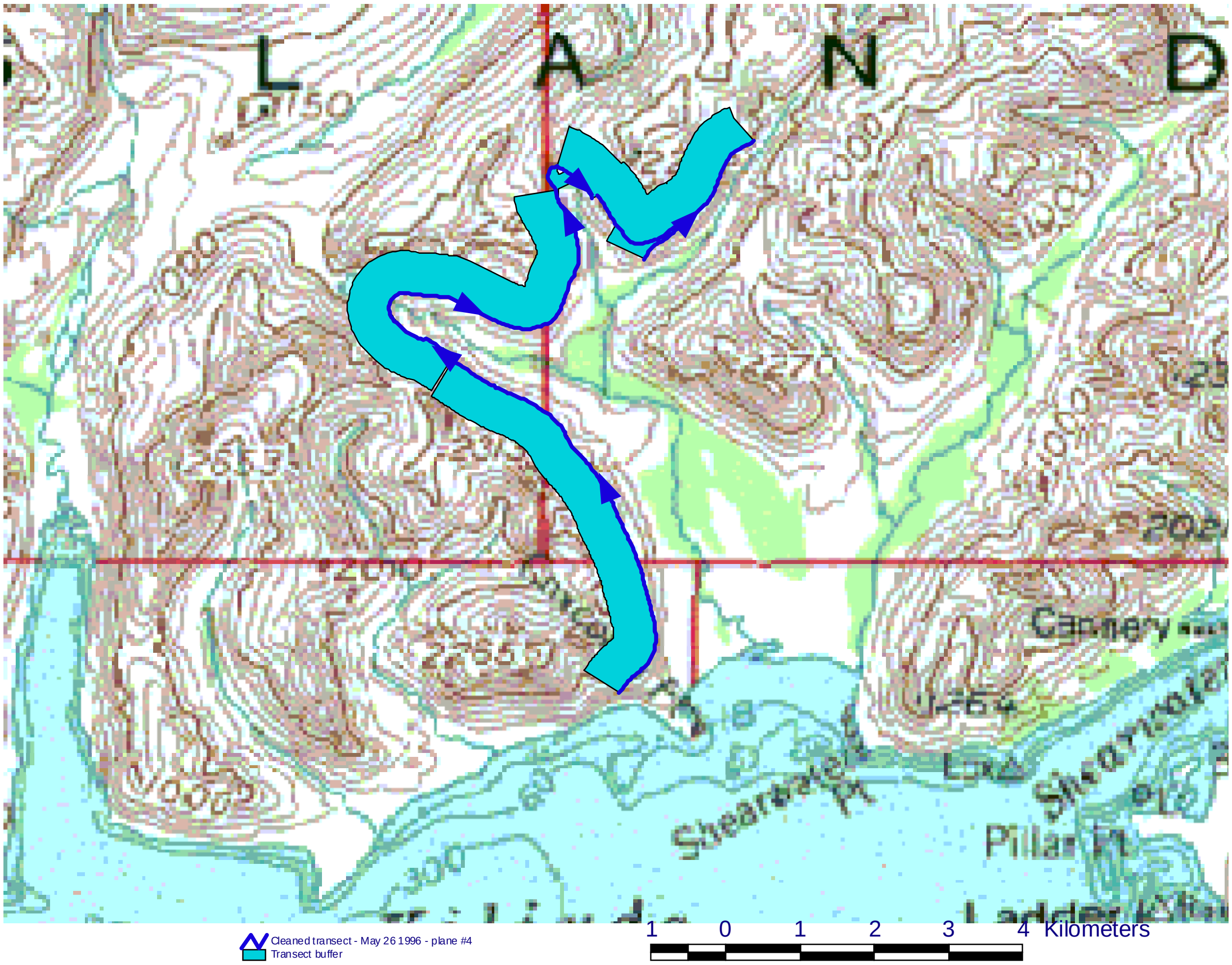

Figure 2. Depiction of area calculation of width *w*, based on the union of right angle translates from the transect line.

Figure 3. Stem and leaf diagram of the transect elevations (ft.) containing brown bears in northern Unit 9B. Decimal point is 2 places to the right of the colon; each number to the right of the colon indicates a bear observation (e.g., 7 : 07 indicates 2 brown bear observations on transects of 700 and 770 ft. elevation). Turning the page 90 degrees to the left presents the reader with a histogram of the dataset.

Hundreds /Tens

```
 2 : 9
 3 : 27778
 4 : 11155
 5 : 18
 6 : 7
 7 : 07
 8 : 16999
 9 : 5577
10 : 22
11 :
12 : 4444
13 : 1345777888
14 : 01111448
15 : 111119
16 : 011111111122223334444455
17 : 33477799
18 : 009
19 : 00022348
20 : 112444
21 : 05599
22 : 4
23 : 19
24 : 234578
25 : 33
26 : 055
27 :
28 :
29 : 111
```

Lake Clark 1999 - - Transect to Bear Ratio, Summary Report

		Transects per plane/computer ID						Black	Brown	Total	Transects to Bear Ratio		
Date	**am/pm**	**Plane 1**	**Plane 2**	**Plane 3**	**Plane 4**	**Plane 5**	**Total**	**Bears**	**Bears**	**Bears**	**Black**	**Brown**	**All Bear**
05/19/1999	pm	5	1	3	5	4	18	3	3	6	**1:** 6.0	**1:** 6.0	**1:** 3.0
	Daily Stats	**5**	**1**	**3**	**5**	**4**	**18**	**3**	**3**	**6**	**1: 6.0**	**1: 6.0**	**1: 3.0**
05/20/1999	am	9	7	8	9	8	41	1	4	5	**1**: 41.0	**1**: 10.3	**1**: 8.2
	pm	6	12	9	11	8	46	3	1	4	**1**: 15.3	**1**: 46.0	**1**: 11.5
	Daily Stats	**15**	**19**	**17**	**20**	**16**	**87**	**4**	**5**	**9**	**1: 21.8**	**1: 17.4**	**1: 9.7**
05/21/1999	am	11	8	10	8	10	47	6	8	14	**1**: 7.8	**1**: 5.9	**1**: 3.4
	pm	8	8	13	9	8	46	3	2	5	**1**: 15.3	**1**: 23.0	**1**: 9.2
	Daily Stats	**19**	**16**	**23**	**17**	**18**	**93**	**9**	**10**	**19**	**1: 10.3**	**1: 9.3**	**1: 4.9**
05/22/1999	am	10	9	15	5	13	52	7	10	17	**1**: 7.4	**1**: 5.2	**1**: 3.1
	pm	8	9	12	12	9	50	4	6	10	**1**: 12.5	**1**: 8.3	**1**: 5.0
	Daily Stats	**18**	**18**	**27**	**17**	**22**	**102**	**11**	**16**	**27**	**1: 9.3**	**1: 6.4**	**1: 3.8**
05/23/1999	am	12	8	13	11	1	45	16	8	24	**1**: 2.8	**1**: 5.6	**1**: 1.9
	pm	6	8	12	9	14	49	6	3	9	**1**: 8.2	**1**: 16.3	**1**: 5.4
	Daily Stats	**18**	**16**	**25**	**20**	**15**	**94**	**22**	**11**	**33**	**1: 4.3**	**1: 8.5**	**1: 2.8**
05/24/1999	am	12	9	11	12	1	45	9	7	16	**1**: 5.0	**1**: 6.4	**1:** 2.8
	pm	4	13	14	10	11	52	13	5	18	**1**: 4.0	**1**: 10.4	**1:** 2.9
	Daily Stats	**16**	**22**	**25**	**22**	**12**	**97**	**22**	**12**	**34**	**1: 4.4**	**1: 8.1**	**1: 2.9**
05/25/1999	am	10	5	10	11	11	47	18	5	23	**1**: 2.6	**1:** 9.4	**1:** 2.0
	pm	7	4	11	4	0	26	6	5	11	**1**: 4.3	**1:** 5.2	**1:** 2.4
	Daily Stats	**17**	**9**	**21**	**15**	**11**	**73**	**24**	**10**	**34**	**1: 3.0**	**1: 7.3**	**1: 2.1**
05/26/1999	am	2	0	0	0	0	2	0	1	1	**1**: -.-	**1:** 2.0	**1:** 2.0
	pm	0	10	12	12	0	34	1	4	5	**1**: 34.0	**1:** 8.5	**1:** 6.8
	Daily Stats	**2**	**10**	**12**	**12**	**0**	**36**	**1**	**5**	**6**	**1: 36.0**	**1: 7.2**	**1: 6.0**
05/27/1999	am	15	6	10	12	0	43	4	5	9	**1**: 10.8	**1**: 8.6	**1:** 4.8
	pm	0	14	11	15	13	53	14	10	24	**1**: 3.8	**1:** 5.3	**1:** 2.2
	Daily Stats	**15**	**20**	**21**	**27**	**13**	**96**	**18**	**15**	**33**	**1: 5.3**	**1: 6.4**	**1: 2.9**
05/28/1999	am	8	11	9	7	3	38	10	7	17	**1**: 3.8	**1:** 5.4	**1:** 2.2
	pm	8	2	3	10	0	23	11	2	13	**1**: 2.1	**1:** 11.5	**1:** 1.8
	Daily Stats	**16**	**13**	**12**	**17**	**3**	**61**	**21**	**9**	**30**	**1: 2.9**	**1: 6.8**	**1: 2.0**
Overall Stats		141	144	186	172	114	757	135	96	231	**1:** 5.6	**1:** 7.9	**1:** 3.3

Lake Clark 2000 - - Transect to Bear Ratio, Summary Report

		Transects per plane/computer ID				Black	Brown	Total	Transects to Bear Ratio		
Date	**am/pm**	**Plane 4**	**Plane 6**	**Plane 9**	**Total**	**Bears**	**Bears**	**Bears**	**Black**	**Brown**	**All Bear**
05/16/2000	pm	2	5	0	7	3	0	3	**1:** 2.3	**1: -.-**	**1:** 2.3
	Daily Stats	**2**	**5**	**0**	**7**	**3**	**0**	**3**	**1:** 2.3	**1: -.-**	**1:** 2.3
05/17/2000	am	9	8	0	17	6	4	10	**1**: 2.8	**1**: 4.3	**1**:1.7
	pm	9	7	0	16	7	2	9	**1**: 2.3	**1**: 8.0	**1**: 1.8
	Daily Stats	**18**	**15**	**0**	**33**	**13**	**6**	**19**	**1: 2.5**	**1: 5.5**	**1: 1.7**
05/18/2000	am	8	14	0	22	3	3	6	**1**: 7.3	**1**: 7.3	**1**: 3.7
	pm	2	3	0	5	1	0	1	**1**: 5.0	**1**: -.-	**1**: 5.0
	Daily Stats	**10**	**17**	**0**	**27**	**4**	**3**	**7**	**1: 6.8**	**1: 9.0**	**1: 3.9**
05/19/2000	am	10	5	7	22	2	7	9	**1**: 11.0	**1**: 3.1	**1**:2.4
	pm	7	6	9	22	4	6	10	**1**: 5.5	**1**: 3.7	**1**: 2.2
	Daily Stats	**17**	**11**	**16**	**44**	**6**	**13**	**19**	**1: 7.3**	**1: 3.4**	**1: 2.3**
05/20/2000	am	13	11	11	35	5	10	15	**1**: 7.0	**1**: 3.5	**1**: 2.3
	pm	6	6	5	17	4	5	9	**1**: 4.3	**1**: 3.4	**1**: 1.9
	Daily Stats	**19**	**17**	**16**	**52**	**9**	**15**	**24**	**1: 5.8**	**1: 3.5**	**1: 2.2**
05/21/2000	am	12	11	11	34	7	4	11	**1**: 4.9	**1:** 8.5	**1:** 3.1
	pm	6	7	5	18	3	5	8	**1**: 6.0	**1:** 3.6	**1:** 2.3
	Daily Stats	**18**	**18**	**16**	**52**	**10**	**9**	**19**	**1: 5.2**	**1: 5.8**	**1: 2.7**
05/22/2000	am	10	16	10	36	9	5	14	**1**: 4.0	**1:** 7.2	**1:** 2.6
	pm	9	7	9	25	12	4	16	**1**: 2.1	**1:** 6.3	**1:** 1.6
	Daily Stats	**19**	**23**	**19**	**61**	**21**	**9**	**30**	**1: 2.9**	**1: 6.8**	**1: 2.0**
05/23/2000	am	6	1	0	7	2	0	2	**1**: 3.5	**1:** -.-	**1:** 3.5
	pm	7	16	8	31	4	4	8	**1**: 7.8	**1:** 7.8	**1:** 3.9
	Daily Stats	**13**	**17**	**8**	**38**	**6**	**4**	**10**	**1: 6.3**	**1: 9.5**	**1: 3.8**
05/24/2000	am	14	13	8	35	6	2	8	**1**: 5.8	**1**: 17.5	**1:** 4.4
	pm	8	2	0	10	1	1	2	**1**: 10.0	**1:** 10.0	**1:** 5.0
	Daily Stats	**22**	**15**	**8**	**45**	**7**	**3**	**10**	**1: 6.4**	**1: 15.0**	**1: 4.5**
05/25/2000	am	6	10	10	26	4	6	10	**1**: 6.5	**1:** 4.3	**1:** 2.6
	pm	4	0	0	4	1	2	3	**1**: 4.0	**1:** 2.0	**1:** 1.3
	Daily Stats	**10**	**10**	**10**	**30**	**5**	**8**	**13**	**1: 6.0**	**1: 3.8**	**1: 2.3**
Overall Stats		148	148	93	389	84	70	154	**1:** 4.6	**1:** 5.6	**1:** 2.5

Talkeetna 2000 - - Transect to Bear Ratio, Summary Report

Date	am/pm	Plane 1	Plane 2	Plane 3	Plane 7	Total	Black Bears	Brown Bears	Total Bears	Black	Brown	All Bear
		Transects per plane/computer ID								Transects to Bear Ratio		
05/13/2000	pm	1	0	1	1	3	2	0	2	1: 1.5	1: -.-	1: 1.5
	Daily Stats	**1**	**0**	**1**	**1**	**3**	**2**	**0**	**2**	**1: 1.5**	**1: -.-**	**1: 1.5**
05/14/2000	am	4	3	7	0	14	4	0	4	1: 3.5	1: -.-	1: 3.5
	pm	0	0	0	1	1	0	0	0	1: -.-	1: -.-	1: -.-
	Daily Stats	**4**	**3**	**7**	**1**	**15**	**4**	**0**	**4**	**1: 3.8**	**1: -.-**	**1: 3.8**
05/15/2000	am	7	0	7	6	20	8	6	14	1: 2.5	1: 3.3	1: 1.4
	pm	3	0	14	10	27	12	3	15	1: 2.3	1: 9.0	1: 1.8
	Daily Stats	**10**	**0**	**21**	**16**	**47**	**20**	**9**	**29**	**1: 2.4**	**1: 5.2**	**1: 1.6**
05/16/2000	am	4	0	9	6	19	9	3	12	1: 2.1	1: 6.3	1: 1.6
	pm	0	5	8	9	22	10	9	19	1: 2.2	1: 2.4	1: 1.2
	Daily Stats	**4**	**5**	**17**	**15**	**41**	**19**	**12**	**31**	**1: 2.2**	**1: 3.4**	**1: 1.3**
05/17/2000	am	0	8	0	10	18	8	1	9	1: 2.3	1: 18.0	1: 2.0
	pm	0	6	18	7	31	4	9	13	1: 7.8	1: 3.4	1: 2.4
	Daily Stats	**0**	**14**	**18**	**17**	**49**	**12**	**10**	**22**	**1: 4.1**	**1: 4.9**	**1: 2.2**
05/18/2000	am	0	3	4	6	13	6	3	9	1: 2.2	1: 4.3	1: 1.4
	pm	2	9	12	7	30	14	4	18	1: 2.1	1: 7.5	1: 1.7
	Daily Stats	**2**	**12**	**16**	**13**	**43**	**20**	**7**	**27**	**1: 2.2**	**1: 6.1**	**1: 1.6**
05/19/2000	am	0	5	0	17	22	10	3	13	1: 2.2	1: 7.3	1: 1.7
	pm	8	8	0	14	30	8	2	10	1: 3.8	1: 15.0	1: 3.0
	Daily Stats	**8**	**13**	**0**	**31**	**52**	**18**	**5**	**23**	**1: 2.9**	**1: 10.4**	**1: 2.3**
05/20/2000	am	0	0	9	6	15	6	0	6	1: 2.5	1: -.-	1: 2.5
	pm	0	13	5	7	25	11	4	15	1: 2.3	1: 6.3	1: 1.7
	Daily Stats	**0**	**13**	**14**	**13**	**40**	**17**	**4**	**21**	**1: 2.4**	**1: 10.0**	**1: 1.9**
05/21/2000	am	0	7	11	6	24	8	1	9	1: 3.0	1: 24.0	1: 2.7
	pm	3	8	6	10	27	26	4	30	1: 1.0	1: 6.8	1: 0.9
	Daily Stats	**3**	**15**	**17**	**16**	**51**	**34**	**5**	**39**	**1: 1.5**	**1: 10.2**	**1: 1.3**
05/22/2000	am	7	5	9	6	27	31	2	33	1: 0.9	1: 13.5	1: 0.8
	pm	3	8	6	7	24	19	5	24	1: 1.3	1: 4.8	1: 1.0
	Daily Stats	**10**	**13**	**15**	**13**	**51**	**46**	**7**	**57**	**1: 1.2**	**1: 7.3**	**1: 0.9**
05/23/2000	am	4	1	0	4	9	11	3	14	1: 0.8	1: 3.0	1: 0.6
	pm	3	4	10	8	25	21	4	25	1: 1.2	1: 6.3	1: 1.0
	Daily Stats	**7**	**5**	**10**	**12**	**34**	**32**	**7**	**39**	**1: 1.1**	**1: 4.9**	**1: 0.9**
05/24/2000	am	10	8	4	4	26	16	6	22	1: 1.6	1: 4.3	1: 1.2
	pm	3	6	10	7	26	12	7	19	1: 2.2	1: 3.7	1: 1.4
	Daily Stats	**13**	**14**	**14**	**11**	**52**	**28**	**13**	**41**	**1: 1.9**	**1: 4.0**	**1: 1.3**
Overall Stats		62	107	150	159	478	256	79	335	1: 1.9	1: 6.1	1: 1.4

APPENDIX: ABSTRACTS TO PAPERS IN REVISION.

Becker, Earl, F., and Pham X. Quang. In revision. A unimodal detection function with application to aerial survey sampling of contour transects using double-count and covariate data. Journal of Agricultural, Biological, and Environmental Statistics.

We developed a procedure for estimating animal population size from aerial survey data collected simultaneously by 2 observers on the same sighting platform. We use a line transect sample design where transects follow elevation contours in mountainous terrain. We fit a line transect model to each observer's data using a partial likelihood model with specialized gamma-shaped detection function; in addition, covariates are incorporated into the model. Our parameterization allows nonshouldered detection apexes, which often occur with aerially collected data. This parameterization allows an apex to occur at each set of covariate classes. We use the double-count portion of the data set to estimate the probability of detection at each apex. A Horvitz-Thompson estimator is used to incorporate the animals' probability of detection into the population estimate. We illustrate our procedure on a previously analyzed brown bear data set (Quang and Becker 1999).